Volume 4

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The Department of Energy's Congressional Budget justification is available on the Office of Chief Financial Officer, Office of Budget homepage at http://www.cfo.doe.gov/crorg/cf30.htm.

For the latest details on the Department of Energy's implementation of the Recovery Act, please visit: http://www.energy.gov/recovery

Science
Proposed Appropriation Language

For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment and other expenses necessary for science activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or facility or for plant or facility acquisition, construction, or expansion, and purchase of not more than 25 passenger motor vehicles for replacement only, including one law enforcement vehicle, one ambulance, and one bus, $5,152,752,000, to remain available until expended: Provided, That $193,300,000 shall be available until September 30, 2015 for program direction.

Explanation of Change

Appropriation language updates reflect the funding and replacement passenger motor vehicle levels requested in FY 2014.

Science
Office of Science

Overview
Appropriation Summary by Program

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Advanced Scientific Computing Research	428,304	443,566	465,593
Basic Energy Sciences	1,644,767	1,698,424	1,862,411
Biological and Environmental Research	592,433	613,287	625,347
Fusion Energy Sciences	392,957	403,450	458,324
High Energy Physics	770,533	795,701	776,521
Nuclear Physics	534,642	550,737	569,938
Workforce Development for Teachers and Scientists	18,500	18,613	16,500
Science Laboratories Infrastructure	111,800	112,485	97,818
Safeguards and Security	80,573	81,066	87,000
Program Direction	185,000	186,132	193,300
Small Business Innovation Research/Technology Transfer (SBIR/STTR) (SC funding)	114,125	0	0
Subtotal, Office of Science	4,873,634	4,903,461	5,152,752
SBIR/STTR (Other DOE funding)	61,346	0	0
Total, Science appropriation/Office of Science[a]	4,934,980	4,903,461	5,152,752

*FY 2013 amounts shown reflect the P.L. 112-175 Continuing Resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

[a] SBIR/STTR:

- FY 2012 Current: SBIR: $100,584,000 was reprogrammed within SC and $54,089,000 was transferred from other DOE programs; STTR: $13,541,000 was reprogrammed within SC and $7,257,000 was transferred from other DOE programs. The transfer amounts include $1,574,000 of SBIR and $189,000 of STTR that are associated with the FY 2011 SBIR/STTR assessment, but was transferred during FY 2012.
- FY 2014 Request: SBIR: $113,793,000 and STTR: $16,253,000 (from SC only).

Office Overview and Accomplishments

The Office of Science mission is to deliver the scientific discoveries and major scientific tools that transform our understanding of nature and advance the energy, economic, and national security of the United States. The Office of Science accomplishes its mission and advances national goals by supporting:

- *The Frontiers of Science*—discovering nature's mysteries from the study of subatomic particles, atoms, and molecules that are the building blocks of the materials of our everyday world to the DNA, proteins, and cells that are the building blocks of entire biological systems;

- *The 21st Century Tools of Science*—providing to the Nation's researchers more than 30 national scientific user facilities, the most advanced tools of modern science including accelerators, colliders, supercomputers, light sources, neutron sources, and facilities for studying the nanoworld; and
- *Energy and Environmental Science*—advancing a clean energy agenda through fundamental research on energy production, conversion, storage, transmission, and use and advancing our understanding of the earth and its climate through basic research in atmospheric and environmental sciences and climate change.

The Office of Science is the Nation's largest Federal sponsor of basic research in the physical sciences and the lead Federal agency supporting fundamental scientific research for energy. The Office of Science FY 2014 request supports about 25,000 investigators at over 300 U.S. academic institutions and at all of the DOE laboratories. Each of the programs in the Office of Science supports research to probe the most fundamental questions of its disciplines. In chemistry, material sciences, and biology, the questions probe the world we live in, encompassing both non-living and the living things:

- How do the remarkable properties of materials, such as catalysts, emerge from the atomic and electronic constituents and how can we control those properties?
- How can we master the nanoscale in order to create new materials with capabilities rivaling those of living things?
- How do materials behave under extreme temperature, pressure, or electromagnetic conditions?
- How can we achieve a systems-level understanding of a microbe or community of microbes to ultimately model and predict characteristics from genetic and environmental interactions?
- What are the roles of earth system components (atmosphere, land, oceans, sea ice, and the biosphere) in determining climate?

In high energy and nuclear physics, the questions probe the subatomic world and origins of the universe:

- What lies beyond the Standard Model?
- What are dark energy and dark matter?
- What is the nature of neutrinos?
- What is the nature of neutron stars and dense nuclear matter?
- What governs the behavior of quarks and gluons?

In plasma and fusion science, the questions probe the 4th state of matter and its control:

- What governs the behavior of self-heated plasmas?
- Can we reduce and control turbulence in plasmas?
- How do plasmas interact with other forms of matter and with light?
- How do the distinct properties of high energy density systems alter hydrodynamic behavior?

Supporting all of these research areas are advances in the numerical methods, mathematical analysis techniques, algorithms, and innovative code development that make possible scientific discovery through computation and simulation using some of the world's fastest computers.

The Office of Science also provides the Nation's researchers with state-of-the-art national scientific user facilities. Many of these facilities extend the frontiers of measurement science, allowing researchers to probe the subatomic, atomic, molecular, and biological worlds and to understand the correlations between structure and function in each of these size regimes—from the subatomic world to entire biological systems. Other facilities extend the frontiers of computation and simulation, allowing researchers to examine phenomena that would be impossible to create in the laboratory. Still other facilities provide researchers with the opportunity to build nanosystems from the bottom up. The scientific user facilities offer capabilities unmatched anywhere in the world, enabling the U.S. to remain at the forefront of science, technology, and innovation. Nearly 29,000 researchers from universities, national laboratories, industry, and international partners are expected to use the Office of Science scientific user facilities in FY 2014.

In FY 2014, the Office of Science continues the construction of new user facilities and facility upgrades to continue to support world class research capabilities in the United States. Ongoing construction and related activities include the 12 GeV Upgrade at the Continuous Electron Beam Accelerator Facility, the U.S. Contributions to ITER Project, the Linac Coherent Light Source-II (LCLS-II) and the Advanced Photon Source (APS) Upgrade projects, initial construction of the Facility for Rare Isotope Beams (FRIB), and continued development of end stations and instruments for the National Synchrotron Light Source-II (NSLS-II) in its early operations. The FY 2014 request begins construction of the Muon to Electron Conversion Experiment (Mu2e) and initiates a new MIE for the Muon g-2 experiment. Planning for the future is an ongoing process involving significant input from the scientific community. Years of research and development (R&D) are often required to determine the technical feasibility and design options for a facility to deliver desired capabilities and maximize the science potential. To that end, the Office of Science FY 2014 request supports R&D in several targeted areas to keep future facilities options open. This includes R&D on superconducting undulators and soft x-ray self-seeding related to next-generation light sources, emerging computer hardware related to energy management and fault tolerance, advanced accelerator technologies such as superconducting magnets and beam dynamics relevant to future accelerator systems for high energy physics and broader applications, beam cooling techniques and energy recovery linacs relevant to a possible next-generation collider, and conceptual studies of potential fusion power systems.

The research programs and the scientific user facilities together provide the foundation for targeted investments by the Office of Science in research to advance energy research and our understanding of climate change. These include investments such as the three DOE Bioenergy Research Centers (BRCs), the Energy Frontier Research Centers (EFRCs), two Energy Innovation Hubs in Fuels from Sunlight and Batteries and Energy Storage, and atmospheric process and climate modeling research. The BRCs have been highly productive in their first five years of operations, generating significant research accomplishments and disseminating results through peer-reviewed publications and intellectual property; they have collectively produced over 1,100 publications and over 400 items of intellectual property (invention disclosures, licenses, patent filings, and patents). Many EFRCs have reported that their fundamental scientific advances are already impacting both technology research and industry. The 46 Centers have authored over 3,400 peer-reviewed publications, have filed over 60 invention disclosures and over 200 patents/applications, and have issued at least 22 licenses for EFRC-generated patents in their first three years. The EFRCs report that more than 30 companies are using the results of EFRC research, including small start-ups.

The Office of Science has long been a leader of U.S. scientific discovery and innovation. Over the decades, Office of Science investments have played a central role in initiating the modern biotechnology revolution and have helped the transition from observing natural phenomena to the science of control and directed design at the nanoscale. We have pushed the frontiers of our understanding of the origins of matter and the universe, and we have built and operated the large-scale scientific facilities that collectively form a major pillar of the current U.S. scientific enterprise. These investments and accomplishments have led to new technologies and created new businesses and industries, making significant contributions to our Nation's economy and quality of life. Scientific accomplishments in FY 2012 enabled by the Office of Science programs are described in the program narratives. Additional descriptions of recent science discoveries can be found at http://science.energy.gov/stories-of-discovery-and-innovation/.

The Office of Science appropriation includes ten programs:

- *Advanced Scientific Computing Research* supports research to discover, develop, and deploy computational and networking capabilities to analyze, model, simulate, and predict complex phenomena important to DOE.
- *Basic Energy Sciences* supports fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels in order to provide the foundations for new energy technologies.
- *Biological and Environmental Research* supports fundamental research focused on three scientific drivers: exploring the frontiers of genome-enabled biology; discovering the physical, chemical, and biological drivers and environmental impacts of climate change; and seeking the geological, hydrological, and biological determinants of environmental sustainability and stewardship.
- *Fusion Energy Sciences* supports research to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation of fusion energy.

- *High Energy Physics* supports research toward understanding how the universe works at its most fundamental level by discovering the most elementary constituents of matter and energy, probing the interactions among them, and exploring the basic nature of space and time itself.
- *Nuclear Physics* supports research to discover, explore, and understand all forms of nuclear matter, supporting experimental and theoretical research to create, detect, and describe the different forms and complexities of nuclear matter that can exist in the universe, including those that are no longer found naturally.
- *Workforce Development for Teachers and Scientists* supports activities that engage students and professionals in science, technology, engineering, and mathematics (STEM) to help ensure that DOE has a sustained pipeline of skilled and diverse workers to support the mission, administer its programs, and conduct its research.
- *Science Laboratories Infrastructure* focuses on ensuring the continued mission readiness of Office of Science laboratories through investment in facilities to maintain the capability of those assets.
- *Safeguards and Security* supports the Department's research mission by ensuring appropriate levels of protection at the ten SC laboratories.
- *Program Direction* supports the Federal workforce overseeing SC investments in scientific research and national scientific user facilities.

The Office of Science is responsible for the oversight of ten DOE national laboratories: Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Princeton Plasma Physics Laboratory, SLAC National Accelerator Laboratory, and Thomas Jefferson National Accelerator Facility.

Alignment to Strategic Plan

Office of Science activities align to three objectives from the DOE Strategic Plan: extend our knowledge of the natural world, deliver new technologies to advance our mission, and sustain a world-leading technical workforce. In support of these strategic objectives and its mission, the Office of Science funding requests and performance expectations presented in the budget are focused on four areas:

- *Research*: Support fundamental research to increase our understanding of and enable predictive control of phenomena in the physical and biological sciences.
- *Facility Operations*: Maximize the reliability, dependability, and availability of the SC scientific user facilities.
- *Future Facilities*: Build future and upgrade existing facilities and experimental capabilities to ensure maximum benefit from the investments in SC scientific user facilities.
- *Scientific Workforce*: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers.

Supporting DOE Priority Goals

Maintaining existing and selecting new discovery-class scientific user facilities are among the Office of Science's most important activities. Prioritization across fields of science is required, cognizant of the importance of the science that the facility would support, the readiness of the facility for construction, and the estimated cost of the facility. Therefore SC supports the following DOE Priority Goal:

- *Prioritization of scientific facilities to ensure optimal benefit from Federal investments.* By September 30, 2013, formulate a 10-year prioritization of scientific facilities across the Office of Science based on (1) the ability of the facility to contribute to world-leading science, (2) the readiness of the facility for construction, and (3) an estimated construction and operations cost of the facility.

Goal/Program Alignment Summary

	Research	Facility Operations	Future Facilities	Workforce
Advanced Scientific Computing Research	43%	53%	4%	0%
Basic Energy Sciences	44%	45%	11%	0%
Biological and Environmental Research	66%	34%	0%	0%
Fusion Energy Sciences	35%	15%	50%	0%
High Energy Physics	50%	35%	15%	0%
Nuclear Physics	32%	55%	13%	0%
Workforce Development for Teachers and Scientists	0%	0%	0%	100%
Science Laboratories Infrastructure	0%	0%	100%	0%
Total, Office of Science	44%	40%	15%	1%

Explanation of Changes

The Office of Science FY 2014 request is for $5.15 billion, growing by $218 million or 4.4% relative to the FY 2012 Appropriation. Net of SBIR/STTR funding transferred from other DOE programs, which has not yet been transferred in FY 2014, this reflects growth of $279 million or 5.7% over the two years, which is an annualized growth rate of 2.8%. This growth, within the context of an overall budget that stays within the FY 2014 discretionary funding cap established by the Budget Control Act of 2011 and amended by the American Taxpayer Relief Act of 2012, demonstrates that investment in scientific discovery and innovation remains a high priority for the President.

Advanced Scientific Computing Research grows $37.3 million or 8.7%. Increases support for research and evaluation prototypes for next-generation computing systems, investments in research and tools underpinning data-intensive science, and upgrades for production computing at NERSC.

Basic Energy Sciences grows $217.6 million or 13.2%. Increases support the operation of most scientific user facilities at near-optimal levels. Support is continued for the construction of LCLS-II and NSLS-II, and for Major Items of Equipment for the Advanced Photon Source Upgrade and the NSLS-II Experimental Tools projects. Core research at the FY 2012 level is supported, in addition to two Energy Innovation Hubs and the portfolio of EFRCs, which is re-competed.

Biological and Environmental Research increases by $32.9 million or 5.6%. Increases biological systems science support biosystem design tools, integrative analysis of experimental data sets to examine cross-scale (molecules to mesoscale) relationships, and optimal facility operations. Radiological Sciences decreases as several research activities are completed. New observations of clouds, aerosols, and sensitive ecosystems will address uncertainty in climate models.

Fusion Energy Sciences increases $65.4 million or 16.6%. Funding for the U.S. Contributions to the ITER project grows to $225 million, as the project enters into its full construction phase. Research and operations on two scientific user facilities increase, and research in high energy density laboratory plasmas decreases as activities are consolidated.

High Energy Physics increases by $6.0 million or 0.8%. Investments support full operations of existing HEP facilities, the planned construction funding profile for the new Mu2e experiment, and a new MIE for the Muon g-2 experiment.

Nuclear Physics increases $35.3 million or 6.6%. The increase supports funding for the construction of Facility for Rare Isotope Beams (FRIB). NP core research and national user facilities operations are increased, while the construction of the 12 GeV CEBAF Upgrade project ramps down as the project nears completion.

High-Risk, High-Reward Research[a]

The Office of Science incorporates high-risk, high-reward basic research elements in its research portfolios to drive scientific discoveries and technological breakthroughs. High-risk, high-reward research ideas that challenge current thinking, yet are scientifically sound, are integrated with other mission-driven fundamental research within the Office of Science program portfolios, projects, and individual awards. The Office of Science continues to emphasize cultivating and improving the program management practices and policies that foster support for this research. Committees of Visitors composed of external experts review SC program portfolios triennially to assess, among other things, the balance and impact of the portfolios.

Several mechanisms are used by the Office of Science to identify and develop high-reward research topics, including Federal advisory committees, program and topical workshops, interagency working groups, National Academies studies, and special Office of Science program solicitations. These activities have identified opportunities for new, compelling research and guide the programs in determining future funding priorities. As examples, some of these opportunities are captured in the following reports: *Research at the Intersection of the Physical and Life Sciences*, by the National Research Council (2010); *Grand Challenges for Biological and Environmental Research: A Long-Term Vision*, by the Biological and Environmental Research Advisory Committee (2010); *Science for Energy Technology: Strengthening the Link between Basic Research and Industry*, by the Basic Energy Sciences Advisory Committee (2010); *Research Opportunities in Plasma Astrophysics*, FES workshop report (2010); *Report of the Extreme-scale Solvers: Transition to Future Architectures*, ASCR workshop report (2012); *Fundamental Physics at the Intensity Frontier* workshop report (2011); *New Worlds, New Horizons in Astronomy and Astrophysics, the astronomy and astrophysics decadal survey* (Astro2010 report), by the National Research Council (2010); and *Nuclear Physics: Exploring the Heart of the Matter*, by the National Research Council (2012).

Basic and Applied R&D Coordination

Coordination between the Department's basic research and applied technology programs is a high priority for the Secretary of Energy. The Department has a responsibility to coordinate its basic and applied research programs to effectively integrate R&D conducted by the science and technology communities (e.g., national laboratories, universities, and private companies) that support the DOE mission. The Department's efforts have focused on improving communication and collaboration between federal program managers and increasing opportunities for collaborative efforts among researchers targeted at the interface of scientific research and technology development to ultimately accelerate DOE mission and national goals.

Coordination between the basic and applied programs is enhanced through activities such as joint planning meetings and technical community workshops, joint annual contractor/awardee meetings, joint research solicitations, jointly-funded scientific facilities, and the program management activities of the DOE Small Business Innovation Research and Small Business Technology Transfer programs. Additionally, co-funding research activities and facilities at the DOE laboratories and funding mechanisms that encourage broad partnerships are also means by which the Department facilitates greater communication and research integration within the basic and applied research communities. Specific collaborative activities are highlighted in the "Basic and Applied R&D Coordination" sections of each individual Office of Science program budget justification narrative.

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[a] In compliance with the reporting requirements in the America COMPETES Act of 2007 (P.L. 110-69, section 1008).

Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR)

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Advanced Scientific Computing Research	0	—	14,899
Basic Energy Sciences	0	—	52,945
Biological and Environmental Research	0	—	19,756
Fusion Energy Sciences	0	—	6,672
High Energy Physics	0	—	21,457
Nuclear Physics	0	—	14,317
SBIR/STTR (SC funding)	114,125	—	0
Subtotal, SBIR/STTR	114,125	—	130,046
SBIR/STTR transfer from other DOE programs	61,346	—	N/A
Total, SBIR/STTR	175,471	—	N/A

SBIR and STTR funding is transferred from research programs across the Department to the Small Business Innovation Research/Technology Transfer programs in the Office of Science for distribution to award recipients. All contributing programs participate in the selection of awards.

In FY 2012, 2.95% of funding subject to the SBIR/STTR mandate was transferred (2.6% for SBIR and 0.35% for STTR). In FY 2013, the rate increases to 3.05% (2.7% for SBIR and 0.35% for STTR) and increases to 3.20% in FY 2014 (2.8% for SBIR and 0.4% for STTR). The FY 2012 SBIR/STTR reprogramming (SC funding) and transfer (other DOE programs) is complete so funding is reflected within the SBIR/STTR program in tables. For FY 2014, the reprogramming and transfer have not yet occurred, so SBIR/STTR funding is included within the various SC and other DOE programs that contribute SBIR/STTR funding.

Office of Science
Funding by Site by Program

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Ames Laboratory			
Advanced Scientific Computing Research	300	—	80
Basic Energy Sciences	23,145	—	19,817
Biological and Environmental Research	500	—	500
Fusion Energy Sciences	192	—	0
Workforce Development for Teachers and Scientists	219	—	0
Safeguards and Security	993	—	952
Total, Ames Laboratory	25,349	—	21,349
Ames Site Office			
Program Direction	472	—	461
Argonne National Laboratory			
Advanced Scientific Computing Research	83,267	—	74,306
Basic Energy Sciences	220,950	—	252,139
Biological and Environmental Research	24,061	—	26,137
Fusion Energy Sciences	90	—	90
High Energy Physics	21,533	—	15,952
Nuclear Physics	28,195	—	27,807
Workforce Development for Teachers and Scientists	942	—	0
Science Laboratories Infrastructure	40,000	—	0
Safeguards and Security	8,858	—	8,858
Total, Argonne National Laboratory	427,896	—	405,289
Argonne Site Office			
Program Direction	3,446	—	3,996
Berkeley Site Office			
Program Direction	4,002	—	4,159

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Brookhaven National Laboratory			
Advanced Scientific Computing Research	529	—	231
Basic Energy Sciences	266,921	—	247,105
Biological and Environmental Research	19,144	—	19,151
Fusion Energy Sciences	46	—	0
High Energy Physics	58,060	—	51,185
Nuclear Physics	186,720	—	185,673
Workforce Development for Teachers and Scientists	613	—	0
Science Laboratories Infrastructure	15,500	—	0
Safeguards and Security	12,696	—	11,866
Total, Brookhaven National Laboratory	560,229	—	515,211
Brookhaven Site Office			
Program Direction	4,907	—	5,200
Chicago Office			
Advanced Scientific Computing Research	46,098	—	24,162
Basic Energy Sciences	278,662	—	319,044
Biological and Environmental Research	143,992	—	114,048
Fusion Energy Sciences	155,737	—	93,032
High Energy Physics	129,539	—	116,178
Nuclear Physics	92,212	—	121,374
Workforce Development for Teachers and Scientists	150	—	0
Science Laboratories Infrastructure	1,385	—	1,385
Safeguards and Security	133	—	42
Program Direction	35,069	—	29,844
SBIR/STTR	175,471	—	0
Total, Chicago Office	1,058,448	—	819,109

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Fermi National Accelerator Laboratory			
Advanced Scientific Computing Research	265	—	90
Basic Energy Sciences	35	—	30
High Energy Physics	403,596	—	368,189
Nuclear Physics	550	—	25
Workforce Development for Teachers and Scientists	115	—	0
Science Laboratories Infrastructure	0	—	34,900
Safeguards and Security	3,856	—	3,433
Total, Fermi National Accelerator Laboratory	408,417	—	406,667
Fermi Site Office			
Program Direction	2,425	—	2,554
Golden Field Office			
Workforce Development for Teachers and Scientists	572	—	0
Idaho National Laboratory			
Basic Energy Sciences	1,700	—	0
Biological and Environmental Research	790	—	0
Fusion Energy Sciences	2,222	—	2,610
Workforce Development for Teachers and Scientists	96	—	0
Total, Idaho National Laboratory	4,808	—	2,610

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Lawrence Berkeley National Laboratory			
Advanced Scientific Computing Research	118,066	—	115,158
Basic Energy Sciences	164,873	—	153,254
Biological and Environmental Research	138,531	—	137,670
Fusion Energy Sciences	5,508	—	0
High Energy Physics	56,186	—	57,877
Nuclear Physics	24,646	—	18,521
Workforce Development for Teachers and Scientists	598	—	0
Science Laboratories Infrastructure	12,975	—	0
Safeguards and Security	5,427	—	5,093
Total, Lawrence Berkeley National Laboratory	526,810	—	487,573
Lawrence Livermore National Laboratory			
Advanced Scientific Computing Research	39,410	—	7,580
Basic Energy Sciences	4,856	—	3,106
Biological and Environmental Research	16,506	—	15,364
Fusion Energy Sciences	15,222	—	7,279
High Energy Physics	2,226	—	1,290
Nuclear Physics	2,312	—	1,676
Workforce Development for Teachers and Scientists	54	—	0
Total, Lawrence Livermore National Laboratory	80,586	—	36,295
Los Alamos National Laboratory			
Advanced Scientific Computing Research	6,910	—	6,526
Basic Energy Sciences	38,595	—	31,416
Biological and Environmental Research	23,593	—	25,741
Fusion Energy Sciences	6,652	—	2,280
High Energy Physics	3,155	—	1,725
Nuclear Physics	10,622	—	14,378
Workforce Development for Teachers and Scientists	182	—	0
Total, Los Alamos National Laboratory	89,709	—	82,066

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
	(dollars in thousands)		
National Energy Technology Laboratory			
Workforce Development for Teachers and Scientists	120	—	0
National Renewable Energy Laboratory			
Advanced Scientific Computing Research	186	—	186
Basic Energy Sciences	14,028	—	8,123
Biological and Environmental Research	1,755	—	932
Workforce Development for Teachers and Scientists	75	—	0
Total, National Renewable Energy Laboratory	16,044	—	9,241
Nevada Site Office			
Basic Energy Sciences	244	—	244
New Brunswick Laboratory			
Science Laboratories Infrastructure	0	—	900
Safeguards and Security	8	—	0
Program Direction	6,214	—	5,948
Total, New Brunswick Laboratory	6,222	—	6,848
Oak Ridge Institute for Science and Education			
Advanced Scientific Computing Research	3,146	—	0
Basic Energy Sciences	1,214	—	100
Biological and Environmental Research	5,718	—	3,178
Fusion Energy Sciences	1,394	—	494
High Energy Physics	1,388	—	0
Nuclear Physics	1,063	—	412
Workforce Development for Teachers and Scientists	13,213	—	0
Safeguards and Security	1,845	—	1,645
Total, Oak Ridge Institute for Science and Education	28,981	—	5,829

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Oak Ridge National Laboratory			
Advanced Scientific Computing Research	103,362	—	90,922
Basic Energy Sciences	322,307	—	308,649
Biological and Environmental Research	79,029	—	75,348
Fusion Energy Sciences	123,041	—	239,193
High Energy Physics	50	—	150
Nuclear Physics	26,156	—	25,562
Safeguards and Security	9,016	—	9,016
Total, Oak Ridge National Laboratory	662,961	—	748,840
Oak Ridge National Laboratory Site Office			
Program Direction	4,655	—	6,051
Oak Ridge Office			
Advanced Scientific Computing Research	523	—	0
Basic Energy Sciences	882	—	0
Biological and Environmental Research	797	—	0
Fusion Energy Sciences	215	—	0
High Energy Physics	535	—	0
Nuclear Physics	642	—	0
Science Laboratories Infrastructure	5,338	—	5,751
Safeguards and Security	18,444	—	18,795
Program Direction	37,525	—	34,081
Total, Oak Ridge Office	64,901	—	58,627

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Office of Scientific and Technical Information			
Advanced Scientific Computing Research	163	—	132
Basic Energy Sciences	157	—	132
Biological and Environmental Research	205	—	199
Fusion Energy Sciences	132	—	125
High Energy Physics	140	—	124
Nuclear Physics	135	—	125
Science Laboratories Infrastructure	0	—	200
Safeguards and Security	535	—	472
Program Direction	8,667	—	8,400
Total, Office of Scientific and Technical Information	10,134	—	9,909
Pacific Northwest National Laboratory			
Advanced Scientific Computing Research	8,598	—	5,349
Basic Energy Sciences	25,710	—	20,633
Biological and Environmental Research	124,765	—	106,156
Fusion Energy Sciences	1,774	—	1,735
High Energy Physics	1,894	—	9,060
Nuclear Physics	110	—	83
Workforce Development for Teachers and Scientists	733	—	0
Safeguards and Security	11,317	—	10,731
Total, Pacific Northwest National Laboratory	174,901	—	153,747
Pacific Northwest Site Office			
Program Direction	5,138	—	5,204

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Princeton Plasma Physics Laboratory			
Advanced Scientific Computing Research	94	—	93
Fusion Energy Sciences	76,029	—	63,087
High Energy Physics	237	—	230
Workforce Development for Teachers and Scientists	140	—	0
Safeguards and Security	2,507	—	2,232
Total, Princeton Plasma Physics Laboratory	79,007	—	65,642
Princeton Site Office			
Program Direction	1,706	—	1,763
Sandia National Laboratories			
Advanced Scientific Computing Research	15,843	—	9,090
Basic Energy Sciences	43,996	—	34,063
Biological and Environmental Research	6,339	—	11,019
Fusion Energy Sciences	2,913	—	1,605
Workforce Development for Teachers and Scientists	80	—	0
Safeguards and Security	40	—	0
Total, Sandia National Laboratories	69,211	—	55,777
Savannah River National Laboratory			
Basic Energy Sciences	530	—	430
Biological and Environmental Research	65	—	221
Total, Savannah River National Laboratory	595	—	651

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
SLAC National Accelerator Laboratory			
Advanced Scientific Computing Research	240	—	140
Basic Energy Sciences	211,015	—	285,882
Biological and Environmental Research	4,475	—	4,575
Fusion Energy Sciences	947	—	2,000
High Energy Physics	86,064	—	90,506
Nuclear Physics	75	—	0
Workforce Development for Teachers and Scientists	269	—	0
Science Laboratories Infrastructure	24,110	—	25,482
Safeguards and Security	3,026	—	2,676
Total, SLAC National Accelerator Laboratory	330,221	—	411,261
SLAC Site Office			
Program Direction	2,645	—	2,580
Thomas Jefferson National Accelerator Facility			
Advanced Scientific Computing Research	10	—	29
Basic Energy Sciences	1,850	—	500
Biological and Environmental Research	600	—	600
High Energy Physics	2,847	—	100
Nuclear Physics	140,926	—	131,569
Workforce Development for Teachers and Scientists	287	—	0
Science Laboratories Infrastructure	12,337	—	29,200
Safeguards and Security	1,485	—	1,484
Total, Thomas Jefferson National Accelerator Facility	160,342	—	163,482
Thomas Jefferson Site Office			
Program Direction	1,918	—	1,911

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Washington Headquarters			
Advanced Scientific Computing Research	1,294	—	131,519
Basic Energy Sciences	23,097	—	177,744
Biological and Environmental Research	1,568	—	84,508
Fusion Energy Sciences	843	—	44,794
High Energy Physics	3,083	—	63,955
Nuclear Physics	20,278	—	42,733
Workforce Development for Teachers and Scientists	42	—	16,500
Science Laboratories Infrastructure	155	—	0
Safeguards and Security	387	—	9,705
Program Direction	66,211	—	81,148
Total, Washington Headquarters	116,958	—	652,606
Total, Science	4,934,980	4,903,461	5,152,752

*FY 2013 amounts shown reflect the P.L. 112-175 Continuing Resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

Advanced Scientific Computing Research
Funding Profile by Subprogram and Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Mathematical, Computational, and Computer Sciences Research			
Applied Mathematics	45,547	—	49,500
Computer Science	46,131	—	54,580
Computational Partnerships	45,961	—	46,918
Next Generation Networking for Science	13,929	—	15,931
SBIR/STTR	0	—	5,518
Total, Mathematical, Computational, and Computer Sciences Research	151,568	—	172,447
High Performance Computing and Network Facilities			
High Performance Production Computing	57,800	—	65,605
Leadership Computing Facilities	156,000	—	147,000
Research and Evaluation Prototypes	26,922	—	38,552
High Performance Network Facilities and Testbeds	36,014	—	32,608
SBIR/STTR	0	—	9,381
Total, High Performance Computing and Network Facilities	276,736	—	293,146
Total, Advanced Scientific Computing Research[a]	428,304	443,566	465,593

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $11,073,000 and STTR $1,491,000 (transferred out of ASCR in FY 2012 Current column)
- FY 2014 Request: SBIR $13,037,000 and STTR $1,862,000

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 102-468, "Energy Policy Act of 1992"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

The Advanced Scientific Computing Research (ASCR) program's mission is to advance applied mathematics and computer science; deliver, in partnership with disciplinary science, the most advanced computational scientific applications; advance computing and networking capabilities; and develop, in partnership with the research community, including U.S. industry, future generations of computing hardware and tools for science. In this way, ASCR supports the science goal of the Department of Energy (DOE) 2012 Strategic Plan to maintain a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity and underpins the targeted outcome to "develop and deploy high-performance computing hardware and software systems through exascale platforms."

Over the past two decades, in both theory and experiment, computing has become a ubiquitous tool for science and engineering that allows researchers to delve deeper, think bigger, and explore regimes previously out of reach. ASCR and its predecessor organizations, in partnership with the National Nuclear Security Administration's Advanced Simulation and Computing (ASC) program, has led this computing revolution for the past decade, building on a foundation of over 50 years of research and collaboration. This partnership has delivered the scientific promise of high performance computers for national security, science, and engineering and has driven the world leadership of U.S. vendors in high performance computing. Together, ASCR and ASC led the transition to parallel computing with interconnected commercial processors in the 1990s. In 2009, ASCR delivered the first petascale systems for open science that helped increase our understanding of diseases such as Parkinson's and Alzheimer's and disasters such as earthquakes and hurricanes along with enabling improvements in the energy efficiency of aircraft and long-haul trucks. In addition, ASCR-supported software, such as the Message Passing Interface (MPI) built into all massively parallel software, has enabled the worldwide parallel computing industry—from dual core laptops to supercomputers. ASCR-developed software, protocols, advanced storage technologies, data tools and math libraries are used throughout industry and academia. ASCR's Scientific Discovery through Advanced Computing (SciDAC) program improved the performance of DOE applications up to 10,000 percent and have enabled dozens of applications to run at the petascale enabling researchers to increase the efficiency of combustion engines, understand the physical mechanisms of stress-corrosion cracking, reduce uncertainties in global climate models such as those due to the transport of ice sheets, predict the behavior of fusion plasmas, explain the progression of supernovae, predict structure and decay of novel isotopes, and calculate the subatomic interactions that determine nuclear structure.

Growth in the use of computing, the demand for both capability and capacity computing and the impact on science and engineering continues to challenge and inspire the ASCR program. ASCR's FY 2014 budget positions the Department to address scientific challenges that require 1,000 fold increases in computing capability and scientific data. The transition to the next generation of high performance computing is fundamentally different than the transition to parallel computing because the electric power required to move data now dwarfs the power necessary for calculations, and because the increases in parallelism are now multilayered—both on the chips and between them. ASCR's research investments seek to ensure DOE applications continue to efficiently harness the potential of commercial hardware while controlling power bills at DOE computing facilities, which based on current technologies, are projected to rise dramatically in order to achieve performance increases.

Since the power and parallelism challenges span the computing industry, ASCR's research investments will impact computing at all scales from the largest scientific computers to home laptops.

The strategy to accomplish this, like the strategy that has underpinned the Department's leadership during the past half century, has two thrusts: developing and maintaining world-class computing and network facilities for science; and research in applied mathematics, computer science and advanced networking. ASCR leverages partnerships to bring the first two thrusts together to transform science.

Through both the Research and Evaluation Prototype activity and the facility upgrade projects, ASCR has a history of successfully partnering with the research community, including industry to improve the programmability of the next generation of computers while readying applications to run on those computers from the first day of operations. The current upgrade of the Argonne Leadership Computing Facility to a 10 petaflop system is the direct result of a five year partnership between Argonne and Lawrence Livermore national laboratories and industry, funded through the Research and Evaluation Prototype activity. In addition, Argonne has been working with computer science researchers and 15 "early science applications" that best represent DOE applications, take advantage of the novel features of the system, and identify any remaining issues before the machine is transitioned to operations. This technique has been successfully used at all of the ASCR facilities to identify hardware and software issues in the early stages of deployment. In addition, the planned National Energy Research Scientific Computing (NERSC-7) upgrade will triple NERSC's capacity and will be the first installation of a High Productivity Computing System developed through the Research and Evaluation Prototype partnership with DARPA. The Oak Ridge Leadership Computing Facility has worked extensively with hardware and software vendors to develop the tools, system software, and user interfaces necessary to enable DOE applications to effectively use hybrid technologies such as those incorporated into the upgrade currently underway at the facility.

The U.S. is not alone in recognizing the growing importance of high performance computing and its potential economic impact. The potential from broad adoption of more advanced computing for our society, our economy, and the Department's missions is tremendous and has been well documented through numerous reports from DOE, DARPA, the National Academies, the Council on Competitiveness, and other workshops, studies, and reports[a]. Today, the United States is the clear leader in high-performance computing (HPC), with 90% of HPC platforms employing U.S.-developed technologies and most of the work performed on supercomputers using software developed by U.S. researchers. Seeing HPC as a key to economic competitiveness, China, the European Union, India, and Japan, have significantly increased their investments in HPC hardware, software, and applications. A new Japanese machine is one of the most powerful computers in the world; it was built using processors from a Japanese vendor and has a specially designed interconnection network developed in Japan. The Chinese, who didn't have a noticeable presence in HPC ten years ago, have also developed one of the world's fastest computers using processors from U.S. vendors with a Chinese interconnection network. There is a real possibility that within ten years a Chinese company, with significant investments from the Chinese government, will produce the world's most powerful supercomputer using processors designed and manufactured in China. In November 2012, DOE, using U.S.-developed components, dominated the list of the Top 500 supercomputers[b] with ASCR's Titan machine at the Oak Ridge Leadership Computing Facility topping the list at 27 petaflops. The FY 2014 budget seeks to build on that accomplishment with open science upgrades and application support that delivers on the promise of leadership computing today while also making strategic research investments for the future.

[a] www.science.energy.gov/ascr/programdocuments
[b] www.top500.org

Basic and Applied R&D Coordination

Coordination across disciplines and programs is an ASCR cornerstone. Partnerships within SC are mature and continue to advance the use of high performance computing and scientific networks for science. A growing area of collaboration will be in the area of data-intensive science. ASCR continues to have a strong partnership with the National Nuclear Security Administration that is essential to achieving the Department's goals for exascale computing. In April 2011, ASCR and the NNSA strengthened this partnership by signing a memorandum of understanding for collaboration and coordination of exascale research within the Department. Key areas of mutual interest between ASCR and the DOE technology programs, particularly the Office of Electricity Delivery and Energy Reliability and the Office of Nuclear Energy, continue to be applied mathematics for the optimization of complex systems, control theory, and risk assessment. Through the National Information Technology Research and Development (NITRD) Subcommittee of the National Science and Technology Council's Committee on Technology, the interagency networking and information technology R&D coordination effort, ASCR also coordinates with similar programs across the Federal Government.

Program Accomplishments and Milestones

DOE Computers Dominate November 2012 Top500 list. DOE's Oak Ridge National Laboratory (ORNL), Lawrence Livermore National Laboratory (LLNL), and Argonne National Laboratory (ANL) put DOE back on the top of the world's most powerful supercomputers as measured by the November 2012 Top500 list, with ORNL's Titan ranking first at 27 petaflops, LLNL's Sequoia is second at 20 petaflops, and ANL's Mira is fourth at 10 petaflops. Two of these machines are the result of a long-standing research and development partnership among ANL, LLNL, and industry.

Small Business Uses OLCF to Rapidly Move from Simulations to New Turbo Compressor. A small, Seattle-based energy R&D firm is developing a novel gas compressor system based on shock wave technology used in supersonic flight applications. This technology has important promise for the turbo machinery industry of engines and compressors. With support from OLCF, the company has dramatically increased its ability to use high performance simulation to solve complex engineering problems. Simulations at the OLCF guide the testing of prototypes to optimize aerodynamic performance improvements. Such a process requires a system like Jaguar, with hundreds of thousands of processors, along with sophisticated mathematical algorithms to analyze and predict this optimal solution. According to the firm, use of the OLCF has cut the projected time from concept to a commercial product by at least two years and the cost by over $2 million.

NERSC Enables A New Approach to Water Desalination. The availability of fresh water is dwindling in many parts of the world, a problem that is expected to grow with populations. One promising source of potable water is seawater, but so far desalination technology has been too expensive for widespread use. Using NERSC supercomputers, researchers from the Massachusetts Institute of Technology have come up with a new approach for desalinating sea water using graphene, one-atom-thick sheets of carbon. Reverse osmosis, a common method of desalination, uses membranes to filter the salt from the water. Graphene is 99.9% thinner than reverse osmosis membranes. Using NERSC, the researchers were able to simulate the properties of the material down to the atomic level, producing a graphene sheet perforated with precisely sized holes. The new graphene system will operate at a much lower pressure and could purify water at far lower costs.

Co-design Center Challenges Conventional Wisdom. The Center for Exascale Simulation of Advanced Nuclear Reactors, or CESAR, has performed some preliminary studies to understand the various uncertainties in a reactor simulation. Conventional wisdom suggests that in considering the uncertainties, the numerical approximations are not a factor and the uncertainties in the physical data (such as nuclear reaction cross-sections) used in these simulations are major contributors. However, CESAR's studies, incorporating advanced uncertainty quantification techniques, have suggested otherwise. These preliminary studies have paved the way for more detailed studies that will improve how we characterize and quantify uncertainties in nuclear reactors simulations.

New Technique Compresses Scientific Data up to 50%, Lowers Memory Footprint and Saves Energy. ASCR supported researchers at ORNL have developed ISOBAR, a compression technique for hard-to-compress scientific datasets. ISOBAR exhibits both read and write performance gains proportional to the degree of data reduction, up to 46% on scientific datasets, in addition to reducing the total amount of data that is being stored and accessed. By operating on a lower memory footprint in parallel, this method offers high throughput, reduced data movement, and data reduction that collectively translate to a 50% reduction in energy consumption.

ESnet-5, A New 100 Gigabit per second Nationwide Platform for Science Discovery, Wins Awards. Currently ESnet carries up to 10 petabytes of data every month. Traffic over ESnet has increased an average of 10 times every 4 years, propelled by the rising tide of data produced by supercomputers, global collaborations that can involve thousands of researchers, and specialized facilities like the Large Hadron Collider and digital sky surveys. After three years of planning and deployment, ESnet-5—ESnet's fifth generation network—launched in November 2012 and became the world's fastest science network and the first continental 100 Gbps network. This provided an immediate tenfold increase in bandwidth to DOE research sites at the same cost. ESnet has also created a national-scale network testbed, available to researchers and industry for experiments with new network technologies, protocols, and applications at 100 Gbps. *FierceGovernment* chose the ESnet5 Deployment Team as a recipient of the annual Fierce 15 award, in recognition of "federal employees and teams who have done particularly innovative things." Information Week named ESnet as one of the "top 15 innovators in government IT for 2012" stating that "Advanced research can't exist on high-performance computing alone. It needs big bandwidth, too."

Milestone	**Date**
Initiate at least four new teams to conduct fundamental computer science research and at least three new applied mathematics research awards that address issues of fault tolerance or energy management for massive scale heterogeneous systems. (Applied Mathematics and Computer Science)	4^{th} Qtr, FY 2013
Independent review of co-design center progress in influencing industry designs and preparing applications for next generation hardware. (Computational Partnerships)	4^{th} Qtr, FY 2013

Program Planning and Management

ASCR planning, program evaluation, and priority setting strongly benefit from input and review by outside experts. ASCR peer review and oversight processes are designed to regularly assess the quality, relevance, and performance of the ASCR portfolio, and are consistent with the President's management agenda[a].

The Advanced Scientific Computing Advisory Committee (ASCAC) provides input to ASCR in response to charges from the Office of Science. For example, ASCAC organizes regular Committees of Visitors (COVs) and other subcommittees to review ASCR research management, identify opportunities and challenges in specific areas of research, review the impact of ASCR scientific user facilities, and track progress toward the long-term goals of the program. In 2012, ASCAC delivered a report on the opportunities and challenges associated with exascale computing, a review of the data policies of ASCR relevant communities, a COV report on the Next Generation Networking for Science elements of the ASCR program, a report on the management and impact of the Computational Science Graduate Fellowship, and a COV on the Computer Science activity. Currently, ASCAC is responding to charges to identify the critical areas where exascale and data-intensive science intersect, with attention to opportunities for high pay-off research; to provide input for Office of Science prioritization of planned scientific user facilities; and to conduct a COV for the Applied Mathematics activity. The first two reports are due in spring 2013 and the COV will report later in 2013.

The Department's mission applications require the ASCR portfolio to be continuously assessed and shifted to support critical new research efforts. FY 2014 will require significant shifts across the research portfolio to emphasize the rapid development of new tools and methods to allow DOE applications to continue to make effective use of commercial HPC.

Critical tools for managing ASCR scientific user facilities include tailored project management principles, annual operational reviews, and regular requirements gathering workshops. For example, ESnet and NERSC conduct requirements workshops with at least two SC program offices every year in order to accurately characterize their near-, medium-, and long-term network and computing requirements. The ASCR facilities are also required to understand the challenges of evolving hardware vis-à-vis their users and to ensure that users are ready to meet those challenges and continue to mission-relevant science. This means scientific support staff at the facilities work with scientists and their applications to get them ready to run effectively on the new architectures.

Other planning and management tools include community-driven workshops, NITRD participation, and studies by outside groups such as the National Research Council and the U.S. Council on Competitiveness.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Enable high performance computational science and engineering to increase our understanding of and enable predictive control of phenomena in the physical and biological sciences.
- *Facility Operations*: Maximize the performance, usability, and capacity of the SC scientific computing user facilities and connect Office of Science researchers, labs, and facilities via an ultra-reliable, high performance scientific network.
- *Future Facilities*: Build future and upgrade existing facilities and capabilities to get the best value from investments and advance continued U.S. leadership in computational science and engineering.
- *Scientific Workforce*: Continue to support graduate students and Post-Docs on research projects to ensure a sustained pipeline of highly skilled, computationally savvy, and diverse science, technology, engineering, and mathematics (STEM) workers.

[a] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Mathematical, Computational, and Computer Sciences Research	100%	0%	0%	0%
High Performance Computing and Network Facilities	10%	85%	5%	0%
Total, Advanced Scientific Computing Research	43%	53%	4%	0%

Performance Measures

Performance Goal (Measure)	**ASCR Facility Operations**—Average achieved operation time of ASCR user facilities as a percentage of total scheduled annual operation time		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 90%	≥ 90%	≥ 90%
Result	Met		
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		

Performance Goal (Measure)	**ASCR Research**—Discovery of new applied mathematics and computer science tools and methods that enable DOE applications to deliver scientific and engineering insights with a significantly higher degree of fidelity and predictive power		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	Develop exascale plan coordinated with the NNSA and socialized with the community and policy makers	Accept and put into service 10 petaflop upgrades at Argonne and Oak Ridge Leadership Computing Facilities	Initiate at least four new teams to conduct fundamental computer science research and at least three new applied mathematics research awards that address issues of fault tolerance or energy management for next-generation computing systems
Result	Not Met		
Endpoint Target	Develop and deploy high-performance computing hardware and software systems through exascale platforms		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Explanation of Funding and Program Changes

The FY 2014 budget includes increases and priority shifts to deliver world-class computing and network facilities for science and to support research in applied mathematics, computer science, and advanced networking for computing in a new era of hardware parallelism. ASCR will also support partnerships to bring the first two thrusts together.

In FY 2014, ASCR will continue its long history as a leader in research and tools underpinning advances in storing, sending, sharing, analyzing, visualizing, and validating big data. Data-intensive science faces many of the same hardware challenges as computing-intensive science. In the past, the workflow for computational science and experiments at other SC scientific user facilities was represented by large-scale data collection or simulation followed by off-line data analyses and visualizations. However, data being produced by experiments and simulations today are rapidly outstripping our current ability to explore and understand them. Increasingly, simulations require that some analyses and visualizations be performed while data is still resident in memory, so-called in-situ analysis and visualization. Because of ASCR's close partnerships with other Office of Science programs, which steward research and facilities currently facing the immense challenges of big data, it is uniquely positioned to focus on the intersection between data-intensive science and next-generation computing research.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Mathematical, Computational, and Computer Sciences Research	151,568	172,447	+20,879
Research will focus on the linked challenges of emerging computing hardware (such as energy management and fault tolerance) and on data-intensive science. There are increases for core research efforts in Applied Mathematics, Computer Science, and Next Generation Networking for Science for this purpose. The cornerstones of ASCR's data-intensive science investments within Computational Partnerships will continue to be our Scalable Data Management Analysis and Visualization (SDAV) Institute and data-intensive co-design center. The goal of these efforts is to develop new and improved tools to broadly help scientists manage and analyze massive data with SDAV focused on the near term and co-design focused on emerging hardware.			
High Performance Computing and Network Facilities	276,736	293,146	+16,410
Increased funding supports operations, lease payments, and user support for ASCR facilities. ESnet expands production use of the 100 Gbps optical ring. Research and Evaluation Prototypes will expand investments in critical technologies for exascale and will begin planning system integration efforts. The focus of these efforts is to improve the energy efficiency and usability of next generation systems for the Department's science and engineering applications.			
Total, Advanced Scientific Computing Research	428,304	465,593	+37,289

Mathematical, Computational, and Computer Sciences Research
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Applied Mathematics	45,547	—	49,500
Computer Science	46,131	—	54,580
Computational Partnerships	45,961	—	46,918
Next Generation Networking for Science	13,929	—	15,931
SBIR/STTR	0	—	5,518
Total, Mathematical, Computational, and Computer Sciences Research[a]	151,568	—	172,447

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $4,019,000 and STTR $541,000 (transferred out of ASCR in FY 2012 Current column)
- FY 2014 Request: SBIR $4,828,000 and STTR $690,000

Overview

The Mathematical, Computational, and Computer Sciences Research subprogram supports research activities aimed at effectively utilizing the Department's forefront computational and networking capabilities to advance DOE missions and extending these capabilities to forge the future of high performance computing and networking. Computational science is increasingly central to progress at the frontiers of science and to our most challenging engineering problems. Accordingly, the subprogram must be positioned to address scientifically challenging questions, to deliver:

- new mathematics required to more accurately model systems involving processes taking place across broad time and length scales;
- software, tools, and middleware to efficiently and effectively harness the potential of today's high performance computing systems and advanced networks for DOE science and engineering applications;
- operating systems, data management, analyses, representation model development, user interfaces, and other tools required to make effective use of future-generation supercomputers and the data sets from current and future scientific user facilities;
- computer science and algorithm innovations that increase the energy efficiency of future-generation supercomputers; and
- networking and collaboration tools to make scientific resources readily available to scientists, in university, national laboratory, and industrial settings.

Explanation of Funding Changes

The challenges of high performance computing systems during a period of significant hardware changes, the demands of DOE's science and engineering applications, data-intensive research, and next generation scientific user facilities require us to look ahead and make coordinated investments across the ASCR research portfolio. The research program will need to rapidly develop methods, software, and tools that enable DOE to effectively use commercial products for HPC systems. This requires a renewed focus on energy management, data movement, resiliency to work through individual chip failures, and methods and tools to improve HPC usability up to the exascale and exabytes.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Applied Mathematics	45,547	49,500	+3,953
Increased research efforts will focus on the most critical challenges from emerging hardware for DOE mission applications with increased emphasis on energy management, data movement, and resiliency.			
Computer Science	46,131	54,580	+8,449
Increased research efforts will focus on tools and software that make emerging high performance computing hardware more usable for DOE mission applications with emphasis on improving the fault tolerance, data management, and energy utilization of applications.			
Computational Partnerships	45,961	46,918	+957
The cornerstones of ASCR's data-intensive science investments within Computational Partnerships will continue to be our Scalable Data Management Analysis and Visualization (SDAV) Institute and data-intensive co-design center. The goal of these efforts is to develop new and improved tools to broadly help scientists manage and analyze massive data with SDAV focused on the near term and co-design focused on emerging hardware.			
Next Generation Networking for Science	13,929	15,931	+2,002
Research will focus on the challenges of moving, sharing, and validating massive quantities of data from DOE scientific user facilities and large scale collaborations via high speed optical networks. This includes the challenges in building, operating, and maintaining the network infrastructure over which these data pass.			
SBIR/STTR	0	5,518	+5,518
In FY 2012, $4,019,000 and $541,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012, 3.05% in FY 2013 and 3.2% in FY 2014.			
Total, Mathematical, Computational, and Computer Sciences Research	151,568	172,447	+20,879

Applied Mathematics

Overview

The Applied Mathematics activity supports the research and development of applied mathematical models, methods, and algorithms for understanding complex natural and engineered systems related to DOE's mission. These mathematical models, methods, and algorithms are the fundamental building blocks for describing physical and biological systems computationally. Applied Mathematics research underpins all of DOE's modeling and simulation efforts.

This activity supports the development of:

- numerical methods related to problems such as fluid flow, magneto-hydrodynamics, wave propagation, and other natural or physical processes;
- computational meshing tools for developing ways in which physical domains can be efficiently partitioned into smaller, possibly geometrically complex, regions as part of a larger-scale simulation;
- advanced linear algebra libraries for fast and efficient numerical solutions of linear algebraic equations that often arise when simulating physical processes;
- optimization of mathematical methods for minimizing energy or cost, finding the most efficient solutions to engineering problems, or discovering physical properties and biological configurations;
- multiscale mathematics and multiphysics computations for connecting the very large with the very small, the very long with the very short, and multiple physical models in a single simulation;
- uncertainty quantification methodology and techniques to improve our overall understanding of complex scientific and engineering problems and allow us to make quantitative predictions about the behavior of these systems;
- efficient new mathematical models, algorithms, libraries, and tools for next generation computers that blur the boundary between applied mathematics and computer science;
- mathematics for the analysis of extremely large datasets for identifying key features, determining relationships between the key features, and extracting scientific insights from large, complex data sets; and
- mathematical optimization and risk assessment in complex systems such as cyber security or the electric grid that address anomalies in existing engineered systems, modeling of large-scale systems, and understanding dynamics and emergent behavior in these systems.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Initiated new long-range, multi-institutional investments for high-risk applied mathematics research focused on achieving an integrated view of the mathematical methods required to solve difficult challenges in key application areas. The Computational Science Graduate Fellowship program is funded at $6,000,000 within this activity.	45,547
FY 2013	The FY 2013 request proposed $49,500,000 to continue support of new and redirected research efforts to develop algorithms and methods that address the challenges of data-intensive science. There are two broad categories in which DOE's missions lead to unique data-centric computing needs: advanced computing to simulate complex physical and engineering systems and DOE's advanced experimental resources.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	In the FY 2013 Request, the Computational Science Graduate Fellowship (CSGF) program is funded at $6,000,000.	
FY 2014	Due to technology limitations, the next generation of high performance computers will be fundamentally different from today's systems. Although transistor sizes are continuing to decrease, power issues have eliminated meaningful increases in clock rates resulting in rapid increases in parallelism on the chip—from dual core to 24 cores in one upgrade cycle. This trend is further complicated by the addition of specialized accelerator chips. Significant innovation in applied mathematics is needed to realize the potential of these next generation machines. The Applied Mathematics portfolio will shift toward investments aimed at addressing these critical research challenges, as well as associated challenges in complex systems and data intensive science. Energy management, data movement, and resiliency research will be emphasized. The Administration is proposing a comprehensive reorganization of science, technology, engineering, and mathematics (STEM) education programs to increase the impact of Federal investments in four areas: K–12 instruction, undergraduate education, graduate fellowships, and education activities that typically take place outside the classroom. As part of this strategy, the DOE Computational Science Graduate Fellowship will be redirected for inclusion in a consolidated graduate fellowship program at the National Science Foundation. DOE will work with NSF to provide input into the development and implementation of the reformed NSF fellowship program which will reach more students and address national workforce needs.	49,500

Computer Science

Overview

The Computer Science activity supports research to utilize computing at extreme scales and to understand extreme scale data from both simulations and experiments. Industry reports indicate that because of power constraints, data movement, rather than computational operations, will be the limiting factor for future systems. Memory per core is expected to decline sharply due to power requirements and the performance growth of storage systems will continue to lag behind the computational capability of the systems. Multi-level storage architectures that span multiple types of hardware are anticipated and require the activity to support research that develops new approaches to run-time data management and analysis.

A fundamental challenge for researchers supported by this activity is enabling science applications to harness computer systems with increasing scale and increasing complexity that take advantage of technology advances such as multicore chips and specialized accelerator processors. This will require developing system software (operating systems, file systems, compilers, and performance tools) with more dynamic behavior than historically developed to deal with time-varying power and resilience requirements. Substantial innovation is needed to provide essential system software functionality in a timeframe consistent with the anticipated availability of hardware.

This activity supports the development of several areas:

- operating and file systems for extreme scale computers with many thousands of multi-core processors and complicated interconnection networks;
- performance and productivity tools for extreme scale systems that enable users to diagnose and monitor the performance of software and scientific application codes to enable users to improve performance and energy utilization and to get scientific results faster;
- programming models that enable today's computations and discover new models that scale to hundreds of thousands of processors to simplify application code development for petascale computing;
- approaches to simulate and understand the impact of advanced computer architectures on scientific applications critical to the Department; and
- data management and visualization tools to transform extreme scale data into scientific insight through investments in visualization tools that scale to multi-petabyte datasets and innovative approaches to indexing and querying data.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, activity focused on the challenges of emerging extreme scale architectures containing as many as a billion cores and hybrid processors (such as mixed central processing unit/graphical accelerator nodes). Research efforts continued in advanced architectures and related technologies for exascale computing including the associated software with significant investments in simulators for future systems.	46,131

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 request proposed $54,580,000 to continue support of new research efforts to address the challenges of data-intensive science with a focus on full data lifecycle management and analysis for the massive data from DOE scientific user facilities. These efforts look at the full spectrum of the computer science data challenges from hardware to user interfaces and tools. This builds on decades of DOE leadership in this area of computer science and will be informed by recent ASCR workshops and reports including the requirements gathering workshops of NERSC and ESnet and the exascale series of workshops that identified many data challenges across DOE communities and those associated with the complexity of emerging hardware.	—
FY 2014	Significant innovation in computer science is needed to realize the potential of next generation high performance computing systems and other scientific user facilities. There will be continued emphasis on data-intensive science challenges with particular attention to the intersection with exascale computing challenges and the unique needs of DOE scientific user facilities including data management. There will also be expanded efforts in tools, user interfaces, the high performance computing software stack, and visualization and analytics. These efforts are essential to ensure DOE mission applications are able to use commercially available hardware.	54,580

Computational Partnerships

Overview

The Computational Partnerships activity supports the Scientific Discovery through Advanced Computing (SciDAC) program to dramatically accelerate progress in scientific computing that delivers breakthrough scientific results through partnerships among applied mathematicians, computer scientists, and scientists from other disciplines. Efforts apply results from applied mathematics and computer science core research to scientific applications sponsored by other SC programs. These partnerships enable scientists to conduct complex scientific and engineering computations on leadership-class and high-end computing systems at a level of fidelity needed to simulate real-world conditions. SciDAC applications pursue computational solutions to challenging problems in climate science, fusion research, high energy physics, nuclear physics, astrophysics, material science, chemistry, and particle accelerators.

Over the past decade, SciDAC has influenced and shaped the development of a distinct approach to science and engineering research through high performance computation. Today the SciDAC program is recognized as the leader in accelerating the use of high-performance computing to advance the state of knowledge in science applications.

SciDAC focuses on the very high end of high performance computational science and engineering and faces two distinct challenges: to broaden the community and thus the impact of high performance computing, particularly to address the Department's missions, and to ensure that further progress at the forefront is enhanced rather than curtailed by the emergence of hybrid, multi-core architectures. A decade of effort has enabled this program to simultaneously meet both of these important challenges. SciDAC has also shown U.S. industry new ways to use computing to improve competitiveness.

Looking to the challenges of the future, the SciDAC portfolio was recompeted and streamlined in FY 2011 and FY 2012 to support strategic investments in petascale scientific discovery (Institutes and Science Applications) and Co-Design Centers focused on advancing applications that need exascale computing systems while informing the designs of the emerging hardware.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In partnership with other Office of Science programs, ASCR recompeted Science Applications with a focus on the highest priorities of the partner programs and on development of community codes with sustained multi-petaflop performance. The selected applications work with the ASCR-led SciDAC Institutes to enhance capabilities and ready codes for the 10 petaflop leadership computing systems available in FY 2013. These efforts support areas such as nuclear physics, high energy physics, astrophysics, fusion energy, earth system models to understand and quantify the impact of energy production and use on the environment, advanced materials, chemistry, and accelerator design to make more effective use of existing facilities and inform plans for future facilities. In addition, ASCR established a SciDAC Institute for Scientific Data Management, Analysis and Visualization to provide a single point of contact for scientists participating in Science Applications to leverage ASCR expertise to more efficiently and effectively manage, analyze, visualize, and understand their scientific data. The materials, combustion, and nuclear engineering Co-Design Centers are continued.	45,961

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 request proposed $56,776,000 to support new research efforts engaging partners across the Office of Science to address the data-intensive science challenges at the science application level. ASCR supports an additional Co-Design Center with a focus on the challenges to data-intensive science from emerging hardware. This effort engages SC scientific user facilities at the forefront of the data challenge that are also dependent on leveraging commercially available hardware. The dedicated SciDAC Institute for Scientific Data Management, Analysis, and Visualization continues to be supported as well as the other projects selected in FY 2011 and FY 2012.	—
FY 2014	The SciDAC institutes continue to play a key role in assisting DOE mission critical applications to effectively utilize the ASCR production and leadership computing facilities. The strategic partnerships with the other Office of Science programs will continue to address their specific needs as they move toward larger data sets and more complex computing systems. Computational partnerships will also focus on the current set of co-design centers that partner DOE mission applications with forefront researchers and computing vendors. These efforts, including the data-intensive co-design center proposed in FY 2013, will inform core research efforts in applied mathematics and computer science as well as the computing resources for the next generation of scientific user facilities.	46,918

Next Generation Networking for Science

Overview

To facilitate scientific collaborations, ASCR has played a leading role in driving development of the high-bandwidth networks connecting researchers to facilities, data, and each other. The invisible glue that binds today's networks—passing trillions of bits across the world—has roots in ASCR-supported research. For example, ASCR-supported researchers helped establish critical protocols on which the internet is based. Next Generation Networking for Science research makes possible international collaborations such as the Large Hadron Collider and underpins virtual meeting and other commercial collaboration tools. These research efforts build upon results from Computer Science and Applied Mathematics to develop integrated software tools and advanced network services to utilize new capabilities in ESnet to advance DOE missions. These efforts broaden opportunities for other government agencies, U.S. industry, and the American people.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, research in this activity continued to make critical investments, including new protocols that allow hosts to rapidly and efficiently adapt to network conditions to maximize the available bandwidth, new routing algorithms that can improve the performance of routers and switches, a rich suite of secure collaboration tools and services, and advanced simulation environments that duplicate real networks to ensure that science communities achieve their goals.	13,929
FY 2013	The FY 2013 request proposed $16,194,000 to support new research efforts to address the data-intensive science challenges facing scientific communities using unique DOE facilities and engaging in large-scale collaborations. Currently these user communities generate and share multi-petabyte datasets that pass through ESnet and are stored and shared within program-sponsored grids. These datasets will continue to grow, surpassing exabyte scales in the next few years. This presents many challenges in moving, sharing, analyzing, and validating such massive quantities of data. It also presents new challenges in building, operating, and maintaining the network infrastructure over which data passes. This activity focuses on developing new middleware and networking tools for moving, sharing, and verifying such massive datasets and on innovative analysis tools and services.	—
FY 2014	With the production deployment of 100 gigabits per second (Gbps) technologies, research will continue to focus on developing networking software, middleware, and hardware that delivers 99.999% reliability while allowing the successful products of prior research to transition into operation. These investments are increasingly important as ESnet expands production use of very high-throughput and optical technologies.	15,931

High Performance Computing and Network Facilities
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
High Performance Production Computing	57,800	—	65,605
Leadership Computing Facilities	156,000	—	147,000
Research and Evaluation Prototypes	26,922	—	38,552
High Performance Network Facilities and Testbeds	36,014	—	32,608
SBIR/STTR	0	—	9,381
Total, High Performance Computing and Network Facilities[a]	276,736	—	293,146

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $7,054,000 and STTR $950,000 (transferred out of ASCR in FY 2012 Current column)
- FY 2014 Request: SBIR $8,208,000 and STTR $1,173,000

Overview

The High Performance Computing and Network Facilities subprogram delivers forefront computational and networking capabilities to scientists nationwide. These include high performance production computing at the National Energy Research Scientific Computing Center (NERSC) facility at LBNL and Leadership Computing Facilities (LCFs) at ORNL and ANL. These computers and the other SC research facilities generate many petabytes of data each year. Moving data to the researchers who need them requires advanced scientific networks and related technologies provided through High Performance Network Facilities and Testbeds, which includes the Energy Science network (ESnet). The Research and Evaluation Prototypes activity invests in research and development that will play a critical role in delivering world-leading capabilities and achieving the Department’s exascale computing goals.

Computing resources are allocated through competitive processes. Up to 60% of the processor time on the LCFs is allocated through the Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program, which is open to all researchers and results in awards to 20–30 large projects per year. The high performance production computing facilities at NERSC are predominately allocated to researchers supported by SC programs. Remaining processor time on the LCFs and NERSC is allocated through the ASCR Leadership Computing Challenge (ALCC). ALCC is open year-round to scientists from the research community in the national labs, academia, and industry for projects with an emphasis on high-risk, high-payoff research in areas directly related to the DOE’s energy mission, for national emergencies, or for broadening the community of researchers capable of using leadership computing resources.

Allocations on ASCR facilities provide critical resources for the scientific community following the peer reviewed, public access model used by other SC scientific user facilities. In addition, ASCR facilities provide a crucial testbed for U.S. industry to deploy the most advanced hardware and have it tested by the leading scientists across the country in universities, national laboratories, and industry.

Explanation of Funding Changes

Research and Evaluations Prototypes will increase investments in critical technologies for exascale and will begin planning for system integration research, development, and engineering. Continued upgrades to ESnet are supported to be ready for the massive increase in data from next generation scientific user facilities and large-scale collaborations.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
High Performance Production Computing	57,800	65,605	+7,805
Increase supports operations, lease payments, and user support for NERSC including preparations for NERSC-7, which will more than double the capacity of NERSC but also increases the power requirement of NERSC.			
Leadership Computing Facilities	156,000	147,000	-9,000
Supports operations, lease payments, and user support for the 27 petaflop system at the OLCF and 10 petaflop machine at the ALCF. Infrastructure investments are decreased pending identification of specific technology requirements for future upgrades.			
Research and Evaluation Prototypes	26,922	38,552	+11,630
The current Research and Evaluation Prototypes investments in critical technologies will be increased. Planning will begin for system integration research, development, and engineering in partnership with the NNSA. Increase also supports non-recurring engineering investments, in partnership with the NNSA, for near-term technology customization for the ASCR facilities.			
High Performance Network Facilities and Testbeds	36,014	32,608	-3,406
ESnet completes installation and expands production use of 100 Gbps optical ring.			
SBIR/STTR	0	9,381	+9,381
In FY 2012, $7,054,000 and $950,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012, 3.05% in FY 2013, and 3.2% in FY 2014.			
Total, High Performance Computing and Network Facilities	276,736	293,146	+16,410

High Performance Production Computing

Overview

This activity supports the National Energy Research Scientific Computing Center (NERSC) facility located at LBNL. NERSC delivers high-end production computing services for the SC research community. Annually, approximately 5,000 computational scientists in about 500 projects use NERSC to perform basic scientific research across a wide range of disciplines including astrophysics, chemistry, climate modeling, materials, high energy and nuclear physics, and biology. NERSC enables teams to perform modeling, simulation, and data analysis on some of the most capable computational and storage systems in the world to address some of the biggest scientific challenges within the SC mission. NERSC users come from nearly every state in the U.S., with about 65% based in universities, 25% in DOE laboratories, and 10% in other government laboratories and industry. NERSC's large and diverse user base requires an agile support staff to aid users entering the high performance computing arena for the first time as well as those preparing codes to run on the largest machines available at NERSC and other SC computing facilities.

NERSC is a vital resource for the SC research community and it is consistently oversubscribed, with requests exceeding capacity by a factor of 3–10. This gap between demand and capability exists despite upgrades to the primary computing systems approximately every 3 years. NERSC regularly gathers requirements from SC programs through a robust process that informs NERSC upgrade plans. These requirements activities are also vital to planning for SciDAC and other ASCR efforts to prioritize research directions and inform the community of new computing trends, especially as the computing industry moves toward heterogeneous, multi-core computing.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Supported operation of the NERSC high-end capability systems (NERSC-5 and NERSC-6), lease payments, user support, and preparation for future system upgrades.	57,800
FY 2013	The FY 2013 request proposed $65,605,000 to support staff, maintenance, operations, and lease payments for the NERSC high-end capability systems and an upgrade to NERSC-7, while NERSC-6 remains in production.	—
	The NERSC-7 upgrade will be installed in the current NERSC facility; however, this machine takes power and space at this facility to its maximum. NERSC has selected a new site adjacent to the laboratory with a projected move in date in 2015. As part of the NERSC-7 upgrade, FY 2013 funding supports site preparations at current facility for NERSC-7 and for the planned relocation to the new site.	
FY 2014	Supports operation of the NERSC high-end capability systems (NERSC-7) including increased power costs, lease payments, and user support. Also supports, as part of the NERSC-7 upgrade project, continued site preparations for the new NERSC facility on the LBNL campus.	65,605

Leadership Computing Facilities

Overview

The Leadership Computing Facilities (LCFs) enable open scientific applications, including industry applications, to harness the potential of leadership computing to advance science and engineering. The era of petaflop science opened significant opportunities to dramatically advance research as simulations more realistically capture complex behavior in natural and engineered systems. The success of this effort is built on the gains made in Research and Evaluation Prototypes and ASCR research efforts. LCF staff operates and maintains forefront computing resources. One LCF strength is the staff support provided to INCITE projects, ASCR Leadership Computing Challenge projects, scaling tests, early science applications, and tool and library developers. Support staff experience is critical to the success of industry partnerships to address the challenges of next-generation computing.

The Oak Ridge Leadership Computing Facility (OLCF) 27 petaflop system is the most powerful computer in the world for scientific research, according to the November 2012 Top 500 list. Through INCITE allocations, several applications, including combustion studies in diesel jet flame stabilization, simulations of neutron transport in fast reactor cores, and groundwater flow in porous media, are running at the multi-petaflop scale. OLCF staff is sharing its expertise with industry to broaden the benefits for the Nation. For example, OLCF worked with industry to significantly reduce the need for costly physical prototyping and wind tunnel testing to advance the integration of a next generation aircraft rotor and to increase fuel efficiency in 18 wheelers.

The Argonne Leadership Computing Facility (ALCF) provides a 10 petaflop machine with relatively low-electrical power requirements. The Blue Gene/Q was developed through a joint research project with support from the NNSA, industry, and ASCR's Research and Evaluation Prototypes activity. The ALCF and OLCF systems are architecturally distinct and this diversity of resources benefits the Nation's HPC user community. ALCF supports many applications, including molecular dynamics and materials, for which it is better suited than OLCF or NERSC. Through INCITE, ALCF also transfers its expertise to industry, for example, helping to study the complex interactions of billions of atoms to determine how tiny submicroscopic structures impact the characteristics of the ingredients in soaps, detergents, lotions, and shampoos, as well as in fire retardants and foams used in national security applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, this activity supported staff, operations, and lease payments. OLCF completed sited preparations and phase 1 of their upgrade to a 27 petaflop system by replacing the processor boards and interconnects, while continuing to support users and managing INCITE allocations. At ALCF, installation and operation of a new test and development system in early FY 2012 provided early science access to the new architecture, with installation of the full 10 petaflop upgrade completed by the end of FY 2012. The upgrade is expected to be accepted in FY 2013. In addition, the ALCF supported users and manage INCITE allocation of the existing ALCF machine.	156,000

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 request proposed $145,000,000 to support staff, operations, and lease payments. OLCF continues completion of phase 2 of the upgrade with the addition of graphical processing units (GPUs) to a portion of the computer cabinets taking it to 20 petaflops and will provide access to early science applications. Overall funding is reduced in FY 2013 due to reduced funding for infrastructure upgrades. ALCF supports full operation and INCITE allocations of their 10 petaflop leadership computing system with associated increased lease and power payments.	—
FY 2014	Supports operation and allocation, through INCITE and ALCC, of the upgraded 20 petaflop OLCF and 10 petaflop ALCF. This includes lease payments, power, and user support. Although the Department approved CD-0, mission need statement, for the next LCF upgrades in December 2012, specific technology requirements for those upgrades are evolving and funding for planning is reduced.	147,000

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Leadership Computing Facility at ANL	62,000	—	60,000
Leadership Computing Facility at ORNL	94,000	—	87,000
Total, Leadership Computing Facilities	156,000	—	147,000

Research and Evaluation Prototypes

Overview

The Research and Evaluation Prototypes activity addresses the challenges of next generation computing systems. These activities are coupled to the co-design centers and the ASCR facilities to strengthen feedback loops in the portfolio. By actively partnering with the research community, including industry, on the development of technologies that enables next-generation machines, ASCR can ensure that the commercially available architectures serve the needs of the scientific community. Coupling this activity to the co-design centers ensures that application and software researchers can gain a better understanding of future systems to get a head start in developing software and models to take advantage of the new capabilities. Research and Evaluation Prototypes prepares researchers to effectively utilize the next generation of scientific computers and seeks to reduce risk for future major procurements.

DOE has been at the forefront of leadership computing for science and national security applications for decades. ASCR continues to invest in leadership class systems at Argonne and Oak Ridge, which play a key role in the health of the U.S. high performance computing industry. However, the next generation of computing hardware is expected to present new challenges for science and engineering applications—most notably from power demands that will restrict memory usage, effectively managing communication between billions of chips and accelerators, and from chip failures and silent errors. This activity supports research and development partnerships with vendors to influence and accelerate critical technologies for exascale, system integration research, development and engineering efforts that are coupled to application development to ensure Department applications are ready to make effective use of commercial offerings.

In addition, this activity partners with the NNSA to support research investments in non-recurring engineering, for near-term technology customization for the ASCR facilities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	ASCR partnered with the NNSA and worked with the research community, including industry, to deliver high bandwidth, power efficient memory, processor, and storage technology for future computer systems. This activity supported basic research and development to optimize the performance and energy capabilities of emerging hybrid memory technology. These investments are critical because the current commercial roadmaps indicated that memory power requirements dominated the power budgets for computers targeted at scientific and engineering applications. The goal of these efforts was to deliver low-energy, high performance memory with the 10–100 fold improvement over current commercial offerings that is required for DOE applications. This approach eased the path to broad commercial adoption in this decade—from individual laptops to servers—leading to energy efficiency gains across the information technology sector.	26,922

Fiscal Year	Activity	Funding (dollars in thousands)
	In addition, this activity supported partnerships with the NNSA and the research community, including industry, to advance the Department's goals for exascale computing. Significant technical challenges must be faced in meeting the needs of the computational science and engineering community over the next decade, among these are power, performance, concurrency, cost, and resiliency. The system goals are aggressive, and thus tradeoffs will be necessary—for example, reducing memory bandwidth can reduce power consumption but slows performance.	
FY 2013	The FY 2013 request proposed 22,500,000 to continue research started in FY 2012 with the NNSA and the research community, including industry, to develop critical technologies and low level software architectures that enable the creation of high performance scientific applications for these computers, as well as the smaller scale commercial versions that will be ubiquitous in the scientific infrastructure. The current portfolio of projects is augmented with a second round of competitively selected research partnerships that reduce risk and fill gaps from the first round of awards.	—
FY 2014	Critical technology research partnerships will continue with increased support for efforts deemed most likely to deliver reductions in power requirements or increased usability for DOE applications. This includes processor R&D to accelerate low power features in next generation processors including low power memory interfaces and the development of low power, high bandwidth memory. In addition, planning will begin for system integration research, development, and engineering, in partnership with the NNSA. This builds on the strengths of the national laboratories and will be critical to delivering systems built from commercially available processors that meet the needs of DOE applications. The increase also supports research investments in non-recurring engineering, in partnership with the NNSA, for near-term technology customization for the ASCR facilities.	38,552

High Performance Network Facilities and Testbeds

Overview

The Energy Sciences Network (ESnet) provides the national network and networking infrastructure connecting DOE science facilities and SC laboratories with other institutions connected to peer academic or commercial networks. This network allows scientific users to effectively and efficiently access, distribute, and analyze the massive amounts of data produced by these science facilities.

The costs for ESnet are dominated by operations, including maintaining the fiber optic backbone and refreshing switches and routers on the schedule needed to ensure the 99.999% reliability required for large-scale scientific data transmission. Additional funds are used to support the continued growth in science data traffic and for testing and evaluation of new technologies and services that will be required to keep pace with the data volume from new DOE facilities and unique DOE scientific instruments.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	ESnet operated the network infrastructure to support critical DOE science applications and unique SC facilities. Building on 2011 procurements, ESnet began to transition the 100 Gbps prototype network to production service replacing the 10 Gbps production link to the first segment of the ESnet backbone. In addition, 100 Gbps production network was extended to additional SC laboratories by upgrading and connecting the Bay area metropolitan ring.	36,014
FY 2013	The FY 2013 request proposed $32,000,000 for ESnet to continue to operate the network infrastructure that supports critical DOE science applications and SC facilities. ESnet continues to extend deployment of 100 Gbps capacity to additional SC laboratories by upgrading additional segments of the backbone network and Metropolitan Area Networks to 100 Gbps speeds.	—
FY 2014	ESnet will operate the network infrastructure to support critical DOE science applications and SC facilities. ESnet extends deployment of 100 Gbps production network by connecting remaining SC laboratories at 100 Gbps speeds.	32,608

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Capital equipment over $500,000	15,300	—	0

Other Supporting Information

Funding Summary

	(dollars in thousands		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	178,490	—	205,481
Scientific user facility operations	249,814	—	245,213
Other	0	—	14,899
Total, Advanced Scientific Computing Research	428,304	443,566	465,593

Scientific User Facility Operations

	(dollars in thousands		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
NERSC	57,800	—	65,605
OLCF	94,000	—	87,000
ALCF	62,000	—	60,000
ESnet	36,014	—	32,608
Total, Scientific User Facility Operations	249,814	—	245,213

Facilities Users and Hours

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
NERSC			
Achieved operating hours	8,500	—	N/A
Planned operating hours	8,585	—	8,585
Optimal hours	8,585	—	8,585
Percent of optimal hours	99%	—	100%
Unscheduled downtime percentage	1%	—	1%
Number of users	4,659	—	5,500

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
ESnet			
Achieved operating hours	8,760	—	N/A
Planned operating hours	8,760	—	8,760
Optimal hours	8,760	—	8,760
Percent of optimal hours	100%	—	100%
Unscheduled downtime percentage	0%	—	0.001%
Number of users[a]	N/A	—	N/A
OLCF			
Achieved operating hours	6,889	—	N/A
Planned operating hours	7,008	—	7,008
Optimal hours	7,008	—	7,008
Percent of optimal hours	98.3%	—	100%
Unscheduled downtime percentage	1.7%	—	1%
Number of users	1,161	—	1,300
ALCF			
Achieved operating hours	6,917	—	N/A
Planned operating hours	7,008	—	7,008
Optimal hours	7,008	—	7,008
Percent of optimal hours	98.7%	—	100%
Unscheduled downtime percentage	1.3%	—	1%
Number of users	828	—	1,000
Total			
Achieved operating hours	31,066	—	N/A
Planned operating hours	31,361	—	31,361
Optimal hours	31,361	—	31,361
Percent of optimal hours (funding weighted)	98.8%	—	100%
Unscheduled downtime percentage	1.2%	—	1%
Number of users	6, 648	—	7,800

[a] ESnet is a high performance scientific network connecting DOE facilities to researchers around the world; user statistics are not collected.

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	210	—	218
Average size	$247,000	—	$265,000
Number of laboratory projects	175	—	178
Number of graduate students (FTEs)	563	—	564
Number of permanent Ph.D.'s (FTEs)	770	—	789
Other scientific employment (FTEs)	270	—	275

Basic Energy Sciences
Funding Profile by Subprogram

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Materials Sciences and Engineering			
Scattering and Instrumentation Sciences Research	62,369	—	62,369
Condensed Matter and Materials Physics Research	124,629	—	124,629
Materials Discovery, Design, and Synthesis Research	73,384	—	73,384
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	—	8,520
Energy Frontier Research Centers (EFRCs)	57,330	—	97,863
Energy Innovation Hubs—Batteries and Energy Storage	19,410	—	24,237
SBIR/STTR	0	—	12,926
Total, Materials Sciences and Engineering	345,642	—	403,928
Chemical Sciences, Geosciences, and Biosciences		—	
Fundamental Interactions Research	75,510	—	76,047
Chemical Transformations Research	94,331	—	94,553
Photochemistry and Biochemistry Research	69,114	—	69,605
Energy Frontier Research Centers (EFRCs)	42,670	—	70,866
Energy Innovation Hubs—Fuels from Sunlight	24,263	—	24,237
General Plant Projects (GPP)	2,852	—	600
SBIR/STTR	0	—	11,085
Total, Chemical Sciences, Geosciences, and Biosciences	308,740	—	346,993
Scientific User Facilities		—	
Synchrotron Radiation Light Sources	381,012	—	464,000
High-Flux Neutron Sources	249,000	—	261,490
Nanoscale Science Research Centers (NSRCs)	102,781	—	106,500
Other Project Costs	7,700	—	28,100
Major Items of Equipment	73,500	—	64,200
Research	24,992	—	36,966
SBIR/STTR	0	—	28,934
Total, Scientific User Facilities	838,985	—	990,190
Subtotal, Basic Energy Sciences	1,493,367	1,546,097	1,741,111

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Construction			
Linac Coherent Light Source-II (LCLS-II), SLAC	0	0	95,000
National Synchrotron Light Source-II (NSLS-II), BNL	151,400	152,327	26,300
Total, Construction	151,400	152,327	121,300
Total, Basic Energy Sciences[a]	1,644,767	1,698,424	1,862,411

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $38,186,000 and STTR $5,140,000 (transferred out of BES in FY 2012 Current column)
- FY 2014 Request: SBIR $46,326,000 and STTR $6,619,000

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 102-468, "Energy Policy Act of 1992"
Public Law 108-153, "21st Century Nanotechnology Research and Development Act 2003"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

The mission of the Basic Energy Sciences (BES) program is to support fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels in order to provide the foundations for new energy technologies and to support DOE missions in energy, environment, and national security.

The research disciplines that BES supports—condensed matter and materials physics, chemistry, geosciences, and aspects of physical biosciences—are those that discover new materials and design new chemical processes that touch virtually every important aspect of energy resources, production, conversion, transmission, storage, efficiency, and waste mitigation. BES research provides a knowledge base to help understand, predict, and ultimately control the natural world and serves as an agent of change in achieving the vision of a secure and sustainable energy future. BES also supports world-class open-access scientific user facilities consisting of a complementary set of intense x-ray sources, neutron scattering centers, electron beam characterization capabilities, and research centers for nanoscale science. BES facilities probe materials in space, time, and energy to interrogate the inner workings of matter—transport, reactivity, fields, excitations, and motion—and answer some of the most challenging grand science questions. BES-supported activities are entering a new era in which materials can be built with atom-by-atom precision and computational models can predict the behavior of materials before they exist. These capabilities—unthinkable only a few decades ago—create unprecedented opportunities to revolutionize the discovery and design of advanced materials and novel chemical processes for advanced energy technologies that can result in broad economic and societal impacts.

As history has proven, major breakthroughs in clean energy technologies will likely be built on a deep foundation of basic research advances. Solar photovoltaic technology has its roots in Einstein's early twentieth-century paper on the photoelectric effect. The electronics used to improve the efficiency of today's internal combustion engine have their root in the transistor, whose development was enabled by the discovery of quantum mechanics. Key to exploiting such discoveries is the ability to create new materials using sophisticated synthesis and processing techniques, precisely define the atomic arrangements in matter, and control physical and chemical transformations. The energy systems of the future—whether they tap sunlight, store electricity, or make fuel by splitting water or reducing carbon dioxide—will revolve around materials and chemical changes that convert energy from one form to another. Such materials will need to be more functional than today's energy materials. To control chemical reactions or to convert a solar photon to an electron requires coordination of multiple steps, each carried out by customized materials with designed nanoscale structures. Such advanced materials are not found in nature; they must be designed and fabricated to exacting standards using principles revealed by basic science.

Basic and Applied R&D Coordination

As a fundamental research program within the Department of Energy, it is important to maintain strong, continual coordination activities between BES and other DOE program offices. Coordination between DOE R&D programs is achieved through a variety of Departmental activities, including joint participation in research workshops, strategic planning activities, solicitation development, and program review meetings. For example, the DOE Hub Working Group meets regularly to coordinate programmatic oversight and promote commonality across the DOE Energy Innovation Hubs. BES also coordinates with DOE technology offices on the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program, including the topical area planning, solicitations, reviews, and award selections.

BES program managers regularly participate in intra-departmental meetings for information exchange and coordination on solicitations, program reviews and project selections in the research areas of biofuels derived from biomass; solar energy utilization; building technologies, including solid-state lighting; advanced nuclear energy systems and advanced fuel cycle technologies; vehicle technologies; improving efficiencies in industrial processes; and superconductivity for grid applications. These activities facilitate cooperation and coordination between BES and the DOE technology offices and defense programs. DOE program managers have also established formal technical coordination working groups that meet on a regular basis to discuss R&D programs with wide applications for basic and applied programs including the Office of Environmental Management. Additionally, DOE technology office staff participates in reviews of BES research, and BES staff participates in reviews of research funded by the technology offices and ARPA-E. In FY 2014, SC and EM will also implement new platforms for coordination such as workshops and formal technical coordination working groups, which have been used to effectively improve coordination between basic research and applied programs in DOE.

Co-funding and co-siting of research by BES and DOE technology programs at the same institutions has proven to be a valuable approach to facilitate close integration of basic and applied research. In these cases, teams of researchers benefit by sharing of resources, expertise, and knowledge of research breakthroughs and program needs. The Department's national laboratory system plays a particularly important role in this regard.

Program Accomplishments and Milestones

Versatile Material for Efficient and Low-Cost Gas Separation. Separation of natural gas for use as a fuel or as a starting material for the synthesis of high purity chemicals could be less costly and more efficient due to the discovery of a new type of hybrid material, a novel iron based metal-organic framework. The new material, which has a sponge-like framework and is primarily composed of carbon, separates gases at nearly ambient conditions and at lower pressures than current commercial processes. The discovery was based on new understanding of how the addition of iron into the structure increased the capture of relevant hydrocarbons from the gases. This material also has potential for capture of carbon dioxide from flue gas exhausts produced by fossil-fuel power plants.

Rare Earth Additions Make the Best Better. One of the best thermoelectric materials, which convert heat to electricity, is now 15% better through the addition of a small amount of a rare earth element, dysprosium. Research has shown that the dysprosium atoms distort the local crystalline lattice and enable energy carriers to move preferentially through the material, improving heat conversion to electricity. This enhanced understanding of how additions of small amounts of other elements impact thermoelectric properties will facilitate the design even better thermoelectric materials.

Predictive Design of Nanoporous Supercapacitors. New theoretical understanding and simulations are guiding the design of new supercapacitors, a type of electrochemical storage system that can potentially outperform traditional batteries by orders of magnitude. Energy storage in supercapacitors hinges on the flow of electrolyte ions through small pores; researchers have developed models that predict their performance as a function of pore size. Predictions from these new models have explained several phenomena observed in these systems. These approaches point to new ways to optimize supercapacitors, increasing their performance for future energy storage use.

Advance in Understanding Plutonium. The first nuclear magnetic resonance (NMR) signature of plutonium has been discovered, establishing a key for deciphering the complex properties of this important element. Understanding the physical and chemical behavior of plutonium compounds is essential for advanced nuclear fuels, stewardship of the Nation's nuclear stockpile, powering interplanetary exploration, and long-term storage of nuclear waste. From the inception of NMR over 50 years ago, scientists searched for the NMR signature of plutonium-239, which had remained the only element with a spin ½ nucleus not detected by NMR. The key to the discovery of the plutonium-239 resonance was the use of a high purity solid sample of plutonium dioxide at very low temperatures.

Materials Resist Radiation Damage. For nuclear reactors, radiation-resistant materials are essential. In an assessment of the interaction between material structure and radiation-induced defects, a sweet spot has been discovered where the damage is repaired as fast as it is created. Exposure to radiation creates defects in materials that can build up over time and lead to failure. Nanoporous materials with high surface areas can allow the defects to escape to the surface and reduce damage accumulation. Recent research has correlated the optimal surface to volume ratio for nanoporous materials enabling full recovery from damage as the defects are created for a given irradiation dose rate.

New Insights into Combustion Chemistry. New probes of gas-phase chemistry that combine synchrotrons with mass spectrometry are enabling detailed studies of combustion reactions. Using tunable light to selectively ionize molecules during reactions, scientists detected a transient species called the Criegee intermediate and characterized its reactivity. This elusive molecule—long hypothesized but never before observed—is a key player in combustion chemistry.

Observing the Motions of Atoms within Molecules. Developments in theory and ultrafast lasers are rapidly advancing our ability to observe and control the motions of atoms and electrons within molecules undergoing chemical transformations. Scientists recently reported the first freeze-frame images of atoms in vibrating oxygen and nitrogen molecules by using the molecule's own electrons to report the positions of its atoms. The technique called laser-induced electron diffraction (LIED) uses the oscillating electromagnetic field of an intense laser to pull an electron from a molecule and then hurl that same electron back to diffract from the molecular ion. The re-scattered electron conveys the molecular structure at the moment when it interacts with the atoms in the molecule.

Solar Recycling of Carbon Dioxide. In a direct mimic of natural photosynthesis, pairings of light absorbers and catalysts have been discovered that harvest sunlight and efficiently drive the conversion of carbon dioxide to methanol and other alcohols. Semiconductors, including gallium phosphide and gallium arsenide, act as the light absorbers in these systems, providing high energy electrons to the partner catalyst, which can accept electrons and use them to form alcohols from carbon dioxide. These new systems show great potential for the solar powered conversion of carbon dioxide to fuels and chemicals, offering a way to recycle carbon waste from burning fossil fuels as an alternative to sequestering it.

Fully Coherent Hard X-rays by Self-Seeding of the LCLS Free Electron Laser. With a thin sliver of diamond, scientists at SLAC National Accelerator Laboratory have transformed the Linac Coherent Light Source (LCLS) into an even more precise tool for exploring the nanoworld. In a process called self-seeding, the diamond filters the laser beam to a single x-ray wavelength, which is then amplified in intensity. This represents a significant improvement over the current process, which relies on self-amplified spontaneous emission to generate laser-like x-ray beams at LCLS. The improvements yield laser pulses with higher intensity in a much narrower band of x-ray wavelengths. This advance promises to extend that revolution to the x-ray regime, providing extraordinary probes of complex material behavior and control of matter through manipulation of core level electrons with fully coherent x-ray pulses.

BES Synchrotron Facility Assists Industry in Developing Revolutionary Solar Energy Technology. Research on solar photovoltaic materials at the Advanced Photon Source

(APS) at Argonne National Laboratory resulted in fundamental information to develop the first solar shingles, which could reinvent the roofs of our houses. Industry researchers conducted a series of studies at APS to investigate the detailed relationship among process, structure, and property of materials that are suitable for solar energy conversion. These studies provided crucial information about the solar active materials to be incorporated as part of the roof shingles.

Milestone	Date
Complete a comprehensive science review of Fuels From Sunlight Energy Innovation Hub. (Chemical Sciences, Geosciences, and Biosciences/Energy Innovation Hubs)	3rd Qtr, FY 2013
Complete a Committee of Visitor's review of the Scientific User Facilities subprogram. (Scientific User Facilities)	3rd Qtr, FY 2013
Award conventional facility construction contract for the Linac Coherent Light Source-II (Construction)	4th Qtr, FY 2014

Program Planning and Management

Factors considered in the planning and management of research activities in BES include:

- new scientific opportunities as determined by recent scientific discoveries and by new ideas submitted in proposals;
- results of external program reviews and international benchmarking activities of entire fields or sub-fields, such as those performed by the National Academy of Sciences; and reports from the federally chartered Basic Energy Sciences Advisory Committee (BESAC);
- in-depth topical workshops, conferences, and principle investigators' meetings of scientists, engineers, and technologists from universities, federal laboratories, and the private sector;
- coordination and planning activities between DOE programs including informal day-to-day contacts among program managers; and interagency coordinating activities;
- evolving mission needs as described by Presidential priorities and DOE and Office of Science (SC) mission statements and strategic plans; and
- Congressional direction.

All research projects supported by BES undergo regular peer review and merit evaluation based on procedures set down in the Title 10 of the Code of Federal Regulations Part 605 for the extramural grant program and in an analogous process for the laboratory programs and scientific user facilities. The BES peer review process evaluates four criteria: scientific and technical merit of the project, appropriateness of the proposed method or approach, competency of the personnel and adequacy of proposed resources, and reasonableness and appropriateness of the proposed budget. The criteria for review may also include other appropriate factors established and announced by BES.

Typically, every BES research project receives external peer review and merit evaluation once every three years to determine whether the research is continued or terminated, consistent with the President's management agenda.[a] Success rates vary, but approximately 10–20% of all BES research projects are terminated over the three-year review cycle. The termination of work that has reached its conclusion, is past its fruition, or has underperformed provides funding to renew or increase support for outstanding performers and initiate promising new research work by scientific investigators with fresh ideas.

Facilities are also reviewed using external, independent review committees operating according to the procedures established for peer review of BES laboratory programs and facilities. Important aspects of the reviews include assessments of the quality of research performed at the facility, the reliability and availability of the facility, user access policies and procedures, user satisfaction, facility staffing levels, R&D activities to advance the facility, management of the facility, long-range goals of the facility, and that all activities are conducted safely and in an environmentally conscientious manner. The outcomes of these reviews help improve operations and develop new models of operation for all BES scientific user facilities.

Facilities that are in design or construction are reviewed according to procedures in DOE Order 413.3B, Program and Project Management for Capital Assets and in the Office of Science's Independent Review Handbook. In general, once a project has entered the construction phase, it is reviewed with external, independent

[a] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

committees approximately twice a year. These Office of Science construction project reviews enlist experts in the technical scope of the facility under construction and focus on its costing, scheduling, and construction management.

Many long-range planning exercises for elements of the BES program are performed under the auspices of BESAC. Of particular note is the BESAC report, *Basic Research Needs to Assure a Secure Energy Future* (2003), which was the foundation for ten follow-on Basic Research Needs workshops (2003–2007) supported by BES in the areas of the hydrogen economy, solar energy utilization, superconductivity, solid-state lighting, advanced nuclear energy systems, combustion of 21st Century transportation fuels, electrical-energy storage, geosciences as it relates to the storage of energy wastes (the long-term storage of both nuclear waste and carbon dioxide), materials under extreme environments, and catalysis for energy applications. Together, these workshops help create a basic research portfolio in the BES program that underpins a national decades-to-century energy strategy.

Building on the series of Basic Research Needs workshops, BESAC wrote five subsequent reports: *Directing Matter and Energy: Five Challenges for Science and the Imagination* (2007) identifies the most important scientific questions and science-driven technical challenges facing BES and describes the importance of these challenges to advances in disciplinary science, to technology development, and to energy and other societal needs. *New Science for a Secure and Sustainable Energy Future* (2008) assimilates the scientific research directions that emerged from the BES Basic Research Needs workshop reports into a comprehensive set of science themes and identifies implementation strategies and tools required to accomplish the science. *Next-Generation Photon Sources for Grand Challenges in Science and Energy* (2008) identifies connections between major new research opportunities and the capabilities of the next generation of light sources. *Science for Energy Technology: Strengthening the Link between Basic Research and Industry* (2010) identifies the scientific priority research directions needed to address the roadblocks and accelerate the innovation of clean energy technologies. *From Quanta to the Continuum: Opportunities for Mesoscale Science* (2012) builds on the decades-long advancements in atomic, molecular, and nano sciences to define the research agenda for mesoscale science—the regime where quantum and classical descriptions of physical phenomena meet.

BESAC also reviews the major elements of the BES program annually using Committees of Visitors (COVs). The first COV review of BES was conducted in 2002, and all elements of the BES program have been reviewed once every three years on a rotating schedule. COVs assess the efficacy and quality of the processes used to solicit, review, recommend, monitor, and document proposal actions; and the quality of the resulting portfolio, specifically the breadth and depth of portfolio elements and the national and international standing of the elements. The next COV will review the Scientific User Facilities subprogram in April 2013, and an additional COV later in 2013 will cover the Energy Frontier Research Centers and Fuels from Sunlight Energy Innovation Hub. All COV reports and BES responses to COV recommendations are available on the BES website at http://science.energy.gov/bes/besac/bes-cov.

Program Goals and Funding

Office of Science performance expectations are focused on four areas:

- Research: Advance fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels to provide foundations for new energy technologies.
- Facility Operations: Sustain a diverse suite of major scientific facilities to provide critical insights to the electronic, atomic, and molecular configurations, often at ultrasmall length and ultrafast time scales.
- Future Facilities: Progress toward completion of the next generation of user facilities that will provide research communities with tools to fabricate, characterize, and develop new materials and chemical processes to advance research across the full range of scientific disciplines and technological research areas.
- Scientific Workforce: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers.

Goal Areas by Subprogram

	Research	Facilities Operations	Future Facilities	Scientific Workforce
Materials Sciences and Engineering	100%	0%	0%	0%
Chemical Sciences, Geosciences, and Biosciences	100%	0%	0%	0%
Scientific User Facilities	7%	84%	9%	0%
Construction	0%	0%	100%	0%
Total, Basic Energy Sciences	44%	45%	11%	0%

Performance Measures

Performance Goal (Measure)	**BES Facility Operations**—Average achieved operation time of BES user facilities as a percentage of total scheduled annual operation time		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 90%	≥ 90%	≥ 90%
Result	Met		
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		

Performance Goal (Measure)	**BES Solar Fuels**—Demonstrate a scalable solar-fuels generator using Earth-abundant elements that produces fuel (without wires) from the sun 10 times more efficiently than current agriculturally produced plants		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	N/A	Establish benchmarking capabilities for comparison of homogeneous/heterogeneous catalysts and light absorbers under standardized testing conditions	Design first prototype device for testing components, such as catalysts, light harvesters, membranes, and interfaces, as an integrated system
Result	N/A		
Endpoint Target	Demonstration of a scalable solar-fuels generator using Earth-abundant elements that produces fuel (without wires) from the sun 10 times more efficiently than current agriculturally produced plants. The performance goal will be achieved by the *Fuels from Sunlight* Energy Innovation Hub.		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Explanation of Funding and Program Changes

In FY 2014, BES will support ongoing research at the FY 2012 funding level and the two Energy Innovation Hubs (Fuels from Sunlight and Batteries and Energy Storage). The FY 2014 budget request reflects difficult choices between operating existing facilities, upgrading facilities, and building new user facilities. In FY 2014, BES will support the National Synchrotron Light Source-II (NSLS-II) construction and early operations, Linac Coherent Light Source-II (LCLS-II) construction, and the operations of the five synchrotron light source facilities and the three neutron source facilities at optimal levels. Major item of equipment (MIE) projects for the Advanced Photon Source Upgrade (APS-U) and the NSLS-II Experimental Tools (NEXT) are also continued in FY 2014. The Energy Frontier Research Centers (EFRCs) portfolio will undergo an open re-competition to select new EFRCs and consider renewal applications for existing EFRCs. The FY 2014 EFRC solicitation will feature new scientific initiatives including recently identified opportunities in the computational design of materials and chemical processes and mesoscale science. In FY 2014, responsibility is transferred from the Office of Environmental Management (EM) to BES for long term surveillance and maintenance (LTS&M) for completed EM work scope and for remaining legacy cleanup work scope at BNL and SLAC.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Materials Sciences and Engineering	345,642	403,928	+58,286
Core research activities continue at the FY 2012 level. A competitive solicitation will be issued for both renewal and new EFRCs. Additional one-time funding is requested to fully forward fund some of the new/renewal EFRC awards. The Batteries and Energy Storage Hub continues at the planned level.			
Chemical Sciences, Geosciences, and Biosciences	308,740	346,993	+38,253
Core research activities and EFRCs continue at the FY 2012 level. A competitive solicitation will be issued for both renewal and new EFRCs. Additional one-time funding is requested to fully forward fund some of the new/renewal EFRC awards. The Fuels from Sunlight Hub continues at the planned level.			
Scientific User Facilities	838,985	990,190	+151,205
Operation of the BES user facilities continue at optimal levels—five light sources, five Nanoscale Science Research Centers, and three neutron sources. Funding will continue the early operations of the NSLS-II in preparation for full operations in FY 2016. Funding for the APS Upgrade and NEXT MIE projects are increased. In FY 2014, responsibility is transferred from EM to BES for long term surveillance and maintenance (LTS&M) and for remaining legacy cleanup work scope at BNL and SLAC ($+12,873,000).			
Construction	151,400	121,300	-30,100
Construction of the National Synchrotron Light Source-II (NSLS-II) will be ramped down and funding for the Linac Coherent Light Source-II (LCLS-II) will increase as scheduled.			
Total, Basic Energy Sciences	1,644,767	1,862,411	+217,644

Materials Sciences and Engineering
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Scattering and Instrumentation Sciences Research	62,369	—	62,369
Condensed Matter and Materials Physics Research	124,629	—	124,629
Materials Discovery, Design, and Synthesis Research	73,384	—	73,384
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	—	8,520
Energy Frontier Research Centers (EFRCs)	57,330	—	97,863
Energy Innovation Hubs—Batteries and Energy Storage	19,410	—	24,237
SBIR/STTR	0	—	12,926
Total, Materials Sciences and Engineering[a]	345,642	—	403,928

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $9,618,000 and STTR $1,295,000 (transferred out of BES in FY 2012 Current column
- FY 2014 Request: SBIR $11,310,000 and STTR $1,616,000

Overview

Materials are critical to nearly every aspect of energy generation and end-use. Materials limitations are often the barrier to improved energy efficiencies, longer lifetimes of infrastructure and devices, or the introduction of new energy technologies. The *Materials Sciences and Engineering* subprogram supports research to provide the understanding of materials synthesis, behavior, and performance that will enable solutions to these wide ranging challenges as well as opening new directions that are not foreseen based on existing knowledge. The research explores the origin of macroscopic material behaviors and their fundamental connections to atomic, molecular, and electronic structures. At the core of the subprogram is the quest to enable the predictive design and discovery of new materials with novel structures, functions, and properties. Such understanding and control are critical to science-guided design of highly efficient energy conversion processes, such as the conversion of sunlight to electricity, new electromagnetic pathways for enhanced light emission in solid-state lighting, and multi-functional nanoporous structures for optimum ionic and electronic transport in batteries and fuel cells.

To accomplish these goals, the portfolio includes three integrated research activities:

- **Scattering and Instrumentation Sciences**—Advancing new tools and techniques to characterize and correlate materials performance, structure, and dynamics on multiple time and length scales and in the environments in which materials are used.
- **Condensed Matter and Materials Physics**—Understanding the foundations of material functionality and behavior.
- **Materials Discovery, Design, and Synthesis**—Developing novel synthesis strategies to design and precisely assemble structures in order to control materials properties and enable discovery of new materials with unprecedented functionalities.

The portfolio emphasizes understanding how to direct and control energy flow in materials systems over multiple time and length scales. The research will enable prediction of materials behavior, transformations, and processes in challenging real-world systems—for example, for materials with many atomic constituents, complex structures, and a broad range of defects that are exposed to extreme environments. To maintain leadership in materials discovery, the research explores new frontiers and unpredicted, emergent materials behavior in materials systems (e.g., magnetism and superconductors), utilization of nanoscale control, and systems that are metastable or far from equilibrium. Finally, the subprogram exploits the interfaces between physical and biological sciences to explore bio-mimetic processes as new approaches to novel materials design. This subprogram is also the home of the DOE Experimental Program to Stimulate Competitive Research (EPSCoR) that supports basic research spanning the broad range of DOE's science and technology programs in states that have historically received relatively less Federal research funding.

In addition to single-investigator and small-group research, the subprogram supports Energy Frontier Research Centers that were established in FY 2009 and the Batteries and Energy Storage Energy Innovation Hub that began in FY 2013. These research modalities support multi-investigator, multidisciplinary research and focus on forefront energy technology challenges. The Energy Frontier Research Centers support teams of investigators to perform basic research to accelerate transformative solutions for a wide range of energy technologies. The Batteries and Energy Storage Hub supports a large, tightly integrated team and research that spans basic and applied regimes with the goal of providing the scientific understanding that will enable the next generation of electrochemical energy storage for vehicles and the electrical grid.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Scattering and Instrumentation Sciences Research	62,369	62,369	0
Research continues at the FY 2012 level.			
Condensed Matter and Materials Physics Research	124,629	124,629	0
Research continues at the FY 2012 level.			
Materials Discovery, Design, and Synthesis Research	73,384	73,384	0
Research continues at the FY 2012 level.			
Experimental Program to Stimulate Competitive Research (EPSCoR)	8,520	8,520	0
Research continues at the FY 2012 level.			
Energy Frontier Research Centers (EFRCs)	57,330	97,863	+40,533
A competitive solicitation will be issued for both renewal and new EFRCs. Additional one-time funding of $39,863,000 is provided to fully forward fund some of the new/renewal EFRC awards.			
Energy Innovation Hubs—Batteries and Energy Storage	19,410	24,237	+4,827
In FY 2014, Batteries and Energy Storage Hub operations are supported at the planned level.			

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
SBIR/STTR	0	12,926	+12,926
In FY 2012, $9,618,000 and $1,295,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is statutorily set at 3.20% of non-capital funding in FY 2014.			
Total, Materials Sciences and Engineering	345,642	403,928	+58,286

Scattering and Instrumentation Sciences Research

Overview

Advanced characterization tools with very high precision in space and time are essential to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels. These capabilities provide the foundation for research central to DOE missions in energy, environment, and national security. Research in Scattering and Instrumentation Science supports innovative techniques and instrumentation for scattering, spectroscopy, and imaging using electrons, neutrons, and x-rays. These tools provide precise information on the atomic structure and dynamics in materials. DOE's longstanding investments in world-leading electron, neutron, and synchrotron x-ray scattering facilities at the DOE national laboratories are a testament to the importance of this activity to the DOE mission. Revolutionary advances in these techniques will enable transformational research on advanced materials to address energy challenges.

The unique interactions of electrons, neutrons and x-rays with matter enable a range of complementary tools with different sensitivities and resolution for the characterization of materials at length- and time-scales spanning several orders of magnitude. Recent advances in investigations of dynamic phenomena in real-time and relevant conditions provide a window into material functions under the conditions in which the materials are used. New instrumentation in the ultrafast regime will investigate dynamics at very fast timescales related to electronic, catalytic, magnetic, and other transport processes. A distinct aspect of this activity is the development of innovative neutron optics and techniques with polarized neutrons to probe the properties of materials.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012 research supported scattering research, including continued enhancement of ultrafast research and development of techniques to observe, control and understand material dynamics through the use of electron, optical, neutron, and x-ray techniques and sources.	62,369
FY 2013	The FY 2013 Request proposed $73,721,000 for research that would emphasize timely exploitation of the tremendous enhancements in intensities at DOE's world-leading facilities and new technologies in optics, detectors, and electronics to develop new techniques not previously possible. New research would initiate development of in situ analysis capabilities for materials and chemistry by design and development and application of forefront scattering capabilities, including ultrafast techniques, to address key issues for clean energy. This research would advance the development and utilization of new capabilities with increasing physical, chemical, structural, and temporal precision by the broader clean energy research community, opening new avenues for mesoscale research. Proposed research would emphasize soft and hybrid materials.	—
FY 2014	The research will continue to emphasize the opportunities afforded by x-ray, neutron and electron scattering, spectroscopy, and imaging for the development of new functional materials for energy production, storage, and distribution. Scattering science will enable unique insights into the structure and dynamics of new energy materials over relevant time and length scales. Research will advance the development and utilization of new capabilities with increasing physical, chemical, structural, and temporal precision for materials research. Research on soft and hybrid materials will be emphasized.	62,369

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Electron and Scanning Probe Microscopes	24,390	—	24,390
Neutron and X-Ray Scattering	37,979	—	37,979
Total, Scattering and Instrumentation Sciences Research	62,369	—	62,369

Condensed Matter and Materials Physics Research

Overview

Understanding the foundations of how to control and change the properties of materials is critical to improving their functionality on every level and is essential to fulfilling DOE's energy mission. The Condensed Matter and Materials Physics activity supports experimental and theoretical research to advance our current understanding of phenomena in condensed matter—solids and liquids with structures that vary in size from the nanoscale to the mesoscale, the materials that make-up the infrastructure for energy technologies, including electronic, magnetic, optical, thermal, and structural materials.

A central focus is research to characterize and understand materials whose properties are derived from the strong interactions of the electrons in their structure, such as superconductors and magnetic materials. An emphasis is placed on investigating low-dimensional systems, including nanostructures, and studies of the electronic properties of materials under extreme conditions such as ultra-low temperatures and extremely high magnetic fields. The research is relevant to energy technologies and advances the fundamental understanding of the elementary energy conversion steps related to photovoltaics and solid state lighting, the energetics of hydrogen storage, and electron spin-phenomena and basic semiconductor physics relevant to next generation information technologies and electronics. Fundamental studies of the quantum mechanical behavior of electrons in materials will lead to an improved understanding of electrical and thermal conduction in a wide range of material systems. There is a critical need to couple theories that describe properties at the atomic scale to properties at the macroscale where the influence of size, shape, and composition is not adequately understood.

The activity also emphasizes understanding how materials respond to their environments, including temperature, electromagnetic fields, radiation, and chemical environments. The influence of defects in materials and their effects on strength, structure, deformation, and failure over a wide range of length and time scales will enable the design of materials with superior properties and resistance to change under the influence of radiation.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, combined computational and experimental research supported development of validated theoretical models, which includes additional efforts in predictive theory and modeling, some of which are funded jointly with the Office of Advanced Scientific Computing Research under the SciDAC program. Research supported further advances in our understanding of approaches to control materials properties and to push the frontiers and scientific foundations for new materials such as topological insulators, graphene, and metamaterials. Research continued on materials that underpin the evolution of energy technologies such as superconductors, radiation resistant materials, and photovoltaic, optical, and electronic applications. Research was reduced in granular materials, surface diffusion and reconstruction, liquid crystals, and heat transfer in nanofluidics.	124,629
FY 2013	The FY 2013 Request proposed $148,723,000 to continue to emphasize experimental and theoretical research in newly discovered systems that exhibit correlation effects including graphene and topological insulators. Research on ultra-cold atom clusters would be supported to provide new insights into the evolution of condensed matter behavior.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	New research in materials and chemistry by design would emphasize development of validated software that could be used by the broader community, including the development of new theoretical tools that relate directly to clean energy technologies. Additional research would explore mesoscale phenomena and enhance use-inspired clean energy research relevant to solar energy utilization, mechanical properties and radiation effects, and correlated electron behavior in materials, such as superconductivity and magnetism that are important to a number of energy technologies. The new research would focus on advancing our fundamental understanding of defects in materials, which was needed to extend lifetimes and enhance performance of materials used in energy generation and use. Proposed research would continue to support fundamental insights to the understanding of structure-property relationships, including the influence of reduced dimensionality and defects on physical, optical, and electrical properties, and controlling material functionality in response to multiple external stimuli such as temperature, pressure, magnetic and electric fields, and radiation.	
FY 2014	Research will continue to emphasize experimental and theoretical research on materials that exhibit correlation effects, including new phenomena observed in topological surface states and the development of new theoretical tools and validated software for materials discovery that is relevant to energy technologies. Research will focus on advancing our fundamental understanding of defects in materials, which is needed to extend the lifetime and enhance the performance of materials used in energy generation and energy end-use technologies. This activity will support research on large, ultra-cold atom clusters that can exhibit both bosonic or ferminoic behavior to provide new insights into the evolution of condensed matter behavior. There will be continued support for research on understanding structure-property relationships in materials by studying the influence of reduced dimensionality and defects on the physical, optical, and electrical properties of materials; and controlling material functionality in response to external stimuli such as temperature, pressure, magnetic and electric fields, and radiation	124,629

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Experimental Condensed Matter Physics	43,441	—	43,441
Theoretical Condensed Matter Physics	35,544	—	35,544
Mechanical Behavior and Radiation Effects	20,226	—	20,226
Physical Behavior of Materials	25,418	—	25,418
Total, Condensed Matter and Materials Physics Research	124,629	—	124,629

Materials Discovery, Design, and Synthesis Research

Overview

The discovery and development of new materials has long been recognized as the engine that drives science frontiers and technology innovations. Predictive discovery of new forms of matter with tailored properties is still a significant challenge for materials sciences. A strong, vibrant research enterprise in the discovery of new materials is critical to world leadership—scientifically, technologically and economically. One of the goals of this activity is to grow and maintain U.S. leadership in materials discovery by investing in advanced synthesis capabilities and by coupling these with state-of-the-art user facilities and advanced computational capabilities at DOE national laboratories.

A key part of this portfolio is biomimetic and bioinspired materials research—translating biological processes into impactful approaches to the design and synthesis of materials with the remarkable properties found in nature, e.g., self-repair and adaptability to the changing environment. Synthesis science and materials chemistry research underpin many energy-related technological areas such as batteries and fuel cells, catalysis, solar energy conversion and storage, friction and lubrication, and membranes for advanced separations, efficient ion transport and highly selective gas storage.

Major research directions include the controlled synthesis of nanoscale materials and their assembly into functional materials with desired properties; porous materials with tailored reactivities and porosities; mimicking the energy-efficient synthesis approaches of biology to generate new, advanced materials for use under harsher, non-biological conditions; bio-inspired materials that assemble autonomously and, in response to external stimuli, dynamically assemble and disassemble; and adaptive and resilient materials that also possess self-repairing capabilities. Synthesis science supports fundamental research on the development of new methods and techniques to synthesize materials with targeted structure and properties. An important element of this activity is the development of real-time monitoring tools, diagnostic techniques, and instrumentation that can provide information on the progression of structure and properties as a material is formed, in order to understand the underlying physical mechanisms and to gain atomic level control of material synthesis and processing.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, research was focused on enhancing the scientific foundations for understanding the fundamentals of synthesis, fabrication and processing of materials with physical, chemical, and biomimetic approaches. Additional emphasis areas included integration of theory, computation, and experiment to enhance capabilities for materials discovery. Research was reduced in activities on ion beam assisted growth techniques, artificial enzymes, and synthesis of individual nanowires, particles, etc.	73,384
FY 2013	The FY 2013 Request proposed $84,585,000 for research to continue to emphasize integration of experimental and theory activities to accelerate progress in understanding synthesis and discovery of new materials, bio-inspired synthesis toward more efficient processes that would scale to larger quantities and result in resilient materials, porous materials modeled after biological membranes, and related features.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	New directions in use-inspired clean energy research would have considered opportunities related to mesoscale science, including self-healing materials to extend the lifetimes of materials in solar devices and for solar energy conversion. New research underpinning carbon capture would take advantage of novel chemistries and approaches for gas storage and release, including innovative biomolecular materials research. Research would focus on obtaining a deeper understanding of the role of interfaces in the processes underpinning energy storage and catalytic technologies.	
	Experimental research would support materials and chemistry by design, including predictive design of materials synthesis through development of validated software for physical and chemical synthesis and processing techniques. Proposed research would continue to emphasize the development of new strategies and methods to direct and control the assembly of materials structures across a range of length scales.	
FY 2014	Research will continue on the development of guiding principles for the predictive design and synthesis of materials across multiple length scales—from atomic and molecular to nano to meso and ultimately to bulk. Predictive design of materials synthesis will be coupled to experimental research on biology-inspired, physical, and chemical synthesis and processing techniques. This will be made possible by more effective integration of theory and experiment, modeling of synthetic pathways and experimental designs. Synthesis pathways may be precisely controlled by the use of in situ diagnostic tools and will pave the way for atom- and energy-efficient syntheses of new forms of matter with tailored properties. Research on understanding of carbon capture will take advantage of novel chemistries and approaches for gas storage and release, including innovative biomolecular materials research.	73,384

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Materials Chemistry and Biomolecular Materials	53,382	—	53,382
Synthesis and Processing Science	20,002	—	20,002
Total, Materials Discovery, Design, and Synthesis Research	73,384	—	73,384

Experimental Program to Stimulate Competitive Research (EPSCoR)

Overview

DOE's Experimental Program to Stimulate Competitive Research (EPSCoR) is a Federal-State partnership program designed to enhance the capabilities and research infrastructure of designated states and territories to conduct sustainable and nationally competitive research. This activity supports basic research spanning the broad range of science and technology related to DOE mission areas in states and territories that have historically received relatively less Federal research funding than other states. The EPSCoR states/territories are listed below. EPSCoR helps these states develop their infrastructure and research capabilities so that they can successfully compete for research funding. The research supported by EPSCoR includes materials sciences, chemical sciences, physics, energy-relevant biological sciences, geological and environmental sciences, high energy physics, nuclear physics, fusion energy sciences, advanced computing, and the basic sciences underpinning fossil energy, nuclear energy, and energy efficiency and renewable energy.

EPSCoR promotes strong research collaboration between scientists/engineers in the designated states/territories and the world-class national laboratories, leveraging national user facilities and taking advantage of opportunities for intellectual collaboration across the DOE system. DOE EPSCoR supports Implementation Grants (large grants that promote development of infrastructure and research teams) and State-Laboratory partnership grants (individual university-based principal investigators teaming with national laboratories). EPSCoR is science-driven and supports the most meritorious proposals based on peer review and programmatic priorities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research continued to support basic research related to DOE mission areas with emphasis on science underpinning the DOE energy technology programs broadly.	8,520
FY 2013	The FY 2013 Request proposed $8,520,000 for research efforts that would continue to span science areas in support of the DOE mission, with emphasis on science underpinning the DOE energy technology programs broadly. EPSCoR implementation grants would be enhanced.	—
FY 2014	Efforts will continue to span science in support of the DOE mission, with continued emphasis on science that underpins DOE energy technology programs. Collaborative efforts with DOE laboratories and user facilities will continue to be supported and funding for implementation grants will be enhanced.	8,520

EPSCoR Distribution of Funds by State

(dollars in thousands

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Alabama	0	—	0
Alaska	0	—	0
Arkansas	0	—	0
Delaware	979	—	150
Guam	0	—	0

	(dollars in thousands		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Hawaii	0	—	0
Idaho	0	—	0
Iowa[b]	0	—	0
Kansas	150	—	0
Kentucky	590	—	0
Louisiana	0	—	0
Maine	600	—	0
Mississippi	0	—	0
Missouri	0	—	0
Montana	125	—	0
Nebraska	0	—	0
Nevada	0	—	0
New Hampshire	700	—	0
New Mexico	150	—	150
North Dakota	150	—	150
Oklahoma	0	—	0
Puerto Rico	1,511	—	0
Rhode Island	1,932	—	150
South Carolina	0	—	0
South Dakota	0	—	0
Tennessee[b]	1,333	—	553
U.S. Virgin Islands	0	—	0
Utah[b]	0	—	0
Vermont	0	—	0
West Virginia	300	—	0
Wyoming	0	—	0
Technical Support	0	—	75
Other[a]	0	—	7,292
Total, EPSCoR	8,520	—	8,520

[a] Uncommitted funds in FY 2013 and FY 2014 will be competed among the EPSCoR states.

[b] Iowa, Tennessee, and Utah will lose EPSCoR eligibility in FY 2013; existing awards will continue to their end date.

Energy Frontier Research Centers

Overview

The Energy Frontier Research Centers (EFRCs), initiated in FY 2009, are a unique and important research modality, bringing together the skills and talents of teams of investigators to perform energy-relevant, basic research with a scope and complexity beyond that possible in standard single-investigator or small-group awards. These multi-investigator, multi-disciplinary centers foster, encourage, and accelerate basic research to provide the basis for transformative energy technologies. In the first award cycle, there were 46 EFRC awards, 16 funded for a full 5-year award term through the American Recovery and Reinvestment Act (ARRA) of 2009 and 30 funded on a continuing basis through annual appropriations through this subprogram and the Chemical Sciences, Geosciences, and Biosciences subprogram. The EFRCs supported in this subprogram are focused on: the design, discovery, synthesis, and characterization of novel, solid-state materials that improve the conversion of solar energy and heat into electricity and fuels and that enhance the conversion of electricity to light; the development of the understanding of materials and processes required to enable improved electrical energy storage and to increase materials resistance to corrosion, decay, or failure in extreme conditions of temperature, pressure, radiation, or chemical exposures; and the exploration of emergent phenomena, such as superconductivity, that can optimize energy flow and boost the efficiency of energy transmission.

BES's active management of the EFRCs is an important feature of the program. A variety of methods are used to regularly assess the ongoing progress of the EFRCs, including annual progress reports, monthly phone calls with the EFRC Directors, periodic Directors' meetings, and on-site visits by program managers. BES has also conducted two in-person reviews by outside experts. Each EFRC underwent a review of its management structure and approach in the first year of operation (2010) and a midterm assessment that focused on each EFRC's scientific program and progress compared to its 5-year research goals (2012). In addition, BES organized a meeting of EFRC scientific staff in the second year, 2011, to facilitate collaboration and information exchanges; a second meeting is planned for the fourth year, 2013. These meetings and Directors' meetings provide opportunities for communication between the EFRCs and DOE programs. Representatives from the DOE technology programs are invited to these events to discuss the latest advances in scientific understanding from EFRC research. The technology offices also help to ensure, through presentations and individual interactions, that the EFRCs are cognizant of the current problems facing different energy sectors.

The mid-term assessment in FY 2012 provided a comprehensive peer review of the entire EFRC portfolio. The process found that the EFRCs are accelerating energy science by bringing together world-class scientists from different disciplines to tackle challenging problems in new ways; providing an environment that encourages high-risk, high-reward research that would not be done otherwise; integrating synthesis, characterization, theory, and computation to accelerate the rate of scientific progress; developing new, innovative experimental and theoretical tools that illuminate fundamental processes in unprecedented detail; and creating an enthusiastic, inter-disciplinary community of energy-focused scientists that will ensure a future workforce for the United States in these critical fields. The EFRCs have demonstrated significant scientific productivity as shown by publications, invention disclosures, patents, and transfer of research results to companies and applied research efforts. As of January 2013, the EFRCs had authored over 3,400 peer-reviewed publications. Although the focus of the EFRCs is fundamental energy-use-inspired science, many centers have reported that their results are already impacting both technology research and industry. There are over 200 patents/applications, with at least 30 associated licenses, plus more than 60 unpatented invention disclosures. Centers have reported that 60 companies are using the results of EFRC research, including small start-ups and major corporations. Many of the EFRCs are interfacing with DOE's technology and small business programs to accelerate the transition of promising scientific results to commercial applications.

The mid-term assessment found the EFRC program to be strong and to have a unique role in advancing fundamental science relevant to energy technologies. The centers provide an important bridge between basic research and energy technologies and complement other research activities funded by DOE. The remaining funding of the first five-year award period will be distributed in FY 2013. For FY 2014, an open re-competition is planned to select new EFRCs and consider renewal applications for existing EFRCs. As in the original competition, the FY 2014 EFRC solicitation will target basic research across the broad range of science needed to provide a foundation of transformative energy technologies. The solicitation will incorporate new areas of energy-relevant research that have been identified by recent BES and BESAC workshop reports, including: *Computational Materials Science and Chemistry: Accelerating Discovery and Innovation Through Simulation-Based Engineering and Science; From Quanta to the Continuum: Opportunities for Mesoscale Science; Basic Research Needs for Carbon Capture: Beyond 2020;* and *Science for Energy Technology: Strengthening the Link Between Basic Research and Industry*. The FY 2014 EFRC solicitation will feature new scientific initiatives including research to advance the rate of materials and chemical discovery and a "molecules to mesoscale" approach to directed-assembly of mesoscale structures with unique functionality, emulating biological systems in the development of man-made energy materials and systems and enabling bottom-up design of materials with nanoscale functional units to produce next generation technological innovation. Renewal and new applications will be assessed via rigorous peer review; awards will be based on scientific and technical merit and the achievement of a balanced EFRC portfolio for use-inspired basic energy research.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The EFRCs completed their third year of operation in late FY 2012. In January–April 2012, a panel-based peer-review assessed the scientific progress and productivity of each EFRC. At the conclusion of the assessment, BES determined that all centers should continue to the end of the current award period since each is meeting or exceeding the expected progress toward their research goals and is likely to have substantial future impact on their scientific disciplines.	57,330
FY 2013	The FY 2013 Request proposed $68,000,000 for research that would incorporate modifications to research activities and directions resulting from the FY 2012 peer review. Additional funding would accelerate the transition of novel scientific discoveries from the EFRCs into innovative, prototype clean energy technologies and to improve coordination between fundamental research conducted in the EFRCs and applied research and engineering development supported by EERE.	—
FY 2014	A single funding opportunity announcement (FOA) will be issued for both renewal and new EFRCs for five-year awards beginning in FY2014. The EFRC FOA will encourage the formation of effective teams to address the broad range of fundamental science needed to power transformative energy technologies, including newly identified opportunities in the computational design of materials and chemical processes and mesoscale science. All current EFRCs, including those initially funded through ARRA, will have the opportunity to compete for a second five-year performance period. All awards, both new and renewal, will be based on rigorous peer review of the research proposed for the five year award term. Awardees receiving renewal funding will also be assessed on progress during the first five-year award. One-time funding in the amount of $39,863,000 is provided to fully forward fund some of the new/renewal EFRC awards.	97,863

Energy Innovation Hubs—Batteries and Energy Storage

Overview

Energy Innovation Hubs are composed of a large, multidisciplinary team of investigators whose research integrates basic to applied research and focuses on a single critical national energy need. Hubs include a central location for the research and extensive cross-team interactions to accelerate the research and technology development. They are funded as five-year, potentially renewable projects.

Advanced energy storage solutions have become increasingly critical to the Nation with the expanded deployment of renewable energy sources coupled with growth in the numbers of hybrid and electric vehicles. For the electrical grid, new approaches to electrochemical energy storage can provide enhanced grid stability and enable intermittent renewable energy sources to meet continuous electricity demand. For vehicles, new batteries with improved lifetimes, safety, and storage capacities are needed to expand the range of electric vehicles' from a single charge while simultaneously decreasing the manufacturing cost and weight. Today's electrical energy storage approaches suffer from limited energy and power capacities, lower-than-desired rates of charge and discharge, cycle life limitations, low abuse tolerance, high cost, and decreased performance at high or low temperatures. The Batteries and Energy Storage Hub focuses on understanding the fundamental performance limitations for electrochemical energy storage to launch the next generation of energy storage technologies.

The Batteries and Energy Storage Hub will accelerate the development of energy storage solutions that are well beyond current capabilities and approach theoretical limits. This development will be enabled by cross-disciplinary R&D focused on the barriers to transforming electrochemical energy storage, including the exploration of new materials, architectures, chemistries, systems, and novel approaches for transportation and utility-scale storage. Outside of the Hub, battery research is typically focused on one particular problem or research challenge and thus lacks the resources and the diverse breadth of talent to consider holistic solutions. The Hub will provide this critical mass directed on research to overcome the current technical limits for electrochemical energy storage to the point that the risk level will be low enough for industry to further develop the innovations discovered by the Hub and deploy these new technologies into the marketplace.

The Hub's goal is to deliver revolutionary research that will result in new technologies and approaches, rather than focusing on a single technology or incremental improvements to current technologies. While advancing the current understanding and underpinning science for energy storage, the Hub will include the development of working bench-top prototype devices that demonstrate radically new approaches for electrochemical storage that are scalable. These should have the potential to be produced at low manufacturing cost from earth-abundant materials and possess greatly improved properties compared to present commercially available energy storage technologies.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The Hub applications were assessed through peer-review. The Hub proposal and management plan provided specific performance objectives and milestones that were confirmed through the award process and early stages of Hub operations. These provided the baseline for future assessments of Hub progress.	19,410

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $24,237,000 for Hub research that would follow the plan established in the proposal. A management peer review would evaluate the Hub's progress in fulfilling the research plan. The first scientific publications would appear, advisory groups would be operational (including industrial input), and a communications network would be established by the Hub.	—
FY 2014	Hub research on electrochemical energy storage will continue to follow the plans established in the proposal as revised in the initial months of operation in consultation with DOE. Joint Center for Energy Storage Research (JCESR) operations and management processes will be informed by the management review. A full peer review of the technical progress of the Hub research will occur in the September-October time frame.	24,237

Chemical Sciences, Geosciences, and Biosciences
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Fundamental Interactions Research	75,510	—	76,047
Chemical Transformations Research	94,331	—	94,553
Photochemistry and Biochemistry Research	69,114	—	69,605
Energy Frontier Research Centers (EFRCs)	42,670	—	70,866
Energy Innovation Hubs—Fuels From Sunlight	24,263	—	24,237
GPP	2,852	—	600
SBIR/STTR	0	—	11,085
Total, Chemical Sciences, Geosciences, and Biosciences[a]	308,740	—	346,993

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $8,286,000 and STTR $1,115,000 (transferred out of BES in FY 2012 Current column
- FY 2014 Request: SBIR $9,699,000 and STTR $1,386,000

<u>Overview</u>

The transformation of energy between types (optical, electrical, chemical, heat, etc.) and the rearrangement of matter at the atomic, molecular, and nano-scales are critically important in every energy technology. The *Chemical Sciences, Geosciences, and Biosciences* subprogram supports research that explores fundamental aspects of chemical reactivity and energy transduction in order to develop a broad spectrum of new chemical processes, such as catalysis, that can contribute significantly to the advancement of new energy technologies. Research addresses the challenge of understanding physical and chemical phenomena over a tremendous range of spatial and temporal scales, from molecular through nanoscale and on to mesoscale, and at multiple levels of complexity, including the transition from quantum to classical behavior.

At the heart of this research lies the quest to understand and control chemical processes and the transformation of energy at the molecular scale in systems spanning simple atoms and molecules, active catalysts, and larger biochemical or geochemical systems. At the most fundamental level, the development and understanding of the quantum mechanical behavior of electrons, atoms, and molecules is rapidly evolving into the ability to control and direct such behavior to achieve desired results in meso- and macro-scale energy conversion systems.

This subprogram seeks to extend this new era of control science to include the capability to tailor chemical transformations with atomic and molecular precision. Here, the challenge is to achieve fully predictive assembly and manipulation of larger, more complex chemical, geochemical, and biochemical systems at the same level of detail now known for simple molecular systems.

To address these challenges, the portfolio includes coordinated research activities in three areas:

- **Fundamental Interactions**—Structural and dynamical studies of atoms, molecules, and nanostructures with the aim of providing a complete understanding of atomic and molecular interactions in the gas phase, condensed phase, and at interfaces.
- **Chemical Transformations**—Design, synthesis, characterization, and optimization of chemical processes that underpin advanced energy technologies, including catalytic production of fuels,

nuclear energy, and geological sequestration of carbon dioxide.

- **Photochemistry and Biochemistry**—Research on the molecular mechanisms involved in the capture of light energy and its conversion into chemical and electrical energy through biological and chemical pathways.

The portfolio of this subprogram includes several unique efforts that enable these overall research themes. Novel sources of photons, electrons, and ions are developed to probe and control atomic, molecular, nanoscale, and mesoscale matter, particularly ultrafast optical and x-ray techniques to study and direct molecular, dynamics, and chemical reactions. This subprogram supports the Nation's largest Federal effort in catalysis science for the design of new catalytic methods and materials for the clean and efficient production of fuels and chemicals. It also contains a unique effort in the fundamental chemistry of the heavy elements, with complementary research on chemical separations and analysis. Research in geosciences emphasizes analytical and physical geochemistry, rock-fluid interactions, and flow/transport phenomena that are critical to a scientific understanding of carbon sequestration. Natural photosynthetic systems are studied to create robust artificial and bio-hybrid systems that exhibit the biological traits of self-assembly, regulation, and self-repair. Complementary research on artificial systems includes organic and inorganic photochemistry, photo-induced electron and energy transfer, photoelectrochemistry, and molecular assemblies for artificial photosynthesis.

In addition to single-investigator and small-group research, the subprogram supports Energy Frontier Research Centers that were established in FY 2009 and the Fuels from Sunlight Energy Innovation Hub that was awarded in FY 2010. These research modalities support multi-investigator, multidisciplinary research and focus on forefront energy technology challenges. The Hub supports a large, tightly integrated team and research that spans basic and applied regimes with the goal of providing the scientific understanding that will enable the next generation of technologies for the direct conversion of sunlight to chemical fuels.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Fundamental Interactions Research	75,510	76,047	+537
Research continues at approximately the FY 2012 level, which includes additional efforts in predictive theory and modeling, some of which are funded jointly with the Office of Advanced Scientific Computing Research under the SciDAC program.			
Chemical Transformations Research	94,331	94,553	+222
Research continues at approximately the FY 2012 level.			
Photochemistry and Biochemistry Research	69,114	69,605	+491
Research continues at approximately the FY 2012 level			
Energy Frontier Research Centers	42,670	70,866	+28,196
EFRCs continue at the FY 2012 request level. A competitive solicitation will be issued for both renewal and new EFRCs. Additional one-time funding of $28,866,000 is provided to fully forward fund some of the new EFRC awards.			

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Energy Innovation Hubs—Fuels From Sunlight	24,263	24,237	-26
In FY 2014, the Fuels From Sunlight Hub operations are supported at the planned annual level.			
GPP	2,852	600	-2,252
Funds are provided for facility improvements at Ames Laboratory.			
SBIR/STTR	0	11,085	+11,085
In FY 2012, $8,286,000 and $1,115,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is statutorily set at 3.20% of non-capital funding in FY 2014.			
Total, Chemical Sciences, Geosciences, and Biosciences	308,740	346,993	+38,253

Fundamental Interactions Research

Overview

This activity builds the fundamental science basis essential for technological advances in a diverse range of energy processes. Research encompasses structural and dynamical studies of atoms, molecules, and nanostructures, and the description of their interactions in full quantum detail. The ultimate objective, often gained through studies of model systems, is a complete understanding of reactive chemistry in the gas phase, condensed phase, and at interfaces. In complement, this activity supports development of novel experimental and theoretical tools. New sources of photons, electrons, and ions are used to probe and control atomic, molecular, nanoscale, and mesoscale matter and processes on ultrafast time scales. New algorithms for computational chemistry are developed and applied in close coordination with experiment. Areas of emphasis are use-inspired, with relevance for example to combustion and catalysis, but the knowledge and techniques produced by this activity form a science base to underpin numerous aspects of the DOE mission.

The principle research thrusts are in atomic, molecular, and optical (AMO) sciences and chemical physics. AMO research emphasizes the interactions of atoms, molecules, and nanostructures with photons, particularly those from BES light sources, to characterize and control their behavior. AMO research examines energy transfer within isolated molecules that provides the foundation for understanding the making and breaking of chemical bonds. Chemical physics research builds from the AMO research foundation by examining reactive chemistry of molecules that are not isolated, but whose chemistry is profoundly affected by the environment. It explores the transition from molecular-scale chemistry to collective phenomena in complex systems, such as the effects of solvation or interfaces on chemical structure and reactivity. This transition is often accompanied by a parallel transition from quantum mechanical behavior to classical or continuum behavior. Understanding such collective behavior is critical in a wide range of energy and environmental applications, from solar energy conversion to improved methods for handling radiolytic effects in context of advanced nuclear fuel or waste remediation. Gas-phase chemical physics emphasizes the incredibly rich chemistry of combustion—burning diesel fuel involves thousands of chemical reactions and hundreds of distinct species. Combustion simulation and diagnostic studies address the subtle interplay between combustion chemistry and the turbulent flow that characterizes all real combustion devices. This activity includes support for the Combustion Research Facility (CRF), a multi-investigator research laboratory at Sandia National Laboratory in Livermore, CA, for the study of combustion science.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Core research activities continued with emphasis on the development and application of new ultrafast x-ray and optical probes of matter. New research emphasized the chemistry associated with stochastic combustion processes and the fundamental science of liquid fuel injection, both of which are required to further enable the predictive simulation of internal combustion engines. Additional new research emphasized advancing predictive theory and modeling, some of which are funded jointly with the Office of Advanced Scientific Computing Research under the SciDAC program. Topical focus areas included advanced computational chemistry for catalysis and improved treatment of electronic states for advancing predictive capability for photovoltaic and photocatalytic materials.	75,510

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $71,562,000 for AMO sciences research that would emphasize the development and application of new ultrafast x-ray and optical probes of matter, including experiments at the Linac Coherent Light Source and BES synchrotron light sources and theoretical and computational methods for the interpretation of ultrafast measurements. Chemical physics research would have been emphasized development of new theoretical and simulation techniques relevant to a wide variety of potential applications. As part of the effort on materials and chemistry by design, increases would provide for the use of optical fields to control and design quantum mechanical systems and for new computational chemistry approaches to electronically excited states in molecules and extended mesoscale systems, which are critically important in solar energy conversion. As part of science in supporting a clean energy agenda, an increase would be provided for advanced combustion research to accelerate the predictive simulation of internal combustion engines.	—
FY 2014	AMO sciences research will continue to emphasize the development and application of forefront ultrafast x-ray and optical probes of matter, utilizing the Linac Coherent Light Source and BES synchrotron light sources, and new theoretical methods for the interpretation of ultrafast measurements. Emphasis will be placed on novel x-ray probes of matter, including non-linear optical approaches and time-resolved imaging to take snapshots of complex chemical and biochemical phenomena, and to advance fundamental understanding. New computational chemistry will stress improved methods for electronically excited states in molecules and extended mesoscale systems, which are critically important to the design of energy conversion processes and materials. Chemical physics research will emphasize development of new theoretical and simulation techniques relevant to a wide variety of potential applications. Work will continue on advanced combustion research to accelerate the predictive simulation of highly efficient and clean internal combustion engines.	76,047

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Chemical Physics Research	54,453	—	54,840
Atomic, Molecular, and Optical Science	21,057	—	21,207
Total, Fundamental Interactions Research	75,510	—	76,047

Chemical Transformations Research

Overview

Chemical Transformation Research emphasizes the design, synthesis, characterization, and optimization of chemical processes that underpin advanced energy technologies including the catalytic production of fuels, nuclear energy, and geological sequestration of carbon dioxide. A tremendous breadth of novel chemistry is covered: inorganic, organic, and hybrid molecular complexes; nanostructured surfaces; electrochemistry; nanoscale membranes; bio-inspired chemistry; and analytical and physical geochemistry. This activity develops unique tools for chemical analysis, using laser-based and ionization techniques for molecular detection, with an emphasis on imaging chemically distinct species.

This activity has a leadership role in the application of basic science to unravel the principles that define how catalysts work—how they accelerate and direct chemistry. Such knowledge enables the rational synthesis of novel catalysts, designed at the nanoscale but operating at the mesoscale, which will lead to increased energy efficiency and chemical selectivity. Because so many processes for the production of fuels and chemicals rely on catalysts, improving catalytic efficiency and selectivity has enormous economic and energy consequences. Advanced gas separation schemes for the removal of carbon dioxide from post-combustion streams are explored—these are essential to making carbon capture an economic reality. Fundamental studies of the structure and reactivity of actinide-containing molecules provides the basis for their potential use in advanced nuclear energy systems. Geosciences research emphasizes a greater understanding of the consequences of deliberate storage, or accidental discharges, of energy related products (carbon dioxide or waste effluents), which require ever more refined knowledge of how such species react and move in the subsurface environment.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Core research activities continued and included emphasis on the combination of computational design, directed synthesis, and molecular-scale characterization to create and optimize novel catalysts. Other areas of research emphasis included fluid flow in nanoscale membranes, fundamental actinide chemistry, and the translation of interfacial chemistry into the geosciences arena in order to improve our understanding of subsurface geochemistry.	94,331
FY 2013	The FY 2013 Request proposed $110,875,000. As part of the materials and chemistry by design effort, an increase would be provided for the development of computational methods and software tools for the simulation of photo-catalytic, fuel-forming reactions and for complementary efforts in synthesis and characterization of new catalytic materials that are designed at the nanoscale to function on the mesoscale. As part of science in supporting a clean energy agenda, increases would provide for novel approaches to the separation of carbon dioxide from post-combustion gas streams and oxygen from air prior to oxy-combustion and for research on the multi-scale dynamics of flow and plume migration in carbon sequestration, which can lead to improved models and risk assessment for carbon sequestration. Additional clean energy increases were proposed for actinide research in support of advanced nuclear energy systems, with emphasis on complex separation chemistry addressing the multiplicity of chemical forms and oxidation states in actinides for nuclear fuels and waste forms, and for advanced catalytic approaches to the conversion of biomass to fuels and other chemical products.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Research will emphasize the complementary development of computational methods for the simulation of photo-catalytic, fuel-forming reactions with efforts in synthesis and characterization of new catalytic materials that are designed at the nanoscale to function on the mesoscale. The catalytic conversion of biomass to fuels and other chemical products will be a major emphasis. Novel approaches to the separation of carbon dioxide from post-combustion gas streams and oxygen from air prior to oxy-combustion and for research on the multi-scale dynamics of flow and plume migration in carbon sequestration, which can lead to improved models and risk assessment for carbon sequestration, will be explored. Actinide research in support of advanced nuclear energy systems will continue, with emphasis on complex separation chemistry addressing the multiplicity of chemical forms and oxidation states in actinides for nuclear fuels and waste forms.	94,553

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Catalysis Science	46,110	—	46,438
Separations and Analysis	12,664	—	12,754
Heavy Element Chemistry	15,042	—	14,700
Geosciences Research	20,515	—	20,661
Total, Chemical Transformations Research	94,331	—	94,553

Photochemistry and Biochemistry Research

Overview

This activity supports research on the molecular mechanisms that capture light energy and convert it into electrical and chemical energy in both natural and man-made systems. The work is of critical importance for the effective use of our most abundant and durable energy source—the sun. More energy from the sun strikes the earth in one hour than is used by its entire human population in a year.

Natural photosynthesis is studied to provide roadmaps for the creation of robust artificial and bio-hybrid systems that exhibit the biological traits of self-assembly, regulation, and self-repair and that span from the atomic scale through the mesoscale. Physical science tools are extensively utilized to elucidate the molecular and chemical mechanisms of biological energy transduction, including processes beyond primary photosynthesis such as carbon dioxide reduction and subsequent deposition of the reduced carbon into energy-dense carbohydrates and lipids. Complementary research on artificial systems encompasses organic and inorganic photochemistry, light-driven energy and electron transfer processes, as well as photo-electrochemical mechanisms and molecular assemblies for artificial photosynthetic fuel production.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Ongoing research activities included efforts to define molecular-level structure-function relationships of the natural photosynthetic apparatus and apply that knowledge to synthetic solar fuel systems, including the design of ligands that further increase the reactivity of metal-based catalytic complexes. Efforts continued to understand the biophysical and biochemical parameters that make the plant cell wall recalcitrant to catalytic conversion into fuels and other value-added products.	69,114
FY 2013	The FY 2013 Request proposed $77,822,000. As part of the materials and chemistry by design effort, an increase would provide for the development of computational methods and software tools for the simulation of light harvesting and conversion of solar energy into electricity and fuels (in coordination with the *Chemical Transformations* activity). As part of science in supporting a clean energy agenda, increases provide for experimental research on direct conversion of solar energy to fuels and for advancing the catalytic conversion of biomass to fuels, both of which require translation from the nano to the mesoscale. These include studies of the mechanisms that protect and self-repair the natural photosynthetic apparatus; photocatalytic generation of fuels in synthetic systems via semiconductor/polymer interfaces, dye-sensitized solar cells, inorganic-organic molecular complexes, and nano-scale water splitting assemblies; and advanced analysis of the structure of plant cell walls to elucidate catalytic routes for the conversion of biomass to fuels and other chemical products (in coordination with the *Chemical Transformations* activity).	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	The development of computational methods for the simulation of light harvesting and conversion of solar energy into electricity and fuels will be emphasized (in coordination with the *Chemical Transformations* activity). Experimental research on direct conversion of solar energy to fuels and for advancing the catalytic conversion of biomass to fuels, both of which require translation from the nano to the mesoscale, will be supported. These include studies of the mechanisms that protect and self-repair the natural photosynthetic apparatus; photocatalytic generation of fuels in synthetic systems via semiconductor/polymer interfaces, dye-sensitized solar cells, inorganic-organic molecular complexes, and nano-scale water splitting assemblies; and advanced analysis of the structure of plant cell walls to elucidate catalytic routes for the conversion of biomass to fuels and other chemical products (in coordination with the *Chemical Transformations* activity).	69,605

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Photosynthetic Systems	16,920	—	17,040
Physical Biosciences	16,274	—	16,390
Solar Photochemistry	35,920	—	36,175
Total, Photochemistry and Biochemistry Research	69,114	—	69,605

Energy Frontier Research Centers

Overview

The Energy Frontier Research Centers (EFRCs), initiated in FY 2009, are a unique and important research modality, bringing together the skills and talents of teams of investigators to perform energy-relevant, basic research with a scope and complexity beyond that possible in standard single-investigator or small-group awards. These multi-investigator, multi-disciplinary centers foster, encourage, and accelerate basic research to provide the basis for transformative energy technologies. There were 46 EFRC awards, 16 funded for a full 5-year award term through the American Recovery and Reinvestment Act (ARRA) of 2009 and 30 funded on a continuing basis through annual appropriations through this subprogram and the Materials Science and Engineering subprogram. The EFRCs supported in this subprogram are focused on the design, discovery, control, and characterization of the chemical, biochemical, and geological moieties and processes for the advanced conversion of solar energy into chemical fuels; for improved electrochemical storage of energy; for the creation of next-generation biofuels via catalytic chemistry and biochemistry; for the clean and efficient combustion of advanced transportation fuels; and for science-based carbon capture and geological sequestration.

BES's active management of the EFRCs is an important feature of the program. A variety of methods are used to regularly assess the ongoing progress of the EFRCs, including annual progress reports, monthly phone calls with the EFRC Directors, periodic Directors' meetings, and on-site visits by program managers. BES has also conducted two in-person reviews by outside experts. Each EFRC underwent a review of its management structure and approach in the first year of operation (2010) and a midterm assessment that focused on each EFRC's scientific program and progress compared to its 5-year research goals (2012). In addition, BES organized a meeting of EFRC scientific staff in the second year, 2011, to facilitate collaboration and information exchanges; a second meeting is planned for the fourth year, 2013. These meetings and Directors' meetings provide opportunities for communication between the EFRCs and DOE programs. Representatives from the DOE technology programs are invited to these events to discuss the latest advances in scientific understanding from EFRC research. The technology offices also help to ensure, through presentations and individual interactions, that the EFRCs are cognizant of the current problems facing different energy sectors. The mid-term assessment in FY 2012 provided a comprehensive peer review of the entire EFRC portfolio. The process found that the EFRCs are accelerating energy science by bringing together world-class scientists from different disciplines to tackle challenging problems in new ways; providing an environment that encourages high-risk, high-reward research that would not be done otherwise; integrating synthesis, characterization, theory, and computation to accelerate the rate of scientific progress; developing new, innovative experimental and theoretical tools that illuminate fundamental processes in unprecedented detail; and creating an enthusiastic, inter-disciplinary community of energy-focused scientists that will ensure a future workforce for the United States in these critical fields. The EFRCs have demonstrated significant scientific progress as shown by publications, invention disclosures, patents, and transfer of research results to companies and applied research efforts. As of January 2013, the EFRCs had authored over 3,400 peer-reviewed publications. Although the focus of the EFRCs is fundamental energy-use-inspired science, their results have impacted technology research and industry. There are over 200 patents/applications, with at least 30 associated licenses, plus more than 60 unpatented invention disclosures. Over 60 companies are using the results of EFRC research, including small start-ups and major corporations. Many of the EFRCs are interfacing with DOE's technology and small business programs to advance the transition of promising scientific results to commercial applications.

The mid-term assessment confirmed that the EFRCs are a productive research modality. The centers provide an important bridge between basic research and energy technologies and complement other research activities funded by DOE. The final funding for the first five-year award period will be distributed in FY 2013. For FY 2014, an open re-competition is planned to select new EFRCs and consider renewal applications for existing EFRCs. As in the original competition, the FY 2014 EFRC solicitation will target basic research across the broad range of science needed to provide a foundation of transformative energy technologies. The solicitation will incorporate new areas of energy-relevant research that have been identified by recent BES and BESAC workshop reports, including: *Computational Materials Science and Chemistry: Accelerating Discovery and Innovation Through Simulation-Based Engineering and Science; From Quanta to the Continuum: Opportunities for Mesoscale Science; Basic Research Needs for Carbon Capture: Beyond 2020;* and *Science for Energy Technology: Strengthening the Link Between Basic Research and Industry*. The FY 2014 EFRC solicitation will feature new scientific initiatives including research to advance the rate of materials and chemical discovery and a "molecules to mesoscale" approach to directed-assembly of mesoscale structures with unique functionality, emulating biological systems in the development of man-made energy materials and systems and enabling bottom-up design of materials with nanoscale functional units to produce next generation technological innovation. Renewal and new applications will be assessed via rigorous peer review with awards will be based on scientific and technical merit and the achievement of a balanced EFRC portfolio for use-inspired basic energy research.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The EFRCs completed their third year of operation in late FY 2012. To date, the 46 EFRCs have produced more than 2,000 peer reviewed publications and more than 90 invention disclosures, patent applications, and patents. About 10 start-up companies are commercializing EFRC discoveries. In January–April 2012, a panel-based peer-review assessed the scientific progress of each EFRC. These reviews identified numerous examples of extraordinary performance as well as specific opportunities to enhance scientific impact. Reviewers consistently praised the EFRC approach to delivering scientific advances and innovations.	42,670
FY 2013	The FY 2013 Request proposed $52,000,000 for research that would incorporate modifications to research activities and directions resulting from the FY 2012 peer review. Additional funding would accelerate the transition of novel scientific discoveries from the EFRCs into innovative, prototype clean energy technologies and to improve coordination between fundamental research conducted in the EFRCs and applied research and engineering development supported by EERE.	—
FY 2014	A single funding opportunity announcement (FOA) will be issued for both renewal and new EFRCs for five-year awards beginning in FY2014. The EFRC FOA will encourage the formation of effective teams to address the broad range of fundamental science needed to power transformative energy technologies, including newly identified opportunities in the computational design of materials and chemical processes and mesoscale science. All current EFRCs, including those initially through ARRA, will have the opportunity to compete for a second five-year performance period. Renewal awards will be based on rigorous peer review that includes assessment of progress during the first five-year award and evaluation of the research proposed for the subsequent five years. New EFRC awards will be based on rigorous peer review of research proposed for an initial five-year award period. One-time funding in the amount of $28,866,000 is provided to fully forward fund some of the new/renewal EFRC awards.	70,866

Energy Innovation Hubs—Fuels from Sunlight

Overview

Established in September 2010, the Fuels from Sunlight Hub is designed as a potentially renewable five-year project to bring together a multi-disciplinary, multi-investigator, multi-institutional team to create transformative advances in the development of artificial photosynthetic systems that convert sunlight, water, and carbon dioxide into a range of commercially useful fuels. This Hub, the Joint Center for Artificial Photosynthesis (JCAP), is led by the California Institute of Technology (Caltech) in primary partnership with Lawrence Berkeley National Laboratory (LBNL). Other partners include the SLAC National Accelerator Laboratory and several University of California institutions. JCAP is composed of internationally-renowned scientists and engineers that seek to integrate decades of community effort in light harvesting and conversion, homogeneous and heterogeneous catalysis, interfacing, membrane and mesoscale assembly, and computational modeling and simulation, with more current research efforts using powerful new tools to examine, understand, and manipulate matter at the nanoscale. By studying the science of scale-up and benchmarking both components (catalysts) and systems (device prototypes), JCAP seeks to accelerate the transition from laboratory discovery to industrial use.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, JCAP has successfully completed its proposed milestones for the second project year. The renovations of the JCAP laboratory at Caltech were completed on schedule and on budget; the laboratory is fully equipped and is occupied for use by JCAP staff from Caltech and the University of California partners. Staffing is on pace to achieve the target of 150–180 scientists and engineers, with approximately 60 now participating in JCAP activities on a daily basis. Significant advances have been made on accelerating discovery of new components, including the establishment of innovative high-throughput capabilities for screening an unprecedented number of light absorbers and catalysts. Excellent progress has been made in the design and synthesis of membranes that provide ionic pathways, good optical properties, and are effective at separating product fuels. JCAP has continued its efforts to integrate the solar fuels community through symposia and workshops, tool development, and principal investigators' meetings. In April 2012, an external peer review assessed the scientific and technical progress of JCAP. This review indicated JCAP performance to be on track and provided useful feedback for improving JCAP productivity through enhanced synergy among research projects. The JCAP award was initiated in late September 2010 and JCAP project years correspond approximately to the subsequent fiscal year, e.g., JCAP project year one (supported with FY 2010 funding) occurred in FY 2011 and JCAP project year two occurred in FY 2012 (supported with FY 2011 funding).	24,263
FY 2013	The FY 2013 Request proposed $24,237,000 for JCAP. Performance milestones emphasized the integration and benchmarking of components as part of a complete system. Areas of increased emphasis include extensive use of SC leadership class computational facilities and synchrotron light sources for materials design and characterization, the development of scientific scale-up procedures for nanoscale device components, and the establishment of a number of prototype solar-to-fuels devices for component (light harvesters, catalysts, membranes, etc.) testing and optimization.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	The FY 2013 Budget proposed extensive collaboration between the external scientific and technical communities and JCAP in order to test and redesign light absorbers and catalysts. The proposed efforts would significantly increase interactions with and/or licensing to industry in order to develop targeted direct solar fuels technologies.	
FY 2014	In FY 2014, JCAP performance milestones emphasize prototype development. Areas of increased emphasis will include: analysis of components, materials and chemical inputs, and hardware designs with respect to manufacturability, life-cycle analysis, and reuse to ensure the scalability of the first-generation, solar fuels generation system. Additional efforts will be made to fully optimize catalyst and systems efficiencies and to provide reviews of solar fuels research to the scientific community, establishing strong outreach efforts focused on workforce development.	24,237

General Plant Projects (GPP)

Overview

GPP funding is provided for minor new construction, for other capital alterations and additions, and for improvements to land, buildings, and utility systems principally at the Ames Laboratory and the Combustion Research Facility (CRF) at Sandia National Laboratories. Funding of this type is essential for maintaining the productivity and usefulness of Department-owned facilities and for meeting requirements for safe and reliable facilities operation. The total estimated cost of each GPP project will not exceed $10,000,000.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding will support minor facility improvements at Ames Laboratory, the Ames Sensitive Instrument Facility at Ames Laboratory, and the seismic retrofit for the CRF office building at Sandia National Laboratories.	2,852
FY 2013	The FY 2013 Request proposed $2,315,000 to support minor infrastructure improvements and upgrades at Ames Laboratory.	—
FY 2014	Funding will support minor facility improvements at Ames Laboratory.	600

Scientific User Facilities
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Synchrotron Radiation Light Sources	381,012	—	464,000
High-Flux Neutron Sources	249,000	—	261,490
Nanoscale Science Research Centers	102,781	—	106,500
Other Project Costs	7,700	—	28,100
Major Items of Equipment	73,500	—	64,200
Research	24,992	—	36,966
SBIR/STTR	0	—	28,934
Total, Scientific User Facilities[a]	838,985	—	990,190

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $20,282,000 and STTR $2,730,000 (transferred out of BES in FY 2012 Current column)
- FY 2014 Request: SBIR $25,317,000 and STTR $3,617,000

Overview

The Scientific User Facilities subprogram supports the operation of a geographically diverse suite of major facilities that provide thousands of researchers from universities, industry, and government laboratories unique tools to advance a wide range of sciences. These user facilities are operated on an open access, competitive merit review basis, enabling scientists from every state and of many disciplines from academia, national laboratories, and industry to utilize the facilities' unique capabilities and sophisticated instrumentation.

Studying matter at the level of atoms and molecules requires instruments that can measure structures that are one thousand times smaller than those detectable by the most advanced light microscopes. Thus, to characterize structures with atomic detail, we must use probes such as x-rays, electrons, and neutrons that are at least as small as the atoms being investigated. SC's large-scale user facilities consist of a complementary set of intense x-ray sources, neutron scattering centers, electron beam characterization capabilities, and research centers for nanoscale science. These facilities allow researchers to probe materials in space, time, and energy with the appropriate resolutions that can interrogate the inner workings of matter to answer some of the most challenging grand science questions. By taking advantage of the intrinsic charge, mass, and magnetic characteristics of x-rays, neutrons, and electrons, these tools offer unique capabilities to help understand the fundamental aspects of the natural world.

Advances in tools and instruments often drive scientific discovery. The continual development and upgrade of the instrumental capabilities include new x-ray and neutron experimental stations, improved core facilities, and new stand-alone instruments. The subprogram also supports research in accelerator and detector development to explore technology options for the next generations of x-ray and neutron sources.

Annually, the BES scientific facilities are used by more than 14,000 scientists and engineers in many fields of science and technology. These facilities provide unique capabilities to the scientific community and are a critical component of maintaining U.S. leadership in the physical sciences. Collectively, these user facilities and enabling tools contribute to important research results that span the continuum from basic to applied research and embrace the full range of scientific and technological endeavors, including chemistry, physics, geology, materials science, environmental science, biology, and biomedical science. These capabilities enable scientific insights that can lead to the discovery and design of advanced materials and novel chemical processes with broad societal impacts, from energy applications to information technologies and biopharmaceutical discoveries. The advances enabled by these facilities extend from energy-efficient catalysts for clean energy production to spin-based electronics and new drugs for cancer therapy. For approved, peer-reviewed projects, operating time is available without charge to researchers who intend to publish their results in the open literature.

Explanation of Funding Changes

The overarching strategy for this subprogram focuses on maintaining U.S. scientific leadership by ensuring that the BES-supported scientific tools and instrumentation stay at the technological forefront and continue to charter new paths for revolutionary discoveries. The U.S. is a global leader in the photon sciences as reflected in the stellar performance and impacts of the suite of five synchrotron radiation light source facilities supported by BES. These facilities are critical to maintaining the Nation's base of scientific innovations and require sustained support.

The BES program leads the world in the conception, design, construction, and operation of large-scale synchrotron radiation light sources and neutron scattering facilities. The FY 2014 budget request reflects difficult, considered choices between the operations of existing facilities, upgrading facilities, and building new user facilities that will supersede today's facilities by providing totally new capabilities that are not in existence today. Although it will be several years—and perhaps more than a decade—before major new facilities can contribute directly to the national research effort, their design and construction are essential for the effective evolution of advanced science and technology in the United States. The operation of existing facilities and the design of new facilities complement one another in function, time scale, and required resources. Optimally operating existing facilities is essential for maintaining a healthy pace of scientific discoveries.

The FY 2014 budget request fulfills stewardship responsibilities to ensure continued operations of BES user facilities and high-priority upgrades in their capabilities. FY 2014 will continue the early operations of the National Synchrotron Light Source-II (NSLS-II) in preparation for full operations in FY 2015, and funding will be provided to continue the NSLS-II Experimental Tools (NEXT) project, which will add additional best-in-class beamlines to NSLS-II. The budget request also supports the upgrade of the Advanced Photon Source.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Synchrotron Radiation Light Sources	381,012	464,000	+82,988
Increases in funding allow for continued operations of facilities at an optimal level. The National Synchrotron Light Source-II (NSLS-II) at Brookhaven National Laboratory continues its second year of early operations in FY 2014.			
High-Flux Neutron Sources	249,000	261,490	+12,490
Funding allows for continued operation of HFIR and SNS at an optimal level.			
Nanoscale Science Research Centers (NSRCs)	102,781	106,500	+3,719
Funding allow for continued support of users at the NSRCs at optimal levels.			
Other Project Costs	7,700	28,100	+20,400
Increased funding is requested in FY 2014 for other project costs associated with the NSLS-II at BNL and with the LCLS-II at SLAC according to the project plan.			

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Major Items of Equipment	73,500	64,200	-9,300
Funding will be provided to support the Advanced Photon Source Upgrade (APS-U) at Argonne National Laboratory and NEXT MIE at NSLS-II at Brookhaven National Laboratory. LCLS-II is included as a construction project in the FY 2014 request.			
Research	24,992	36,966	+11,974
Funding to support accelerator and detector research and the electron beam microcharacterization centers continues at the FY 2012 level. In FY 2014, responsibility is transferred from EM to BES for long term surveillance and maintenance (LTS&M) and for remaining legacy clean work scope at BNL and SLAC.			
SBIR/STTR	0	28,934	+28,934
In FY 2012, $20,282,000 and $2,730,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 3.20% of non-capital funding FY 2014.			
Total, Scientific User Facilities	838,985	990,190	+151,205

Synchrotron Radiation Light Sources

Overview

X-rays are an essential tool for studying the structure of matter and have long been used to peer into material through which visible light cannot penetrate. Today's synchrotron light source facilities produce x-rays that are billions of times brighter than medical x-rays. Scientists use these highly focused, intense beams of x-rays to reveal the identity and arrangement of atoms in a wide range of materials. The tiny wavelength of x-rays allows us to see things that visible light cannot resolve, such as the arrangement of atoms in metals, semiconductors, biological molecules, and other materials. The fundamental tenet of materials research is that structure determines function. The practical corollary that converts materials research from an intellectual exercise into a foundation of our modern technology-driven economy is that structure can be manipulated to construct materials with particular desired behaviors. To this end, synchrotron radiation has transformed the role of x-rays as a mainline tool for probing the atomic and electronic structure of materials internally and on their surfaces.

From its first systematic use as an experimental tool in the early 1960s, synchrotron radiation has vastly enhanced the utility of pre-existing and contemporary techniques, such as x-ray diffraction, x-ray spectroscopy, and imaging and has given rise to scores of new ways to do experiments that would not otherwise be feasible with conventional x-ray machines. Moreover, the wavelength can be selected over a broad range (from the infrared to hard x-rays) to match the needs of particular experiments. Together with additional features, such as controllable polarization, coherence, and ultrafast pulsed time structure, these characteristics make synchrotron radiation the x-ray source of choice for a wide range of materials research. The wavelengths of the emitted photons span a range of dimensions from the atom to biological cells, thereby providing incisive probes for advanced research in a wide range of areas, including materials science, physical and chemical sciences, metrology, geosciences, environmental sciences, biosciences, medical sciences, and pharmaceutical sciences.

BES operates a suite of five synchrotron radiation light sources, including a free electron laser, the Linac Coherent Light Source (LCLS) at SLAC National Accelerator Laboratory (SLAC) and four storage ring based light sources—the Advanced Light Source (ALS) at Lawrence Berkeley National Laboratory (LBNL), Advanced Photon Source (APS) at Argonne National Laboratory (ANL), National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory (BNL), and Stanford Synchrotron Radiation Lightsource (SSRL) at SLAC. Funds are provided to support facility operations, enable cutting-edge research and technical support and to administer a robust user program at these facilities, which are made available to all researchers with access determined via peer review of user proposals.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funds were provided to support the continued operations of the BES synchrotron radiation light sources. The FY 2012 funding was below the optimal level and will likely impact machine maintenance and user support.	381,012
FY 2013	The FY 2013 Request proposed $438,800,000 for the National Synchrotron Light Source-II (NSLS-II) early operations in addition to supporting the operations of the five BES synchrotron radiation light source facilities at near optimal levels. New collaborative efforts with EERE would be initiated at BES light sources to accelerate the transition of novel scientific discoveries into innovative, prototype clean energy technologies. Funding requested would support procurement of instrumentation dedicated to clean energy research.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	In FY 2014, funding is requested to continue the early operations of the NSLS-II in addition to supporting the operations of the five BES synchrotron radiation light source facilities at optimal levels	464,000

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Advanced Light Source, LBNL	63,200	—	63,700
Advanced Photon Source, ANL	123,265	—	130,000
National Synchrotron Light Source, BNL	36,000	—	35,000
National Synchrotron Light Source-II, BNL	0	—	69,000
Stanford Synchrotron Radiation Lightsource, SLAC	34,647	—	38,500
Linac Coherent Light Source, SLAC	123,900	—	127,800
Total, Synchrotron Radiation Light Sources	381,012	—	464,000

High-Flux Neutron Sources

Overview

One of the goals of modern materials science is to understand the factors that determine the properties of matter on the atomic scale and to use this knowledge to optimize those properties or to develop new materials and functionality. This process regularly involves the discovery of fascinating new physics, which itself may lead to previously unthought-of capabilities. Among the different probes used to investigate atomic-scale structure and dynamics in scattering experiments, thermalized neutrons have unique advantages:

- they have a wavelength similar to the spacing between atoms, allowing atomic resolution studies of structure and an energy similar to atoms in materials allowing investigation of material dynamics;
- they have no charge, allowing deep penetration into a bulk material;
- they are scattered to a similar extent by both light and heavy atoms but differently by different isotopes, so that different chemical sites can be distinguished in isotope substitution experiments, for example in organic and biological materials;
- they have a suitable magnetic moment for probing magnetism in condensed matter; and
- their scattering cross-section is precisely measurable on an absolute scale, facilitating straightforward comparison with theory and computer modeling.

The High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) generates neutrons via fission in a research reactor. HFIR operates at 85 megawatts to provide state-of-the-art facilities for neutron scattering, materials irradiation, and neutron activation analysis and is the world's leading source of elements heavier than plutonium for medical, industrial and research applications. Two of the triple-axis spectrometers for studying material dynamics and two small-angle scattering spectrometers at the recently installed liquid-hydrogen cold source for measuring structures of condensed matter and biological materials are best in their class world-wide.

Another approach for generating neutron beams is to use an accelerator to generate protons that strike a target made of a heavy metal. As a result of the impact, neutrons are produced in a process known as spallation. The Spallation Neutron Source (SNS) at ORNL is the world's brightest pulsed neutron facility. SNS is in the process of building out the full suite of 18 beamlines to enable scientists to make neutron measurements of greater sensitivity, higher speed, higher resolution, and in more complex sample environments than ever before.

The Lujan Neutron Scattering Center at Los Alamos National Laboratory (LANL), a pulsed spallation source operating at about 100 kW, supports a target hall constructed by Office of Science (SC) and instruments fabricated by SC and the National Nuclear Security Administration (NNSA) that address both of the needs of the basic research community and the NNSA mission of science-based stockpile stewardship.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding was provided to support the operations of the three BES neutron scattering facilities. FY 2012 was the first full year of operation of a new chemical spectrometer for measuring excitations in single crystals, the last instrument built at SNS under the SING-I project.	249,000

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $257,694,000 for near optimal support of user operations. The request supports additional instruments that would have come online at SNS. This would be the first full year of operation of the new chemical spectrometer instrument at SNS.	—
FY 2014	Funding is requested to continue the operations of the HFIR and the SNS at optimal levels. The LANSCE will undergo an upgrade which will reduce the operations of the Lujan Center to 2,000 hours.	261,490

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Spallation Neutron Source, ORNL	180,500	—	190,500
High Flux Isotope Reactor, ORNL	58,000	—	61,175
Lujan Neutron Scattering Center, LANL	10,500	—	9,815
Total, High-Flux Neutron Sources	249,000	—	261,490

Nanoscale Science Research Centers (NSRCs)

Overview

Nanoscience is the study of materials and their behaviors at the nanometer scale—probing single atoms, clusters of atoms, and molecular structures. The scientific quest is to design, observe, and understand how nanoscale structures function, including how they interact with their environment. Developments at the nanoscale have the potential to make major contributions to delivering remarkable scientific discoveries that transform our understanding of energy and matter and advance national, economic, and energy security.

The NSRCs are DOE's premier user centers for interdisciplinary research at the nanoscale, serving as the basis for a national program that encompasses new science, new tools, and new computing capabilities. The five NSRCs are the Center for Nanoscale Materials at Argonne National Laboratory (ANL), Center for Functional Nanomaterials at Brookhaven National Laboratory (BNL), Molecular Foundry at Lawrence Berkeley National Laboratory (LBNL), Center for Nanophase Materials Sciences at Oak Ridge National Laboratory (ORNL), and Center for Integrated Nanotechnologies at Sandia National Laboratories and Los Alamos National Laboratory (SNL/LANL). Each center has particular expertise and capabilities in selected theme areas, such as synthesis and characterization of nanomaterials; catalysis; theory, modeling and simulation; electronic materials; nanoscale photonics; soft and biological materials; imaging and spectroscopy; and nanoscale integration. The centers are housed in custom-designed laboratory buildings near one or more other major BES facilities for x-ray, neutron, or electron scattering, which complement and leverage the capabilities of the NSRCs. These laboratories contain clean rooms, nanofabrication resources, one-of-a-kind signature instruments, and other instruments not generally available except at major user facilities. Operating funds are provided to enable cutting-edge research and technical support and to administer a robust user program at these facilities, which are made available to all researchers with access determined through external peer review of user proposals.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, funding was provided to support the user operations and new synthesis and characterization capabilities through techniques development and procurement of new equipment. The goal is to sustain and further develop a robust user program with high scientific and technological impacts at each of the NSRCs.	102,781
FY 2013	The FY 2013 Request proposed $113,500,000 for near optimal operations of the five NSRCs. Continued emphasis would be on developing world leadership in key nanoscale science thrust areas via advancing the state-of-the-art in nanoscale synthesis and characterization tools and in corresponding theory, modeling, and simulation research.	—
	New collaborative efforts with EERE would be initiated at the NSRCs to accelerate the transition of novel scientific discoveries into innovative, prototype clean energy technologies. Funding would support procurement of instrumentation dedicated to clean energy research.	
FY 2014	Funding is requested to continue operations and support of users at the NSRCs at the optimal level. Continued emphasis will be to cultivate and expand the user base from universities, national laboratories, and industry.	106,500

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Center for Nanoscale Materials, ANL	20,500	—	21,300
Center for Functional Nanomaterials, BNL	20,000	—	21,300
Molecular Foundry, LBNL	20,500	—	21,300
Center for Nanophase Materials Sciences, ORNL	20,781	—	21,300
Center for Integrated Nanotechnologies, SNL/LANL	21,000	—	21,300
Total, Nanoscale Science Research Centers (NSRCs)	102,781	—	106,500

Other Project Costs

Overview

The total project cost (TPC) of DOE's construction or major instrumentation projects comprises two major components—the total estimated cost (TEC) and other project cost (OPC). The TEC includes project costs incurred after Critical Decision-1, such as costs associated with all engineering design and inspection, the acquisition of land and land rights; direct and indirect construction/fabrication; and the initial equipment necessary to place the facility or installation in operation; and facility construction costs and other costs specifically related to those construction efforts. OPC represents all other costs related to the projects that are not included in the TEC. Generally, OPC is costs incurred during the project's initiation and definition phase for planning, conceptual design, research, and development, and during the execution phase for research and development, startup, and commissioning. OPC is always funded via operating funds.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funds were provided in FY 2012 for other project costs associated with the NSLS-II at BNL.	7,700
FY 2013	The FY 2013 Request proposed $24,400,000 for other project costs associated with the NSLS-II at BNL according to the project plan. The increase would support the preparation for the startup of NSLS-II.	—
FY 2014	Funds are requested in FY 2014 for other project costs associated with the NSLS-II at BNL and with the LCLS-II at SLAC according to the project plan.	28,100

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Linac Coherent Light Source-II (LCLS-II)	0	—	700
National Synchrotron Light Source (NSLS-II)	7,700	—	27,400
Total, Other Project Costs	7,700	—	28,100

Major Items of Equipment

Overview

BES supports major item of equipment (MIE) projects to ensure the continual development and upgrade of major scientific instrument capabilities, including fabricating new x-ray and neutron experimental stations, improving core facilities, and providing new stand-alone instruments. In general, each MIE greater than $5,000,000 in total project cost and all line item construction projects are required to follow the DOE Project Management Order 413.3B, which requires formal reviews to obtain critical decisions that advance the development stages of a project. Additional reviews may be required depending on the complexity and needs of the projects in question. BES MIE projects are in two main categories: Synchrotron Radiation Light Sources and High Flux Neutron Sources.

Synchrotron Radiation Light Sources

The Advanced Photon Source Upgrade (APS-U) MIE supports activities to design, build, install, and test the equipment necessary to upgrade an existing third-generation synchrotron light source facility, the Advanced Photon Source (APS). The APS is one of the Nation's most productive x-ray light source facilities, serving over 3,500 users annually and providing key capabilities to enable forefront scientific research in a broad range of fields of physical and biological sciences. The APS is the only hard x-ray GeV source in the U.S. and only one of three in the world, along with the European Synchrotron Radiation Facility (ESRF) in France and Spring-8 in Japan. The high-energy penetrating x-ray is especially critical for probing materials under real working environments, such as a battery or fuel cell in action. Both foreign facilities, commissioned at about the same time as the APS, are well into campaigns of major upgrades due to aging of beamlines as well as technological advancements in accelerator science. With the ever increasing demand for higher penetration power for probing real-world materials and applications, the higher energy hard x-rays (20 keV and above) produced at APS provide unique capabilities in the U.S. arsenal needed for tackling the grand science and energy challenges of the 21st century. The APS-U Project will upgrade the existing APS to provide an unprecedented combination of high-energy, high-average-brilliance, high flux, and short-pulse hard x-rays together with state-of-the-art x-ray beamline instrumentation. The APS-U's high-energy penetrating x-rays will provide a unique scientific capability directly relevant to problems in energy, the environment, new and improved materials, and biological studies. The upgraded APS will complement the capabilities of the 4th generation light sources (e.g., the Linac Coherent Light Source), which occupy different spectral, flux, and temporal range of technical specifications. The project is managed by Argonne National Laboratory.

The NSLS-II Experimental Tools (NEXT) MIE supports activities to add beamlines to the National Synchrotron Light Source-II (NSLS-II) Project. The NEXT Project will provide NSLS-II with complementary best-in-class beamlines that support the identified needs of the U.S. research community and the DOE energy mission. Implementation of this state-of-the-art instrumentation will significantly increase the scientific quality and productivity of NSLS-II. In addition, the NEXT project will enable and enhance more efficient operations of NSLS-II. The project is managed by Brookhaven National Laboratory.

High Flux Neutron Sources

The Spallation Neutron Source Instrumentation Next Generation-II (SING-II) MIE provides funding to fabricate four instruments, competitively selected using a peer review process, to be installed at the SNS. The project has an approved CD-2 Performance Baseline Total Project Cost of $60,000,000 and will complete the installation of these instruments on a phased schedule between FY 2012 and FY 2014. The SING-II instruments are in addition to the five instruments provided by the SING-I project.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The APS-U Project entered the preliminary design phase post Critical Decision 1 (CD-1) and began preparations to attain approval for CD-2, which establishes the project baseline. The project sought and received approval for CD-3A in August 2012, which authorized long lead procurements After receiving CD-1 approval in October 2012 and CD-3A approval in February 2012, LCLS-II began work on design, in-house fabrication, long lead procurement (e.g., construction of an annex building, injector system, and undulator components), detailed design of the two-tunnel option, and project management. The NEXT project achieved CD-1 in early 2012, which provides an alternative selection and cost range for this project and continued work on the preliminary design, working toward CD-2 approval early in FY 2013. SING-II's four instruments received their last year of funding. The first instrument was completed	73,500
FY 2013	The FY 2013 Request proposed $32,000,000 for APS-U and NEXT to continue design work and early procurements during FY 2013 and work toward achieving CD-3 approvals during FY 2013 and begin construction/fabrication of the technical scope. SING-II would continue fabrication of the neutron scattering instruments during FY 2013 with the possibility of an early finish for one or more. LCLS-II was included as a construction project in the FY 2013 request.	—
FY 2014	APS-U is scheduled to request CD-3b approval in the 2Q FY 2014 and begin construction/fabrication of the technical scope. Design and procurement activities will continue in support of the Short-Pulse X-ray source development. NEXT is anticipated to receive CD-3 approval in 1Q FY 2014 and will continue design, procurements (long lead and regular), and begin construction/fabrication activities during FY 2014. LCLS-II is included as a construction project in the FY 2014 request. No MIE funding is requested for this project.	64,200

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Spallation Neutron Source Instrumentation II (SING II)	11,500	—	0
Advanced Photon Source Upgrade (APS-U)	20,000	—	39,200
Linac Coherent Light Source-II (LCLS-II)	30,000	—	0[a]
NSLS-II Experimental Tools (NEXT)	12,000	—	25,000
Total, Major Items of Equipment	73,500	—	64,200

[a] LCLS-II is moved to line item construction in the FY 2014 request.

Research

Overview

This activity supports three electron-beam microcharacterization centers, which operate as user facilities for scientific research and a platform for development of next-generation electron-beam instrumentation. These facilities provide unsurpassed spatial resolution and the ability to simultaneously obtain structural, chemical, and other types of information from sub-nanometer regions. The wide range of capabilities allows study of the fundamental mechanisms of catalysis, energy conversion, corrosion, charge transfer, magnetic behavior, and many other processes. All of these are fundamental to understanding and improving materials for energy applications and the associated physical characteristics and changes that govern performance. The three centers are the Electron Microscopy Center for Materials Research at Argonne National Laboratory (ANL), the National Center for Electron Microscopy at Lawrence Berkeley National Laboratory (LBNL), and the Shared Research Equipment user facility at Oak Ridge National Laboratory (ORNL).

This activity also supports basic research in accelerator physics and x-ray and neutron detectors. Accelerator research is the cornerstone for the development of new technologies that will improve performance of accelerator-based light sources and neutron spallation facilities. Research areas include ultrashort (attosecond) free electron lasers (FEL), new seeding techniques and other optical manipulation to reduce the cost and complexity and improve performance of next generation FELs, and very high frequency laser photocathodes that can influence the design of linac-based FELs with high repetition rates. Detector research is a crucial component to enable the optimal utilization of user facilities. The emphasis of this activity is on research leading to a new and more efficient generation of photon and neutron detectors. Research includes studies on creating, manipulating, transporting, and performing diagnostics of ultrahigh brightness beams.

This activity also supports long term surveillance and maintenance (LTS&M) responsibilities and legacy cleanup work at BNL and SLAC. Prior to FY 2014, this activity was funded by the DOE Environmental Management (EM) program.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, funding was provided to support operations of the three electron beam microcharacterization centers and their corresponding user programs. FY 2012 funding was below the optimal level with likely impact on machine maintenance and user support. Triennial reviews of centers were conducted in FY 2012 to assess the facility performance, user operations, and the scientific output and impact. The results of the reviews demonstrated that these centers are highly productive with significant scientific impact. Accelerator physics and detector research continues to be supported at a reduced level. Research in developing superconducting accelerating cavities and cathode development was reduced. Support continued for the development of smart detectors, with concurrent signal processing capabilities, and solid state detectors optimized for next generation soft x-rays sources.	24,992

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $27,000,000 that would support optimal operations of the three electron beam microcharacterization centers. The emphasis would have been on maintaining a robust user program at the three user facilities. The outcomes of the FY 2012 triennial reviews would be used to inform funding decisions and guide program development at the three centers. The accelerator physics and detector research would maintain a balanced portfolio that continue to push the frontiers in accelerator research in the generation of high-brightness electron beams, ultra-short x-ray pulses (of the order of sub-picoseconds and attoseconds) necessary for the exploration of the atomic structure of matter, and on the development of ultra-fast and high-precision detectors demanded by the high-flux, high-repetition rate of future light sources and neutron scattering facilities.	—
FY 2014	Funding is requested to support optimal operations of the three electron beam microcharacterization centers. The accelerator physics and detector research will maintain a balanced portfolio that continues to push the frontiers in accelerator and detector research in anticipation of advances in source output flux and data volume. Research activities on self-seeding and advanced accelerator methods will be continued. In FY 2014, responsibility is transferred from EM to BES for long term surveillance and maintenance (LTS&M) and for remaining legacy clean work scope at BNL and SLAC ($+12,873,000).	36,966

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Electron-Beam Microcharacterization	10,601	—	11,500
Accelerator and Detector Research	14,391	—	12,593
Long Term Surveillance and Maintenance	0	—	12,873
Total, Research	24,992	—	36,966

Construction
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Linac Coherent Light Source-II (LCLS-II), SLAC	0	—[a]	95,000[b]
National Synchrotron Light Source-II (NSLS-II), BNL	151,400	152,327[c]	26,300
Total, Construction	151,400	152,327	121,300

[a] LCLS remains an MIE in FY 2013 under the CR.
[b] LCLS was funded as an MIE in FY 2012 and FY 2013.
[c] The FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. Pending finalization of FY 2013 funding levels, the TEC and TPC are based on the FY 2013 Request level of $47,203,000.

Overview

Reactors, accelerator-based x-ray light sources, and pulsed neutron sources are expensive but necessary user facilities that enable critical DOE mission-driven science. These user facilities provide the academic, laboratory, and industrial research communities with the tools to fabricate, characterize, and develop new materials and chemical processes to advance basic and applied research, advancing chemistry, physics, earth science, materials science, environmental science, biology, and biomedical science. Regular investments in construction of new user facilities and upgrades to existing user facilities are essential to maintaining U.S. leadership in these research areas.

All BES construction projects are conceived and planned with the scientific community and, during construction, adhere to the highest standards of safety and are executed on schedule and within cost through dogged project management. In accordance with DOE Order 413.3B, each project is closely monitored and must perform within 10% of the cost and schedule performance baselines, established at Critical Decision 2, Approve Performance Baseline, and which are reproduced in the construction project data sheet.

The new facilities that are currently under construction—the National Synchrotron Light Source-II (NSLS-II) and the Linac Coherent Light Source-II (LCLS-II)—will provide state-of-the-art scientific user facilities for the Nation's research community in a cost effective way. NSLS-II will allow scientists to probe the fundamental properties of matter with nanometer-scale resolution and atomic sensitivity paving the way to new scientific discoveries and innovations. LCLS-II will provide an increase in user capacity to LCLS, which offers unprecedented ultrafast coherent x-ray pulses for probing the dynamics of complex structures and their functions, and will also provide new scientific capabilities in both the hard and soft x-ray regimes.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Linac Coherent Light Source-II (LCLS-II)	0	95,000	+95,000
Funding requested for continuation of engineering design and procurements. LCLS-II begins civil and conventional construction activities.			
National Synchrotron Light Source-II (NSLS-II)	151,400	26,300	-125,100
Funding requested for the civil construction will be ramped down, as scheduled.			
Total, Construction	151,400	121,300	-30,100

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Capital equipment over $500,000, including major items of equipment (MIEs)	77,093	—	69,510
General plant projects (GPP) (under $10 million)	3,202	—	600
Accelerator improvement projects (AIP)	13,400	—	16,500
Total, Capital Operating Expenses	93,695	—	86,610

Capital Equipment over $500,000 (including MIEs)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Spallation Neutron Source Instrumentation-II, ORNL (TEC/TPC)	60,000	48,500	11,500	—	0
Advanced Photon Source Upgrade (APS-U), ANL (TEC/TPC)	388,500	0	20,000	—	39,200
Linac Coherent Light Source-II (LCLS-II), SLAC (TEC/TPC)		0	30,000	—	0[a]
NSLS-II Experimental Tools (NEXT), BNL (TEC/TPC)	90,000	0	12,000	—	25,000
Total, Major Items of Equipment (TEC/TPC)			73,500	—	64,200
Other capital equipment projects under $2 million TEC			3,593	—	5,310
Total, Capital equipment			77,093	—	69,510

[a] LCLS-II is requested as a line item construction project in FY 2014.

General Plant Projects (GPP) (TEC under $10 million)

	(dollars in thousands)				
	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Ames Sensitive Instrument Facility	9,900	1,500	952[a]	—	0
Combustion Research Facility	9,500	4,000[b]	1,700	—	0
Other general plant projects under $5 million TEC	n/a	n/a	550	—	600
Total, General Plant Projects			3,202	—	600

Accelerator Improvement Projects (AIP)

	(dollars in thousands)				
	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
LBNL Accelerator Controls	7,600	3,800	1,900	—	0
ORNL SNS Cryogenic Test Facility	5,609	3,452	2,157	—	0
Other accelerator improvement projects under $5 million TEC	n/a	n/a	9,343	—	16,500
Total, AIP			13,400	—	16,500

[a] An additional $3,048,000 of unobligated carryover was provided for this project in FY 2012.

[b] Funds in the amount of $2,550,000 were provided by the Energy Efficiency and Renewable program and Sandia National Laboratories.

Construction Projects Summary

Construction Projects

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
13-SC-10, Linac Coherent Light Source-II (LCLS-II), SLAC					
TEC	385,000	0	0	—	95,000
OPC	20,000	10,600	0	—	700
TPC	405,000[a]	10,600	0[b]	—[c]	95,700
07-SC-06, National Synchrotron Light Source-II, BNL					
TEC	791,200	566,297	151,400	152,327	26,300
OPC	120,800	61,300	7,700	7,747	27,400
TPC	912,000	627,597	159,100	160,074[d]	53,700
Total, Construction					
TEC			151,400	152,327	121,300
OPC			7,700	7,747	28,100
TPC			159,100	160,074	149,400

Construction Project Outyears

(dollars in thousands)

	FY 2015	FY 2016	FY 2017	FY 2018	Outyears to Completion
13-SC-10, Linac Coherent Light Source-II (LCLS-II), SLAC					
TEC	122,500	100,500	0	0	0
OPC	0	700	0	0	0
TPC	122,500	101,200	0	0	0

[a] This project is pre-CD-2; the funding estimate is preliminary.

[b] LCLS-II received $30,000,000 in FY 2012 as an MIE. This funding is included within the total TPC ($22,000,000 as TEC and $8,000,000 as OPC).

[c] FY 2013 funding was requested as a line item, but due to a Continuing Resolution the project is continuing as an MIE. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $63,500,000 for TEC and TPC and $0 for OPC are assumed instead.

[d] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and outyear appropriation assumptions have not been adjusted to reflect this FY 2013 level; the FY 2013 Request level of $47,203,000 for TEC, $24,400,000 for OPC, and $71,603,000 for TPC is assumed.

Other Supporting Information

Funding Summary

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	676,522	—	763,276
Scientific User Facilities Operations	732,793	—	831,990
Major Items of Equipment	73,500	—	64,200
Construction Projects (includes OPC)	159,100	—	149,400
Other	2,852	—	53,545
Total, Basic Energy Sciences	1,644,767	1,698,424	1,862,411

Scientific User Facility Operations

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Synchrotron Radiation Light Source User Facilities			
Advanced Light Source, LBNL	63,200	—	63,700
Advanced Photon Source, ANL	123,265	—	130,000
National Synchrotron Light Source, BNL	36,000	—	35,000
National Synchrotron Light Source-II, BNL	0	—	69,000
Stanford Synchrotron Radiation Lightsource, SLAC	34,647	—	38,500
Linac Coherent Light Source (LCLS), SLAC	123,900	—	127,800
Total, Light Sources User Facilities	381,012	—	464,000
High-Flux Neutron Source User Facilities		—	
Spallation Neutron Source, ORNL	180,500	—	190,500
High Flux Isotope Reactor, ORNL	58,000	—	61,175
Lujan Neutron Scattering Center, LANL	10,500	—	9,815
Total, Neutron Source User Facilities	249,000	—	261,490

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Nanoscale Science Research Center User Facilities			
Center for Nanoscale Materials, ANL	20,500	—	21,300
Center for Functional Nanomaterials, BNL	20,000	—	21,300
Molecular Foundry, LBNL	20,500	—	21,300
Center for Nanophase Materials Sciences, ORNL	20,781	—	21,300
Center for Integrated Nanotechnologies, SNL/LANL	21,000	—	21,300
Total, Nanoscale Science Research Center User Facilities	102,781	—	106,500
Total, Scientific User Facility Operations	732,793	—	831,990

Facilities Users and Hours

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Advanced Light Source			
Achieved operating hours	5,359	—	N/A
Planned operating hours	4,800	—	5,300
Optimal hours	5,600	—	5,300[a]
Percent of optimal hours	96%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	1,995	—	2,050
Advanced Photon Source			
Achieved operating hours	4,969	—	N/A
Planned operating hours	5,000	—	5,000
Optimal hours	5,000	—	5,000
Percent of optimal hours	99%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	4,360	—	4,400

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
National Synchrotron Light Source			
Achieved operating hours	5,446	—	N/A
Planned operating hours	4,800	—	4,500
Optimal hours	5,400	—	4,500[a]
Percent of optimal hours	101%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	2,453	—	1,500
Stanford Synchrotron Radiation Lightsource			
Achieved operating hours	5,162	—	N/A
Planned operating hours	5,200	—	5,400
Optimal hours	5,400	—	5,400
Percent of optimal hours	96%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	1,597	—	1,500
Linac Coherent Light Source			
Achieved operating hours	4,098	—	N/A
Planned operating hours	4,300	—	3,000
Optimal hours	4,500	—	3,000[a]
Percent of optimal hours	91%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	571	—	350
High Flux Isotope Reactor			
Achieved operating hours	3,609	—	N/A
Planned operating hours	3,500	—	3,500
Optimal hours	4,500	—	3,500[b]
Percent of optimal hours	80%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	442	—	450

[a] The optimal hours for LCLS will be adjusted from 4,500 to 3,000 hours in FY 2014 due to planned activities relating to LCLS-II.

[b] The optimal hours for HFIR are adjusted from 4,500 to 3,500 hours in FY 2014 as the facility undergoes scheduled maintenance activities requiring shutdown.

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Lujan Neutron Scattering Center			
Achieved operating hours	2,241	—	N/A
Planned operating hours	3,000	—	2,000
Optimal hours	3,600	—	2,000[a]
Percent of optimal hours	62%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	249	—	250
Spallation Neutron Source			
Achieved operating hours	4,726	—	N/A
Planned operating hours	4,500	—	4,500
Optimal hours	4,900	—	4,500
Percent of optimal hours	96%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	799	—	850
Center for Nanoscale Materials[b]			
Number of users	444	—	400
Center for Functional Nanomaterials[b]			
Number of users	446	—	400
Molecular Foundry[b]			
Number of users	434	—	400
Center for Nanophase Materials Sciences[b]			
Number of users	409	—	400
Center for Integrated Nanotechnologies[b]			
Number of users	356	—	400
Total, All Facilities			
Achieved operating hours	35,610	—	N/A
Planned operating hours	35,100	—	34,200
Optimal hours	38,900	—	34,200
Percent of optimal hours (funding weighted)	94%	—	100%
Unscheduled downtime percentage	<10%	—	<10%
Number of users	14,555	—	13,350

[a] The optimal hours for Lujan are adjusted from 3,000 to 2,000 hours in FY 2014 due to major upgrades of the accelerators components to improve machine reliability.

[b] Facility operating hours are not measured at user facilities that do not rely on one central machine.

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	1,050	—	1,120
Average size per year	230,000	—	230,000
Number of permanent Ph.D.'s (FTEs)	4,640	—	5,170
Number of postdoctoral associates (FTEs)	1,300	—	1,440
Number of graduate students (FTEs)	2,050	—	2,270

13-SC-10, Linac Coherent Light Source-II
SLAC National Accelerator Laboratory, Menlo Park, California
Project Data Sheet is for PED/Construction

1. Summary and Significant Changes

The most recent DOE O 413.3B approved Critical Decision, CD-3A (Approve Long Lead Procurement (LLP) Baseline and Start of LLP), was approved on March 14, 2012. The preliminary Total Project Cost (TPC) range for this project is $350,000,000–$500,000,000. CD-0 (Approve Mission Need) was approved on April 22, 2010 and CD-1 (Approve Alternative Selection and Cost Range) was approved on October 14, 2011.

A Federal Project Director has been assigned to this project and is certified to level III.

This is an update of the FY 2013 PDS. FY 2013 funding was requested as a line item, but due to the Continuing Resolution, the project is continuing as an MIE in FY 2013. The preliminary TPC Range is unchanged.

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	PED Complete	CD-2	CD-3A	CD-3B	CD-4	D&D Start	D&D Complete
FY 2013	4/22/2010	10/14/2011	4Q FY 2016[a]	1Q FY 2013[a]	3/14/2012[a]	3Q FY 2013[a]	4Q FY 2019[a]	N/A	N/A
FY 2014	4/22/2010	10/14/2011	4Q FY 2016[a]	4Q FY 2013[a]	3/14/2012[a]	4Q FY 2013[a]	4Q FY 2019[a]	N/A	N/A

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3A – Approve Long-Lead Procurements
CD-3B – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, D&D	OPC, Total	TPC
FY 2013	18,000	367,000	385,000	20,000	0	20,000	405,000
FY 2014	18,000[b]	367,000[b]	385,000[b]	20,000[b]	0	20,000[b]	405,000[c]

[a] This project is pre-CD-2; the estimated schedule is preliminary. Construction will not be executed without appropriate CD approvals.
[b] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.
[c] The project was included in the FY 2012 Congressional Request as an MIE with a CD-0 cost range of $300,000,000–$400,000,000.

4. Project Description, Scope and Justification

Mission Need

The LCLS-II project's purpose is to expand the x-ray spectral operating range and the user capacity of the existing Linac Coherent Light Source (LCLS) facility by extending performance into spectral regions not addressed by LCLS. The spectral range expansion will enable researchers to tackle new research frontiers that require even shorter or longer x-ray wavelengths; the capacity increase is critically needed as the demand for LCLS capabilities far exceeds the available time allocation to users. Collectively, the project will enable groundbreaking research in a wide range of scientific disciplines in chemical, material and biological sciences.

Scope and Justification for 13-SC-10 Linac Coherent Light Source II

LCLS is based on the existing SLAC linac. The linac was designed to accelerate electrons and positrons to 50 GeV for colliding beam experiments and for nuclear and high energy physics experiments on fixed targets. At present, the last third of the 3 kilometer linac is being used to operate the LCLS facility, and the first 2 kilometers are used for advanced accelerator research. When the LCLS-II is complete, the second kilometer of the linac will be used to produce high-brightness (13.5 GeV) electron bunches at a 120 hertz repetition rate. These electron bunches will be sent to a new undulator tunnel to produce two x-ray beams. The new soft x-ray (SXR) and hard x-ray (HXR) beams will span the tunable photon energy range beyond the existing LCLS facility. The new LCLS-II facilities will largely operate independently of the existing LCLS facility. When traveling through one of the new LCLS-II undulators, the electron bunches will amplify the emitted x-ray radiation to produce an intense, coherent (laser-like) x-ray beam for scientific research. At the completion of the LCLS-II project, the LCLS facilities will operate two independent electron linacs and three independent x-ray sources, supporting up to ten experiment stations.

LCLS used technologies developed at SLAC over many years of operation, as well as the world's brightest source of intense electron beams, producing extraordinary x-rays. SLAC's advances in the creation, compression, transport, and monitoring of bright electron beams have spawned a new generation of x-ray synchrotron radiation sources based on linear accelerators rather than on storage rings.

The LCLS produces a high-brightness x-ray beam with properties vastly exceeding those of current x-ray sources in three key areas: peak brightness, coherence, and ultrashort pulses. The peak brightness of the LCLS is 10 billion times greater than current synchrotrons, providing 10^{11} x-ray photons in a pulse with duration in the range 3–500 femtoseconds. These characteristics of the LCLS have opened new realms of research in the chemical, material, and biological sciences.

The LCLS-II project will construct a new 135 MeV injector to be installed at Sector 10 of the SLAC linac to create the electron beam required for an x-ray free-electron laser. This electron beam will be extracted from the linac near Sector 20, just upstream of the existing LCLS injector. The new electron beam will be transported in sectors 21–30 of the linac in a "bypass line," originally built for the PEP-II facility. Sectors 11–20 of the linac will be modified by adding two magnetic bunch compressors and the magnets guiding the electrons from the linac to the bypass line. Most of the existing linac and its infrastructure will remain unchanged.

The existing LCLS Beam Transport Hall will be expanded and extended to connect to the new undulator hall. This new hall will house the new SXR and HXR sources, electron beam dumps, and x-ray optics. The new Experimental Hall will be constructed for the exploitation of the new x-ray sources.

The combined characteristics (spectral content, peak power, pulse duration, and coherence) of the new SXR and HXR sources will surpass the present capabilities of the LCLS beam in spectral tuning range and brightness. Experience with LCLS has, for the first time, provided data on performance of the x-ray instrumentation and optics required for scientific experiments with the LCLS. The LCLS-II project will take advantage of this knowledge base to design LCLS-II x-ray transport, optics, and diagnostics matched to the characteristics of these sources. The LCLS-II project scope includes a comprehensive suite of instrumentation for characterization of the x-ray sources. Also included in the scope of the LCLS-II project are basic instrumentation and infrastructure necessary to support research at the LCLS facility.

Funding for conceptual design in FY 2011 supported the creation of a facility concept which has been reviewed and approved by DOE. The project initiated engineering design and long lead procurements in FY 2012. FY 2014 funding will continue design, additional site preparation, and begin construction and fabrication of technical equipment.

Key Performance Parameters

The key performance parameters the LCLS-II project must fulfill to achieve CD-4 Project Completion are listed below. These parameters are the minimum acceptable level of performance to mark the end of the project phase and do not represent the final or ultimate performance to be achieved by the project. It is anticipated that during operations following the project completion that most of the technical parameters below will be exceeded. These parameters are preliminary, pre-baseline values. The final key parameters will be established as part of CD-2 Performance Baseline.

Preliminary Key Parameters	Performance
Electron Beam Energy	12.0 GeV
Photon Beam Tuning Range	800–8,000 eV
Additional Space for Instruments	4 Experiment Stations
Facilities Gross Square Feet	>30,000 GSF

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
PED			
FY 2012	2,000[a]	2,000	2,000
FY 2013	—[b]	—	—
FY 2014	4,000	4,000	3,000
FY 2015	4,000	4,000	3,000
FY 2016	3,000	3,000	3,000
FY 2017	0	0	1,500
FY 2018	0	0	500
Total, PED	18,000[c]	18,000[c]	18,000[c]

[a] FY 2012 funding was requested as an MIE. FY 2012 funding was used for design and long lead procurement.

[b] The PED total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $5,000,000 for PED is assumed instead.

[c] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

(dollars in thousands)

	Appropriations	Obligations	Costs
Construction			
FY 2012	20,000[a]	20,000	13,862
FY 2013	—[b]	—	—
FY 2014	91,000	91,000	75,200
FY 2015	100,000	100,000	91,400
FY 2016	97,500	97,500	90,800
FY 2017	0	0	32,150
FY 2018	0	0	4,700
FY 2019	0	0	838
Total, Construction	367,000[c]	367,000[c]	367,000[c]
TEC			
FY 2012	22,000[a]	22,000	15,862
FY 2013	—[b]	—	—
FY 2014	95,000	95,000	78,200
FY 2015	104,000	104,000	94,400
FY 2016	100,500	100,500	93,800
FY 2017	0	0	33,650
FY 2018	0	0	5,200
FY 2019	0	0	838
Total, TEC[c]	385,000[c]	385,000[c]	385,000[c]

[a] FY 2012 funding was requested as an MIE. FY 2012 funding was used for design and long lead procurement.

[b] The construction and TEC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $58,500,000 for construction and $63,500,000 for TEC is assumed instead.

[c] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

(dollars in thousands)

	Appropriations	Obligations	Costs
Other Project Cost (OPC)			
OPC except D&D			
FY 2010	1,126	1,126	938
FY 2011	9,474	9,474	8,033
FY 2012	8,000[a]	8,000	8,893
FY 2013	—[b]	—	—
FY 2014	700	700	500
FY 2015	0	0	450
FY 2016	700	700	500
FY 2017	0	0	536
Total, OPC	20,000[c]	20,000[c]	20,000[c]
Total Project Cost (TPC)			
FY 2010	1,126	1,126	938
FY 2011	9,474	9,474	8,033
FY 2012	30,000[a]	30,000	24,755
FY 2013	—[b]	—	—
FY 2014	95,700	95,700	78,700
FY 2015	104,000	104,000	94,850
FY 2016	101,200	101,200	94,300
FY 2017	0	0	34,186
FY 2018	0	0	5,200
FY 2019	0	0	838
Total, TPC[c]	405,000[c]	405,000[c]	405,000[c]

[a] FY 2012 funding was requested as an MIE. FY 2012 funding was used for design and long lead procurement.

[b] The OPC and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $0 for OPC and $63,500,000 for TPC are assumed instead.

[c] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
PED			
Design	16,500	14,500	N/A
Contingency	1,500	3,500	N/A
Total, PED	18,000[a]	18,000[a]	N/A
Construction			
Site Preparation	4,700	2,000	N/A
Equipment	189,370	188,752	N/A
Other Construction	95,243	86,048	N/A
Contingency	77,687	90,200	N/A
Total, Construction	367,000[a]	367,000[a]	N/A
Total, TEC	385,000[a]	385,000[a]	N/A
Contingency, TEC	79,187	93,700	N/A
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Planning	1,126	1,126	N/A
Conceptual Design	14,974	11,974	N/A
Research and Development	1,100	1,100	N/A
Start-Up	1,920	1,200	N/A
Contingency	880	4,600	N/A
Total, OPC	20,000[a]	20,000[a]	N/A
Contingency, OPC	880	4,600	N/A
Total, TPC	405,000[a]	405,000[a]	N/A
Total, Contingency	80,067	98,300	N/A

[a] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

7. Schedule of Appropriations Requests

Request Year		(dollars in thousands) Prior Years	FY 2012	FY 2013	FY 2014	FY 2015	FY2016	FY2017	Total
FY2012 (MIE)	TEC	0	22,000	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	10,600	8,000	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	10,600	30,000	TBD	TBD	TBD	TBD	TBD	TBD
FY2013	TEC	0	22,000	63,500	80,300	94,000	105,300	19,900	385,000
	OPC	10,600	8,000	0	700	0	700	0	20,000
	TPC	10,600	30,000	63,500	81,000	94,000	106,000	19,900	405,000
FY2014	TEC	0	22,000	—	95,000	104,000	100,500	0	385,000
	OPC	10,600	8,000	—	700	0	700	0	20,000
	TPC	10,600	30,000	—[a]	95,700	104,000	101,200	0	405,000[b]

8. Related Operations and Maintenance Funding Requirements

Not applicable. Project does not have CD-2 approval.

9. Required D&D Information

Area of New Construction: The LCLS-II project will construct new facilities (on-grade enclosures, tunnels, experimental hall and service building) ranging from 30,000 to 59,000 sf.

Area of Existing Facility(s) being replaced and D&D'ed by this Project: N/A

Area of additional D&D space to meet the "one-for-one" requirement from the banked area: All new construction has been offset by existing SLAC and DOE banked space.

10. Acquisition Approach

DOE has determined that the LCLS-II project will be acquired by the SLAC National Accelerator Laboratory under the existing DOE M&O contract.

A Conceptual Design Report for the project was completed and reviewed. Key design activities were specified for the undulator to reduce schedule risk to the project and expedite the startup. Also, the project management systems put in place and tested during the first LCLS Project have been updated and are now maintained as a SLAC-wide resource. Lawrence Berkeley National Laboratory (LBNL) is an institutional partner to SLAC in the LCLS-II Project, with responsibility for design and construction of the necessary high-performance variable gap undulators.

Technical systems design (injector, linac, bunch compressors, transport lines through the undulators) are heavily based on designs from LCLS. Cost estimates for these systems are based on actual costs from LCLS. The availability of reliable, recent cost data has been exploited fully in planning and budgeting for the LCLS-II Project. Design of the technical systems will be

[a] FY 2013 funding was requested as a line item, but due to a Continuing Resolution the project is continuing as an MIE. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $63,500,000 for TEC and TPC and $0 for OPC are assumed instead.

[b] This project has not yet received CD-2 approval; funding estimates are preliminary. The preliminary TPC range for this project is $350,000,000–$500,000,000.

completed by SLAC or LBNL staff. Technical equipment will either be fabricated in-house or subcontracted to vendors with the necessary capabilities.

The conventional construction design, including the tunnels for the undulator and experimental facilities, are heavily based on the designs used successfully in the original LCLS Project. The conventional construction design is subcontracted to an experienced Architect/Engineering firm to perform Title I and II design. An experienced General Contractor will be hired to carry out conventional facilities construction.

All subcontracts will be competitively bid and awarded based on best value to the government. Project performance metrics for SLAC are included in the M&O contractor's annual performance evaluation and measurement plan.

Lessons learned in the LCLS Project are documented in its project completion report and will be exploited fully in planning and executing LCLS-II.

07-SC-06, National Synchrotron Light Source II (NSLS-II)
Brookhaven National Laboratory, Upton, New York
Project Data Sheet is for PED/Construction

1. Summary and Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-3, Start of Construction, which was approved on January 9, 2009, with a Total Project Cost (TPC) of $912,000,000 and a planned CD-4 of June, 2015.

The Federal Project Director is certified at level 4.

This PDS is an update of the FY 2013 PDS.

To support a targeted early project finish, the funding profile has changed from FY 2013 PDS. The change is to move $5,000,000 in Other Project Costs (OPC) from FY 2015 into FY 2014. This will allow optimum project performance in the final year of construction.

The approximate square footage of new construction space was changed from 400,000 to 600,000 square feet to recognize approved baseline changes to authorize widening of the experimental floor and the addition of two Laboratory Office Buildings (LOBs).

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Performance Baseline Validation	(PED Complete)	CD-2	CD-3	CD-4
FY 2007	08/25/2005	1Q FY 2007	N/A	4Q FY 2008	TBD	TBD	TBD
FY 2008	08/25/2005	2Q FY 2007	N/A	2Q FY 2009	TBD	TBD	TBD
FY 2009	08/25/2005	07/12/2007	12/11/2007	2Q FY 2009	2Q FY 2008	2Q FY 2009	3Q FY 2015
FY 2010	08/25/2005	07/12/2007	12/11/2007	2Q FY 2009	01/18/2008	01/09/2009	3Q FY 2015
FY 2011	08/25/2005	07/12/2007	12/11/2007	4Q FY 2010	01/18/2008	01/09/2009	3Q FY 2015
FY 2012	08/25/2005	07/12/2007	12/11/2007	4Q FY 2011	01/18/2008	01/09/2009	3Q FY 2015
FY 2013	08/25/2005	07/12/2007	12/11/2007	09/30/2011	01/18/2008	01/09/2009	3Q FY 2015
FY 2014	08/25/2005	07/12/2007	12/11/2007	09/30/2011	01/18/2008	01/09/2009	3Q FY 2015

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3 – Approved Start of Construction
CD-4 – Approve Project Completion
D&D Start – Start of Demolition & Decontamination (D&D) work, not applicable to this project
D&D Complete – Completion of D&D work, not applicable to this project

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC Except D&D	OPC D&D	OPC, Total	TPC
FY 2007	75,000	TBD	TBD	TBD	TBD	TBD	TBD
FY 2008	75,000	TBD	TBD	TBD	TBD	TBD	TBD
FY 2009	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2010	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2011	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2012	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2013	60,000	731,200	791,200	120,800	0	120,800	912,000
FY 2014	60,000	731,200	791,200	120,800	0	120,800	912,000

4. Project Description, Scope, and Justification

Mission Need

Major advances in energy technologies will require scientific breakthroughs in developing new materials with advanced properties. A broad discussion is given in several recent reports, including the Basic Energy Sciences (BES) Advisory Committee reports entitled *Opportunities for Catalysis in the 21st Century*, *Basic Research Needs to Assure a Secure Energy Future*, *Basic Research Needs for the Hydrogen Economy*, and *Basic Research Needs for Solar Energy Utilization*, in addition to the Nanoscale Science, Engineering, and Technology Subcommittee of the National Science and Technology Committee report entitled *Nanoscience Research for Energy Needs*.

Collectively, these reports underscore the need to develop new tools that will allow the characterization of the atomic and electronic structure, the chemical composition, and the magnetic properties of materials with nanoscale resolution. Non-destructive tools are needed to image and characterize structures and interfaces below the surface, and these tools must operate in a wide range of temperature and harsh environments. The 1999 BES report *Nanoscale Science, Engineering, and Technology Research Directions* identified the absence of any tool possessing these combined capabilities as a key barrier to progress.

In order to fill this capability gap, the Office of Science determined that its mission requires a synchrotron light source that will enable the study of material properties and functions, particularly materials at the nanoscale, at a level of detail and precision never before possible. Only x-ray methods have the potential of satisfying all of these requirements, but advances both in x-ray optics and in x-ray brightness and flux are required to achieve a spatial resolution of 1 nm and an energy resolution of 0.1 meV. Ultimately, the ring is expected to operate a stored electron beam current of 500 mA at 3.0 GeV.

Scope and Justification for 07-SC-06 National Synchrotron Light Source II

An alternatives analysis found no existing light sources in the U.S. could fulfill the requirements identified above. There are no alternative tools with a spatial resolution of 1 nm and energy resolution of 0.1 meV that also have the required capabilities of being non-destructive and able to image and characterize buried structures and interfaces in a wide range of temperatures and harsh environments. In the case of NSLS-I, it was found that it would be impossible to upgrade this light source due to numerous technical difficulties, including accelerator physics and infrastructure constraints, such as its small circumference, which limit the feasible in-place upgrade options. The decision was made to design and build a new synchrotron facility.

The National Synchrotron Light Source II (NSLS-II) will be a new synchrotron light source, highly optimized to deliver ultra-high brightness and flux and exceptional beam stability. It will also provide advanced insertion devices, optics, detectors, robotics, and an initial suite of scientific instruments. Together, these will enable the study of material properties and functions with a spatial resolution of about 1 nm, an energy resolution of about 0.1 meV, and the ultra-high sensitivity required to perform spectroscopy on a single molecule.

The NSLS-II project will design, build, and install the accelerator hardware, experimental apparatus, civil construction, and central facilities including offices and laboratories required to produce a new synchrotron light source. It includes a third generation storage ring, full energy injector, experimental areas, an initial suite of scientific instruments, and appropriate support equipment, all housed in a new building.

Key Performance Parameters

Key Parameters	Performance
Accelerator Facilities:	
Electron Energy	3.0 GeV
Stored Current	25 mA
Conventional Facilities: Building Area	>340,000 GSF
Experimental Facilities: Beamlines installed and ready for commissioning with X-ray beam	6

The key performance parameters are defined in the project execution plan. The NSLS-II project is expected to deliver an electron energy of 3.0 GeV with a stored current of 25 milliamps; build a third generation storage ring of approximately one half mile in circumference and experimental and operations facilities with a total conventional construction of approximately 600 thousand gross square feet, and include an initial suite of six beamlines ready for commissioning with x-ray beam. These are the minimum performance requirements to achieve CD-4.

Current Status

As of December 2012, the project is 84.90% complete. The cumulative cost and schedule performance indices are 0.99 and 0.95 respectively, both well within the BES performance goal of 0.90 to 1.10. Conventional construction activities continue to wind down as the contractors work through the remaining punchlist items and demobilize. All five Lab-Office Buildings (LOBs) have been completed. The installation and commissioning of the Linac has been completed. The installation of the booster, storage ring magnet-girders, and transfer lines is nearly complete. A total of 142 of 150 storage ring magnet girders have been installed. Storage ring magnet production is complete. A number of design reviews for major beamline component contracts were conducted and hutch fabrication and installation continues.

During FY 2013 the project will continue with the fabrication/procurement of remaining components for accelerator systems, experimental systems and the infrastructure. Installation of accelerator and experimental systems will continue, along with system post installation testing. Commissioning of the accelerator systems follows installation. The Booster commissioning is expected to begin in 4Q FY2013. The target date for storage ring commissioning is 1Q FY 2014. Fully commissioned systems will be transitioned to operations and supported by early operation funds (off project).

During FY 2014 the project will focus on the startup and commissioning of the storage ring and remaining accelerator systems, completion of the project beamlines and the transition to operations in anticipation of an early finish. The target early finish date remains June 2014 with CD-4 in June 2015.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Total Estimated Cost (TEC)				
PED				
FY 2007	3,000	3,000	0	2,292
FY 2008	29,727	29,727	0	28,205
FY 2009	27,273	27,273	0	23,044
FY 2010	0	0	0	6,173
FY 2011	0	0	0	286
Total, PED	60,000	60,000	0	60,000
Construction				
FY 2009	66,000	66,000	0	24,092
FY 2009 Recovery Act	150,000	150,000	14,751	0
FY 2010	139,000	139,000	67,424	84,826
FY 2011	151,297	151,297	42,322	162,091
FY 2012	151,400	151,400	22,391	150,597
FY 2013	152,327[a]	47,203	3,112	104,499
FY 2014	26,300	26,300	0	46,831
FY 2015	0	0	0	8,264
Total, Construction	731,200	731,200	150,000	581,200

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC total is based on the FY 2013 Request level of $47,203,000 instead.

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
TEC				
FY 2007	3,000	3,000	0	2,292
FY 2008	29,727	29,727	0	28,205
FY 2009	93,273	93,273	0	47,136
FY 2009 Recovery Act	150,000	150,000	14,751	0
FY 2010	139,000	139,000	67,424	90,999
FY 2011	151,297	151,297	42,322	162,377
FY 2012	151,400	151,400	22,391	150,597
FY 2013	152,327[a]	47,203	3,112	104,499
FY 2014	26,300	26,300	0	46,831
FY 2015	0	0	0	8,264
Total, TEC	791,200	791,200	150,000	641,200
Other Project Cost (OPC)				
OPC except D&D				
FY 2005	1,000	1,000	0	0
FY 2006	4,800	4,800	0	4,958
FY 2007	22,000	22,000	0	20,461
FY 2008	20,000	20,000	0	15,508
FY 2009	10,000	10,000	0	7,101
FY 2010	2,000	2,000	0	5,852
FY 2011	1,500	1,500	0	4,575
FY 2012	7,700	7,700	0	6,705
FY 2013	7,747[b]	24,400	0	24,965
FY 2014	27,400	27,400	0	29,251
FY 2015	0	0	0	1,424
Total, OPC	120,800	120,800	0	120,800

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC total is based on the FY 2013 Request level of $47,203,000 instead.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The OPC total is based on the FY 2013 Request level of $24,400,000 instead.

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Total Project Cost (TPC)				
FY 2005	1,000	1,000	0	0
FY 2006	4,800	4,800	0	4,958
FY 2007	25,000	25,000	0	22,753
FY 2008	49,727	49,727	0	43,713
FY 2009	103,273	103,273	0	54,237
FY 2009 Recovery Act	150,000	150,000	14,751	0
FY 2010	141,000	141,000	67,424	96,851
FY 2011	152,797	152,797	42,322	166,952
FY 2012	159,100	159,100	22,391	157,302
FY 2013	160,074[a]	71,603	3,112	129,464
FY 2014	53,700	53,700	0	76,082
FY 2015	0	0	0	9,688
Total, TPC	912,000	912,000	150,000	762,000

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
PED			
Design	60,000	60,000	49,000
Contingency	0	0	11,000
Total, PED	60,000	60,000	60,000

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TPC total is based on the FY 2013 Request level of $71,603,000 instead.

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction			
Site Preparation	9,243	9,243	9,243
Equipment	31,579	31,579	31,579
Other Construction	628,551	618,003	518,381
Contingency	61,827	72,375	171,997
Total, Construction	731,200	731,200	731,200
Total, TEC	791,200	791,200	791,200
Contingency, TEC	61,827	72,375	182,997
Other Project Cost (OPC)			
Conceptual Planning	24,800	24,800	24,800
Research and Development	35,800	35,800	35,800
Start-Up	51,601	50,200	50,200
Contingency	8,599	10,000	10,000
Total, OPC	120,800	120,800	120,800
Contingency, OPC	8,599	10,000	10,000
Total, TPC	912,000	912,000	912,000
Total, Contingency	70,426	82,375	192,997

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2009 Recovery Act	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2007[a]	TEC	75,000	0	0	0	0	0	0	0	0	75,000
	OPC	46,000	0	0	0	0	0	0	0	0	46,000
	TPC	121,000	0	0	0	0	0	0	0	0	121,000
FY 2008[a]	TEC	65,000	10,000	0	0	0	0	0	0	0	75,000
	OPC	50,800	0	0	0	0	0	0	0	0	50,800
	TPC	115,800	10,000	0	0	0	0	0	0	0	125,800

[a] The FY 2007 and FY 2008 requests were for PED funding only.

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2009 Recovery Act	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2009[a]	TEC	32,727	93,273	0	162,500	252,900	166,100	57,400	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	0	164,500	254,400	173,800	81,800	48,700	5,000	912,000
FY 2010	TEC	32,727	93,273	150,000	139,000	151,600	151,400	46,900	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	150,000	141,000	153,100	159,100	71,300	48,700	5,000	912,000
FY 2011	TEC	32,727	93,273	150,000	139,000	151,600	151,400	46,900	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	150,000	141,000	153,100	159,100	71,300	48,700	5,000	912,000
FY 2012	TEC	32,727	93,273	150,000	139,000	151,600	151,400	46,900	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	150,000	141,000	153,100	159,100	71,300	48,700	5,000	912,000
FY 2013	TEC	32,727	93,273	150,000	139,000	151,297	151,400	47,203	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	24,400	22,400	5,000	120,800
	TPC	80,527	103,273	150,000	141,000	152,797	159,100	71,603	48,700	5,000	912,000
FY 2014	TEC	32,727	93,273	150,000	139,000	151,297	151,400	152,327	26,300	0	791,200
	OPC	47,800	10,000	0	2,000	1,500	7,700	7,747	27,400	0	120,800
	TPC	80,527	103,273	150,000	141,000	152,797	159,100	160,047	53,700	0	912,000

8. Related Operations and Maintenance Funding Requirements

Beneficial occupancy of the experimental floor:	February 2012
Expected useful life (number of years):	25
Expected future start of D&D of this capital asset (fiscal quarter):	N/A

[a] FY 2009 reflects the original validated funding baseline.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC, and TPC totals are based on the FY 2013 Request levels of $47,203,000, $24,400,000, and $71,603,000 instead.

(Related Funding Requirements)

	(dollars in thousands)			
	Annual Costs		Life cycle costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	119,400	119,400	4,470,000	4,470,000
Maintenance	21,100	21,100	789,000	789,000
Total Operations and Maintenance	140,500	140,500	5,259,000	5,259,000

9. Required D&D Information

	Square Feet
Area of new construction:	Approximately 600,000
Area of existing facilities being replaced:	N/A
Area of any additional space that will require D&D to meet the "one-for-one" requirement:	N/A (see below)

The existing facility (NSLS) will be converted to another use. The one-for-one replacement has been met through completed and planned elimination of space at Brookhaven National Laboratory (BNL) along with "banked" space at the Massachusetts Institute of Technology (MIT) in Middleton, MA, and at the East Tennessee Technology Park (ETTP) in Oak Ridge, TN. A waiver from the one-for-one requirement to eliminate excess space at Brookhaven to offset the NSLS-II project was approved by Secretary Bodman on April 20, 2007. The waiver identified approximately 460,000 square feet of banked excess facilities space that was eliminated in FY 2006 at MIT and ETTP. This approved banked excess space, in addition to eliminated space at BNL, exceeds the addition of space by NSLS-II.

10. Acquisition Approach

The acquisition strategy selected relies on the BNL management and operating (M&O) contractor to directly manage the NSLS-II acquisition. The acquisition of large research facilities is within the scope of the DOE contract for the management and operation of BNL.

The design, fabrication, assembly, installation, testing, and commissioning of the NSLS-II project will largely be performed by the BNL NSLS-II scientific and technical staff. Much of the subcontracted work to be performed for NSLS-II consists of hardware fabrication and conventional facilities construction. Each system or component will be procured using fixed price contracts, unless there is a compelling reason to employ another contract type. Best-value competitive procurements will be employed to the maximum extent possible.

Many major procurements are either build-to-print, following BNL/NSLS-II drawings and specifications, or readily available off-the-shelf. Source selection will be carried out in accordance with DOE-approved policies and procedures. Acquisition strategies have been chosen and will continue to obtain the best value based on the assessment of technical and cost risks on a case-by-case basis. For standard, build-to-print fabrications and the purchase of off-the-shelf equipment for routine applications, available purchasing techniques include price competition among technically qualified suppliers and use of competitively awarded blanket purchase agreements are used.

The architect-engineer (A-E) subcontract was placed on a firm-fixed-price basis for the Final (Title II) Design and (Title III) construction support services. The general construction subcontract was also placed on a firm-fixed-price basis. The design specifications are detailed and allow prospective constructors to formulate firm-fixed-price offers without excessive contingency and allowances.

NSLS-II project management has identified major procurements that represent significant complexity or cost and schedule risk. Advance procurement plans (APPs) have been prepared for each major procurement. The APPs include discussion of contract type, special contracting methods, special clauses or deviations required, and lease or purchase decisions. These final APPs will identify critical procurement activities and help to mitigate or avoid schedule conflicts and other procurement-related problems. At appropriate dollar levels, the APPs are approved by the responsible Division Director, the NSLS-II Procurement Manager, the NSLS-II Deputy Director, the NSLS-II Project Director and the DOE Site Office.

Project performance metrics for BNL are included in the M&O contractor's annual performance evaluation and measurement plan.

Biological and Environmental Research
Funding Profile by Subprogram and Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Biological Systems Science			
Genomic Science			
Foundational Genomics Research	63,632	—	76,341
Genomics Analysis and Validation	10,000	—	10,000
Metabolic Synthesis and Conversion	19,122	—	19,462
Computational Biosciences	16,395	—	16,395
Bioenergy Research Centers	75,000	—	75,000
Total, Genomic Science	184,149	—	197,198
Mesoscale to Molecules	0	—	9,680
Radiological Sciences			
Radiochemistry and Imaging Instrumentation	19,410	—	11,400
Radiobiology	15,528	—	7,898
Total, Radiological Sciences	34,938	—	19,298
Biological Systems Facilities and Infrastructure			
Structural Biology Infrastructure	14,895	—	14,895
Joint Genome Institute	68,500	—	69,800
Total, Biological Systems Facilities and Infrastructure	83,395	—	84,695
SBIR/STTR	0	—	10,195
Total, Biological Systems Science	302,482	—	321,066
Climate and Environmental Sciences			
Atmospheric System Research	26,278	—	26,392
Environmental System Science			
Terrestrial Ecosystem Science	40,193	—	45,001
Subsurface Biogeochemical Research	27,404	—	27,380
Total, Environmental System Science	67,597	—	72,381
Climate and Earth System Modeling			
Regional and Global Climate Modeling	28,345	—	28,159
Earth System Modeling	35,336	—	35,569
Integrated Assessment	9,958	—	9,853
Total, Climate and Earth System Modeling	73,639	—	73,581

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Climate and Environmental Facilities and Infrastructure			
Atmospheric Radiation Measurement Climate Research Facility	67,908	—	71,199
Environmental Molecular Sciences Laboratory	50,324	—	46,671
Data Management	3,205	—	3,496
General Purpose Equipment (GPE)	300	—	500
General Plant Projects (GPP)	700	—	500
Total, Climate and Environmental Facilities and Infrastructure	122,437	—	122,366
SBIR/STTR	0	—	9,561
Total, Climate and Environmental Sciences	289,951	—	304,281
Total, Biological and Environmental Research[a]	592,433	613,287	625,347

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the “congressional control” level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $15,092,000 and STTR $2,032,000 (transferred out of BER in FY 2012 Current column)
- FY 2014 Request: SBIR $17,287,000 and STTR $2,469,000

Public Law Authorizations

Public Law 95-91, “Department of Energy Organization Act”, 1977
Public Law 102-468, “Energy Policy Act of 1992”
Public Law 109-58, “Energy Policy Act of 2005”
Public Law 110-69, “America COMPETES Act of 2007”
Public Law 111-358, “America COMPETES Reauthorization Act of 2010”

Overview

The Biological and Environmental Research (BER) program supports fundamental research and scientific user facilities to address diverse and critical global challenges. The program seeks to understand how genomic information is translated to functional capabilities, enabling more confident redesign of microbes and plants for sustainable biofuels production, improved carbon storage, or contaminant bioremediation. BER research advances understanding of the roles of the earth’s biogeochemical systems (the atmosphere, land, oceans, sea ice, and subsurface) in determining climate so we can predict climate decades or centuries into the future, information needed to plan for future energy and resource needs.

BER research uncovers nature’s secrets from the diversity of microbes and plants to understand how biological systems work, how they interact with each other, and how they can be manipulated to harness their processes and products. By starting with the potential encoded by organisms’ genomes, BER scientists seek to define the principles that guide the translation of the genetic code into functional proteins and the metabolic/regulatory networks underlying the systems biology of plants and microbes as they respond to and modify their environments.

BER plays a unique and vital role in supporting research on atmospheric processes, climate change modeling, interactions between ecosystems and greenhouse gases (especially carbon dioxide [CO_2]), and analysis of impacts and interdependencies of climatic change with energy production and use. BER contributes toward understanding the earth’s radiant energy balance associated with clouds, aerosols, and atmospheric greenhouse gases, the three factors contributing the most uncertainty in global climate change models. BER also supports research to understand the impacts of climatic change—warmer temperatures, changes in precipitation, increased levels of greenhouse gases, changing distributions of weather extremes—on different ecosystems such as forests, grasslands, and farmland. Finally, BER research seeks understanding of the critical role that biogeochemical processes play in controlling the cycling and mobility of materials in the earth's subsurface and across key surface-subsurface interfaces in the environment.

BER's scientific impact has been transformative. Efforts to map the human genome, primarily the U.S. supported international Human Genome Project, which DOE formally began in 1990, initiated the era of modern biotechnology and genomics-based systems biology. Today, with its Genomic Sciences Program and the DOE Joint Genome Institute (JGI), BER researchers are using the powerful tools of plant and microbial systems biology to pursue fundamental breakthroughs needed to develop cost-effective cellulosic biofuels. Our three DOE Bioenergy Research Centers lead the world in fundamental biofuels relevant research.

Since the 1950s, BER has been a critical contributor to climate science research in the U.S., beginning with atmospheric circulation studies that were the forerunners of modern climate models. Today, BER research contributes to the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impact of clouds and aerosols—through support of the Atmospheric Radiation Measurement Climate Research Facility (ARM), which is used by hundreds of scientists worldwide. BER has been a pioneer of ecological and environmental studies in terrestrial ecosystems. BER's Environmental Molecular Sciences Laboratory (EMSL) provides powerful suites of instruments and computers to characterize biological organisms and molecules.

Basic and Applied R&D Coordination

BER research underpins the needs of DOE's energy and environmental missions. Basic research on microbes and plants provides fundamental understanding that can be used to develop new bioenergy crops and improved biofuel production processes that are cost effective and sustainable. This research is relevant to other agencies, including DOE's Office of Energy Efficiency and Renewable Energy and the U.S. Department of Agriculture. Coordination with other federal agencies on priority science needs occurs through the Biomass Research and Development Board, a congressionally mandated interagency group created by the Biomass Research and Development Act of 2000, as amended by the Energy Policy Act of 2005, and under the Office of Science and Technology Policy.

BER research to understand and predict future changes in the Earth's climate system provides important tools that link climate predictions to evaluations of new energy policies and help guide the design criteria for next generation energy infrastructures. BER research on the transport and transformation of energy-related substances in subsurface environments provides understanding that can enable DOE's Office of Environmental Management (EM) to develop new strategies for the remediation of weapons-related and other contaminants at DOE sites. DOE program managers have established formal technical coordination working groups that meet on a regular basis to discuss R&D programs with wide applications for basic and applied programs, including the Office of Environmental Management. In general, BER coordinates with DOE's applied technology programs through regular joint program manager meetings, by participating in their internal program reviews, by participating in joint principal investigator meetings, and by conducting joint technical workshops. In FY 2014, SC and EM will also implement new platforms for coordination such as workshops and formal technical coordination working groups, which have been used to effectively improve coordination between basic research and applied programs in DOE.

Program Accomplishments and Milestones

Advancing the science needed for next-generation biofuels. The DOE Bioenergy Research Center (BRC) researchers have developed new approaches for engineering non-food plant biomass that can be more easily and efficiently digested for conversion into biofuels. These include increasing easily-digestible starch levels in the candidate biofuels crop switchgrass and discovering new lignin subunits within plant biomass that could be future engineering targets to make it easier to process into liquid fuel. They have also identified specific genes that enable biofuel-producing microorganisms to cope with toxic and inhibitory chemical components produced during biomass pretreatment processes, avoiding the expense of removing residual toxic chemicals from pretreated biomass.

Genome-based studies to address global carbon cycling processes. Researchers at the DOE Joint Genome Institute recently discovered novel groups of methane-producing microbes in climate-sensitive environments such as Arctic permafrost by directly sequencing genomes from soil samples. Understanding genome-encoded metabolic properties of environmental microbes underpins the development of detailed metabolic models of key organisms involved in globally significant carbon cycling. These models enable a more predictive understanding of how microorganisms impact global carbon flux.

Observations, new data, and science teams advance climate predictions. A team of national laboratory scientists collected new observations to produce a sophisticated aerosol microphysical model that more accurately resolves aerosol sizes and mixing states, and implemented these into the Community Earth System Model. A second team of national laboratory, university, and private research scientists used the Environmental Molecular Sciences Laboratory (EMSL) to show that secondary organic aerosols have much longer lifetimes than previously predicted. A third team of academic scientists advanced a submodel that combines photosynthetic activity with atmospheric solar radiation availability. National laboratory researchers used this collective set of achievements to demonstrate that the improved atmospheric and ecology components of the Community Earth System Model lead to improved confidence in climate predictions.

Atmospheric Radiation Measurement (ARM) facility advances both cloud modeling and NASA satellite capabilities. A research team involving scientists from DOE and NASA laboratories participated in a joint DOE-NASA experiment conducted in 2012 at the Oklahoma ARM site. The ARM facility's three dimensional, high resolution observations represent the only data set that combines a long time series with sequences of severe and extreme thunderstorms impacting the central U.S. Early results are extending capabilities of the Community Earth System Model to accurately represent extreme events (e.g., heat waves, droughts, and storms), and the same data extended the range of applicability of NASA satellite sensors to map two-dimensional global aerosol and cloud fields.

Milestone	Date
All Systems Biology Knowledgebase infrastructure is installed and operational, with initial full public release to enable key scientific objectives in plant and microbial research: integration of data to reconstruct and predict metabolic and gene expression regulatory networks for up to 1,000 microbes and integration of phenotypic and experimental data for bioenergy plants to predict manipulation of biomass properties. (Genomic Science)	2nd Qtr, FY 2013
Use new climate model simulations to quantify the interactions between clouds and climate changes. (Climate and Earth System Modeling)	4th Qtr, FY 2013
The average achieved operation time of the BER scientific user facilities as a percentage of the total scheduled annual operating time is greater than 98%. (Supporting Information/ Facilities Users and Hours)	4th Qtr, FY 2013

Program Planning and Management

BER uses broad input from scientific workshops[a] and external reviews, including those performed by the National Academies, to identify current and future scientific and technical needs and challenges in current national and international research efforts, as well as for program evaluation, consistent with the President's management agenda.[b] BER also receives advice from the Biological and Environmental Research Advisory Committee (BERAC) on the management of its research programs (through Committee of Visitors [COV] reviews), on the direction and focus of its research programs, and on strategies for long-term planning and development of its research activities.

In FY 2011, BERAC issued a report on an overall strategy to inform a long-term vision for BER. A key emphasis of the report was the identification of the greatest scientific challenges in biological, climate, and environmental systems science that BER should address in the long-term (20-year horizon) and how BER should be positioned to

[a] BER scientific workshop reports are available at http://science.energy.gov/ber/news-and-resources.
[b] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

address those challenges; the continued or new fields of BER-relevant science that DOE will need to pursue to achieve its future mission challenges; and the future scientific and technical advances needed to underpin BER's complex systems science. The report, "Grand Challenges for Biological and Environmental Research: A Long-Term Vision"[a] identified grand challenges in complex systems and synthetic biology, climate modeling and climate-related ecosystem science, energy sustainability, computing, and training and workforce development. In 2013, BERAC prepared a companion strategy report, "BER Virtual Laboratory: Innovative Framework for Biological and Environmental Grand Challenges" to inform the technology and facilities priorities to meet an ambitious long-term vision for BER research.

BER supports research at universities, research institutes, private companies, and DOE national laboratories. All BER-supported research undergoes regular peer review and merit evaluation based on procedures established in 10 CFR 605 for the external grant program and using a similar process for research at the national laboratories. BERAC conducts COV reviews of the merit evaluation conducted by BER subprograms every three years. Results of these reviews and BER responses are posted online.[a] The Climate and Environmental Sciences Division will undergo a COV review in FY 2013. A COV will be assembled in 2014 to review the Biological System Science Division.

Every three years, BER also conducts consolidated onsite merit, operational, management, and safety reviews of each of its user facilities. Results of these reviews are used to address management, scientific, operational, and safety deficiencies. The BER program is coordinated with activities of over 14 other federal organizations supporting or conducting complementary research. BER Climate Change Research is coordinated with the U.S. Global Change Research Program (USGCRP), an interagency program codified by Public Law 101–606 and involving other federal agencies and departments.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

Research: Increase our understanding of and enable predictive control of phenomena in complex biological, climatic, and environmental systems sciences.

Facility Operations: Maximize the reliability, dependability, and availability of the SC scientific biological, climatic, and environmental user facilities.

Future Facilities: Build future and upgrade existing facilities and experimental capabilities to ensure the continuing value of the SC scientific user facilities. All construction projects and MIEs are within 10% of their specified cost and schedule baselines.

Scientific Workforce: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers.

[a] http://science.energy.gov/ber/berac/reports/

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Scientific Workforce
Biological Systems Science	72%	28%	0%	0%
Climate and Environmental Sciences	60%	40%	0%	0%
Total, Biological and Environmental Research	66%	34%	0%	0%

Performance Measures

Performance Goal (Measure)	**BER Climate Model**—Develop a coupled climate model with fully interactive carbon and sulfur cycles, as well as dynamic vegetation to enable simulations of aerosol effects, carbon chemistry, and carbon sequestration by the land surface and oceans and the interactions between the carbon cycle and climate		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	Demonstrate coupled climate models at 20-kilometer resolution	Use new climate model simulations to quantify interactions between clouds and climate changes	Use global models to estimate most sensitive elements of terrestrial carbon to climate change for tropics, mid-latitudes, and polar regions
Result	Met		
Endpoint Target	BER supports the Community Earth System Model, a leading U.S. climate model, and addresses two of the most critical areas of uncertainty in contemporary climate science—the impact of clouds and aerosols. Delivery of improved scientific data and models (with quantified uncertainties) about the potential response of the Earth atmosphere system to more accurately predict the Earth's future climate is essential to plan for future energy needs, water resources, and land use. DOE will continue to advance the science necessary to further develop predictive climate and earth system models at the regional spatial scale and decadal to centennial time scales, involving close coordination with the U.S. Global Change Research Program and through the international science community.		

Performance Goal (Measure)	**BER Facility Operations**—Average achieved operation time of BER user facilities as a percentage of total scheduled annual operation time		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 98%	≥ 98%	≥ 98%
Result	Met		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.

Explanation of Funding and Program Changes

Biological and Environmental Research will support key core research areas and scientific user facilities in bioenergy, climate, and environmental research. Increased investments target the development of biosystems design tools and the development of integrative analysis of experimental datasets to examine cross-scale (mesoscale to molecular) relationships among biological processes. Core research in foundational genomics, including the DOE Bioenergy Research Centers, will provide the fundamental biological system science to underpin advances in bioenergy production, carbon cycling in the environment and bioremediation processes. While overall funding for radiological sciences is decreased as funding for activities on human nuclear medicine is completed and radiation studies shift toward linking laboratory-based research with epidemiological research on low dose radiation effects, targeted investments will be made in specific radiological sciences activities to develop radiotracer imaging techniques for bioenergy and environmental processes, and epidemiological research on low dose radiation effects in large populations.

Climate and Environmental Research activities will conduct preliminary scientific analysis of the sensitivity and uncertainty of climate predictions to examine climate sensitive geographies not represented by the Next Generation Ecosystem Experiment (NGEE) Arctic and Tropics studies. New observations of clouds, aerosols, and sensitive ecosystems will address uncertainty in climate models. There will be reduced investment in running climate projections that support global and regional climate assessments as the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR 5) will be completed in FY 2013. Terrestrial Ecosystem research will increase to characterize the complex interdependent processes and interrelationships between climate change and tropical ecosystems.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Biological Systems Science	302,482	321,066	+18,584

Investment in Foundation Genomics increases in the development of biosystems design tools and biodesign technologies and integrative analysis of experimental genomic science datasets to examine cross-scale relationships among biological processes. New activities exploit the powerful tools of the physical sciences to facilitate understanding of organisms from the molecular to mesoscale cellular organization. While overall funding for Radiological sciences research decreases, activities will enhance development of radiotracer imaging techniques for bioenergy and environmental processes, and efforts to link laboratory-based research with epidemiological studies on low dose radiation effects in large populations.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Climate and Environmental Sciences	289,951	304,281	+14,330
BER observational efforts to describe the interrelationships between climate change in Arctic, midlatitude, and tropical ecosystems will deliver new data and more sophisticated multi-scale parameterizations in order to advance earth system models. Modeling efforts will emphasize the interdependencies involving global scale dynamics and higher resolution scale interactions for regions that are of primary interest to both the scientific community and stakeholders. New observations of clouds, aerosols, and sensitive ecosystems will address uncertainty in climate models.			
Total, Biological and Environmental Research	592,433	625,347	+32,914

Biological Systems Science
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Genomic Science			
Foundational Genomics Research	63,632	—	76,341
Genomics Analysis and Validation	10,000	—	10,000
Metabolic Synthesis and Conversion	19,122	—	19,462
Computational Biosciences	16,395	—	16,395
Bioenergy Research Centers	75,000	—	75,000
Total, Genomic Science	184,149	—	197,198
Mesoscale to Molecules	0	—	9,680
Radiological Sciences			
Radiochemistry and Imaging Instrumentation	19,410	—	11,400
Radiobiology	15,528	—	7,898
Total, Radiological Sciences	34,938	—	19,298
Biological Systems Facilities and Infrastructure			
Structural Biology Infrastructure	14,895	—	14,895
Joint Genome Institute	68,500	—	69,800
Total, Biological Systems Facilities and Infrastructure	83,395	—	84,695
SBIR/STTR	0	—	10,195
Total, Biological Systems Science[a]	302,482	—	321,066

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $8,070,000 and STTR $1,087,000 (transferred out of BER in FY 2012 Current column)
- FY 2014 Request: SBIR $8,921,000 and STTR $1,274,000

Overview

Biological Systems Science is unique in the U.S. science enterprise in integrating discovery- and hypothesis-driven science with technology development on plant and microbial systems relevant to DOE bioenergy mission needs. Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multicellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on utilizing systems biology approaches to define the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms.

Key questions that drive these studies include:

- What information is encoded in the genome sequence?
- How is information exchanged between different subcellular constituents?

- What molecular interactions regulate the response of living systems and how can those interactions be understood dynamically and predictively?

The subprogram builds upon a successful track record in defining and tackling bold, complex scientific problems in genomics—problems that required the development of large tools and infrastructure; strong collaboration with the computer sciences community and the mobilization of multidisciplinary teams focused on plant and microbial bioenergy research. The approaches employed include genome sequencing, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, and integration of information into computational models that can be iteratively tested and validated to advance a predictive understanding of biological systems from molecules to mesoscale.

The subprogram supports operation of a scientific user facility, the DOE Joint Genome Institute (JGI), and use of structural biology facilities through the development of instrumentation at DOE's national user facilities. Support is also provided for research at the interface of the biological and physical sciences and instrumentation for radiochemistry to develop new methods for real-time, high-resolution imaging of dynamic biological processes.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Genomic Science	184,149	197,198	+13,049
Genomic Science research remains a priority activity, with Foundational Genomics Research increasing for the development of biosystems design tools and biodesign technologies for plant and microbial systems relevant to bioenergy production, carbon and nutrient cycling, and environmental change. Targeted research in Metabolic Synthesis and Conversion on cellulosic ethanol and biohydrogen continues to be de-emphasized. Genomic Analysis and Validation continues. The DOE Bioenergy Research Centers will conduct research on advanced renewable biofuels. Computational Biosciences will advance the Systems Biology Knowledgebase tools and integrative analyses of plant and microbial functional genomics experimental datasets.			
Mesoscale to Molecules	0	9,680	+9,680
The properties of many complex systems at one observational scale cannot be extrapolated accurately from processes at another scale because the nature of the scaling relationships is unknown. New funding is provided for integrated experimental and computational approaches to investigate the scaling properties of processes occurring from the molecular to the mesoscale and multicellular organization. Identifying scaling relationships allows accurate representation of functional relationships within the cell, facilitating improved predictions of multicellular interactions and biological organism behavior with respect to energy and the environment			

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Radiological Sciences	34,938	19,298	-15,640
Radionuclide imaging research for real-time visualization of dynamic biological processes in energy and environmentally-relevant contexts continues, while concluding training activities in nuclear medicine research. Further decreases in radiobiology reflect a shift towards bioenergy and environmental research within the Biological Systems Science portfolio. Ongoing efforts in radiobiology emphasize a systems biology approach to understanding the subtle effects of low dose radiation on cell processes and epidemiological studies to evaluate statistically significant effects of low dose radiation exposure in large populations.			
Biological Systems Facilities and Infrastructure	83,395	84,695	+1,300
Funding will support large-scale, complex genome sequencing and analysis at the Joint Genome Institute, with increasing emphasis on understanding comparative or community-scale plant and microbial genomics. Support continues for the development of instrumentation at SC's synchrotron light sources, neutron sources, and next-generation user facilities for analyzing biological structure-function relationships. Increases will support refreshment of equipment at the Joint Genome Institute.			
SBIR/STTR	0	10,195	+10,195
In FY 2012, $8,070,000 and $1,087,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.2% in FY 2014.			
Total, Biological Systems Science	302,482	321,066	+18,584

Genomic Science

Overview

The Genomic Science activity supports research aimed at identifying the fundamental principles that drive biological systems relevant to DOE missions in energy, climate, and the environment. These principles guide the translation of the genetic code into functional proteins and the metabolic/regulatory networks underlying the systems biology of plants, microbes, and communities. Advancing fundamental knowledge of these systems will enable new solutions to national challenges in sustainable bioenergy production, understanding the fate and transport of materials such as nutrients and contaminants in the environment, and developing new approaches to examine the role of biological systems in carbon cycling, biosequestration, and global climate.

The major objectives of the Genomic Science activity are to determine the molecular mechanisms, regulatory elements, and integrated networks needed to understand genome-scale functional properties of microbes, plants, and communities; develop "-omics" experimental capabilities and enabling technologies needed to achieve a dynamic, system-level understanding of organism and community functions; and develop the knowledgebase, computational infrastructure, and modeling capabilities to advance predictive understanding, manipulation and design of biological systems. Research efforts in biosystems design, including environmental, ethical, legal, and societal impacts, are coordinated across the Federal Government.

The Systems Biology Knowledgebase is designed to be an integrated experimental framework for accessing, comparing, analyzing, modeling, and testing large scale Genomic Science data. The team-based multi-institutional DOE Bioenergy Research Centers focus on innovative research to achieve the basic science breakthroughs needed to develop sustainable and effective methods of producing cellulosic biofuels.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Supported core research activities in plant and microbial systems-level functional genomics and for the three Bioenergy Research Centers, including the development of new synthetic toolkits and testbeds to facilitate biosystems design engineering applications in bioenergy production, environmental remediation, and carbon cycling. This new activity was informed by the 2011 Biosystems Design Workshop report.[a] Computational Biosciences further developed a Systems Biology Knowledgebase to integrate microbial community genomic, proteomic, and transcriptomic experimental data sets from research conducted at the DOE Bioenergy Research Centers, the Joint Genome Institute, and the Genomic Science supported activities.	184,149

[a] http://science.energy.gov/ber/news-and-resources/

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $188,149,000 for investment in the development of biosystems design tools, biodesign technologies, and integrative analysis of experimental genomic science datasets. The resulting new molecular-level insight into the design, function, and regulation of plants, microbes, and biological communities contributes to cost-effective production of next generation biofuels as a major secure national energy resource. Support continues for core research activities in plant and microbial systems-level functional genomics and networks, with completion of Metabolic Synthesis and Conversion targeted research on cellulosic ethanol and biohydrogen. The three DOE Bioenergy Research Centers begin a renewal funding period in FY 2013, continuing research on advanced biofuels. Computational Biosciences supports the Systems Biology Knowledgebase effort to develop predictive simulation efforts in microbial community interactions. The first phase of the knowledgebase effort becomes fully operational in FY 2013 with the integration of plant and microbial experimental and genomic sequencing datasets.	—
FY 2014	Increased investment will advance core research areas in Foundational Genomics Research with emphasis on continued development of biosystems design tools and biodesign technologies for bioenergy research, integrative analysis of large experimental genomic science datasets, and efforts to gain a predictive understanding of carbon cycling in the environment. The research portfolio will stress the integration of genome science with experiment and computational modeling to advance a predictive understanding of the design, function and regulation of plants, microbes, and biological communities contributing to the cost-effective production of next generation biofuels as a major secure national energy resource. At least 5% of the funding for biodesign efforts will be used to study the environmental, ethical, legal, and societal impacts. Support will provide for core research activities in plant and microbial systems-level functional genomics and networks, with completion of Metabolic Synthesis and Conversion targeted research on cellulosic ethanol and biohydrogen. Research efforts at the Bioenergy Research Centers will advance biofuels development from foundational biological systems science. Computational Biosciences will advance the Systems Biology Knowledgebase effort to develop predictive simulation efforts in plant and microbial community interactions.	197,198

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Foundational Genomics Research	63,632	—	76,341
Genomics Analysis and Validation	10,000	—	10,000
Metabolic Synthesis and Conversion	19,122	—	19,462
Computational Biosciences	16,395	—	16,395
Bioenergy Research Centers	75,000	—	75,000
Total, Genomic Science	184,149	—	197,198

Mesoscale to Molecules

Overview

BER approaches to systems biology have focused on the rich terrain between genotype and phenotype—from the genome up through the mechanisms that power living cells, communities of cells, and whole organisms. But there is also a need to explore the terrain between the mesoscale structures within living cells and the molecular effects in biological macromolecules. The Mesoscale to Molecules activity will encourage joint efforts between systems biologists and physical scientists and engineers, to focus on fostering interdisciplinary approaches and leveraging tools and resources at the national scientific user facilities to solve DOE mission needs in energy and environment.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	There is no funding for this activity in FY 2012.	0
FY 2013	There is no funding for this activity in FY 2013.	0
FY 2014	Research is initiated to understand the genomic and physical rules that govern the formation and architecture of subcellular organelles in biological systems. The relationship between composition and function will be explored, leveraging imaging tools and resources at the national scientific user facilities.	9,680

Radiological Sciences

Overview

Radiological Sciences supports radionuclide synthesis and imaging research for real-time visualization of dynamic biological processes in energy and environmentally relevant contexts. The activity has significantly transitioned from its historical focus on nuclear medicine research and applications for health to focus on real-time, whole organism understanding of metabolic and signaling pathways in plants and nonmedical microbes. Radionuclide imaging continues to be a singular tool for studying living organisms in a manner that is quantitative, three dimensional, temporally dynamic, and non-perturbative of the natural biochemical processes. The instrumentation research focuses on improved metabolic imaging in the living systems, including plants and microbial-communities, relevant to biofuels production and bioremediation of interest to DOE. The activity also supports fundamental research on integrated gene function and response of biological organisms to low dose radiation exposure, through systems genetics analysis in model systems and epidemiological studies. This activity contributes a scientific foundation for informed decisions regarding remediation of contaminated DOE sites and for determining acceptable levels of human health protection, for both cleanup workers and the public, in the most cost-effective manner.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Core research activities in radiotracer synthetic chemistry and complementary imaging instrumentation continued. Additional activity included nuclear medicine research with human application and research to help determine health risks from exposures to low levels of ionizing radiation, as well as studies of health impacts at and around the Fukushima Daiichi nuclear plant as directed by Congress (in the FY 2012 Energy and Water Development Appropriations conference report [H. Rpt. 112-331]). Research is completed for integrated training in radiotracer synthetic methodology and in vivo imaging and detection relevant to nuclear medicine applications.	34,938
FY 2013	The FY 2013 Request proposed $28,160,000 to continue core research activities in radiotracer synthetic chemistry for real-time visualization of dynamic biological processes in the energy and environmentally-relevant contexts. Research is completed for the development of a limited number of systems genetic reference mouse populations. Priority research begins to address integration of mechanism-based models that incorporate both radiobiology and epidemiology.	—
FY 2014	Core research activities will emphasize radiotracer synthetic chemistry for real-time visualization of dynamic biological processes in the energy and environmentally-relevant contexts. Funding is decreased as human nuclear medicine research is transitioned to integrative training opportunities in nuclear medicine. Opportunities to transition nuclear medicine training activities to agencies with a human-health focus mission will continue to be explored. Decreases in radiobiology research reflect an emphasis on bioenergy and environmental missions within the Biological Systems Science portfolio and emphasize a systems biology approach to understanding the effects of low dose radiation on cellular processes and epidemiological studies to uncover statistically significant effects of low dose radiation in large populations.	19,298

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Radiochemistry and Imaging Instrumentation	19,410	—	11,400
Radiobiology	15,528	—	7,898
Total, Radiological Sciences	34,938	—	19,298

Biological Systems Science Facilities and Infrastructure

Overview

Biological Systems Science supports unique scientific facilities and infrastructure related to genomics and structural biology that are widely used by researchers in academia, the national laboratories, and industry. The DOE Joint Genome Institute (JGI) is the only federally funded major genome sequencing center focused on genome discovery and analysis in plants and microbes for energy and environmental applications. High-throughput DNA sequencing underpins modern systems biology research, providing fundamental biological data on organisms and groups of organisms. By understanding shared features of multiple genomes, scientists can identify key genes that may link to biological function. These functions include microbial metabolic pathways and enzymes that are used to generate fuel molecules, affect plant biomass formation, degrade contaminants, or capture CO_2, leading to the optimization of these organisms for biofuels production and other DOE missions.

The JGI is developing aggressive new strategies for complex genome assembly using next-generation sequencing platforms and genomic analysis tools. The JGI also performs metagenome (genomes from multiple organisms) sequencing and analysis from environmental samples and is developing single cell sequencing techniques on hard-to-culture cells from environments relevant to the DOE missions.

BER also supports development and use of specialized instrumentation for biology at major DOE user facilities, such as synchrotron light sources and neutron facilities, in collaboration with the other SC program offices. These research facilities enable science aimed at understanding the structure and properties of biological systems at resolutions and scales not accessible with instrumentation available in university, institute, or industrial laboratories. This information is critical in contributing to our understanding of the relationship between genome, biological structure, and function, leading to practical applications of this knowledge for energy and the environment.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	JGI supported the large-scale genome sequencing data acquisition and analysis needs of the scientific user community and the DOE Bioenergy Research Centers with a greater emphasis on metagenome expression and sequencing of environmental microbial communities and functional analysis and verification of genome-scale models. JGI initiated efforts to transform its capabilities and provide functional genomic interpretations of biological systems in large scale multi-disciplinary environmental and targeted systems biology studies while maintaining operating performance at 98% of scheduled operating time. Support continued for research at established structural biology instrumentation at the synchrotron light sources and neutron facilities, informed by the report of the 2011 workshop on "Applications of new DOE National User Facilities in Biology."[a]	83,395

[a] http://science.energy.gov/ber/news-and-resources/

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $84,082,000 to supports a greater JGI emphasis on functional genomics analysis for plants and microbes combining massive sequencing capability with high performance computing for data management, integration, and analysis in conjunction with BER's Systems Biology Knowledgebase effort. JGI continues to utilize new technologies for higher-throughput genome analysis and integration with other proteomic and metabolomic datasets and develop new high-throughput sample processing to ease pre-sequencing sample preparation bottlenecks to large scale sequencing projects. JGI sequencing capabilities also support biosystems design efforts. Support continues to develop structural biology instrumentation and end stations and new research capabilities at the synchrotron light sources and neutron facilities.	—
FY 2014	JGI will emphasize large scale, complex sequencing of plants and microbial communities in support of fundamental research for DOE bioenergy and environmental missions. JGI will facilitate genome science through its massive sequencing capability coupled with high performance computing for data management, integration, and analysis. JGI activities are closely coordinated with BER's Systems Biology Knowledgebase effort and will seek opportunities to integrate high-throughput technologies that can bring added functional understanding to the genome sequences generated. The priority needs for these technologies are informed by the report from the community workshop, "JGI Strategic Planning for the Genomic Sciences," held in FY 2012. JGI sequencing capabilities also support biosystems design efforts. Support continues to develop new instrumentation and end stations for structural biology and new research capabilities at the Office of Science synchrotron light sources and neutron facilities.	84,695

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Structural Biology Infrastructure	14,895	—	14,895
Joint Genome Institute	68,500	—	69,800
Total, Biological Systems Facilities and Infrastructure	83,395	—	84,695

Climate and Environmental Sciences
Funding Schedule by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Atmospheric System Research	26,278	—	26,392
Environmental System Science			
Terrestrial Ecosystem Science	40,193	—	45,001
Subsurface Biogeochemical Research	27,404	—	27,380
Total, Environmental System Science	67,597	—	72,381
Climate and Earth System Modeling			
Regional and Global Climate Modeling	28,345	—	28,159
Earth System Modeling	35,336	—	35,569
Integrated Assessment	9,958	—	9,853
Total, Climate and Earth System Modeling	73,639	—	73,581
Climate and Environmental Facilities and Infrastructure			
Atmospheric Radiation Measurement Climate Research Facility (ARM)	67,908	—	71,199
Environmental Molecular Sciences Laboratory	50,324	—	46,671
Data Management	3,205	—	3,496
General Purpose Equipment (GPE)	300	—	500
General Plant Projects (GPP)	700	—	500
Total, Climate and Environmental Facilities and Infrastructure	122,437	—	122,366
SBIR/STTR	0	—	9,561
Total, Climate and Environmental Sciences[a]	289,951	—	304,281

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $7,022,000 and STTR $945,000 (transferred out of BER in FY 2012 Current column)
- FY 2014 Request: SBIR $8,366,000 and STTR $1,195,000

Overview

The Climate and Environmental Sciences subprogram supports fundamental science and research capabilities that enable DOE leadership in climate-relevant atmospheric-process and ecosystem research and modeling. This includes research on clouds, aerosols, and the terrestrial carbon cycle; large-scale climate change modeling; experimental research on the effects of climate change on ecosystems; integrated analysis of climate change impacts; and advancing fundamental understanding of coupled physical, chemical, and biological processes controlling contaminant mobility in the environment. This integrated portfolio of research of molecular-level to field-scale studies emphasizes multidisciplinary experimentation and advanced computer models and is aimed at developing predictive, systems-level understanding of the fundamental science associated with climate change. The Department will continue to advance the science necessary to further develop predictive climate and earth system models at the regional spatial scale and decadal to centennial time scales, involving close coordination with the U.S. Global Change Research Program (USGCRP) and the international science community.

The subprogram supports three primary research activities and two national scientific user facilities. The two user facilities are the Atmospheric Radiation Measurements Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL). ARM provides unique, multi-instrumented capabilities for continuous, long-term observations needed to develop and test understanding of the central role of clouds and aerosols on the earth's climate. EMSL provides integrated experimental and computational resources needed to understand the physical, chemical, and biological processes that underlie DOE's energy and environmental mission.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Atmospheric System Research	26,278	26,392	+114
Research will continue to improve formulations for aerosols, clouds, and aerosol-cloud-precipitation interactions in order to improve estimates of how these feedbacks have and will impact climate.			
Environmental System Science	67,597	72,381	+4,784
The activity will support new experimental field activities at the tropics Next-Generation Ecosystem Experiment (NGEE) to study and contribute to predictive models that characterize the relationships between various tropical ecosystems and climate change. Terrestrial modeling activities are integrated into the Climate and Earth System Modeling portfolio to promote stronger model research coordination. Subsurface biogeochemical research continues to focus on environmental research across scales as a continuum of complex interdependent processes, while reducing emphasis on contaminant mobility and on geologic barriers to groundwater contaminant transport.			
Climate and Earth System Modeling	73,639	73,581	-58
Investments continue to evolve climate modeling capabilities using more flexible and adaptive software to support new physics and be compatible with next generation high performance computing assets. Basic research will focus on the science underpinning high-resolution predictability and uncertainty quantification using adaptive grids.			

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Climate and Environmental Facilities and Infrastructure	122,437	122,366	-71
Funding is increased for ARM to support both initiation of long term measurements at Oliktok, AK, and the Azores Islands, and the increased analysis of data collected from those sites; corresponding decreases occur in ARM capital equipment. ARM will support its approximately 1,000 users. EMSL funding for operations increases to support approximately 750 users who will access the facility's suite of instruments for research on biological interaction and dynamics; geochemistry and biogeochemistry of subsurface science; and science of interfacial phenomena. EMSL funding decreases overall as funding for the Mass Spectrometer MIE was completed in FY 2012.			
SBIR/STTR	0	9,561	+9,561
In FY 2012, $7,022,000 and $945,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.2% in FY 2014.			
Total, Climate and Environmental Sciences	289,951	304,281	+14,330

Atmospheric System Research

Overview

Atmospheric System Research (ASR) is the primary U.S. activity addressing the two major areas of uncertainty in climate change model projections: the role of clouds and the effects of aerosols on precipitation and the atmospheric radiation balance. ASR coordinates with the ARM facility, utilizing the facility's continuous long-term datasets that provide three dimensional measurements of radiation, aerosols, clouds, precipitation, dynamics, and thermodynamics over a range of environmental conditions at climatically diverse locations. The long-term observational datasets are supplemented with laboratory studies and shorter-duration ground-based and airborne field campaigns to target specific atmospheric processes under a diversity of locations and atmospheric conditions. ASR research results are incorporated into earth system models developed by Climate and Earth System Modeling to both understand the processes that govern atmospheric components and to advance earth system model capabilities with greater certainty of predictions. Finally, ASR seeks to develop integrated, scalable test-beds that incorporate process-level understanding of the life cycles of aerosols, clouds, and precipitation into dynamic models.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	ASR used data from the new instruments at the ARM sites specifically supporting research on the development of three-dimensional representation of clouds in climate models. Research continued on marine boundary layer clouds, Arctic clouds and their interactions with aerosols, and processes and atmospheric transformations involving biogenic aerosols.	26,278
FY 2013	The FY 2013 Request proposed $26,392,000 for ASR process studies and modeling efforts to emphasize developing improved formulations for aerosols, clouds, and aerosol-cloud interactions in order to improve estimates of how these feedbacks have and will impact the climate. Specific focuses include Arctic and tropical aerosol-cloud-precipitation interactions, and high altitude (cirrus) clouds and their life cycles and impacts on radiation budget.	—
FY 2014	ASR focuses on process studies and modeling efforts that improve formulations of aerosols, mixed phase clouds, and precipitation process interdependencies, in order to improve estimates of feedbacks on climate in mid-latitude, tropical, and Arctic regions. Specific focuses include the description of aerosol-cloud-precipitation interdependences during larger scale dynamical events, such as those that occur in the tropics and mid-latitudes.	26,392

Environmental System Science

Overview

Environmental System Science supports research that provides scientific understanding of the effects of climate change on terrestrial ecosystems, the role of terrestrial ecosystems in global carbon cycling, and the role of subsurface biogeochemical processes determining flow and transport in the subsurface and how the subsurface and above ground environments interact.

A significant fraction of the carbon dioxide (CO_2) released to the atmosphere during fossil fuel combustion is taken up by terrestrial ecosystems, but the impacts of the timing and magnitude of climatic change, particularly warming, on the uptake of CO_2 by the terrestrial biosphere remain poorly understood. The significant sensitivity of climate models to terrestrial carbon cycle feedback and the uncertain signs of that feedback make resolving the role of the terrestrial biosphere on the carbon balance a high priority. The research focuses on understanding, observing, and modeling the processes controlling exchange rates of greenhouse gases, in particular CO_2 and methane (CH_4), between atmosphere and terrestrial biosphere, evaluating terrestrial source-sink mechanisms for CO_2 and CH_4, and improving the representation of terrestrial ecosystems in coupled earth system models.

Subsurface biogeochemical research supports integrated research, ranging from molecular to field scales, to understand and predict the role that biogeochemical processes play in controlling the cycling and mobility of materials in the subsurface and across key surface-subsurface interfaces in the environment, including environmental contamination from past nuclear weapons production.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research focused on potential effects of warming, changes in rainfall, and increasing concentrations of atmospheric CO_2 on terrestrial ecosystems and the terrestrial carbon cycle. A shift in emphasis focused on a new next-generation ecosystem-climate change experiment to predict changes in Arctic permafrost. Research efforts continue to test and evaluate computer models describing subsurface mobility of radionuclides and nutrients. In addition, experimental research at the three Integrated Field Research Challenge (IFRC) sites emphasized sites where there are biological and biogeochemical process controls over heavy metal and radionuclide flow and transport, reducing activities at two of the sites.	67,597
FY 2013	The FY 2013 Request proposed $79,337,000 to support the Arctic Next Generation Ecosystem Experiment (Arctic NGEE) to improve the representation of the major carbon sinks associated with changes in Arctic permafrost ecosystems in earth system and regional climate models. A second NGEE is initiated to address poorly understood ecosystem processes that govern biogenic aerosol emissions to the atmosphere in the tropics. Focusing on one of the most climatically-sensitive tropical regions, the tropics NGEE experiment examines the role of rainfall stress on Amazonian ecosystems and the resulting shifts in released aerosols that serve as cloud condensation nuclei.	—

Fiscal Year	Activity	Funding (dollars in thousands)
	Subsurface Biogeochemical Research continues support to advance the predictive understanding of processes controlling the mobility of radionuclides and nutrients in the environment, including field-based activities at one IFRC site. The focus of the multi-disciplinary field-based investigations retains a focus to advance a science-based general modeling framework, based on a shift to larger system scales as recommended in the 2010 workshop report, "Complex Systems Science for Subsurface Fate and Transport."[a]	
FY 2014	The research will emphasize the Arctic and tropics Next Generation Ecosystem Experiments (NGEE) and AmeriFlux to improve the representation of the major carbon sinks associated with changing climates. Specific tropics NGEE field studies will be conducted based on the recommendations provided during the NGEE Tropics Workshop held in FY 2012. Support for terrestrial modeling activities will be shifted to Climate and Earth System Modeling portfolio, to promote stronger model research coordination and cost efficiencies. In addition, more efficiency will be gained by consolidating investments in terrestrial and subsurface biogeochemistry, nutrient flow, and soil science.	72,381

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Terrestrial Ecosystem Science	40,193	—	45,001
Subsurface Biogeochemical Research	27,404	—	27,380
Total, Environmental System Science	67,597	—	72,381

[a] http://science.energy.gov/ber/news-and-resources/

Climate and Earth System Modeling

Overview

Climate and Earth System Modeling develops physical, chemical, and biological model components, including the interactions of human and natural earth systems, needed to simulate climate variability and change from decades to centuries at regional and global scales. The research specifically focuses on quantifying and reducing the uncertainties in earth system models based on more advanced model development, diagnostics, and climate system analysis. Priority model components include the ocean, sea-ice, land-ice, aerosols, atmospheric chemistry, terrestrial carbon cycling, multi-scale dynamical interdependencies, and dynamical cores.

A unique objective of the BER Climate and Earth System Modeling investments is the study and modeling of both historical and current climate change, with an objective to validate and improve future climate projections based on the prediction successes using existing data testbeds. To rapidly and efficiently advance model capabilities, BER supports a unique and powerful inter-comparison resource, the Program for Climate Model Diagnosis and intercomparison (PCMDI), for global climate model development, validation, diagnostics, and outputs, using all 23 world-leading climate models. This ensures BER can exploit the best available science and practice within each of the world's leading climate research programs.

BER and the National Science Foundation (NSF) support the Community Earth System Model which is designed by the research community with open access and broad use by climate researchers worldwide. This model provides a critical capacity for regional climate projections, including information on how the frequency of occurrence and intensity of storms, droughts, and heat waves will change as climate evolves. Demonstrating the critical linkages between DOE's climate modeling investments, the scientific priorities for improvement of the community model are based on the outputs of the intercomparison and validation resource. DOE has also provided computational power and expertise to the Earth System modeling community, through its internal partnership between BER and the Office of Science's Advanced Scientific Computing Research program, innovating code design for optimal model computation on its petascale computers. Climate modeling tools are essential for informing investment decision-making processes for infrastructures associated with future large-scale deployment of energy supply and transmission.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Model enhancements focused on adding additional representations of processes within the coupled models while improving understanding and representations of complex systems dynamics. For example, ice sheet and ocean models were coupled in the Community Earth System Model to be capable of projecting sea-level rise, and systems dynamics were explored within and among earth system and integrated assessment models. Additional work centered on development of a variable grid coupled climate model, able to produce predictions at 20 km resolution by the 4th quarter of FY 2012. Tools for the dissemination of climate model output in support of the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR 5) were implemented.	73,639

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $78,450,000 for research focusing on the development of an enhanced validation and verification capability to compare models and measurements with common framework and sophisticated software tools. A framework to use ARM measurements to validate the clouds and terrestrial carbon measurements to validate the land model will be included in this toolbox. The toolbox will be used on new climate model simulations to quantify the interactions between clouds and climate changes. Research is increased to enhance resolution of climate models operating on regional scales, and to expand model diagnostics, databases, and intercomparison studies. Funding is provided to augment the data and diagnostic technical and analysis capabilities within the national laboratories so that climate projections are carried out in support of the IPCC AR5 and completed.	—
FY 2014	Research on climate model development and analysis will focus on the science underpinning high-resolution predictability using adaptive grids and uncertainty characterization. Emphasis will also be placed on regional predictions for the Arctic and tropics that map into extended Community Land Model capabilities using data from the NGEE experiments. In addition, understanding dynamical interdependencies that describe larger scale variabilities (such as El Niño) that influence regional climate predictability will be prioritized.	73,581

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Regional and Global Climate Modeling	28,345	—	28,159
Earth System Modeling	35,336	—	35,569
Integrated Assessment	9,958	—	9,853
Total, Climate and Earth System Modeling	73,639	—	73,581

Climate and Environmental Facilities and Infrastructure

Overview

Climate and Environmental Facilities and Infrastructure includes two scientific user facilities, climate data management for the climate science community, and general purpose equipment and plant projects for the Oak Ridge Institute for Science and Education (ORISE). The scientific user facilities—the Atmospheric Radiation Measurement Climate Research Facility (ARM) and the Environmental Molecular Sciences Laboratory (EMSL)—provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate science in areas integral to BER's mission.

ARM is a multi-platform multi-site national scientific user facility, providing the world's most comprehensive continuous field measurements of climate data to promote the advancement of atmospheric process understanding and climate models through precise observations of atmospheric phenomena. ARM currently contains four fixed long-term measurement facility sites (in Oklahoma, Alaska, the Azores, and the western Pacific), three mobile facilities, and an airborne research capability that operates at sites selected by the scientific community. The ARM fixed sites and mobile measurement campaigns are distributed around the world in locations where we most critically need data to incorporate into climate models and improve model performance and predictive capabilities. Each of the ARM sites contains scanning radars, lidar systems, and in situ meteorological observing capabilities; the sites are additionally used to demonstrate technologies as they are developed by the community. ARM experiments to study the impact of evolving clouds, aerosols, and precipitation on the earth's radiative balance and rate of climate change address the two most significant scientific uncertainties in climate research. BER is also maintaining the exponentially increasing data archive to support enhanced analyses and model development. The data extracted from the archive are used to improve climate projections at higher resolution, greater sophistication, and lower uncertainty, all to better specify tipping points associated with permafrost thaw and other patterns of extreme events.

Data sets generated by ARM and other DOE and Federal earth observing activities, as well as from earth system modeling activities, are large. The information in earth observations data can be used to achieve broad benefits ranging from natural disaster impact mitigation to commercial supply chain management to natural resource management. Access to and use of these data are fundamental to supporting decision-making, scientific discovery, and technological innovation. DOE's data management activities will be coordinated with the Big Earth Data Initiative in the President's FY 2014 Budget, which invests in standardizing and optimizing the management of data from Federal earth observations systems. Interagency coordination for this effort will be accomplished through the USGEO Subcommittee of the National Science and Technology Council (NSTC), led by the Office of Science and Technology Policy (OSTP), and in coordination with the USGCRP Observations Working Group. This research will be in collaboration with the Office of Science's Advanced Scientific Computing Research program.

EMSL provides integrated experimental and computational resources for discovery and technological innovation in the environmental molecular sciences. With more than fifty leading-edge instruments, EMSL enables users to undertake molecular-scale experimental and theoretical research on aerosol chemistry, biological systems, biogeochemistry, and interfacial and surface science. EMSL thus provides a unique opportunity to use multiple experimental systems to provide fundamental understanding of the physical, chemical, and biological processes that underlie DOE's energy and environmental mission areas, including alternative energy sources, improved catalysts and materials for industrial applications, insights into factors influencing climate change and carbon sequestration processes, and subsurface biogeochemical drivers at contaminated sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	ARM continued its long-term measurements for users to address key scientific uncertainties with a goal to achieve 98% of scheduled operating time. Mobile facilities supported the India experiment as well an experiment on the Madden Julian Oscillation on Gan Island in the Indian Ocean. Instrumentation was obtained and site preparation was initiated for the mobile facility at Oliktok Point, AK for three dimensional measurements of cloud and aerosol properties over land, sea, and ice and the ARM fixed site in the Azores for observations of marine clouds and aerosols. EMSL supported facility operations that underpin user research to obtain a fundamental understanding of the physical, chemical, and biological processes and a goal to achieve 98% of scheduled operating time. Funding was completed for the High Magnetic Field Mass Spectrometer. Data management activities continue.	122,437
FY 2013	The FY 2013 Request proposed $122,018,000 for ARM support of long-term measurements at fixed and mobile facilities for users to address key scientific uncertainties. The ARM measurements at Oliktok Point, AK and the Azores are fully operational. EMSL supports facility operations that underpin user research to obtain a fundamental understanding of the physical, chemical, and biological processes. The focus is to provide users with enhanced access to new capabilities in molecular beam epitaxy and nano-secondary ion mass spectrometry. Data management activities continue for data-intensive science. The activities advance the use of ARM data to inform and validate the earth system model development.	—
FY 2014	ARM will fully support its long-term measurements at fixed sites, and the mobile facilities will be deployed to three climate-sensitive regions demanding targeted measurements: the Amazon Basin; Oliktok, Alaska; and Finland. These observations are key to reducing the earth system model uncertainties attributed to clouds and aerosols. EMSL will support facility operations that underpin user research to obtain a fundamental understanding of the physical, chemical, and biological processes that map to DOE mission needs. New capabilities of the Radiological Annex, including X-ray photo emission spectrometers, electron microscopy, electron probe microanalyzer, transmission electron microscopy and scanning electron microscopy, come on line in FY 2014 to study contaminated materials, and examine radionuclides and chemical signatures. BER will participate in the Big Earth Data initiative to adapt the ARM data archive and other DOE Earth data sets to specifications aimed at increasing interoperability and consistent with the needs of the scientific community. In addition, ARM will continue to format its databases in order to conform to the needs of the evolving climate modeling community.	122,366

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Atmospheric Radiation Measurement Climate Research Facility	67,908	—	71,199
Environmental Molecular Sciences Laboratory	50,324	—	46,671
Data Management	3,205	—	3,496
General Purpose Equipment (GPE)	300	—	500
General Plant Projects (GPP)	700	—	500
Total, Climate and Environmental Facilities and Infrastructure	122,437	—	122,366

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Capital equipment over $500,000, including major items of equipment (MIEs)	25,134	—	7,467
General plant projects (GPP) (under $10 million)	2,183	—	500
Total, Capital Operating Expenses	27,317	—	7,967

Capital Equipment over $500,000 (including MIEs)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Major items of equipment (TEC over $2 million)					
Atmospheric Radiation Measurement Climate Research Facility (ARM)					
Dual-Frequency Scanning Cloud Radar for Oliktok, Alaska ARM Site (TEC/TPC)	3,500	0	3,500	—	0
Dual-Frequency Scanning Cloud Radar for ARM Azores Climate Activity (TEC/TPC)	3,070	0	3,070	—	0
Environmental Molecular Sciences Laboratory (EMSL)					
Next Generation, High Magnetic Field Mass Spectrometer (TEC/TPC)	17,500	10,250	7,250	—	0
Total, Major items of equipment, TEC/TPC			13,820	—	0
Other capital equipment projects under $2 million TEC			11,314	—	7,467
Total, Capital equipment			25,134	—	7,467

Atmospheric Radiation Measurement Climate Research Facility

Dual-frequency scanning cloud radar for the ARM Arctic Climate activity. This instrument will provide the capability to measure cloud properties in a volume and will provide three-dimensional cloud properties at Oliktok, Alaska: essential data for developing high-resolution climate models.

Dual-frequency scanning cloud radar for the ARM Azores Climate activity. This instrument will provide the capability to measure cloud properties in a volume and will provide three-dimensional cloud properties in the Azores: essential data for developing high-resolution climate models.

Environmental Molecular Sciences Laboratory

Next Generation, High Magnetic Field Mass Spectrometer system is a world-leading system to measure and characterize complex mixtures of intact proteins and other biomolecules, aerosol particles, petroleum, and constituents from other types of fluids. The Total Project Cost (TPC) was reviewed and approved at CD-2/3a, Approve Performance Baseline and Authorization to Award Magnet Procurement Contract, on August 30, 2011. The system will enable world-leading proteomics, metabolomics, and lipidomics with application to bioenergy, as well as provide insights relevant to climate science, fossil fuel processing, and catalysis.

General Plant Projects (GPP) (TEC under $10 million)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Other general plant projects under $5 million TEC	n/a	n/a	2,183	—	500

Other Supporting Information

Funding Summary

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	389,806	—	402,026
Scientific user facilities operations and research	187,807	—	202,565
Major items of equipment	13,820	—	0
Other[a]	1,000	—	20,756
Total, Biological and Environmental Research	592,433	613,287	625,347

Scientific User Facilities Operations and Research

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Biological Systems Science			
Structural Biology Infrastructure	14,895	—	14,895
Joint Genome Institute	68,500	—	69,800
Total, Biological Systems Science	83,395	—	84,695
Climate and Environmental Sciences			
Atmospheric Radiation Measurement Climate Research Facility	67,908	—	71,199
Environmental Molecular Sciences Laboratory	50,324	—	46,671
Total, Climate and Environmental Science	118,232	—	117,870
Total Science user facilities operations and research	201,627	—	202,565

[a] Includes SBIR, STTR, GPE, and non-Facility related GPP.

Facilities Users and Hours

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Joint Genome Institute[a]			
Achieved operating hours	8,544	—	N/A
Scheduled operating hours	8,316	—	8,616
Optimal hours	8,316	—	8,616
Percent of optimal hours	102.7%	—	100.0%
Unscheduled downtime hours	0	—	N/A
Number of users[b]	992	—	940
Atmospheric Radiation Measurement Climate Research Facility (ARM)[c]			
Achieved operating hours	8,198	—	N/A
Scheduled operating hours	7,906	—	7,906
Optimal hours	7,906	—	7,906
Percent of optimal hours	103.7%	—	100.0%
Unscheduled downtime hours	0	—	N/A
Number of users[d]	1,231	—	1,000

[a] JGI scheduled and optimal hours are based on being open 24 hours a day, 7 days a week (less holidays, planned downtime for maintenance, installation of new instrumentation, etc.) Actual hours can differ when maintenance and instrument upgrades, etc. take more or less time than planned.

[b] All JGI users are remote. Primary users are individuals associated with approved projects being conducted at the JGI in a reporting period. Each user is counted once per year regardless of how many proposals their name may be associated with. Additionally, different users reflect vastly differing levels of JGI resources.

[c] ARM scheduled and optimal hours are base on the average over the fixed sites. The hours are estimated based on planned downtime for maintenance, installation of new instrumentation, weather history of each site, etc. Actual hours can differ when maintenance and instrument upgrades, weather related downtime, etc. take more or less time than planned.

[d] ARM users are both onsite and remote. A unique scientific user is defined by the use of an ARM Facility's on-site assets, off-site services, or data services during the defined reporting period. Prior to FY 2013 an ARM user could be counted more than once by using multiple ARM capabilities. This change reduces the FY 2013 ARM user count.

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Environmental Molecular Sciences Laboratory[a]			
Achieved operating hours	4,265	—	N/A
Scheduled operating hours	4,296	—	4,272
Optimal hours	4,296	—	4,272
Percent of optimal hours	99.3%	—	100.0%
Unscheduled downtime hours	31	—	N/A
Number of users[b]	718	—	750
Total Facilities			
Achieved operating hours	21,007	—	NA
Scheduled operating hours	20,518	—	20,794
Optimal hours	20,518	—	20,794
Percent of optimal hours (funding weighted)	102.2%	—	100.0%
Unscheduled downtime hours	31	—	N/A
Number of users	2,941	—	2,690

Structural Biology Infrastructure activities are at Basic Energy Sciences user facilities and the user statistics are included in the BES user statistics.

[a] EMSL scheduled and optimal hours are generalized to 12 hours a day, seven days a week (4,380 hours), less holidays (96 hours), because some capabilities are available 24/7 while others require EMSL staff assistance. Leap years, as well as planned downtime for maintenance, installation of new instrumentation, etc. can also modify the hours available. Actual hours can differ when maintenance, instrument upgrades, etc. take more or less time than planned.

[b] EMSL users are both onsite and remote. Individual users are counted once per year. On-site users are individuals who are physically present using an EMSL capability at least once during the reporting period as part of an active project. Remote users are members of an approved research project team who remotely access and operate EMSL capabilities; reduce, collate or otherwise modify project data; modify open source codes originally developed by EMSL; and send or receive materials/samples. Individual users are counted once per year.

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	470	—	480
Average size per year	$340,000	—	$340,000
Number of laboratory projects	195	—	200
Number of permanent Ph.D.'s[a]	1,500	—	1,515
Number of postdoctoral associates[b]	345	—	350
Number of graduate students[b]	495	—	500
Number of Ph.D.'s awarded[c]	110	—	115

[a] The number of permanent Ph.D.s is estimated. Information is not readily available on the total number of permanent Ph.D. scientists associated with each research project. In addition to the principal investigator for each research project funded by BER, individual projects typically have between 1 and 20 additional Ph.D.-level scientists who are funded collaborators. Information on scientific collaborators is not routinely tracked.

[b] The number of Postdoctoral Associates and graduate students is estimated for national laboratory projects.

[c] The number of Ph.D.s awarded is estimated. Information is not available on the number of Ph.D.s awarded as a result of BER funded research at universities or national laboratories.

Fusion Energy Sciences
Funding Profile by Subprogram and Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Science			
DIII-D Research	30,974	—	28,200
Alcator C-Mod Research	10,595	—	0
International Research	8,325	—	8,300
Diagnostics	3,538	—	3,500
Other	7,950	—	8,312
NSTX Research	16,940	—	17,500
Experimental Plasma Research	10,965	—	10,500
High Energy Density Laboratory Plasmas	25,257	—	6,575
Madison Symmetric Torus	6,000	—	5,700
Theory	24,450	—	20,670
SciDAC	8,310	—	6,875
General Plasma Science	16,706	—	15,000
SBIR/STTR	0	—	6,672
Total, Science	170,010	—	137,804
Facility Operations			
DIII-D	38,715	—	36,960
Alcator C-Mod	18,217	—	0
NSTX	33,959	—	36,300
Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)	1,565	—	900
MIE: U.S. Contributions to ITER Project	105,000	—	225,000
Total, Facility Operations	197,456	—	299,160
Enabling R&D			
Plasma Technology	14,652	—	11,660
Advanced Design	2,611	—	1,400
Materials Research	8,228	—	8,300
Total, Enabling R&D	25,491	—	21,360
Total, Fusion Energy Sciences[a]	392,957	403,450	458,324

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the “congressional control” level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $7,085,000 and STTR $954,000 (transferred out of FES in FY 2012 Current column)
- FY 2014 Request: SBIR $5,838,000 and STTR $834,000

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act," 1977
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

The Fusion Energy Sciences (FES) program mission is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. This is accomplished by studying plasma and its interactions with its surroundings across wide ranges of temperature and density, developing advanced diagnostics to make detailed measurements of its properties and dynamics, and creating theoretical and computational models to resolve essential physics principles.

The pursuit of fusion energy is one of the most challenging programs of scientific research ever undertaken, with manifold potential long-term benefits. Controlled fusion has the potential of delivering base-load power with zero greenhouse gas emissions. Fusion has no possibility of a runaway reaction or meltdown, and any radioactive waste will be low level.

Plasma physics, the science underpinning much of fusion energy research, enables quantitative understanding of a broad class of exotic phenomena observed in the universe. Plasmas—the fourth state of matter—are like gases, but with temperatures high enough that electrons have been knocked free of atomic nuclei through collisions. The Sun is a plasma, and plasma dynamics explain solar flares, galactic jets, and the accretion of material around black holes. Plasma is also the stuff of lightning and flames. Plasma physics describes the processes giving rise to the aurorae that gently illuminate the far northern and southern nighttime skies. Plasma science is central to myriad applications ranging from optimization of processes in the semiconductor industry to development of technologies deployed for national defense and homeland security. Practical applications of plasmas are found in lighting, manufacturing, and televisions. The scientific challenge in all cases is that of understanding, predicting, and mastering the control of plasma dynamics.

The leading approach to fusion being studied is the confinement of hot plasma with a magnetic field. This approach is the primary focus of the research conducted in the FES program, and its science has enabled the entirety of the plasma sciences to flourish. Fusion is routinely created and controlled in our research laboratories; experiments have generated millions of watts of fusion power for seconds at a time. Also, we have demonstrated that the ability to control magnetically confined plasmas for fusion—for example, to modify stability and confinement properties and to tailor the equilibrium shape and the pattern of heat exhausted—is grounded in a deep theoretical understanding. However, researchers have not yet tested their ability to control a plasma that is vigorously undergoing fusion to the point of being in the self-heated, or burning, plasma state, in which the amount of fusion power generated is much higher and the length of time it is continuously generated is considerably longer than presently possible.

A second approach to realizing fusion in the laboratory is to compress the fuel, thereby raising its temperature rapidly, and then to rely on the inertia of the fuel itself to keep it confined long enough for fusion to happen. The plasma science of this inertial fusion energy approach is part of a broader class of science—high energy density laboratory plasma physics—that includes and extends beyond inertial fusion. In the past, High Energy Density Laboratory Plasma (HEDLP) physics has been stewarded in part through a program managed and sponsored jointly by the National Nuclear Security Administration (NNSA) and FES. Here again, the science is that of plasma dynamics and control.

The ITER facility being constructed in Cadarache, France, will help us address the scientific challenges presented by the burning plasma state. ITER will be a powerful tool for scientific discovery. It aims to generate fusion power 30 times the levels produced to date and to exceed the external power applied to the plasma by at least a factor of ten. The U.S. is a partner in this international project, and its design and prospects for success hinge critically on U.S. research, project execution, and industry. Executing a plasma sciences program with well-aligned domestic and international components will sustain U.S. international leadership in fusion energy sciences. The U.S. magnetic fusion research program in experiment, theory, and computation is configured to make strong contributions to ITER's science and to bring a high level of scientific return from it. ITER joins the broader FES research portfolio in elevating plasma sciences for both practical benefit and increased understanding of the natural world.

Other opportunities in fusion science include understanding and developing materials that can tolerate the extreme conditions in a fusion environment, including extracting heat and generating fuel in a fusion system. A fusion plasma will present a uniquely hostile environment to the materials of the system, due to enormous heat fluxes—tens of millions of watts per square meter impinging on a wall—and to a harsh shower of neutrons that will displace constituent atoms and thus potentially change the materials' strength and other characteristics.

Another opportunity resides in leveraging U.S. computational prowess with experimentally validated simulation as a means for reducing fusion's risks in development and as a tool for discovery. The U.S. has led the world in establishing the strong coupling between detailed measurement and theory that is a hallmark of the fusion and plasma science research enterprise. FES supports much of this work through the Scientific Discovery Through Advanced Computing (SciDAC) program, in concert with the Advanced Scientific Computing Research (ASCR) program. FES will continue to nurture this class of research, including the use of targeted experiments to validate theories that underlie simulation codes.

FES also supports discovery plasma science. Fusion's theory-based computational tools have been used to explain the unexpectedly low brightness of the plasma accretion disk surrounding the super massive black hole at the center of our galaxy. Scaled laboratory experiments enable control and manipulation of plasma states that exhibit characteristics of their extraterrestrial cousins, enabling their study. This class of research is also connected to FES-supported research on the fine-scale manipulation of plasmas at low temperature, which can have profound implications for the efficiency of plasma processes that are used in medical, industrial, and consumer applications.

Basic and Applied R&D Coordination

A discovery-driven program is carried out in concert with the National Science Foundation (NSF), with research extending to a wide range of natural phenomena, including the origin of magnetic fields in the universe and the heating of the solar corona. Also, FES operates a joint program with NNSA in HEDLP physics, which includes discovery-driven research that is central to understanding a range of physical systems, from the cores of the giant planets and the interiors of stars to black hole accretion disks. Both programs involve coordination of solicitations, peer reviews, and workshops. The Fusion Energy Sciences Advisory Committee (FESAC) provides technical and programmatic advice to FES and NNSA for the joint HEDLP program.

Program Accomplishments and Milestones

ITER component fabrication begins. Working with Japan and the ITER Organization, the U.S. ITER Project Office found a solution for manufacturing a qualified conductor with which to construct the superconducting central solenoid magnets. Major design elements for U.S. contributions were completed, including that for the central solenoid magnetic systems. U.S. industrial partners began fabrication of superconducting strand materials for the toroidal field conductor.

New tool developed for suppression of plasma instabilities. An Edge Localized Mode (ELM) is a plasma instability in tokamaks causing potentially violent bursts of heat and particles from the hot, confined plasma. Large ELMs can damage interior components of a tokamak, and avoiding and/or controlling them is critical to preserving plasma stability. One method for making ELMs smaller is the injection of small frozen pellets of fusion fuel at the plasma boundary. New pellet injection experiments on the DIII-D tokamak were able to reduce the energy lost per ELM by 90%. The results will contribute to the scientific basis for our in-kind fabrication of such a system for ITER.

Low-temperature plasma science yields advances in medical sterilization. Researchers have demonstrated that plasmas interacting with water can be controlled to create antibacterial compounds, leaving the water a useful disinfectant for up to seven days. The use of plasma-activated water shows potential for improvement over traditional heat and chemical methods for sterilization of medical equipment and wounds. The Centers for Disease Control and Prevention have estimated that 1.7 million healthcare-associated infections occur each year in the U.S., with direct medical costs approaching $45 billion. Improvements in sterilization technologies will have widespread benefits, especially in low resource and disaster-stricken regions.

New experimental capability expands the breadth of possibilities in high energy density plasma research. The Matter in Extreme Conditions (MEC) endstation at the Linac Coherent Light Source (LCLS) at the SLAC National Accelerator Laboratory was completed ahead of schedule and below budget, and is currently undergoing user-assisted commissioning. MEC currently stands at the forefront of x-ray high-energy-density science, combining the unique high-power optical laser beams of LCLS with a suite of dedicated diagnostics for the investigation of high energy density physics, warm dense matter physics, and high pressure regimes. MEC fabrication was funded through the American Recovery and Reinvestment Act (ARRA).

Progress made in understanding the transition of fusion plasmas into states of high confinement efficiency. A fusion reactor's size and cost are driven substantially by the efficiency of the magnetic bottle used to confine the fusion fuel. Fusion plasmas can spontaneously jump into an enhanced confinement state where that efficiency is roughly doubled, but the physics of this transition has been a lasting puzzle. At DIII-D, a new measurement technique produced the first experimental evidence that the interaction of drift waves with zonal flows is central to the transition to the enhanced confinement state. Also, in coordinated studies across the major U.S. devices, researchers made significant progress toward understanding the resultant plasma state and developing predictive capability from this new understanding.

Plasma-material interaction experiments reveal new physics. Deuterium and tritium are fuels for fusion reactions, and research aims to understand the interaction of tritium with plasma confinement vessel wall materials such as beryllium. Researchers measured for the first time the temperature and heating dependence of the capture and release of deuterium (chemically similar to tritium) from solid beryllium in ITER-like conditions. The results are important for designing how to operate ITER reliably within tritium inventory safety margins.

Innovative method to handle high heat exhaust wins a 2012 R&D 100 Award. A critical problem for a tokamak fusion reactor is distributing the heat exhaust of hundreds of megawatts over a sufficiently large area inside the vacuum chamber. A new concept, which uses a snowflake-shape magnetic configuration in the divertor region, has demonstrated at least a fourfold reduction of the power density in experiments on NSTX, DIII-D, and a tokamak in Switzerland.

Milestones	Date
Trim coils designed by PPPL to fine tune the magnetic configuration of the Wendelstein 7-X (W7-X) stellarator in Germany will be completed and delivered to the W7-X site. (International Research)	3rd Qtr, FY 2013
The U.S. ITER Project Office will complete R&D for the ITER roughing pumps and electron cyclotron heating systems, finalize additional procurement arrangements, ship 800 meters of "mock-up" toroidal field conductor to Europe for validation of its coil manufacturing processes, and award the contract for high-voltage transformers for the steady-state electric power network. (U.S. Contributions to ITER Project)	4th Qtr, FY 2013
40% of the fabrication and assembly of the National Spherical Torus Experiment (NSTX) Upgrade will be completed, including the fourth and final inner toroidal field coil quadrant. (NSTX Facility Operations)	4th Qtr, FY 2013
To simulate fusion neutron effects on materials, samples of reduced-activation ferritic (RAF) steel irradiated in the High Flux Isotope Reactor (HFIR) under a U.S.-Japan collaboration will reach 80 displacements per atom. This will provide world-record exposure data for a fusion material and is over half the exposure level expected in a fusion power plant. (Materials Research)	4th Qtr, FY 2013

Milestones	Date
Edge Localized Mode (ELM) instability control techniques that may lead to nearly quiescent conditions on ITER and a reactor will be deployed on the major U.S. facilities and their physics basis assessed by means of a coordinated effort in experiment, theory, and computation. (DIII-D and NSTX Science)	4th Qtr, FY 2013

Program Planning and Management

FES program planning, program evaluation, and priority setting strongly benefit from input and review by outside experts. FES peer review and oversight processes are designed to regularly assess the quality, relevance, and performance of the FES portfolio and are consistent with the President's management agenda.[a]

A hierarchy of sources guides the development of the FES program vision as well as particular programmatic decisions. Studies by the National Research Council (NRC) of the National Academy of Sciences influence the overall FES program vision. Federal advisory committee-based studies are undertaken to identify strategic elements and to further inform particular approaches. The advisory committee studies are supported by community-based activities to identify broad classes of research needs in particular areas.

Leading examples of studies that have shaped the FES approach to program planning at the highest level include the 2004 NRC study, *Burning Plasmas: Bringing a Star to Earth*,[b] which underscored the readiness and opportunities for the U.S. to participate in a magnetically confined burning plasma experiment such as ITER, and *Plasma Science: Advancing Knowledge in the National Interest* (2007),[c] which urged SC to exercise strong federal stewardship of general plasma science which includes and goes beyond fusion energy applications. The National Academies recently issued a report *An Assessment of the Prospects for Inertial Fusion Energy* (2013), which evaluated the prospects for and needs of inertial fusion energy (IFE) science and technology.[d]

Fusion Energy Science Advisory Committee (FESAC) activities that have been particularly informative include a comprehensive analysis of gaps in the world program titled *Priorities, Gaps, and Opportunities: Towards a Long Range Strategic Plan for Magnetic Fusion Energy* (2007). The report highlighted needs for fusion science overall and opportunities for U.S. leadership. This report was followed by a community-wide effort that yielded a Magnetic Fusion Energy Sciences (MFES) Research Needs Workshop (ReNeW) and a report, *Research Needs for Magnetic Fusion Energy Sciences* (2009). The ReNeW report describes a broad palette of scientific research that could be executed in parallel with ITER to develop the scientific and technical basis for fusion energy. In 2012, FESAC issued two reports: *International Collaboration in Fusion Energy Sciences Research: Opportunities and Modes during the ITER Era*, and *Materials Science and Technology Research Opportunities Now and in the ITER Era: A Focused Vision on Compelling Fusion Nuclear Science Challenges*. A strategic plan being developed for research in the fusion energy sciences will be informed by all of the sources described above, as well as a recent FESAC report *Priorities of the Magnetic Fusion Science Program* (2013).

Beyond magnetic fusion, FES sponsored a series of workshops during 2008 and 2009 that focused on providing additional input so as to identify opportunities for general plasma science. The first workshop covered the field of low temperature plasma physics and produced the report entitled *Low Temperature Plasma Science: Not Only the Fourth State of Matter but All of Them* (2008). A workshop of a similar nature to ReNeW was held regarding HEDLP (2009), yielding a report entitled *Basic Research Needs for High Energy Density Laboratory Physics,* published in October 2010. A FESAC report on scientific issues and opportunities in both fundamental and mission-driven HEDLP, *Advancing the Science of High Energy Density Laboratory Plasmas* (2009), was used as the technical basis for the workshop.

Finally, FESAC Committee of Visitors (COV) panels regularly assess the efficacy and quality of the FES processes used to solicit, review, recommend, monitor,

[a] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

[b] Available at http://www.nap.edu/catalog.php?record_id=10816.

[c] Available at http://www.nap.edu/catalog.php?record_id=11960.

[d] Available at http://www.nap.edu/catalog.php?record_id=18289.

and document the application, proposal, and award actions and the quality of the resulting portfolio.

Program Goals and Funding

FES has four strategic goals:

- Advance the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source;
- Support the development of the scientific understanding required to design and deploy the materials needed to support a burning plasma environment;
- Pursue scientific opportunities and grand challenges in high energy density plasma science to explore the feasibility of the inertial confinement approach as a fusion energy source, to better understand our universe, and to enhance national security and economic competitiveness, and;
- Increase the fundamental understanding of basic plasma science, including both burning plasma and low temperature plasma science and engineering, to enhance economic competiveness and to create opportunities for a broader range of science-based applications.

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Support fundamental research to increase our understanding of and enable predictive control of the plasma state and its surrounding environment.
- *Facility Operations*: Maximize the reliability, dependability, and availability of the FES scientific user facilities to enable U.S. researchers to define world-leading research in the fusion energy and plasma sciences.
- *Future Facilities*: Build future facilities and upgrade existing facilities and experimental capabilities to get the best value from investments and advance continued U.S. leadership in the fusion energy and plasma sciences.
- *Scientific Workforce*: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers.

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Science	100%	0%	0%	0%
Facility Operations	0%	25%	75%	0%
Enabling R&D	100%	0%	0%	0%
Total, Fusion Energy Science	35%	15%	50%	0%

Performance Measures

Performance Goal (Measure)	**FES Facility Based Experiments**—Experiments conducted on major fusion facilities (DIII-D, Alcator C-Mod, NSTX) leading toward predictive capability for burning plasmas and configuration optimization		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	Conduct experiments and analysis on major fusion facilities leading toward improved understanding of core transport and enhanced capability to predict core temperature and density profiles. Assess the level of agreement between predictions from theoretical and computational transport models and the available experimental measurements of core profiles, fluxes and fluctuations. The research is expected to exploit the diagnostic capabilities of the facilities (Alcator C-Mod, DIII-D, NSTX) along with their abilities to run in both unique and overlapping regimes. The work will emphasize simultaneous comparison of model predictions with experimental energy, particle and impurity transport levels and fluctuations in various regimes, including those regimes with significant excitation of electron modes. Along with new experiments, work will include analysis of relevant previously-collected data and collaboration among the research teams. The results achieved will be used to improve confidence in transport models used for extrapolations to planned ITER operation.	Conduct experiments and analysis to explore enhanced confinement regimes without large edge instabilities, but with acceptable edge particle transport and a strong thermal transport barrier. Coordinated experiments, measurements, and analysis will be carried out to assess and understand the operational space for these conditions. Exploiting the complementary parameters and tools of the devices, joint teams will work to strengthen the basis for extrapolation of these regimes to ITER and other future fusion devices.	Conduct experiments and analysis to investigate and quantify plasma response to non-axisymmetric (3D) magnetic fields in tokamaks. Effects of 3D fields can be both beneficial and detrimental and research will aim to validate theoretical models in order to predict plasma performance with varying levels and types of externally imposed 3D fields. Dependence of response to multiple plasma parameters will be explored in order to gain confidence in predictive capability of the models.
Result	Met		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Endpoint Target	Magnetic fields are the principal means of confining the hot ionized gas of a plasma long enough to make practical fusion energy. The detailed shape of these magnetic containers leads to many variations in how the plasma pressure is sustained within the magnetic bottle and the degree of control that experimenters can exercise over the plasma stability. These factors, in turn, influence the functional and economic credibility of the eventual realization of a fusion power reactor. The key to their success is a detailed physics understanding of the confinement characteristics of the plasmas in these magnetic configurations. The major fusion facilities can produce plasmas that provide a wide range of magnetic fields, plasma currents, and plasma shapes. By using a variety of plasma control tools, appropriate materials, and having the diagnostics needed to measure critical physics parameters, scientists will be able to develop optimum scenarios for achieving high performance plasmas in ITER and, ultimately, in reactors.

Performance Goal (Measure)	**FES Facility Operations**—Average achieved operation time of FES user facilities as a percentage of total scheduled annual operation time		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 90%	≥ 90%	≥ 90%
Result	Met		
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		

[a] 2013 targets reflects DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Explanation of Funding and Program Changes

The most notable changes in this budget proposal as compared to previous years are as follows:

- *Increase in the request for U.S. ITER Project funding*—The increase for U.S. Contributions to ITER Project from $105,000,000 in FY 2012 to $225,000,000 requested for FY 2014 reflects the acceleration of the project as it enters its full construction phase. The increase will enable the U.S. to accelerate long-lead procurements and is required for the U.S. to meet its obligations to the internationally agreed-upon project schedule.
- *Increases in research and facility operations on the largest domestic confinement experiments*—DIII-D facility run time is increased to 16 weeks, which is 64% of the optimal level. The request also maintains the approved baseline of the NSTX Upgrade project at PPPL.
- *Termination of the research effort at the Massachusetts Institute of Technology's (MIT) Alcator C-Mod tokamak*—Research and facility operations funding provided in FY 2013 will be utilized to complete the safe shutdown of the facility.
- *Consolidation of HEDLP activities*—HEDLP activities are contracted to focus on science at the Matter in Extreme Conditions (MEC) endstation at the Linac Coherent Light Source (LCLS) at SLAC. The joint program with NNSA in HEDLP activities will be discontinued.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Science	170,010	137,804	-32,206
C-Mod is shut down, and support for MIT researchers is eliminated. HEDLP activities are contracted to focus on science at the MEC endstation at LCLS. Support for Theory and SciDAC is reduced.			
Facility Operations	197,456	299,160	+101,704
The growth is driven by increases to U.S. Contributions to the ITER Project as the pace of construction accelerates and significant procurement contracts are placed with domestic suppliers for component fabrication. The baseline schedule for the NSTX Upgrade is maintained.			
Enabling R&D	25,491	21,360	-4,131
Reductions will are applied selectively across the activity.			
Total Funding Change, Fusion Energy Sciences	392,957	458,324	+65,367

Science
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
DIII-D Research	30,974	—	28,200
Alcator C-Mod Research	10,595	—	0
International Research	8,325	—	8,300
Diagnostics	3,538	—	3,500
Other	7,950	—	8,312
NSTX Research	16,940	—	17,500
Experimental Plasma Research	10,965	—	10,500
High Energy Density Laboratory Plasmas	25,257	—	6,575
Madison Symmetric Torus	6,000	—	5,700
Theory	24,450	—	20,670
SciDAC	8,310	—	6,875
General Plasma Science	16,706	—	15,000
SBIR/STTR[a]	0	—	6,672
Total, Science	170,010	—	137,804

[a] SBIR/STTR Funding
- FY 2012 Appropriation: SBIR $7,084,750 and STTR $954,000 (transferred out of FES in FY 2012 Current column)
- FY 2014 Request: SBIR $5,838,000 and STTR $834,000

Overview

The Science subprogram advances the predictive understanding of plasma properties, dynamics, and interactions with surrounding materials. The greatest emphasis is on understanding magnetically confined fusion-grade plasmas; discovery-oriented research in the broader plasma sciences is also stewarded. Among the activities supported by this subprogram are:

- Research at the major experimental facilities aimed at resolving fundamental issues of fusion plasma physics, developing predictive science needed for ITER operations, and providing solutions to high-priority ITER issues.
- Research on small- and medium-scale magnetic confinement experiments to elucidate the physics principles underlying toroidal confinement and to validate theoretical models and simulation codes.
- Research performed at a new generation of international fusion research facilities to exploit their unique capabilities and characteristics, especially in areas that leverage U.S. expertise and that can provide arenas for U.S. influence in program leadership at these experiments.
- Theoretical work on the fundamental description of magnetically confined plasmas and the development of advanced simulation codes on current and emerging high-performance computers.
- Development of unique measurement capabilities and diagnostic instruments to enable experimental validation and provide tools for feedback control of fusion devices.
- Research addressing fundamental scientific questions on high energy density laboratory

plasmas, through experimental, theoretical, and modeling efforts.

- Research that advances basic understanding of the broad, multidisciplinary field of general plasma science, which has far-reaching impacts, from developing new products through low-temperature plasmas to understanding exotic phenomena in the cosmos.

Explanation of Funding Changes

In the FY 2014 request, significant reductions will occur in several program elements.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
DIII-D Research	30,974	28,200	-2,774
DIII-D research staff will be reduced and the research effort will be concentrated on ITER priority issues.			
Alcator C-Mod Research	10,595	0	-10,595
The C-Mod research effort is ended as the facility is shut down completely with the use of funding provided in FY 2013.			
International Research	8,325	8,300	-25
Scientific collaborations on a new generation of international fusion research facilities, including the EAST (China) and KSTAR (Korea) superconducting tokamaks and the Wendelstein 7-X (Germany) superconducting stellarator, will continue at a constant level of effort.			
Diagnostics	3,538	3,500	-38
Research on advanced diagnostics will continue at approximately the same level of effort.			
Other	7,950	8,312	+362
Funding for the U.S. Burning Plasma Organization (USBPO), Fusion Energy Sciences Advisory Committee (FESAC) activities, and Historically Black Colleges and Universities will be increased.			
NSTX Research	16,940	17,500	+560
NSTX researchers will continue to be involved in collaborations on other domestic and international facilities, development of the NSTX Upgrade research plan, and fabrication of new or upgraded diagnostics for the first experimental campaign on NSTX Upgrade.			
Experimental Plasma Research (EPR)	10,965	10,500	-465
Research on experiments with emphasis on validation of theoretical models and simulation codes will be reduced.			

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
High Energy Density Laboratory Plasmas (HEDLP)	25,257	6,575	-18,682
HEDLP activities will be contracted to focus on science at the Matter in Extreme Conditions (MEC) endstation at the Linac Coherent Light Source (LCLS) at SLAC. The joint program with NNSA on HEDLP activities will be discontinued.			
Madison Symmetric Torus (MST)	6,000	5,700	-300
Diagnostic and modeling efforts will be reduced.			
Theory	24,450	20,670	-3,780
The scope of this activity will be narrowed and the level of effort at universities, national laboratories, and private industry—including research staff and graduate students—will be reduced.			
SciDAC	8,310	6,875	-1,435
Funding levels for most projects in the portfolio will decrease. Research in the area of integrated modeling will not be supported, narrowing the scope of the SciDAC activity.			
General Plasma Science	16,706	15,000	-1,706
The overall level of effort will be reduced. Focus will be on targeted investments enhancing progress on fundamental questions of plasma science.			
SBIR/STTR	0	6,672	+6,672
SBIR/STTR funding is statutorily set at 3.2% of non-capital funding in FY 2014. FY 2012 funding of $8,039,000 has been transferred to the SBIR and STTR programs.			
Total Funding Change, Science	170,010	137,804	-32,206

DIII-D Research

Overview

The DIII-D research program is carried out on the DIII-D tokamak at General Atomics in San Diego, California—the largest magnetic fusion facility in the U.S.

The DIII-D research goal is to establish the scientific basis for the optimization of the tokamak approach to magnetic confinement fusion. Much of this research concentrates on the development of the advanced tokamak concept in which active control techniques are used to manipulate and optimize the plasma to obtain conditions scalable to robust operating points and high fusion gain for ITER and future fusion reactors. Near-term targeted efforts address scientific issues important to the ITER design. Longer-term research is focused on advanced scenarios to maximize ITER performance. Another high-priority DIII-D research area is general fusion science, pursuing a basic scientific understanding across all fusion plasma topical areas.

Scientists from many U.S. laboratories and universities participate in the DIII-D research program. The DIII-D program also plays a central role in U.S. international collaborations, hosting many foreign scientists and sending DIII-D scientists to participate in foreign experiments. DIII-D research scientists lead and participate in topical studies organized by the U.S. Burning Plasma Organization (USBPO) and the International Tokamak Physics Activity (ITPA).

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	After a brief operating period at the beginning of FY 2012, during which experiments were conducted to simulate the potential effects of the ITER test blanket modules, the facility was shut down for maintenance and upgrade activity. Subsequently, high-priority experiments were carried out in the areas of plasma dynamics and control, burning plasma physics, and boundary and pedestal studies. Advanced imaging techniques enabled more detailed studies of the plasma edge region.	30,974
FY 2013	The FY 2013 Request proposed $26,703,000. Research in FY 2013 will focus on using the existing microwave heating, neutral beam, and diagnostic systems to explore advanced tokamak plasmas and address scientific issues important to ITER and advanced fusion plasma system concepts. The DIII-D program will continue to strengthen collaborations with the international community by hosting and participating in joint experiments.	—
FY 2014	Research will be conducted in three program areas, with DIII-D staff and collaborator support for diagnostics and data analysis to exploit the additional DIII-D operations in FY 2014: ▪ dynamics and control studies to prepare for burning plasmas in ITER and develop viable steady-state options for fusion energy production ▪ boundary and pedestal research to improve the understanding of Edge Localized Mode control and particle and energy transport in the edge plasma, and ▪ burning plasma physics to advance the predictive capabilities to simulate future devices Studies of 3D field effects will utilize a new enhanced set of magnetic sensors. Disruption mitigation studies will focus on providing a firm physics basis for the ITER disruption mitigation system.	28,200

Alcator C-Mod Research

Overview

C-Mod at the Massachusetts Institute of Technology operated as a national scientific user facility through FY 2012. C-Mod scientists led and participated in USBPO and ITPA topical studies and made significant contributions to the world's fusion program in many areas relevant to burning plasmas. The C-Mod facility is being closed in FY 2013, as described in the Facility Operations section.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The C-Mod team used a new radio-frequency (RF) antenna developed with ARRA funding. This advanced antenna was designed to match the magnetic field geometry of C-Mod in order to examine plasma antenna interaction effects. The C-Mod team also concentrated on several other ITER- and power plant-relevant topics, such as disruption mitigation techniques and a targeted effort to improve understanding of core transport physics and enhance the capability to predict core temperature and density profiles. High priority was given to performing experiments required to complete the research of the C-Mod graduate students.	10,595
FY 2013	The FY 2013 Request proposed $8,396,000. While no operations are planned in FY 2013 as the C-Mod facility is shut down, most of the research staff will be retained in FY 2013 to evaluate data taken in prior years and publish the results, while beginning the transition to collaborative activities involving experiments on other domestic and international facilities.	—
FY 2014	The Alcator C-Mod facility will be shut down using funding provided in FY 2013, and no additional support for C-Mod research is planned in FY 2014 and beyond.	0

International Research

Overview

In addition to their work on domestic facilities, U.S. researchers participate in experiments at fusion facilities in Europe, Japan, Russia, China, South Korea, and India. Collaborations focus on facilities in the UK (JET), Germany (ASDEX-U), France (Tore Supra), and Japan (Large Helical Device).

U.S. researchers are also beginning to participate in experiments on a new generation of magnetic confinement facilities overseas. Superconducting tokamaks based on U.S. design studies are now operating in China (EAST) and South Korea (KSTAR), and a new superconducting stellarator (Wendelstein 7-X) will begin operation in Germany in late FY 2014. These facilities are making good progress and their directors have expressed strong interest in having a U.S. leadership voice in their programs. Such scientific collaborations help to maintain a vigorous U.S. fusion community that is active at the frontiers of fusion research.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Experiments on JET concentrated on optimizing plasma performance in a facility lined with ITER-like plasma facing components. In ASDEX-U, the focus was on operation with tungsten walls and control of edge instabilities with internal magnet coils. In addition, U.S. researchers applied their expertise in stellarator physics to fabricate a set of trim coils for Wendelstein 7-X for use in joint experiments on stellarator optimization. The first of these coils was delivered to Germany in June 2012.	8,325
FY 2013	The FY 2013 Request proposed $8,946,000. In FY 2013, FES will expand collaborations on unique foreign facilities, such as superconducting tokamaks and stellarators. These facilities will ultimately be able to explore sustainment and control of magnetically confined plasmas for hundreds of seconds. Such scientific collaborations will help to maintain a vigorous U.S. fusion community that is active at the frontiers of fusion research. U.S. researchers will complete the fabrication of the set of trim coils for Wendelstein 7-X, and these coils will be delivered to Germany as required to meet the Wendelstein 7-X construction schedule.	—
FY 2014	FES will fabricate and deliver the power supplies for the Wendelstein 7-X trim coils. Collaborative efforts will continue and focus on building a close working relationship with the international program teams.	8,300

Diagnostics

Overview

Diagnostics—the scientific instruments used to make detailed measurements of the behavior of plasmas—are key to advancing our abilities to predict and control the behavior of fusion plasmas in a variety of device configurations. Diagnostics are also an excellent vehicle to involve the university and industrial communities in fusion research on major facilities and international collaboration as the FES program advances into the burning plasma era. This program activity involves developing new diagnostic techniques and the theory supporting the application of existing diagnostic methods.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research was carried out at universities, private industry, and national laboratories on the development of advanced diagnostics. A solicitation was issued to competitively select new and renewal awards at universities and private industry for FY 2013 funding.	3,538
FY 2013	The FY 2013 Request proposed $3,519,000. A solicitation for new research in this program activity for both national laboratories and non-laboratory institutions (universities and private industry) will be issued.	—
FY 2014	Research efforts initiated in FY 2013, as well as continuing efforts at national laboratories, will be maintained at approximately constant level of effort.	3,500

Other

Overview

Funding in this category supports activities such as research at Historically Black Colleges and Universities (HBCUs), the U.S. Burning Plasma Organization (a national organization that coordinates research in burning plasma science), peer reviews for solicitations across the program, and the Fusion Energy Sciences Advisory Committee (FESAC).

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	U.S. Burning Plasma Organization (USBPO) activities, FESAC, and HBCUs in the fusion and plasma sciences were supported.	7,950
FY 2013	The FY 2013 Request proposed $9,193,000. FES will continue support for all the elements in this category at a reduced level.	—
FY 2014	Funding will support all the elements in this category, with further support for USBPO activities, HBCUs, and FESAC.	8,312

NSTX Research

Overview

The National Spherical Torus Experiment (NSTX) is a national scientific user facility designed to explore the physics of plasmas confined in a spherical torus (ST) configuration. A major advantage of this configuration is the ability to confine plasma with pressure that is high compared to the pressure of the magnetic field that confines it. The configuration, with its very strong magnetic curvature, has different confinement and stability properties from those of conventional tokamaks. Research on the ST configuration could lead to the development of smaller, more economical future fusion research facilities.

Research on NSTX is conducted by a collaborative team of physicists and engineers from about 30 U.S. laboratories, universities, and industry groups. NSTX is being upgraded to have a higher magnetic field, higher plasma current, and greater neutral beam heating power and, after completion, will be renamed NSTX Upgrade (NSTX-U).

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In December 2011, the NSTX team began fabrication of the new center stack and preparations to install the second neutral beam line. The NSTX team analyzed existing data, carried out analyses to support the upgrade project planning for future research operations, and prepared for collaborations on domestic and international facilities.	16,940
FY 2013	The FY 2013 Request proposed $16,836,000. In FY 2013, the NSTX-U facility will still be shut down due to the upgrade. NSTX researchers will continue to analyze existing data and begin collaborations on domestic and foreign facilities that can carry out experiments relevant to the future NSTX-U program. These experiments include plasma start-up, lithium first-wall coatings, energy and particle confinement, plasma stability and control, energetic particle physics, and radio frequency heating.	—
FY 2014	The NSTX research staff will finish up the collaborations on other U.S. and international facilities, complete development of advanced control algorithms for NSTX Upgrade, and work on the design of the next generation of divertor plates, control coils, heating system upgrades, and diagnostics to be implemented during the next five-year research campaign.	17,500

Experimental Plasma Research

Overview

Experimental Plasma Research (EPR) provides data in regimes of relevance to the FES mainline magnetic confinement and materials science efforts and helps validate theoretical models and simulation codes in support of the FES goal to develop an experimentally-validated predictive capability for magnetically confined fusion plasmas. Consisting of small-scale experiments primarily at universities, EPR emphasizes plasma physics studies in a wide range of magnetic configurations. Recent investments have supported the operation of a variety of experimental facilities, a center that provides theory and computational support to EPR experiments, and several other investigations.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Emphasis was placed on elements in the portfolio that contribute to elucidating the underlying physics principles upon which concepts of toroidal confinement are based and to validating computational models and simulation codes.	10,965
FY 2013	The FY 2013 Request proposed $10,500,000. EPR will examine a wide range of magnetic confinement configurations with an emphasis on establishing the scientific connections across concepts so as to help establish an experimentally validated predictive capability for magnetically confined fusion overall. An open solicitation for EPR proposals will be issued, resulting in a competitive, external peer review of all projects in the current portfolios.	—
FY 2014	EPR will test the general validity of plasma physics and technology in a wider expanse of parameter regimes than those provided by the major magnetic confinement facilities.	10,500

High Energy Density Laboratory Plasmas

Overview

High Energy Density Laboratory Plasma (HEDLP) science involves broad, cross-cutting research in areas ranging from laboratory astrophysics to materials under extreme conditions, as well as national security. The Matter in Extreme Conditions (MEC) endstation at the SLAC Linac Coherent Light Source (LCLS) provides access to and diagnosis of high energy density physics, warm dense matter physics, and high pressure regimes.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	A joint solicitation was held by FES and NNSA on discovery-science HEDLP topics identified in the FESAC and ReNeW reports on HEDLP. Awards were recommended for university discovery HEDLP science, laboratory-led discovery HEDLP science, and fundamental IFE science. Additionally, funds were provided for research operations at MEC and the National Drift Compression Experiment-II (NDCX-II) and for ongoing research in heavy ion fusion.	25,257
FY 2013	The FY 2013 Request proposed $16,933,000. FES will rebalance the HEDLP program, informed by the needs and opportunities identified in the FESAC report on scientific issues and opportunities in fundamental and mission-driven HEDLP. The decrease in the HEDLP budget will require a re-assessment of priorities. Program specifics will be informed in part by the outcome of a competitive review of much of the program in FY 2012 and FY 2013 and the National Research Council (NRC) Inertial Fusion Energy (IFE) study report. The MECI will continue to be a high priority.	—
FY 2014	The HEDLP program will be consolidated to focus on MEC, further developing a world-leading capability for broad HEDLP science unique to the Office of Science. HEDLP community investments through the Joint Program with NNSA will be discontinued.	6,575

Madison Symmetric Torus

Overview

The Madison Symmetric Torus (MST) experiment at the University of Wisconsin-Madison focuses on increasing the fundamental understanding of the physics of the reversed field pinch (RFP) magnetic configuration, expanding validated predictive capability of toroidal magnetic confinement, and advancing basic plasma physics and links to astrophysics.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Measurements of the radial profile of fast ions created by neutral beam injection were made with a compact neutral particle analyzer. Also, the MST team designed a low-power antenna for characterizing plasma instabilities.	6,000
FY 2013	The FY 2013 Request proposed $5,750,000. Planned research tasks include measurements of short-wavelength electron temperature fluctuations with the use of a fast Thomson scattering diagnostic. A low-power antenna to be installed in FY 2012 will enable the excitation and measurement of plasma instabilities. The MST team will also investigate momentum transport and dynamo effects and compare the experimental results against the predictions of extended magnetohydrodynamic codes.	—
FY 2014	The MST program will focus on RFP experiments and modeling efforts supporting mainline tokamak research. Measurements of short-wavelength density and magnetic field fluctuations, and comparison with gyrokinetic calculations, will be made. Equilibrium reconstructions will be developed for the 3D helical state, and pressure-limiting mechanisms in the RFP will be assessed.	5,700

Theory

Overview

The Theory activity is focused on advancing the scientific understanding of the fundamental physical processes governing the behavior of magnetically confined plasmas. In addition to its scientific discovery mission, the Theory activity is also responsible for providing the scientific grounding for and establishing the limitations and ranges of applicability of the underlying physics models implemented in the SciDAC advanced simulation codes. Theorists in larger groups, located mainly at national laboratories and in private industry, generally support major experiments, work on large problems requiring a team effort, and tackle complex issues requiring multidisciplinary teams. Theorists at universities play a significant role in supporting innovative validation being carried out on smaller experiments and experimental platforms. They also work on fundamental problems in the plasma science of magnetic fusion.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Areas of emphasis included the elucidation of theoretical issues associated with the scientific foundations of the gyrokinetic theory, the development of improved models for major disruptions in tokamaks, continued studies of the interaction of radio-frequency fields with antenna surfaces and plasma, and the further understanding of the potential of 3D magnetic perturbations for attaining improved confinement regimes in tokamak plasmas.	24,450
FY 2013	The FY 2013 Request proposed $20,836,000. In FY 2013, funding is reduced and will result in a reduction of the number of projects at universities and national laboratories and a narrowing of the scope of the Theory program. Priority will be given to research relevant to burning plasmas, as well as to efforts leveraging the FES SciDAC portfolio. In addition, fewer projects may be selected for an award during the annual theory solicitation.	—
FY 2014	Continuing research activities at universities, national laboratories, and private industry are supported at the FY 2013 level. For the selection of new and renewal awards via competitive merit reviews, priority will be given to theoretical and computational research activities addressing issues of importance to ITER and burning plasmas.	20,670

SciDAC

Overview

The FES Scientific Discovery Through Advanced Computing (SciDAC) activity, a component of the SC-wide SciDAC program, is aimed at advancing scientific discovery in fusion plasma science by exploiting leadership-class computing resources and associated advances in computational science. The FES SciDAC portfolio contributes to the FES goal of advancing the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source. In addition, the computational modules developed under the SciDAC program will become the building blocks of future large-scale integrated simulation efforts.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The five FES SciDAC Centers competitively selected in FY 2011 continued advancing scientific discovery in fusion plasma science in the areas of microturbulence-driven transport, macroscopic stability, the interaction of RF waves with plasmas, and the physics of energetic particles. Two new multi-institutional interdisciplinary Centers in the areas of edge physics and computational materials science, co-funded by FES and ASCR, joined the FES SciDAC portfolio in FY 2012, following the peer-review of the proposals submitted to the joint FES-ASCR SciDAC solicitation for *Scientific Computation Application Partnerships in Fusion Energy Science*.	8,310
FY 2013	The FY 2013 Request proposed $6,556,000. In FY 2013, the FES SciDAC projects will continue focusing on problems of importance to burning plasmas. The five projects started in FY 2011 will be entering their third year of operation and will undergo a mid-term progress review. The reduction in funding in FY 2013 will necessitate the reduction of the level of support for all projects in the FES SciDAC portfolio, including those selected for an award in FY 2012.	—
FY 2014	Research activities are maintained at approximately the FY 2013 level of effort. The two partnerships selected in FY 2012 will undergo a mid-term progress review.	6,875

General Plasma Science

Overview

The General Plasma Science (GPS) program focuses on increasing the understanding of basic and low-temperature plasma science through research addressing outstanding questions related to fundamental plasma properties and processes, as well as multidisciplinary activities. Major activities of the program are the NSF/DOE Partnership in Basic Plasma Science and Engineering, which supports university single-investigator-scale research; Plasma Science Centers, which are focused multi-institutional teams (specifically the Low Temperature Plasma Science Center, the Center for Magnetic Turbulence and Flow Self-Organization, and the Max Planck-Princeton Center for Plasma Physics); intermediate-scale facilities; and basic and applied plasma science research at DOE national laboratories.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The major elements of the GPS program continued with the annual solicitation of the NSF/DOE Partnership in Basic Plasma Science and Engineering and with FES participation in the Center for Magnetic Self Organization (an NSF Frontier Science Center at the University of Wisconsin) and in the Basic Plasma Science Facility (at UCLA). The Plasma Science Centers addressed predictive control of kinetic processes in low temperature plasmas and self-organization processes of momentum and turbulence in plasmas. An international center for plasma physics using both DOE and NSF funds was established involving PPPL, Princeton University, and the Max Planck Society of Germany.	16,706
FY 2013	The FY 2013 Request proposed $13,151,000. The support for Plasma Science Centers and laboratory general plasma science will be decreased. An open competition for GPS research at the DOE laboratories is planned in order to maintain program balance through competitive peer review. Support for the NSF/DOE Partnership will be maintained.	—
FY 2014	Core activities will be enhanced, including interagency partnerships, Plasma Science Centers, and user activities at the Basic Plasma Science Facility.	15,000

Facility Operations
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
DIII-D	38,715	—	36,960
Alcator C-Mod	18,217	—	0
NSTX	33,959	—	36,300
Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)	1,565	—	900
MIE: U.S. Contributions to ITER Project	105,000	—	225,000
Total, Facility Operations	197,456	—	299,160

Overview

The Facility Operations subprogram mission is to provide support for required plasma diagnostics, operation, maintenance, and minor modifications at the major U.S. fusion user facilities, to carry out major upgrades to existing facilities when necessary, and to construct new facilities to advance progress toward a fusion energy source.

The current major experimental user facilities in the FES program—the DIII-D tokamak at General Atomics in San Diego, California, and NSTX at the Princeton Plasma Physics Laboratory (PPPL) in Princeton, New Jersey—provide critical tools for the U.S. and international research community to explore and resolve fundamental issues of fusion plasmas. Both DIII-D and NSTX are operated as national scientific user facilities and involve users from many laboratories, industries, and universities. The support for these facilities is balanced to ensure safe operation; provide modern experimental tools such as heating, fueling, and exhaust systems; and provide the operating time to meet the needs of users to conduct world-class innovative research. ITER, presently under construction in Cadarache, France, by an international team, is designed to be the first magnetic fusion facility to achieve self-heated (burning) plasmas and will thus open a new era in fusion energy science.

Explanation of Funding Changes

As ITER construction activities ramp up, efficient management of the U.S. contributions to the international project by the U.S. ITER Project Office (USIPO) at Oak Ridge National Laboratory (ORNL) will be a high priority for FES. NSTX will not operate in FY 2014, while efforts focus on completion of the upgrade by FY 2015. The Alcator C-Mod facility shutdown will be completed with funding provided in FY 2013. The DIII-D tokamak will be the only major fusion experiment operating in the U.S. during FY 2014, and operating time will be increased to accommodate demand.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
DIII-D	38,715	36,960	-1,755
Run time will be increased from 15 weeks to 16 weeks. Only high- priority tokamak system refurbishments to improve the reliability of operations and targeted facility upgrades, such as further enhancements of the microwave heating system, will be supported. Other upgrades will be deferred in order to enhance run weeks.			
Alcator C-Mod	18,217	0	-18,217
The safe shut-down of the Alcator C-Mod facility will be completed with funding provided in FY 2013.			
NSTX	33,959	36,300	+2,341
Overall funding for NSTX Facility Operations and the NSTX-U major item of equipment (MIE) project is increased. Priority is given to the NSTX-U project so that it can be completed in FY 2015. The non-MIE Facility Operations funding will support critical facility and diagnostic upgrades important to the future NSTX-U research program, including power supplies, control systems, and long-pulse diagnostics.			
Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)	1,565	900	-665
Funding, which supports non-research infrastructure PPPL, will be reduced.			
U.S. Contributions to ITER Project (MIE)	105,000	225,000	+120,000
The funding increase will enable the U.S. to place significant procurement contracts with domestic suppliers for fabrication of components and increase deliveries of in-kind components to the ITER Organization in fulfillment of internationally agreed-upon obligations.			
Total Funding Change, Facility Operations	197,456	299,160	+101,704

DIII-D

Overview

The DIII-D user facility is the largest magnetic fusion research experiment in the U.S. and can magnetically confine plasmas at close to temperatures relevant to burning plasma conditions. Researchers from the U.S. and abroad are able to perform experiments on DIII-D for studying stability, confinement, and other properties of fusion-grade plasmas under a wide variety of conditions.

DIII-D has considerable experimental flexibility and extensive world-class diagnostic instrumentation to measure the properties of high-temperature tokamak plasmas. Capabilities of this facility include a highly flexible field-shaping coil system to produce a wide variety of plasma shapes, all-carbon plasma-facing material, coil sets both inside and outside the vacuum vessel which are used to correct error fields and study the plasma response to perturbing magnetic fields, a broad range of auxiliary heating and current drive systems, over 50 state-of-the-art diagnostic systems to examine plasma parameters, and an advanced digital control system for feedback control of the plasma.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	After a few weeks of operation in October 2011, the facility completed a 4-month maintenance and upgrade period. During this time, work continued on the Recovery Act upgrade to the microwave heating system to add a 7th high-power microwave tube (gyrotron). An advanced infrared/visible viewing system (periscope) was also installed. Research operations were conducted in the second half of FY 2012 to complete 15 weeks of experiments.	38,715
FY 2013	The FY 2013 Request proposed $33,260,000. Funding reductions mandate that additional facility upgrades and refurbishments will be deferred. DIII-D will conduct 10 weeks of research operations in FY 2013 to address the highest-priority ITER and advanced tokamak issues.	—
FY 2014	Research operations will be increased to 16 weeks. Work on some targeted, high-priority upgrades and diagnostic enhancements, such as continued improvements to the microwave heating system, will be supported. A new 3D magnetic coil sensor system will be used to support research.	36,960

Alcator C-Mod

Overview

The compact size and high field of the Alcator C-Mod tokamak made it especially useful for dimensionless scaling studies relevant to ITER and future fusion reactors. It also contributed to research on plasma-wall interactions and radio-frequency wave heating.

The Alcator C-Mod facility will be put in a safe shutdown configuration by the end of FY 2013. Some of the C-Mod research staff may transition to other activities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research operations continued at the beginning of FY 2012 with the use of the new advanced ion cyclotron RF antenna. New fast ferrite tuners (funded by the Recovery Act) were ordered for installation on three RF transmitters to allow for more efficient power coupling to the plasma. A total of 18 weeks of research operations was planned, and 19 weeks were achieved.	18,217
FY 2013	The FY 2013 Request proposed $7,848,000. In FY 2013, the C-Mod facility will be shut down. Systems will be disconnected, dismantled, and made available for use by other U.S. research facilities. No research operations are planned.	—
FY 2014	The facility closure will be completed. No research operations will be planned in FY 2014 and beyond.	0

NSTX

Overview

The NSTX user facility is an innovative fusion science facility at PPPL based on a spherical torus (ST) confinement configuration. A major advantage of this configuration is the ability to confine plasma with pressure that is high compared to the magnetic field energy density.

The NSTX Upgrade MIE project is currently underway. The new center stack will double the magnetic field and plasma current, while increasing the plasma pulse length to 5 seconds, making NSTX the world's highest-performing ST. The addition of a second neutral beam system will double the heating power, which will make it possible to achieve higher plasma pressure and provide improved neutral beam current drive efficiency and current profile control, which is needed for achieving fully non-inductive operation. Together, these upgrades will support a strong research program to develop the improved understanding of the ST magnetic confinement configuration required to establish the physics basis for next-step ST facilities, broaden scientific understanding of plasma confinement, and maintain U.S. world leadership in ST research. The capability for controllable fully-non-inductive current drive will also contribute to an assessment of the ST as a potentially cost-effective path to fusion energy. The total project cost (TPC) baseline of $94,300,000 was approved at Critical Decision-2 (CD-2) in December 2010, and CD-3 approval to start fabrication was achieved in December 2011. Project completion is anticipated in FY 2015.

In parallel with the upgrade, preparations for the resumption of facility operations are underway, including minor upgrades of diagnostics, control systems, data acquisition and data analysis systems.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	$13,514,000 supported maintenance and repairs on all of the systems that are not involved in the upgrade project. NSTX Upgrade activities included initiating machine disassembly, continuing refurbishment of the neutral beam, and continuing component fabrication and assembly, including the machining of the toroidal field inner coils.	33,959
FY 2013	The FY 2013 Request proposed $6,593,000. NSTX will be shut down for the upgrade during FY 2013. Operations funding of $6,593,000 will support continued maintenance and repairs of all systems not involved in the upgrade project. NSTX Upgrade activities will include fabrication of the center stack, installation of new cable runs for the new center stack assembly, installation of new racks for diagnostic instrumentation, and completion of the refurbishment of the second neutral beam and its move into the test cell.	—
FY 2014	As upgrade work continues, NSTX will continue its shut down. Installation of the new center stack assembly and the second neutral beamline will be completed. Operations funding of $12,600,000 will support preparation of the systems not involved in the upgrade for resumption of operation in FY 2015.	36,300

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
NSTX Operations	13,514	—	12,600
NSTX Upgrade (MIE)	20,445	—	23,700
Total	33,959	—	36,300

Other, General Purpose Equipment (GPE), and General Plant Projects (GPP)

Overview

Funding in this category provides support for general infrastructure repairs and upgrades for the PPPL site. This funding is based upon quantitative analysis of safety requirements, equipment reliability, research needs, and environmental monitoring needs.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	An uninterruptable power supply, new window assemblies, and drainage modifications on various buildings were installed. Environmental monitoring needs were supported. Prior Recovery Act funding to improve PPPL's infrastructure reduced the need for GPP funding in the near term.	1,565
FY 2013	The FY 2013 Request proposed $975,000. Funding will upgrade the chilled water system and various fire alarm systems and will support environmental monitoring needs.	—
FY 2014	Modification to the Emergency Services Building to improve its waterproofing, Phase 2 of the underground chilled water utility upgrade, and upgrade of the Large Torus Building/Carpentry shop roofing system will be completed. Environmental monitoring needs will be supported.	900

U.S. Contributions to ITER Project (MIE)

Overview

The ITER Project is building a research facility capable of generating the world's first sustained (300 seconds, self-heated) burning plasma. The research at ITER will be aimed at assessing the scientific and technical feasibility of fusion energy. The ITER Project is being designed and built by an international consortium consisting of the U.S., China, India, Japan, South Korea, the Russian Federation, and the European Union (the host). The U.S. remains committed to the scientific mission of ITER and will work with ITER partners to accomplish this goal, while maintaining a balanced domestic research portfolio.

The U.S. Contributions to ITER Project (U.S. ITER Project) MIE activity is 9.09% of the ITER Project construction costs. The US contributions, consisting of in-kind hardware components, personnel, and cash to the ITER Organization (IO) for the ITER construction phase, are established by the terms of the ITER Joint Implementation Agreement. The US contributions are managed by the U.S. ITER Project Office (USIPO), located at Oak Ridge National Laboratory (ORNL), in partnership with Princeton Plasma Physics Laboratory and Savannah River National Laboratory. The U.S. ITER Project differs from most other DOE and Office of Science (SC) projects in its in-kind hardware contribution obligations and in the risks associated with performing work that depends in large part on the execution of project responsibilities by our international partners. In December 2012, the Deputy Secretary issued a memorandum clarifying the U.S. ITER Project's designation within DOE's portfolio of projects. Due to its many unique features, the U.S. ITER Project was found to fall outside the definition of a Capital Asset project. This clarification enables better definition of project requirements and roles and responsibilities within the Department for project planning, execution, and oversight.

This clarification has not changed SC's overall management approach for the U.S. ITER Project. As with all SC projects, the principles encoded in DOE Order 413.3b will be applied including critical decision milestones and their supporting prerequisite activities. Requirements for project documentation, monitoring and reporting, change control, and regular independent peer reviews will be applied with the same degree of rigor.

The U.S. ITER Project CD-1 cost range established in 2008 is $1,450,000,000 - $2,200,000,000. Since that time, factors that delayed CD-2 approval (e.g., schedule delays, design and scope changes, and risk mitigations) have also placed upward pressure on the cost range. In the spring of 2012, in efforts to address budgetary constraints, DOE and its oversight organizations agreed to support an annual funding level of no more than $225,000,000 per year beginning in FY 2014. DOE believes these annual funding levels will enable the U.S. to fulfill its obligations. The achievement of First Plasma is the primary major milestone on the path to total project completion as it signifies completion of machine assembly, integration, and commissioning in support of initial operations. At this annual funding level, the pre-CD-2 estimate for the total cost to meet the U.S. obligations for First Plasma, a subset of our total obligations, is $2,400,000,000. This total cost is not a bottom-up estimate but is the judgment by DOE and its oversight organizations of appropriate cost for reaching first plasma. Before establishing a formal CD-2 project baseline for First Plasma scope or total U.S. commitments, and in consideration of this pre-CD-2 cost determination, the U.S. will initiate further discussions with the leadership of the ITER Organization and the ITER Members regarding how the project can best be completed within U.S. spending constraints.

Until such time as CD-2 can be approved, the U.S. contributions will be managed with a performance plan that focuses on a two-year time horizon and that is also supportive of the longer-term project requirements. This two-year plan is developed, executed, and monitored with the use of the project management principles in DOE Order 413.3b with project management systems (Earned Value, Risk Management, Project Reporting) tailored specifically to this project's circumstances.

Current U.S. ITER Project efforts are focused on procurement and fabrication of U.S. in-kind commitments to ITER. The substantial increase in funding for the U.S. ITER Project in FY 2014 is driven by the ITER construction schedule, which requires support for significant ongoing contracts with U.S. suppliers and the production of in-kind hardware components. Over 80% of the U.S. contributions to the ITER MIE Project funding will be spent on in-kind hardware sourced from U.S. industries, national laboratories, and universities.

The FY 2013–2014 scope of the U.S. ITER Project spans all twelve technical subsystems that the U.S. is responsible for providing. Performance milestones have been identified for the FY 2013–2014 work scope against which performance will be measured. Project cost estimates that support the work scope proposed in the plan are based on a resource-loaded schedule. The plan has been reviewed by the Office of Project Assessment and an independent panel. The majority (by cost) of the work scope proposed in this Plan is in Final Design or beyond with an estimated eight final design reviews planned for either components (partial sub-system) or entire technical subsystem reviews in the next two years. The plan assumes $150,000,000 to be available in FY 2013, per the Administration request to Congress, and $225,000,000 in FY 2014, per this budget proposal. The plan, including the scope of deliverables, will be revisited when the final FY 2013 funding level is determined.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Ongoing design activities and the placement of contracts for the U.S. contributions to ITER construction were supported. These contracts included approved long-lead procurements such as the tokamak cooling water system and the steady-state electrical network, which are key critical-path items for ITER.	105,000
FY 2013	The FY 2013 Request proposed $150,000,000. The proposed funding will continue fabrication activities ($89M), mostly performed by U.S. companies, for ongoing U.S. systems. At the request level, the USIPO will continue work toward completion of designs for several key U.S. systems. As part of the FY 13 request, the U.S. will provide a cash contribution to the project in accordance with the ITER Organization (IO) budget request ($31M).	—
FY 2014	According to the plan reviewed by the Office of Project Assessment and an independent panel, the U.S. ITER Project Office proposes to deliver to the ITER Organization four shipments of toroidal field conductor, drain tanks for tokamak cooling water, and hardware for the steady-state electrical network, as well as start fabrication of the first central solenoid module, complete various design reviews for the vacuum auxiliary system, and award subcontracts for diagnostic design work.	225,000

Design and Construction Schedule

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4
FY 2006	7/5/2005	TBD	TBD	TBD	TBD	TBD
FY 2007	7/5/2005	TBD	TBD	4Q FY 2007	TBD	TBD
FY 2008	7/5/2005	1/25/2008	TBD	4Q FY 2008	TBD	TBD
FY 2009	7/5/2005	1/25/2008	TBD	4Q FY 2010	TBD	TBD
FY 2010	7/5/2005	1/25/2008	TBD	4Q FY 2011	TBD	TBD

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4
FY 2011	7/5/2005	1/25/2008	TBD	4Q FY 2011	TBD	TBD
FY 2012	7/5/2005	1/25/2008	TBD	3Q FY 2012	TBD	TBD
FY 2013	7/5/2005	1/25/2008	TBD	TBD[a]	TBD	TBD
FY 2014	7/5/2005	1/25/2008	TBD	TBD	TBD	TBD

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3 – Approve Start of Construction
CD-4 – Approve Project Completion

Funding Profile History (DOE Only)

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	Outyears	Total
FY 2006	TEC	358,000	191,000	189,000	151,000	120,000	29,000	0	0	1,038,000
	OPC	38,300	16,500	10,300	9,300	6,200	3,400	0	0	84,000
	TPC	396,300	207,500	199,300	160,300	126,200	32,400	0	0	1,122,000
FY 2007	TEC	202,366	208,500	208,500	180,785	130,000	116,900	30,000	0	1,077,051
	OPC	36,949	6,000	1,500	500	0	0	0	0	44,949
	TPC	239,315	214,500	210,000	181,285	130,000	116,900	30,000	0	1,122,000
FY 2008	TEC	202,366	208,500	208,500	181,964	130,000	116,900	30,000	0	1,078,230
	OPC	36,949	6,000	821	0	0	0	0	0	43,770
	TPC	239,315	214,500	209,321	181,964	130,000	116,900	30,000	0	1,122,000
FY 2009	TEC	54,866	208,500	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	32,075	6,000	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	89,941	214,500	TBD	TBD	TBD	TBD	TBD	TBD	TBD
FY 2010	TEC	80,366	109,000	105,000	TBD	TBD	TBD	TBD	TBD	TBD
	OPC	25,019	15,000	30,000	TBD	TBD	TBD	TBD	TBD	TBD
	TPC	105,385	124,000	135,000	TBD	TBD	TBD	TBD	TBD	TBD

[a] The CD-2 date will be determined upon acceptable resolution of outsanding issues related to US in-kind contributions including: final definition of interfaces for US contributions with buildings and non-U.S. systems under construction as well as finalization of French nuclear regulatory requirements.

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	Outyears	Total
FY 2011	TEC	80,366	109,000	115,000	75,000	TBD	TBD	TBD	TBD	TBD
	OPC	25,019	15,000	20,000	5,000	TBD	TBD	TBD	TBD	TBD
	TPC	105,385	124,000	135,000	80,000	TBD	TBD	TBD	TBD	TBD
FY 2012	TEC	80,366	109,000	115,000	TBD	90,000	TBD	TBD	TBD	TBD
	OPC	25,019	15,000	20,000	TBD	15,000	TBD	TBD	TBD	TBD
	TPC	105,385	124,000	135,000	TBD	105,000	TBD	TBD	TBD	TBD
FY 2013	TEC	80,366	109,000	115,000	67,000	104,930	140,965	TBD	TBD	TBD
	OPC	25,019	15,000	20,000	13,000	70	9,035	TBD	TBD	TBD
	TPC	105,385	124,000	135,000	80,000	105,000	150,000	TBD	TBD	TBD
FY 2014	TEC	80,366	109,000	115,000	67,000	104,930	105,572	225,000	TBD	TBD
	OPC	25,019	15,000	20,000	13,000	70	70	0	TBD	TBD
	TPC	105,385	124,000	135,000	80,000	105,000	105,642[a]	225,000	TBD	TBD

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year and based on the FY 2012 funding level for ITER. The TEC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level is assumed instead..

Enabling R&D
Funding Profile by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Plasma Technology	14,652	—	11,660
Advanced Design	2,611	—	1,400
Materials Research	8,228	—	8,300
Total, Enabling R&D	25,491	—	21,360

Overview

The Enabling R&D subprogram addresses scientific challenges by developing and continually improving the hardware, materials, and technology that are incorporated into existing and next-generation fusion research facilities, thereby enabling these facilities to achieve higher levels of performance and flexibility, and consequently allowing the exploration of new scientific regimes. In addition, this subprogram supports conceptual studies of future fusion systems to characterize critical research gaps.

Explanation of Funding Changes

The funding changes reflect the need to maintain the efforts that address the significant long-term materials challenges as fusion moves into the burning plasma era and advances toward a viable energy source.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Plasma Technology	14,652	11,660	-2,992
Maintain at a reduced level all technology elements, including heating, fueling, and magnets.			
Advanced Design	2,611	1,400	-1,211
Reduce effort on scoping studies to characterize significant research gaps in the materials and fusion nuclear sciences program.			
Materials Research	8,228	8,300	+72
Increase modestly the effort in both experiments and modeling activities.			
Total Funding Change, Enabling R&D	25,491	21,360	-4,131

Plasma Technology

Overview

The Plasma Technology program develops technologies to heat, fuel, and confine the plasma; breed and process the deuterium and tritium fuel; protect the interior surface of the plasma chamber from the harsh fusion environment; and assure that fusion facilities are operated in a safe and environmentally responsible manner. This program addresses potential ITER operational issues and frequently plays a significant part in our international collaboration activities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Efforts in all areas identified above continued, including research on issues of tritium-materials interaction in the ITER mixed-material environment of tungsten, carbon, and beryllium. A series of material science experiments was continued under a U.S.-Japan collaborative program on plasma-facing and blanket materials for use in future facilities.	14,652
FY 2013	The FY 2013 Request proposed $11,666,000. Efforts identified above will continue, but at a reduced level. In addition, the program will focus on completing the last series of tritium-materials interactions experiments as part of the U.S.-Japan collaborative program on plasma facing and blanket materials for use in future facilities.	—
FY 2014	Efforts in all areas will be maintained to address the challenges and gaps in the program. A new U.S. Japan collaborative program will engage in a materials characterization initiative to evaluate improved tungsten alloys as a viable plasma-facing material capable of withstanding the harsh fusion environment.	11,660

Advanced Design

Overview

Advanced Design funding provides support for conceptual studies of potential fusion systems. These studies help to identify the various scientific challenges to fusion energy and determine how to address them. In addition, this activity supports program planning activities and the Virtual Laboratory for Technology (VLT), an organization that coordinates fusion technology research throughout the country.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Efforts continued on the study of plasma-material interaction and control issues for fusion power plants.	2,611
FY 2013	The FY 2013 Request proposed $1,611,000. By late FY 2013, the current study of the systems level issues associated with PMI and plasma control will be completed. The final report will be written, and the results distributed by way of presentations at the appropriate conferences. During FY 2013, a broad effort will be initiated to develop options for the next study.	—
FY 2014	Efforts will focus on identifying gaps in materials and nuclear science.	1,400

Materials Research

Overview

The Materials Research program supports the development, characterization, and modeling of structural, plasma-facing, and blanket materials used in the fusion environment, which is extremely harsh in terms of temperature, particle flux, and irradiation. Having materials that can withstand this environment under the long-pulse or steady-state conditions anticipated in future fusion experiments is essential.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Efforts continued on R&D activities dedicated to materials and joining technologies. The focus was on the effects of helium bubble and void generation in materials, neutron irradiation damage, and predictive simulation codes. Tungsten, reduced activation ferritic/martensitic steels, nanostructured ferritic alloys, oxide dispersion strengthened (ODS) steels, and silicon carbide (SiC) composites were investigated.	8,228
FY 2013	The FY 2013 Request proposed $9,371,000. In FY 2013, funding will continue for R&D dedicated to structural, plasma-facing, and blanket materials and joining technologies. Design studies aimed at the eventual fabrication of component systems and possible new experimental facilities with increasingly relevant fusion conditions will be started. The fundamental scientific understanding garnered through FY 2012 will be utilized for initial design of components, systems, and fabrication and joining technologies, emphasizing an integrated approach, as opposed to studying individual materials in isolation.	—
FY 2014	Efforts will continue in all activities identified above. The focus will be on joining of ODS steels and SiC composites, fabrication of tungsten and corrosion resistant steels, liquid divertors and first wall technologies, and modeling/simulation of solid state and liquid materials.	8,300

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Operating expenses	263,290	—	208,499
Capital equipment over $500,000, including major items of equipment (MIEs)	128,612	—	249,425
General plant projects (GPP) (under $10 million)	1,055	—	400
Total, Fusion Energy Sciences	392,957	403,450	458,324

Capital Equipment over $500,000 (including MIEs)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Major items of equipment (TEC over $2 million)					
National Spherical Torus Experiment Upgrade					
TEC	83,665	13,250	20,445	—	23,700
OPC	10,635	10,635	0	—	0
TPC	94,300	23,885	20,445	—[a]	23,700
U.S. Contributions to ITER					
TEC	TBD	371,366	104,930	—	225,000
OPC	TBD	73,019	70	—	0
TPC	TBD	444,385	105,000	—	225,000
Total MIEs					
TEC			125,375	—	248,700
OPC			70	—	0
TPC			125,445	—	248,700

[a] The TEC, OPC, and TPC totals have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $20,570,000 is assumed instead.

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Other capital equipment projects under $2 million TEC			3,167	—	725
Total, Capital equipment (excludes MIE OPC)			128,612	—	249,425

Facility Operations MIEs:

National Spherical Torus Experiment Upgrade. This MIE project includes a new center stack to double the magnetic field and plasma current while increasing the plasma pulse length and a second neutral beam system to double the heating power, making NSTX the world's highest-performance spherical torus. Start of construction/execution (CD-3) was approved in December 2011. NSTX will be shut down in FY 2012 through part of FY 2015 for the upgrade. The performance baseline for the MIE Project is $94,300,000 with completion in FY 2015.

U.S. Contributions to ITER. This MIE project funds the U.S. 9.09% share of in-kind hardware, personnel, and cash contributions to the international ITER Project, as agreed to under the ITER Joint Implementation Agreement. The seven Members of ITER along with the ITER Organization will build, operate, and decommission this cooperative project. The project is under construction.

Other Supporting Information

Funding Summary

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	195,501	—	159,164
Scientific user facility operations	70,446	—	49,560
Major items of equipment	125,445	—	248,700
Other (GPP, GPE, and infrastructure)	1,565	—	900
Total, Fusion Energy Sciences	392,957	403,450	458,324

Scientific User Facility Operations and Research

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
DIII-D			
Operations	38,715	—	36,960
Facility Research	30,974	—	28,200
Total, DIII-D	69,689	—	65,160
Alcator C-Mod			
Operations	18,217	—	0
Facility Research	10,595	—	0
Total, Alcator C-Mod	28,812	—	0
NSTX			
Operations	13,514	—	12,600
Facility Research	16,940	—	17,500
Total, NSTX	30,454	—	30,100
Scientific user facilities operations and research			
Operations	70,446	—	49,560
Facility Research	58,509	—	45,700
Total, Scientific user facilities operations and research	128,955	—	95,260

Facilities Users and Hours

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
DIII-D National Fusion Facility			
Achieved operating hours	608	—	N/A
Planned operating hours	520	—	640
Optimal hours	1,000	—	1,000
Percent of optimal hours	61%	—	64%
Unscheduled downtime hours	32	—	N/A
Number of users	230	—	250
Alcator C-Mod			
Achieved operating hours	608	—	N/A
Planned operating hours	544	—	0
Optimal hours	800	—	0
Percent of optimal hours	76%	—	0%
Unscheduled downtime hours	24	—	N/A
Number of users	194	—	0
National Spherical Torus Experiment			
Achieved operating hours	0	—	N/A
Planned operating hours	0	—	0
Optimal hours	0	—	0
Percent of optimal hours	N/A	—	N/A
Unscheduled downtime hours	0	—	N/A
Number of users	145	—	165
Total, Facilities users and hours			
Achieved operating hours	1,216	—	N/A
Planned operating hours	1,064	—	640
Optimal hours	1,800	—	1,000
Percent of optimal hours (funding weighted)	68%	—	64%
Unscheduled downtime hours	56	—	N/A
Number of Users	569	—	415

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	325	—	265
Number of laboratory projects	158	—	150
Number of permanent Ph.D.’s (FTEs)	760	—	667
Number of postdoctoral associates (FTEs)	115	—	80
Number of graduate students (FTEs)	325	—	243
Number of Ph.D.’s awarded	42	—	41

High Energy Physics
Funding Profile by Subprogram and Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Energy Frontier Experimental Physics			
Research	91,757	—	96,129
Facility Operations and Experimental Support	68,240	—	58,558
Projects	0	—	0
Total, Energy Frontier Experimental Physics	159,997	—	154,687
Intensity Frontier Experimental Physics			
Research	53,261	—	53,562
Facility Operations and Experimental Support	143,844	—	180,481
Projects	86,570	—	37,000
Total, Intensity Frontier Experimental Physics	283,675	—	271,043
Cosmic Frontier Experimental Physics			
Research	47,840	—	62,364
Facility Operations and Experimental Support	11,207	—	12,022
Projects	12,893	—	24,694
Total, Cosmic Frontier Experimental Physics	71,940	—	99,080
Theoretical and Computational Physics			
Research			
Theory	55,929	—	51,196
Computational HEP	8,536	—	8,474
Total, Research	64,465	—	59,670
Projects	2,500	—	3,200
Total, Theoretical and Computational Physics	66,965	—	62,870
Advanced Technology R&D			
Research			
HEP General Accelerator R&D	59,280	—	57,856
HEP Directed Accelerator R&D	46,587	—	23,500
Detector R&D	28,139	—	23,947
Total, Research	134,006	—	105,303

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Facility Operations and Experimental Support	23,100	—	17,150
Total, Advanced Technology R&D	157,106	—	122,453
Accelerator Stewardship			
Research	0	—	6,581
Facility Operations and Experimental Support	2,850	—	3,350
Total, Accelerator Stewardship	2,850	—	9,931
SBIR/STTR	0	—	21,457
Subtotal, High Energy Physics	742,533	767,529	741,521
Construction			
Long Baseline Neutrino Experiment	4,000	4,025	0
Muon to Electron Conversion Experiment	24,000	24,147	35,000
Total, Construction	28,000	28,172	35,000
Total, High Energy Physics[a]	770,533	795,701	776,521

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $17,915,000 and STTR $2,412,000 (transferred out of HEP in FY 2012 Current column)
- FY 2014 Request: SBIR $18,775,000 and STTR $2,682,000

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 102-468, "Energy Policy Act of 1992"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

The High Energy Physics (HEP) program mission is to understand how the universe works at its most fundamental level, which is done by discovering the elementary constituents of matter and energy, probing the interactions between them, and exploring the basic nature of space and time.

The knowledge acquired in this pursuit also yields substantial benefits of a more tangible nature for society as a whole–for example, the discovery of x-rays was driven not by physicians in search of a better way to diagnose bone fractures but by physicists engaged in basic research.

The Standard Model of particle physics, first established in the 1970s, describes the behavior of elementary particles and forces, often to very high precision. Nevertheless, the Standard Model fails at the high energies now being created in particle accelerators and describes only normal visible matter—only about 5% of the universe. Astronomical observations indicate that the remaining 95% of the universe consists of "dark matter" and "dark energy"; the fundamental nature of which remains a mystery.

A world-wide program of particle physics research is underway to explore what lies beyond the Standard Model. To this end, HEP supports a program focused on three scientific frontiers:

- *The Energy Frontier,* creating particles never before seen in the laboratory, revealing their interactions, and investigating fundamental forces using the highest energy accelerators available;
- *The Intensity Frontier,* investigating fundamental forces and particle interactions by studying events that occur rarely in nature through the use of intense particle beams, massive detectors, and/or high precision detectors; and
- *The Cosmic Frontier,* making measurements of astrophysical phenomena that offer new insight and information about the nature of dark matter and dark energy and about fundamental particle properties and leading to the discovery of new phenomena.

Together, these complementary discovery frontiers offer the opportunity to answer some of the most basic questions about the world around us, including:

- *Are there undiscovered principles of nature, such as new symmetries or new physical laws?*

  The laws of quantum physics that describe elementary particles and forces are based on underlying symmetries of nature. Some of these symmetries prevail only at very high energies. A possible new symmetry, called supersymmetry, predicts a superpartner for every particle currently known. The search for such superparticles will be carried out with experiments at the Energy Frontier or indirectly with measurements at the Intensity or Cosmic Frontiers.

- *Why are there so many kinds of particles?*

  Three different pairings, or families, of quarks and leptons have been discovered. Does nature require that there are only three families, or are there more? The various quarks and leptons also have widely different masses and force couplings. These differences suggest there may be an undiscovered explanation that unifies quarks and leptons. Detailed studies that employ Energy Frontier accelerators, as well as precision measurements made at Intensity Frontier facilities, may provide dramatic insights into this complex puzzle.

- *Do all the forces become one?*

  All the basic forces in the universe could be various manifestations of a single unified force. Unification was Einstein's great, unrealized dream and advances in string theory give hope of achieving it. The discovery of superpartners or extra dimensions at Energy Frontier accelerators, or hints of them at the Intensity or Cosmic Frontiers, would lend strong support to current ideas about unification.

Some investigations are best suited to the tools and techniques of one of the Frontiers; but, the strong connections and overlaps among many key questions necessitate coordinated initiatives across the three frontiers. HEP creates new technologies and pushes current technologies to new limits to answer these questions and to meet the challenges of research at the frontiers. HEP supports theoretical and experimental studies by individual investigators and large collaborative teams—some who gather and analyze data from accelerator facilities in the U.S. and around the world, and others who develop and deploy ultra-sensitive instruments to detect particles from space and observe astrophysical phenomena that advance our understanding of fundamental particle properties.

The continuous improvement of accelerator and detector technology necessary to pursue high energy physics as well as the scale of the science itself has had transformative impacts on the Nation's economy, security, and society. HEP, as the primary steward of accelerator science and advanced accelerator technology R&D in the Office of Science has developed knowledge and technologies that are the foundation for Office of Science major accelerator user facilities. HEP's contributions to the underlying technologies now used in medicine, science, industry, and national security are also well known. HEP coordinates accelerator research investments with the Advanced Scientific Computing Research (ASCR), Basic Energy Sciences (BES) and Nuclear Physics (NP) programs and plans to expand its coordination role in FY 2014.

Development of accelerator, detector, electronics, and magnet technologies is likely to have a significant impact in a number of areas where accelerators use is expanding, including: homeland and national security where accelerators and detectors enable hazardous material detection and non-proliferation verification; industry; and medicine where research could help lower the cost of accelerators, detectors, and magnets for cancer treatment and diagnosis.

The HEP budget has been restructured to align with the long-range plan developed by the HEPAP subpanel, Particle Physics Project Prioritization Panel (P5), in their report *US Particle Physics: Scientific Opportunities A Strategic Plan for the Next Ten Years*[a] (June 2008). The three experimental physics subprograms are Energy Frontier, Intensity Frontier, and Cosmic Frontier, as described in the P5 report. These replace the Proton Accelerator-based Physics, Electron Accelerator-based Physics, and Non-accelerator Physics subprograms. The Theoretical Physics subprogram is renamed the Theoretical and Computational subprogram to more accurately reflect its activities. There are also changes to the Advanced Technology R&D subprogram; the accelerator technology R&D activities that have a broad benefit beyond high energy physics are identified in the Accelerator Stewardship subprogram and SBIR/STTR activities are moved into a separate subprogram. The purpose of these changes is to increase transparency of the HEP budget and demonstrate clear goals and progress along the scientific thrusts of the field.

Basic and Applied R&D Coordination

Many applications of technology developed by HEP research have been unforeseen. Although it has been recognized that many of these technology developments can have transformative impacts in the areas of national security, medicine, energy and environment, industry, and discovery science (including accelerator science), there has been no systematic way of enhancing technology transfer to these other fields.

In order to better leverage possible future applications of accelerators, as well as key technical areas HEP convened a task force of accelerator R&D experts drawn from universities, national laboratories, and industry to help identify specific research areas and infrastructure gaps where HEP investments could have significant impacts beyond the "traditional" HEP program.

HEP coordinates its program with other offices and agencies with related programs and missions. The U.S. LHC program is supported by HEP and NSF Physics Division and overseen by a Joint Oversight Group (JOG). Dark matter research is also jointly sponsored by those agencies, and the agencies are coordinating their planning on next generation experiments. Both HEP and NSF Physics use HEPAP as part of their advisory structure. HEP also coordinates with NSF Astronomy on the Dark Energy Survey experiment and the Large Synoptic Survey Telescope Project, each of which is overseen by a JOG. Both agencies as well as NASA receive advice from the Astronomy and Astrophysics Advisory Committee on areas of joint interest.

Program Accomplishments and Milestones

FY 2012 saw major, paradigm-shifting accomplishments on all three frontiers of particle physics that reaffirmed the power of basic research to inspire innovation and redefine the future directions of scientific inquiry.

LHC experiments announced the discovery of a new particle compatible with the Standard Model Higgs boson (Energy Frontier). The LHC luminosity increased by an order of magnitude in 2012, and one of the primary results is the discovery of a new particle observed at about 125 GeV. This new particle is compatible, within the achieved statistical accuracy, with being the long-sought Standard Model Higgs boson. Other recent results, include strong limits on the masses of supersymmetric particles that are substantially tighter than those from the Tevatron. HEP supported researchers at home and abroad have leading roles in the operations of the detectors and the LHC data analyses. Further data from the LHC will determine if this is the Standard Model Higgs Boson or another particle predicted by supersymmetry or other beyond the Standard Model theories.

Nobel Prize in Physics awarded for discovery of dark energy (Cosmic Frontier). Saul Perlmutter of Lawrence Berkeley National Laboratory was awarded the 2011 Nobel Prize in Physics along with Adam Reiss and Brain Schmidt for the discovery of the acceleration of the expansion of the universe. This expansion has been attributed to a new force called "dark energy", which is now one of the most active areas of research in cosmology and high energy physics. In 2012 a new instrument, the DOE-supported Dark Energy Camera (DECam), was completed and installed on the Blanco telescope in Chile, and a new technique to measure dark energy was demonstrated by the Baryon Oscillation Spectroscopic Survey.

Daya Bay Experiment makes the first definitive measurement of the remaining unknown neutrino mixing

[a] http://science.energy.gov/~/media/hep/pdf/files/pdfs/p5_report_06022008.pdf

angle (Intensity Frontier). In China, the Reactor Neutrino Experiment detectors are installed and taking data. Using a partially complete experiment, the collaboration led by U.S. and Chinese physicists has reported a measurement of the mixing angle responsible for changing muon neutrinos to electron neutrinos. The Daya Bay result definitively confirms results from European and Japanese experiments that suggested a large mixing angle. This means that, in the current neutrino oscillation model, the possibility of matter-antimatter asymmetry and the hierarchy of neutrino masses can be definitively explored with new experiments, including the soon-to-be-completed NOvA experiment.

Milestones	Date
First light for DECam, the DOE contribution to the Dark Energy Survey (DES) experiment (Cosmic Frontier Experimental Physics, Research)	4th Qtr, FY 2012
Shutdown of the Fermi National Accelerator Laboratory (Fermilab) accelerator complex for installation of the NuMI Off-Axis Neutrino Appearance (NOvA) Accelerator Upgrades: These upgrades will raise the beam power available for Neutrinos at the Main Injector (NuMI) beam from 320 kilowatts to 700 kilowatts. (Intensity Frontier Experimental Physics, Projects)	3rd Qtr, FY 2012
Completion of NOvA Accelerator Upgrades and resumption of operations of the Fermi accelerator complex (Intensity Frontier Experimental Physics, Facility Operations and Experimental Support, and Projects)	3rd Qtr, FY 2013
Improve the measurement of the mixing angle between muon neutrinos and electron neutrinos ($\sin^2(2\theta_{13})$) by measuring disappearance of electron antineutrinos with Daya Bay Reactor Experiment at an increased accuracy (the measurement of $\sin^2(2\theta_{13})$ should have uncertainty of 0.0075 or smaller) (Intensity Frontier Experimental Physics, Research)	4th Qtr, FY 2013

Milestones	Date
Start of operations of the NOvA experiment with the full detector in order to continue the study of neutrino mixing, study the neutrino mass hierarchy, and search for violation of charge-parity (CP) symmetry. The NOvA experimental program is planned to last six years.	4th Qtr, FY 2014

Program Planning and Management

To ensure that resources are allocated to the most scientifically promising experiments and projects and program are run effectively and efficiently, HEP actively seeks external input and evaluation using a variety of advisory bodies. The High Energy Physics Advisory Panel (HEPAP), jointly chartered by DOE and the National Science Foundation (NSF) under the provisions of the Federal Advisory Committee Act (FACA), provides advice regarding the scientific opportunities and priorities of the national high energy physics research program. HEPAP and its subpanels undertake special studies and planning exercises in response to specific charges from the funding agencies.

The HEPAP P5 report[a] provided important input informing HEP programmatic priorities. A subsequent HEPAP report to identify and prioritize the scientific opportunities and options that can be pursued at different funding levels to achieve an optimum program in particle astrophysics refined this guidance. The National Academies Decadal Survey of Astronomy and Astrophysics (Astro2010) report[b] (August 2010) recommended priorities for the next decade for the U.S. program in astronomy and astrophysics under various funding scenarios. This study provides advice on the opportunities for HEP participation in astrophysics experiments and also provides guidance on scientific and technical aspects of the proposed program. HEP's budget and planning for FY 2014 are consistent with the advice obtained from the scientific community and the implementation of a coordinated interagency national program that will deliver the best science with the available resources in this scientific area. The Astronomy

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[a] http://science.energy.gov/~/media/hep/pdf/files/pdfs/p5_report_06022008.pdf

[b] http://www.nap.edu/catalog.php?record_id=12951

and Astrophysics Advisory Committee (AAAC) reports annual and on a continuing basis to DOE, NSF, National Aeronautics and Space Administration (NASA) and Congress with advice on the direction and management of the national astronomy and astrophysics research programs as well as coordination between the agencies. The AAAC operates similarly to HEPAP, and the two advisory bodies have been charged to form joint task forces or subpanels to address research issues at the intersection of high energy physics, astrophysics, and astronomy, such as dark energy and dark matter and the study of high energy cosmic and gamma rays. HEP's budget and planning for FY 2014 are consistent with the advice obtained from the scientific community and the implementation of a coordinated interagency national program that will deliver the best science with the available resources in this scientific area.

Consistent with Office of Science best practices for program management and evaluation, and the President's management agenda[a], HEP triennially convenes a Committee of Visitors (COV) to perform an independent review of HEP's solicitation, proposal, and research management processes, as well as an evaluation of the quality, performance, and relevance of the research portfolio, including an assessment of its breadth and balance. The fourth HEP COV review is planned for fall 2013.

HEP reviews and provides ongoing oversight of its research portfolio. All university research proposals are subject to an external peer review process to ensure high quality research and relevance to achieving the goals of the national program. Proposals for grant support are peer-reviewed by external technical experts, as they are for all Office of Science research programs, following the guidelines established by 10 CFR Part 605.

Following recommendations of recent COV panels, HEP has implemented a new review process for high energy physics research and basic technology R&D efforts at both universities and DOE laboratories. Laboratory high energy physics research and technology R&D groups are peer-reviewed triennially on a rotating basis using the same criteria established for the university reviews. In 2013, HEP plans to review the Intensity Frontier, Cosmic Frontier, and Advanced Technology R&D subprograms; in 2014 we plan to review the Theoretical and Computational Physics subprogram. Laboratory proposals involving significant new research scope are also subject to peer-review by external experts on an ad hoc basis. University grant proposals are now comparatively reviewed against their peers in the specific research areas that they are proposing to investigate in order to identify and select the strongest proposals and improve the overall quality of the program.

Program Goals and Funding

Offices of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Carry out research across the three experimental frontiers of particle physics to address the most basic questions about the world around us.
- *Facility Operations*: Support optimal utilization of the HEP user facilities to deliver maximum data to the user community, while carrying out a maintenance and improvement program to keep the facilities productive well into the future.
- *Future Facilities*: Develop new facilities and instrumentation for the Energy, Intensity and Cosmic Frontiers for a scientific leadership program in the U.S. All construction projects and MIEs are within 10% of their specified cost and schedule baselines.
- *Scientific Workforce*: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers.

[a] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Energy Frontier Experimental Physics	60%	40%	0%	0%
Intensity Frontier Experimental Physics	20%	70%	10%	0%
Cosmic Frontier Experimental Physics	65%	10%	25%	0%
Theoretical and Computational Physics	95%	0%	5%	0%
Advanced Technology R&D	85%	15%	0%	0%
Accelerator Stewardship	65%	35%	0%	0%
Construction	0%	0%	100%	0%
Total, High Energy Physics	50%	35%	15%	0%

Performance Measures

Performance Goal (Measure)	**HEP Facility Operations**—Average achieved operation time of HEP user facilities as a percentage of total scheduled annual operation time		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 80%	≥ 80%	≥ 80%
Result	Met		
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Performance Goal (Measure)	**HEP Neutrino Model**—Carry out series of experiments to test the standard 3-neutrino model of mixing		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	N/A	Measure mixing angle between muon neutrinos and electron neutrinos ($\sin^2(2\theta_{13})$) by measuring disappearance of electron antineutrinos with Daya Bay Reactor Experiment (should have uncertainty of 0.0075 or smaller)	Begin operation of full NOvA detector using neutrino beam from Fermilab for purpose of measuring mixing angle between muon neutrinos and electron neutrinos ($\sin^2(2\theta_{13})$) using the appearance of electron neutrinos
Result	N/A		
Endpoint Target	Similar to quarks, the mixing between neutrinos is postulated to be described by a unitary matrix. Measuring the independent parameters of this matrix in different ways and with adequate precision will demonstrate whether this model of neutrinos is correct. Such a model is needed to correctly extract evidence for CP violation in the neutrino sector.		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Explanation of Funding and Program Changes

In the FY 2014 Request, funds are shifted from research categories to support: full operations of existing HEP facilities and experiments; the planned construction funding profile for the Muon to Electron Conversion Experiment (Mu2e); and a new MIE for the Muon g-2 experiment. This new Intensity Frontier MIE to fabricate an experiment to measure the muon anomalous magnetic moment,is planned to utilize the proton beam from the accelerator complex at Fermilab to produce the muons. Capital equipment funding is requested to support the planned funding profiles for the camera for the Large Synoptic Survey Telescope (LSSTcam) and a U.S. contribution to the upgrade of the Belle detector at the Super B-Factory in Japan (Belle-II).

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Energy Frontier Experimental Physics	159,997	154,687	-5,310
Reductions in funding are due to the continued ramp-down of Tevatron research and reduced demand for LHC detector operations activities during the planned LHC shutdown in FY 2014.			
Intensity Frontier Experimental Physics	283,675	271,043	-12,632
Reductions are dominated by the ramp-down of funding associated with Current Projects (particularly NOvA). This is offset by increases in funding for initial operations of the upgraded NuMI beamline for NOvA, refurbishment of the oldest portions of the Fermilab accelerator complex, and R&D and fabrication of other experiments.			

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Cosmic Frontier Experimental Physics	71,940	99,080	+27,140
Funding for operations of current facilities is increased to accommodate new and ongoing experiments. Funding for research activities increases to support these investments. Funding increases for the LSST MIE according to its planned profile.			
Theoretical and Computational Physics	66,965	62,870	-4,095
Funding for theory research is reduced consistent with the overall programmatic direction that provides more resources for investments in future facilities within the overall budget constraints. Computational HEP activities are maintained with approximately constant funding.			
Advanced Technology R&D	157,106	122,453	-34,653
Reductions are due to the completion of International Linear Collider R&D program in FY 2012, the reduced funding for accelerator testing infrastructure at Fermilab in 2013 as that effort nears completion, and the reallocation of some R&D efforts to the Accelerator Stewardship subprogram.			
Accelerator Stewardship	2,850	9,931	+7,081
This new subprogram focuses on the fundamental physics of charged particle beams and on accelerator technology that can broadly benefit fields both within and outside of HEP. Funding comes from redirection of some broadly applicable research activities away from HEP-only focused activities.			
SBIR/STTR	0	21,457	+21,457
Funding is provided in accordance with the legislatively directed percentage of HEP operating budgets.			
Construction	28,000	35,000	+7,000
Funding is provided for the completion of the Mu2e PED and the beginning of construction.			
Total, High Energy Physics	770,533	776,521	+5,988

Energy Frontier Experimental Physics
Funding Profile by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	91,757	—	96,129
Facility Operations and Experimental Support	68,240	—	58,558
Total, Energy Frontier Experimental Physics	159,997	—	154,687

Overview

The Energy Frontier Experimental Physics subprogram supports LHC research and ongoing analysis of data from the Tevatron experiments at Fermilab with the goal of determining whether the Standard Model continues to be the correct description of the natural world. Discoveries made and experimental techniques introduced at the Tevatron over the years are now the foundation for much of the LHC research program.

Research activities at the Energy Frontier in FY 2014 will primarily be focused on the LHC. In 2014, the LHC experiments will come back on-line after a planned shutdown that began in FY 2013 to bring the LHC to the full design energy of 14 TeV. Data collected during this period will be used to determine answers to many fundamental questions in particle physics, including:

- *Have we discovered the Higgs boson?*

  The Higgs boson is thought to be responsible for generating the mass for all fundamental particles. In July 2012, CERN announced the discovery of a new particle consistent, within the limited statistical accuracy, with being the Standard Model Higgs boson. More data are required to measure its properties such as decay rates in the various channels (γγ, ZZ, WW, bb and ττ) and ultimately its spin and parity and thereby ascertain whether it is indeed the Standard Model Higgs boson or the result of new physics beyond the standard model.

- *Are there undiscovered principles of nature, such as new symmetries or new physical laws?*

  Researchers at the LHC hope to find evidence of what lies beyond the Standard Model or significantly constrain current models of new physics such as Supersymmetry, mechanisms for black hole production, extra dimensions, and other exotic phenomena.

LHC hosts two large multi-purpose particle detectors, CMS and ATLAS, that were fabricated and now maintained and operated by scientific collaborations consisting of thousands of research scientists from universities and national laboratories around the world who analyze the data and publish their results. U.S. researchers make up approximately 20% of the ATLAS collaboration and approximately 30% of the CMS collaboration. Results from multiple experiments are often combined as appropriate to improve the statistical significance of the results, including results obtained from Tevatron analyses.

The Energy Frontier Experimental Physics subprogram also supports the LHC detector operations program, which covers the maintenance of U.S. supplied detector systems for the ATLAS and CMS detectors at the LHC and the U.S. based computer infrastructure for the analysis of LHC data by U.S. physicists.

Explanation of Funding Changes

The decreases in the overall level of funding for the Energy Frontier is due to the end of the Tevatron Collider operations in September 2011. In FY 2014 activities are concentrated on research at the LHC and a few legacy analyses using Tevatron data. Legacy analysis of the Tevatron data will continue at a modest level.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	91,757	96,129	+4,372
Research activities at the Energy Frontier in FY 2014 will primarily be focused on LHC Efforts include foundational research that will lead to the development of upgraded LHC detectors that will be needed in several years.			
Facility Operations and Experimental Support	68,240	58,558	-9,682
LHC Detector Operations are funded in this activity. Funding is reduced due to a long shutdown of the LHC accelerator, which will extend into FY 2014.			
Total, Energy Frontier Experimental Physics	159,997	154,687	-5,310

Research

Overview

University-based Energy Frontier research is carried out by groups at over 60 institutions performing experiments at the LHC and legacy analyses of data collected at the Tevatron. Grant-supported scientists typically constitute about 50–75% of the personnel needed to create, run, and analyze an experiment, usually working in collaboration with other university and laboratory groups. Grant-based research efforts are selected based on external peer review; funding allocations take into account the quality and scientific priority of the research proposed. Energy Frontier research also supports physicists from five national laboratories. These are typically large groups that also have significant responsibilities for detector operations, maintenance, and upgrades, particularly when their laboratory hosts large computing centers and analysis-support centers. HEP conducted an external peer review of laboratory research groups in this activity in 2012, and findings from this review were used to inform the funding decisions in subsequent years. HEP will review this activity again in 2015 and evaluate progress.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research funding at the Energy Frontier was dominated by activities at the LHC (operating at 8 TeV) and data analysis at the Tevatron. High priority data analysis efforts in the Tevatron Collider program were maintained, but there was a reduction in the broader Tevatron research effort. Research efforts were selected based on a comparative peer-review process in order to maintain activities with the highest scientific impact and potential.	91,757
FY 2013	The FY 2013 Request proposed $97,667,000. While scientists analyze the large data samples collected in more than two years of running, the LHC will shut down early in the fiscal year to perform repairs that will allow it to operate at its design energy of 14 TeV.	—
FY 2014	The LHC will resume operations in FY 2014 after completion of machine repairs and detector maintenance to allow collecting data at the design energy of 14 TeV. U.S. university and laboratory scientists will participate in the preparation of components built in the United States for operation at higher energy and higher data rates. Funding is reduced for Tevatron legacy analyses as they are completed. Research efforts will be selected based on a comparative peer-review process in order to maintain activities with the highest scientific impact and potential.	96,129

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Grants	48,446	—	41,449
National Laboratories	42,861	—	51,830
University Service Accounts	450	—	300
Other Research	0	—	2,550
Total, Research	91,757	—	96,129

Facility Operations and Experimental Support

Overview

U.S. LHC Detector Operations supports the maintenance of U.S. supplied detector systems for the CMS and ATLAS detectors at the LHC and for the U.S. based computer infrastructure used by U.S. physicists to analyze LHC data, including pre-conceptual detector R&D to support eventual upgrades of ATLAS and CMS enabling runs at higher energies and data rates and Tier 1 computing centers at Fermilab and the Brookhaven National Laboratory (BNL). Achieving a U.S. leadership role at the Energy Frontier requires effective integration of U.S. researchers in the LHC detector calibration and data analysis efforts and implementation and optimization of the U.S. data handling and computing capabilities needed for full participation in the LHC research program.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The LHC Detector Operations program continued and included LHC detector support and R&D and pre-conceptual design for LHC Upgrades.	68,240
FY 2013	The FY 2013 Request proposed $63,069,000 for the LHC Detector Operations program. The funding level is decreased compared to FY 2012, reflecting the shutdown for maintenance and upgrades to reach the design energy.	—
FY 2014	Funding for the LHC Detector Operations program is decreased approximately $10 million compared to the FY 2012 level, reflecting the fact that the LHC will not operate for part of the year to allow for maintenance and upgrades to reach the design energy	58,558

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
LHC Detector Operations			
ATLAS Detector and Computing Support	30,335	—	26,044
CMS Detector and Computing Support	34,511	—	30,730
Total, LHC Detector Operations	64,846	—	56,774
Other Facilities	3,394	—	1,784
Total, Facility Operations and Experimental Support	68,240	—	58,558

Intensity Frontier Experimental Physics
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	53,261	—	53,562
Facility Operations and Experimental Support	143,844	—	180,481
Projects	86,570	—	37,000
Total, Intensity Frontier Experimental Physics	283,675	—	271,043

Overview

The Intensity Frontier Experimental Physics subprogram investigates some of the rarest processes in nature including unusual interactions of fundamental particles or subtle effects requiring large data sets to measure.

Activities at the Intensity Frontier in FY 2014 will be focused primarily on operating new and existing facilities while continuing investments to maintain a world-leading program in the future. These facilities and investments are concentrated primarily in the areas of neutrino and muon physics, making use of extensive experience and infrastructure at Fermilab. In 2014, the Daya Bay Reactor Neutrino Experiment will continue its operation, and the NOvA neutrino detector will be completed and start taking data with the upgraded NuMI beamline from Fermilab. Fabrication funding is initiated for the Muon g-2 experiment. Data collected during this period will be used to determine answers to fundamental questions in particle physics, including:

- *What are neutrinos telling us?*

  Of all the known particles, neutrinos are perhaps the most enigmatic and certainly the most elusive. The three known varieties of neutrinos were all discovered by HEP researchers working at U.S. facilities. Many trillions of neutrinos can pass through an area the size of a postage stamp every second with little or no interaction with their surroundings and their detection requires intense neutrino sources and large detectors. HEP supports research into fundamental neutrino properties; because, they may reveal important clues to the unification of forces and the very early history of the universe.

- *What happened to the antimatter?*

  The universe today appears to contain very little antimatter. Antimatter is continually produced by naturally occurring nuclear reactions only to undergo near immediate annihilation. The Big Bang, however, should have produced equal amounts of both matter and antimatter, which agrees with the study of high-energy collisions in the laboratory, so the lack of antimatter observed today is a mystery. Precise Intensity Frontier measurements of the subtle asymmetries present in the weak nuclear interaction may shed light on how this matter-antimatter asymmetry arose.

Many of the experiments in this subprogram are done in coordination with international partners. Experiments at U.S. facilities are managed and primarily supported by DOE and the NSF, with experiments at foreign facilities managed and primarily supported by the host country and institution.

Explanation of Funding Changes

Increases in operations support for the Intensity Frontier are offset by decreases in the Energy Frontier due to completion of Tevatron Collider operations in September 2011, as the Fermilab accelerator complex pivots its focus to new experiments. Completion of the NOvA project in FY 2014 and the transition of the Mu2e project from the R&D phase to the design and construction phase lead to a reduction in Projects funding. Programmatically, the latter is offset by increases in Construction funding for Mu2e.

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
	(dollars in thousands)		
Research	53,261	53,562	+301
Intensity Frontier research is held approximately constant to support the major initiatives on the Intensity Frontier, the beginning of the NOvA and MicroBooNE experiment programs as well as scientific support of the design for the Mu2e project and ongoing research in support of the Long Baseline Neutrino Experiment (LBNE).			
Facility Operations and Experimental Support	143,844	180,481	+36,637
Funding for the Fermilab Accelerator Complex is increased to implement infrastructure improvements needed to support the shift from Energy Frontier to Intensity Frontier operations. Funding is provided for Accelerator Improvement Project (AIP) and General Plant Project (GPP) facility enhancements to support new experiments with muons, and a program of equipment replacement for the oldest part of the complex is started to increase the reliability of the complex. Funding is provided for safety and maintenance activities and support of the LUX and Majorana demonstrator experiments at the Homestake Mine.			
Projects	86,570	37,000	-49,570
The funding ramps down due to the completion of the NOvA and MicroBooNE MIEs and the end of Other Project Costs (OPC) funding for Mu2e. All remaining funding for Mu2e is in the Construction subprogram. Muon g-2 receives initial Total Equipment Cost (TEC) funding in FY 2014. Funding is also provided for LBNE OPC and for exploratory R&D for possible future projects.			
Total, Intensity Frontier Experimental Physics	283,675	271,043	-12,632

Research

Overview

The HEP experimental research activity at the Intensity Frontier consists of groups at over 50 academic institutions, and physicists from 8 national laboratories, performing experiments at a variety of locations. As discussed in the Energy Frontier subprogram, the laboratory groups typically have a portfolio of responsibilities ranging from detector operations and maintenance to computing and data analysis. HEP will conduct an external peer review of all laboratory research groups in this subprogram in 2013, and findings from this review will be used to inform the funding decisions in subsequent years. All research grants are selected using external peer review.

Intensity Frontier activity at Fermilab uses beams from the proton accelerator complex to measure neutrino oscillations with increasing precision and different experimental approaches (Main Injector Neutrino Oscillation Search [MINOS] and NOvA) and to measure neutrino interaction cross-sections in different energy ranges and various detector technologies (MiniBooNE, Main Injector Experiment v-A [MINERvA], and MicroBooNE). The Fermilab muon program uses beams from the Booster beamline to search for muon to electron conversion (Mu2e), and as a source for the Muon g-2 measurement.

The Intensity Frontier studies of rare decays include participation in the upgrade of the Belle detector at the Japanese B-Factory (Belle-II) at the National Laboratory for High Energy Physics (KEK). The Japanese B-Factory is scheduled for a major upgrade in FY 2014–2015 that will improve its luminosity by a factor of 50–100 in order to increase its sensitivity to physics beyond the Standard Model. Additional studies of neutrino oscillations are taking place at accelerators (Tokai to Kamioka [T2K], at JPARC in Tokai, Japan) and at nuclear reactors (Double Chooz in France and Daya Bay in China).

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Research activities supported include data analysis of the accelerator-based neutrino oscillation and neutrino cross-section experiments, reactor neutrino experiments, and completion of final analyses from the previous generation of B-factory detectors as noted above. Physics studies for possible future experiments were also supported.	53,261
FY 2013	The FY 2013 Request proposed $56,427,000. First data with the partially-completed NOvA detector will be calibrated and analyzed. Analyses of ongoing neutrino experiments are continued. Researchers will also provide some support for neutrino experiment maintenance during the shutdown for the upgrade of the NuMI beamline.	—
FY 2014	Datataking and analysis with the completed NOvA detector will begin to enable key measurements of neutrino properties. In parallel, the MicroBooNE experiment will study important low energy neutrino cross sections using the Booster neutrino beam at Fermilab. Final analyses of the Double Chooz reactor data will be completed.	53,562

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Grants	20,493	—	20,729
National Laboratories	32,226	—	28,833
University Service Accounts	542	—	0
Other Research	0	—	4,000
Total, Research	53,261	—	53,562

Facility Operations and Experimental Support

Overview

There are several distinct facility operations and experimental support efforts in the Intensity Frontier subprogram. The largest is the Fermilab Accelerator Complex User Facility. The operation of the accelerator, detectors, and computing are included in this activity. In FY 2014, the major experimental efforts will be the NOvA and MicroBooNE experiments utilizing the NuMI and Booster neutrino beams.

HEP also supports the operation of the Homestake Mine which currently houses a dark matter experiment and a technology demonstration for neutrinoless double beta decay experiment supported by the Nuclear Physics program. Homestake is proposed as the primary site of the large detector for the LBNE project. Supported activities include pumping water to maintain the mine, operation of the hoists to transport personnel and materials, and safety related maintenance.

The remaining activities are the disassembly and removal of the PEP-II accelerator components from the accelerator tunnel at SLAC and the detector operation and maintenance and computing for experiments that are not located at DOE national laboratories such as the Daya Bay reactor neutrino experiment in China.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The Fermilab Accelerator Complex, the operation of the Homestake Mine, and the disassembly of the PEP-II accelerator were all supported.	143,844
FY 2013	The FY 2013 Request proposed $162,979,000 to support all of the above activities. An increase in funding for the Fermilab Accelerator Complex is provided to begin a program of equipment replacement to improve the reliability of the complex. The replacements will be targeted at the oldest part of the complex, which are now over 40 years old.	—
FY 2014	Funding is increased for the Fermilab accelerator complex to support GPP and AIP projects to develop the common infrastructure needed to carry out muon experiments. Funding is increased for safety and maintenance activities and support of the LUX and Majorana demonstrator experiments at the Homestake Mine.	180,481

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Experimental Operations and Support	6,615	—	7,245
Fermilab Complex Operations			
Accelerator Operations	83,348	—	107,334
Detector and Computing	29,021	—	34,556
Other Complex Support	7,175	—	14,548
Total, Fermilab Complex Operations	119,544	—	156,438

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
B-Factory			
Accelerator Operations	2,839	—	3,000
Detector and Computing	6,892	—	1,600
Other Complex Support	300	—	0
Total, B-Factory	10,031	—	4,600
Homestake[a]	5,478	—	10,000
Other Facilities	2,176	—	2,198
Total, Facility Operations and Experimental Support	143,844	—	180,481

[a] Per a Memorandum of Understanding between DOE and NSF, HEP provided LHC detector operations funding ($4,022,000) to offset NSF contributions for Homestake Dewatering activities during the FY 2012 Continuing Resolution.

Projects

Overview

This activity supports the fabrication of major items of equipment for the Intensity Frontier subprogram. It also covers preconceptual R&D for new Intensity Frontier initiatives and the other project costs (OPC) of line item construction for the Intensity Frontier.

The Muon g-2 project is a new MIE in FY 2014. The project will utilize an existing muon storage ring from a previous experiment at BNL, but it will be located at Fermilab in order to utilize the high intensity proton beam.

The Belle-II Project is an MIE to build detector subsystems for the Belle-II detector at KEK.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The NOvA and MicroBooNE projects were in full fabrication. The Belle-II project received CD-1 approval and OPC funding was provided. FY 2012 was the last year of project funding for the Daya Bay Reactor Neutrino Project, CD-4 approval received August 20, 2012. Funding was provided for the LBNE and Mu2e OPC.	86,570
FY 2013	The FY 2013 Request proposed $61,337,000. FY 2013 is the final year for funding of both the NOvA and MicroBooNE projects. Funding for the Belle-II TEC begins in FY 2013. Also, funding is provided for the LBNE and Mu2e OPC.	—
FY 2014	The Muon g-2 project is a new MIE in FY 2014. Funding is also provided to continue Belle-II activities. Funding for the Mu2e OPC was completed in FY 2013. Preconceptual R&D for possible upgrade of the front-end of the Fermilab accelerator complex to significantly enhance the beam power is included. R&D for LBNE continues.	37,000

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Current			
MIE			
NOvA	41,240	—	0
MicroBooNE	6,000	—	0
Reactor Neutrino Detector at Daya Bay	500	—	0
Belle-II	1,030	—	8,000
Muon g-2	0	—	9,000
Total, MIE	48,770	—	17,000

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Line Item OPC			
LBNE	17,000	—	10,000
Mu2e	8,000	—	0
Total, Line Item OPC	25,000	—	10,000
Total, Current	73,770	—	27,000
Future Project R&D	12,800	—	10,000
Total, Projects	86,570	—	37,000

Cosmic Frontier Experimental Physics
Funding Profile by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	47,840	—	62,364
Facility Operations and Experimental Support	11,207	—	12,022
Projects	12,893	—	24,694
Total, Cosmic Frontier Experimental Physics	71,940	—	99,080

Overview

The Cosmic Frontier Experimental Physics subprogram supports the study of high energy physics through measurements of astrophysical phenomena. The activities in this subprogram use diverse tools and technologies, from ground-based telescopes and space-based probes to large detectors deep underground, to probe fundamental physics questions associated with naturally occurring phenomena.

Experiments in this subprogram can be classified into three main categories: searches for dark matter, studies of the nature of dark energy, and measurements of high-energy cosmic and gamma rays. Data collected will be used to determine answers to fundamental questions in particle physics, including:

- *How can we solve the mystery of dark energy?*

  Observations of supernovae suggest that, for approximately the last six billion years, the universe has been expanding at an accelerating rate due to a mysterious "dark energy" that overcomes gravitational attraction. This acceleration was discovered in 1998 as a result of observations made by HEP-supported researchers among others. The Nobel Prize in Physics in 2011 was awarded for the discovery of the acceleration of the expansion of the universe.

- *What is dark matter?*

  A wide variety of astronomical data all point to the existence of a new species of matter that does not have a place in the Standard Model of particle physics. This "dark matter", so-called because it does produce or reflect light, likely played a dominant role in the formation of structures in the Universe. "Direct-detection" experiments search for dark matter particles' rare interactions with atomic nuclei, while "indirect-detection" observatories search for signatures in high-energy cosmic particles.

Most of the experiments in this subprogram are done in partnership or coordination with other U.S. agencies and/or international partners. Some are carried out by providing the necessary instrumentation for use on telescope facilities or observatories belonging to other agencies or private institutions, and some are conducted in domestic or foreign underground laboratories. Partner federal institutions include NSF and NASA.

Explanation of Funding Changes

Overall, funding for Cosmic Frontier activities ramps up due to the increase for the Large Synoptic Survey Telescope (LSST) experiment camera (LSSTcam), and for facilities operations for dark energy and dark matter research. Experimental operations and research funding increase to support the increased activities in this area.

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
	(dollars in thousands)		
Research	47,840	62,364	+14,524
Funding for research activities increases to support pre-conceptual design efforts on new projects and data analysis for current and newly completed projects.			
Facility Operations and Experimental Support	11,207	12,022	+815
Funding for operations increases as the small experiments completed in recent years continue in their operating phase and the newly completed HAWC experiment begins its operating phase. The Dark Energy Survey experiment moves from commissioning into its fully operational phase.			
Projects	12,893	24,694	+11,801
Funding for Projects ramps up to support engineering and design for LSSTcam.			
Total, Cosmic Frontier Experimental Physics	71,940	99,080	+27,140

Research

Overview

The Cosmic Frontier experimental research program consists of groups at over 35 academic and research institutions and 7 national laboratories performing experiments at a wide variety of locations. As discussed in the Energy Frontier subprogram, these groups typically have a broad portfolio of responsibilities including experimental design, fabrication, operations and maintenance, led by the scientific collaborations, as well as computing and data analysis. HEP will conduct an external peer review of all laboratory research groups in this subprogram in 2013, and findings from this review will be used to inform the funding decisions in subsequent years. All research grants are selected using scientific peer review.

Ongoing research is supported on several small "first-generation" direct-detection dark matter experiments that implement a wide variety of cutting-edge particle detection technologies to identify the rare interactions of dark matter with ordinary matter. In parallel, research will be supported to enable "second-generation" dark matter (DM-G2) experiments that are expected to have at least 10 times the detection sensitivities of first-generation experiments.

The dark energy program uses several complementary observational methods to constrain the nature of this mysterious force that seems to pervade the universe. Ground-based telescopes are the primary tool used, often with specialized instrumentation for imaging or spectroscopic surveys. Research activities support the currently operating experiments, including the Baryon Oscillation Spectroscopic Survey (BOSS), the Dark Energy Survey (DES) which starts its science survey in FY 2014, and science studies in preparation for the LSST and other future experiments.

Studies of high energy gamma rays are being done by several experiments covering different energy ranges, including HAWC which starts its science operations in FY 2014. This data will be used to search for dark matter particles that decay to gamma rays. Data analysis continues on studies of cosmic rays using the Pierre Auger observatory in Argentina and the Alpha Magnetic Spectrometer (AMS) experiment on the International Space Station. AMS data will also be used for searches of dark matter and antimatter in the universe and will provide the world's largest data set on the energy, abundance and other properties of cosmic rays. Small efforts continue on studies of the properties of the early universe using cosmic microwave background measurements.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Support was provided for research on Cosmic Frontier experiments described above.	47,840
FY 2013	The FY 2013 Request proposed $49,107,000. The DES experiment starts data-taking. R&D is supported for the competitively selected DM-G2 experiments.	—
FY 2014	Data-taking is completed on BOSS, though data analysis continues. Scientific activities increase to support the LSSTcam, which ramps up its engineering and design efforts in FY 2014. Data analysis continues on other supported experiments.	62,364

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Grants	12,880	—	11,775
National Laboratories	34,960	—	47,065
Other Research	0	—	3,524
Total, Research	47,840	—	62,364

Facility Operations and Experimental Support

Overview

This activity supports the personnel, data processing, and other expenses necessary for the commissioning, maintenance, operations, and data production of Cosmic Frontier experiments. Many experiments have large multi-national collaborations and DOE's fraction of the support cost is based on the magnitude of U.S. roles and responsibilities. In addition, there are DOE-only experiments and partnerships with NSF and NASA. HEP conducted a scientific peer review of Cosmic Frontier operations in 2012. Findings from this and subsequent reviews are being used to inform decisions concerning the continuation of specific activities in subsequent years.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Support was provided for operations expenses for the Cosmic Frontier experiments, including DES for installation and commissioning phase and continued operations for BOSS, supernova surveys, and small dark matter experiments. Operations continued for the AMS and Pierre Auger cosmic ray experiments and the VERITAS and FGST high energy gamma ray experiments.	11,207
FY 2013	The FY 2013 Request proposed $9,376,000. The DES experiment begins its data-taking phase.	—
FY 2014	Data-taking ends for BOSS, with data processing and analysis expected to continue for another year. Some selected experiments will ramp down or end their DOE-supported operations activities this year, based in part on outcomes from the 2012 operations review. HAWC starts full scientific operations.	12,022

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Experimental Operations and Support	8,405	—	7,500
Other Facilities	2,802	—	4,522
Total, Facility Operations and Experimental Support	11,207	—	12,022

Projects

Overview

This activity supports all costs for design and fabrication of Cosmic Frontier projects, including major items of equipment (MIEs) and small experiments. The selection of projects is based on the HEPAP/P5 and the Particle Astrophysics Scientific Assesment Group (PASAG) report supplemented with advice from Federal Advisory Committees and National Academy panels followed by merit reviews of individual proposals. The Cosmic Frontier subprogram currently supports the fabrication of several MIEs. In FY 2012 fabrication was begun on the High Altitude Water Cerenkov (HAWC) project, which is designed to study TeV scale gamma and cosmic rays. In FY 2013, engineering and design funding ramps up for the DOE's responsibility on the LSST experiment, a 3 billion pixel camera (LSSTcam) with fabrication starting for long-lead procurements in FY 2014.

HEP issued a solicitation in FY 2012 for R&D proposals enabling next-generation dark matter (DM-G2) detectors. Successful proposals were funded for one year of R&D and pre-conceptual design work in FY 2013. Increased R&D funding in FY 2013 for DM-G2 experiments was requested to enable these efforts.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The HAWC MIE project began fabrication and the DES project ended its fabrication phase. Preliminary design studies continued for LSSTcam. R&D and fabrication support for small dark matter and other experiments continued.	12,893
FY 2013	The FY 2013 Request proposed $26,463,000. With these funds, the MIE funding for HAWC fabrication is completed. The increase in overall support is due to two efforts: ramp up of engineering and design for LSSTcam; and, support for R&D leading to second-generation dark matter (DM-G2) experimental concepts.	—
FY 2014	LSSTcam fabrication begins.	24,694

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Current			
MIE			
HAWC	1,500	—	0
Large Synoptic Survey Telescope (LSSTcam) Camera	5,500	—	22,000
Total, MIE	7,000	—	22,000
Other Projects	2,513	—	1,200
Total, Current	9,513	—	23,200
Future Project R&D	3,380	—	1,494
Total, Projects	12,893	—	24,694

Theoretical and Computational Physics
Funding Profile by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research			
Theory	55,929	—	51,196
Computational HEP	8,536	—	8,474
Total, Research	64,465	—	59,670
Projects	2,500	—	3,200
Total, Theoretical and Computational Physics	66,965	—	62,870

Overview

The Theoretical and Computational Physics subprogram provides the mathematical and phenomenological framework to understand and extend our knowledge of the dynamics of particles and forces, and the nature of space and time.

This subprogram supports theoretical research ranging from detailed calculations of the predictions of the Standard Model to the formulation and exploration of possible theories of new phenomena and the identification of experimental signatures that would validate these new ideas. This subprogram also supports computational approaches to advance understanding the fundamental physics of the HEP program, including computational science and simulations for scientific discovery and computing and software tools to enable and advance experimental and theoretical research at the three High Energy Physics frontiers.

Major research thrusts include the search for a more complete theory that goes beyond the Standard Model. In particular, theories that can explain why there are so many "fundamental" particles and forces; why (most of) these particles have mass; and the nature of dark matter and dark energy and how they relate to particle physics.

Explanation of Funding Changes

The Theoretical and Computational Physics subprogram is decreased compared to the FY 2012, consistent with the overall programmatic direction that provides more resources for investments in future facilities within overall budget constraints. Computational HEP activities are maintained with approximately constant funding.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	64,465	59,670	-4,795

This activity funds research at university and laboratory groups as well as activities in computational HEP and the Particle Data Group. Funding is reduced consistent with overall programmatic reductions in HEP Research activities, resulting in support for fewer researchers in this area.

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
	(dollars in thousands)		
Projects	2,500	3,200	+700
Increased funding is provided for the LQCD computational project according to its planned profile.			
Total, Theoretical and Computational Physics	66,965	62,870	-4,095

Theory

Overview

The HEP theory research activity supports groups at over 70 academic and research institutions supported by research grants. University research groups play leading roles in addressing the leading research areas discussed above. Research grant proposals are selected based on external peer review.

HEP theory research also currently supports physicists from 7 national laboratories focusing on data modeling and interpretation. This work helps to provide a clear understanding of the significance of measurements from ongoing experiments and assists in shaping and developing the laboratories' experimental high energy physics programs. Using the unique computing capabilities available at national laboratories, theory groups also make major contributions to the lattice quantum chromodynamics (LQCD) and computational cosmology efforts. HEP conducted an external peer-review of all laboratory research efforts in 2011, whose findings have been used to inform the funding decisions in this request.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding for theoretical research supported the ongoing program described above. Research efforts were selected based on comparative peer review to maintain the activities with the highest scientific impact and potential.	55,929
FY 2013	The FY 2013 Request proposed $54,406,000 to support the ongoing program described above, at a somewhat reduced level-of-effort.	—
FY 2014	Funding for theoretical research supports the ongoing program described above, at a reduced level of effort. Research efforts will be selected based on comparative peer review to maintain the activities with the highest scientific impact and potential.	51,196

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Grants	27,746	—	24,123
National Laboratories	24,720	—	24,340
Other Research	3,463	—	2,733
Total, Theory	55,929	—	51,196

Computational HEP

Overview

Scientific computing, simulation, and computational science expertise are critical for the success of the HEP mission. Along with experiment and theory, computation is one of the primary paths forward in our understanding the nature of matter and the universe through the Energy, Intensity, and Cosmic Frontiers. Computation is necessary at all stages of an experiment—from planning and constructing accelerators and detectors, to theoretical modeling, to supporting computationally intensive experimental research, and large-scale data and data analysis. In addition, scientific simulation and advanced computing help extend the boundaries of scientific discovery to regions not directly accessible by experiments, observations, or traditional theory.

Computational HEP supports research in two broad categories: collaborations providing crucial computational tools and techniques to specific targeted HEP research topics and scientific computing infrastructure supporting the broader HEP community. The Scientific Discovery through Advanced Computing (SciDAC) program generally supports the first category and the Scientific Computing category supports the latter. The SciDAC portfolio focuses on computational science research requiring leadership class computing to solve fundamental science questions and computing research funded via partnerships. Scientific Computing supports computing R&D, frameworks, networks, data resources, and related infrastructure and expertise at the laboratories; and community software.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The SciDAC Program was re-competed jointly with the Advanced Scientific Computing Research program in FY 2012 as SciDAC 3 and some other partnerships with ASCR were funded. Distributed computing and data tools for LHC experiments were funded in partnership with NSF along with some Proof of Concept Scientific Computing projects.	8,536
FY 2013	The FY 2013 Request proposed $8,112,000. With these funds, SciDAC and other collaborative projects continue. A limited number of new research and R&D initiatives in computational HEP will be supported.	—
FY 2014	SciDAC projects will be reviewed for progress toward their milestones in accelerator modeling, computational cosmology, and lattice QCD algorithm and software development. Programmatic emphasis may be modified based on the outcomes of this review. Other computational activities will continue at approximately the FY 2012 level of effort.	8,474

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
SciDAC	4,794	—	4,916
Scientific Computing	3,742	—	3,558
Total, Computational HEP	8,536	—	8,474

Projects

Overview

The Projects activity funds dedicated hardware for the Lattice QCD (LQCD) computing initiative in partnership with the Office of Nuclear Physics.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding was provided for the LQCD computational project.	2,500
FY 2013	The FY 2013 Request ($2,500,000) is in accordance with the project's approved baseline.	—
FY 2014	Funding continues according to the approved baseline.	3,200

Advanced Technology R&D
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research			
HEP General Accelerator R&D	59,280	—	57,856
HEP Directed Accelerator R&D	46,587	—	23,500
Detector R&D	28,139	—	23,947
Total, Research	134,006	—	105,303
Facility Operations and Experimental Support	23,100	—	17,150
Total, Advanced Technology R&D	157,106	—	122,453

Overview

The Advanced Technology R&D subprogram fosters world-leading research in the physics of particle beams, accelerator research and development (R&D), and particle detection—all necessary for continued progress in high energy physics. New developments are stimulated and supported through proposal driven, peer reviewed research. This subprogram supports and advances research at all three Frontiers.

Advanced Technology R&D comprises both HEP programmatic mid-term and long-term R&D on accelerator and beam physics areas. Long-term multi-purpose accelerator research, applicable to fields beyond HEP, is carried out under the Accelerator Stewardship subprogram.

HEP General Accelerator R&D focuses on understanding the science underlying the technologies used in particle accelerators and storage rings, as well as the fundamental physics of charged particle beams. Long-term research goals include developing technologies to enable breakthroughs in particle accelerator size, cost, beam intensity, and control.

HEP Directed Accelerator R&D supports innovative technologies for possible future HEP accelerator projects, with proof-of-principle demonstrations, prototype component development, and other milestones advancing technical readiness. Research efforts within this activity are generally limited in time and have concrete milestones. For FY 2014, there are two components of the HEP Directed Accelerator R&D activity: LHC Accelerator Research Program (LARP) and the Muon Accelerator Program (MAP).

Detector R&D addresses the need for continuing development of the next generation instrumentation and detectors at the Energy, Intensity, and Cosmic Frontiers. New instrumentation and detectors must be developed with increased capabilities while keeping the cost and time from conception to operation at a minimum. To meet these challenges, HEP actively supports investment in innovative, generic instrumentation and detector research.

Facility Operations and Experimental Support provides operations funding for user facilities like the Facility for Advanced Accelerator Experimental Tests (FACET) as well laboratory experimental and test facilities. The Berkeley Lab Laser Accelerator (BELLA) facility and the Superconducting Radio-Frequency (SRF) infrastructure at Fermilab fall into these categories.

Explanation of Funding Changes

Overall funding for this subprogram is reduced due to redirection of long-term accelerator R&D with broader applications to the Accelerator R&D Stewardship subprogram, the reduction of liquid argon detector R&D as this effort moves to LBNE-related research, and completion of funding for the development of the SRF Infrastructure at Fermilab.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	134,006	105,303	-28,703
The major driver of the decrease in funding is the completion of the R&D program for the International Linear Collider and redirection of selected long-term accelerator R&D to the Accelerator R&D Stewardship subprogram. Funding in other program components will support research with FACET, the electron-beam driven plasma wakefield accelerator test facility at SLAC, and BELLA, the laser driven plasma wakefield accelerator facility at LBNL. Other activities are maintained at approximately the FY 2012 level-of-effort.			
Facility Operations and Experimental Support	23,100	17,150	-5,950
The decrease reflects the final increments of funding for development of the SRF Infrastructure at Fermilab. Operation of the SRF processing and test facilities is supported.			
Total, Advanced Technology R&D	157,106	122,453	-34,653

HEP General Accelerator R&D

Overview

This activity supports research at 8 DOE national laboratories and about 30 academic or other research institutions. Funding is awarded based on external peer reviews. The program also trains new accelerator physicists with approximately 50 graduate students supported per year and supports the U.S Particle Accelerator School, which is held twice a year at rotating institutions to bring accelerator physics classes to students and practicing accelerator physicists who do not have regular access to such training.

Research efforts are also focused on the long-range development of new accelerating structures and techniques needed to achieve very high accelerating gradients. There are three different facilities to study wakefield acceleration techniques. At Argonne, the wakefields are created in a dielectric, while at LBNL and SLAC the wakefields are created in plasmas using a laser (BELLA) and electron beam (FACET) respectively. Normal conducting high gradient structures are tested at SLAC.

Research activities supported include: improving properties of advanced superconducting materials and magnet technology including niobium-tin and high temperature superconductors; studies of surface physics affecting the performance of SRF cavities to achieve higher accelerating gradients and/or quality factors; and a broad program on the physics of beams including numerical simulations and modeling. These efforts develop concepts and technology needed to realize the higher energy and intensity accelerators needed by the HEP program.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Supported major accelerator R&D efforts at national laboratories and universities as described above, including the first user run at FACET to study beam driven plasma wakefields.	59,280
FY 2013	The FY 2013 Request proposed $64,942,000 to support major accelerator R&D efforts at national laboratories and universities at approximately the FY 2012 level of effort. Increased funding was requested to support optimal utilization of the FACET plasma wakefield accelerator facility at SLAC. Research begins with the laser driven plasma wakefields using BELLA.	—
FY 2014	Support for ongoing major accelerator R&D efforts at national laboratories and universities in this subprogram continue at approximately FY 2012 level-of-effort. Decreased funding reflects redirection of selected long-term, grant-based R&D to the Accelerator Stewardship subprogram.	57,856

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Grants	10,729	—	7,896
National Laboratories	48,550	—	45,960
Other Research	1	—	4,000
Total, HEP General Accelerator R&D	59,280	—	57,856

HEP Directed Accelerator R&D

Overview

This activity demonstrates the feasibility of HEP accelerator concepts and technical approaches on an engineering scale. This includes R&D and prototyping to bring new concepts to a stage of engineering readiness where they can be incorporated into existing facilities or be applied to the design of new facilities. The efforts that comprise this activity are the LHC Accelerator Research Program (LARP) and the Muon Accelerator Program (MAP). The research program for the International Linear Collider was completed in FY 2012 and the Technical Design Report (TDR) was delivered in FY 2013.

The work is primarily done at four national laboratories and seven universities. The major areas of R&D are superconducting magnet and related materials technology; beam cooling and instrumentation; normal and superconducting accelerator systems; beam dynamics; and development of large simulation programs. The latter effort is coordinated with the SciDAC accelerator simulation project.

The LARP program supports superconducting magnet and accelerator instrumentation development needed to increase the luminosity at the Large Hadron Collider (LHC).

The MAP R&D plan for muon-based accelerators includes milestones and deliverables aimed at demonstrating the advanced technologies needed to realize muon-based accelerators for future muon colliders and neutrino factories. These programs are peer reviewed annually to evaluate the scientific quality of their work, progress against their milestones, and performance of the program management at the national laboratories.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Supported major directed R&D efforts as discussed above. In addition, FY 2012 was the last year of funding the ILC R&D program.	46,587
FY 2013	The FY 2013 Request proposed $23,090,000 to support major directed R&D efforts as discussed above. The completion of the Technical Design Report concludes the five-year ILC R&D program. No funds were requested for the ILC R&D program in FY 2013.	—
FY 2014	MAP and LARP are the only activities in this category supported in FY 2014 and they are funded at a constant level of effort. LARP will be developing prototype superconducting quadrupole magnets with large apertures needed to increase luminosity at the LHC. MAP will be studying the operation of RF accelerating cavities in magnetic fields, a critical technology for the collection of muons into beams usable in an accelerator.	23,500

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
LHC Accelerator Research	12,390	—	11,500
International Linear Collider	21,497	—	0
Muon Accelerators	12,700	—	12,000
Total, HEP Directed Accelerator R&D	46,587	—	23,500

Detector R&D

Overview

The Detector R&D activity addresses fundamental scientific challenges in particle detection, measurement, and data processing and provides support for developing and prototyping detector systems to bring the technologies to maturity and be incorporated into future particle physics experiments.

This activity is supported at 5 national laboratories and 25 universities. Efforts supported tend to be "generic" detector development with the potential for wide applicability and/or high-payoff. Research grants are selected using external peer review. Research groups work on a range of new technologies, including: silicon strip and pixel trackers that can work in high radiation environments and accommodate prodigious data rates; techniques for increasing the energy and directional sensitivities in neutrino detectors using new detector media (such as liquid argon) while significantly reducing their cost; and developing ever more sensitive charge-coupled devices (CCD) for telescope cameras.

Notable recent projects include research in producing a photo-detector with large area coverage but compact and inexpensive readout and the development of an inexpensive solvent to add to water to make it scintillate (emit light) in the presence of high energy charged particles. This work on the large area photo-detector was carried out at ANL and received an R&D 100 award in 2012. HEP conducted an external peer review of all laboratory research groups in this activity in 2012, and findings from this review are used to inform subsequent funding decisions.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding enabled a broad research program in advanced detector concepts and related technologies as noted above. New awards were made for successful proposals in response to a targeted funding opportunity announcement for Collider Detector Research and Development.	28,139
FY 2013	The FY 2013 Request proposed $29,856,000 to continue support of Detector R&D efforts, with selection of activities based in part on findings from the review of the laboratory research program in 2012. Funding is increased to support the ramp up of funding for new detector R&D activities. Emphasis will shift towards the R&D needs of Intensity Frontier experiments such as liquid argon detector development.	—
FY 2014	Funding for liquid argon detector R&D is reduced.	23,947

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Grants	2,944	—	3,206
National Laboratories	25,195	—	20,741
Total, Detector R&D	28,139	—	23,947

Facility Operations and Experimental Support

Overview

BELLA, FACET, and the SRF infrastructure at Fermilab are now transitioning into their operation phase to support user experiments and testing. FACET, an accelerator R&D user facility, supports experiments driven by its high-energy, ultrashort electron beam, including plasma wakefield acceleration, dielectric wakefield acceleration, terahertz radiation generation, beam diagnostics, and ultra fast magnetic switching in materials. In 2012, FACET had its first user run for eight peer-reviewed experiments conducted by 50 users from 16 institutions.

The BELLA laser-driven accelerator test facility supports research carried out by LBNL staff and their collaborators. Funding from this subprogram covers the operations and maintenance of the facility.

The Fermilab SRF Infrastructure supports the processing and testing of individual SRF cavities and modules of assembled cavities. The SRF infrastructure includes: cleaning systems, clean room assembly areas, cryogenic systems, RF power generation and distribution, instrumentation, and beam sources which can be used for the development of SRF cavities and modules for future accelerators and research on the performance of such cavities.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Supported facility operations, commissioning and experimental supports at FACET, BELLA, and the SRF Infrastructure at Fermilab.	23,100
FY 2013	The FY 2013 Request proposed $23,700,000 to continue support of facility operations, commissioning and experimental supports at FACET and BELLA. Funding for FACET operation is increased, while commissioning support for the Fermi SRF infrastructure is reduced.	—
FY 2014	Support for activities at FACET and BELLA is held constant. Funding for the SRF Infrastructure is decreased as this facility transitions to operation.	17,150

Accelerator Stewardship
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	0	—	6,581
Facility Operations and Experimental Support	2,850	—	3,350
Total, Accelerator Stewardship	2,850	—	9,931

Overview

This subprogram supports long-term accelerator R&D that underpins future accelerator concepts and technologies for applications that may extend beyond high energy physics. HEP manages this program in consultation with other programs in the Office of Science that develop and build particle accelerators.

HEP and other Office of Science programs will continue to conduct programmatic near- and mid-term R&D on accelerator and beam physics issues related to the scientific facilities they operate. This subprogram is not intended to replace those directed R&D efforts, which are driven by program-specific goals and priorities.

The need for a national, coordinated program has been highlighted by past advisory committee reports, the Accelerators for America's Future workshop in late 2009, language in the FY 2012 Congressional appropriation bill report, and a subsequent community task force that provided input[a] on specific R&D topics that could benefit from a sustained and coordinated approach that reaches out to accelerator users beyond the traditional HEP community. This budget request has been formulated using that input.

The research supported by this subprogram, together with making available laboratory accelerator test facilities and infrastructure for non-HEP users and providing increased support at beam test facilities, will help advance applications in energy and the environment, medicine, industry, national security, and discovery science.

Research activities are grouped into eight areas: superconducting radio frequency (SRF); new accelerator concepts; accelerator, beam, and computational physics; superconducting magnets; normal-conducting, high-gradient accelerator structures; particle sources; beam instrumentation and control; and RF sources.

Explanation of Funding Changes

This subprogram was created as part of the HEP budget restructuring effort in FY 2013. This subprogram captures HEP Accelerator R&D efforts that would be appropriately reclassified as Accelerator Stewardship activities, including university-based research, national laboratory research, and operations of existing accelerator test facilities that can provide access to users conducting research on accelerator stewardship topics. Prior year funding that would have been classified as supporting Accelerator Stewardship activities has been estimated.

[a] http://www.acceleratorsamerica.org/report/accelerator_task_force_report.pdf

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	0	6,581	+6,581
Reclassification of research activities identified as Accelerator Stewardship efforts, which benefit areas broader than HEP.			
Facility Operations and Experimental Support	2,850	3,350	+500
Provides a modest increase in support for FACET Operations for stewardship research.			
Total, Accelerator Stewardship	2,850	9,931	+7,081

Research

Overview

This research category supports activities that have been identified for applications in areas broader than just HEP. Research is conducted at national laboratories and universities. The stewardship program focuses on long-term accelerator R&D that promotes scientific innovations to enable breakthroughs in particle accelerator size, cost, beam intensity, and control. Research topics include superconducting radio frequency (SRF); new accelerator concepts; accelerator, beam, and computational physics; superconducting magnets; normal-conducting, high-gradient accelerator structures; beam instrumentation and control; particle sources; and RF sources. This activity incorporates the research program of approximately 20 university grants in advanced accelerator science, beam physics and related technologies that had previously been supported under Advanced Technology R&D.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Based upon an internal Office of Science review, a number of activities are moved into the Accelerator Stewardship subprogram because of their potential applicability beyond the HEP program. The activities include accelerator R&D efforts at national laboratories: beam physics and accelerator modeling and computation at SLAC and PPPL.	6,581

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Grants	0	—	5,481
National Laboratories	0	—	1,100
Total, Research	0	—	6,581

Facility Operations and Experimental Support

Overview

The Accelerator R&D Stewardship subprogram supports facility operations and experimental support at the Accelerator Test Facility (ATF) at BNL. Experiments at ATF are studying the interactions of high power electromagnetic radiation and high brightness electron beams, including free-electron lasers and laser acceleration of electrons and the development of electron beams with extremely high brightness, photo-injectors, electron beam and radiation diagnostics and computer controls. During FY 2012, 34 users from 12 institutions set up and conducted a total of eleven experiments and received a total of 188 run-days.

This stewardship subprogram also provides incremental support for the Facility for Accelerator Science and Experimental Test Beams (FACET) at SLAC.

Experiments at these facilities are selected using a peer review process managed by the laboratories.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Supported facility operation at the ATF.	2,850
FY 2013	The FY 2013 Request proposed $2,900,000 to support facility operations at the ATF.	—
FY 2014	Supports facility operation at the ATF and modest incremental support for FACET Operations for stewardship research.	3,350

SBIR/STTR
Funding Profile by Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
SBIR/STTR[a]	0	—	21,457

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $17,915,000 and STTR $2,412,000 (transferred out of HEP in FY 2012 Current column)
- FY 2014 Request: SBIR $18,775,000 and STTR $2,682,000

Overview

SBIR/STTR funding is set at 3.2% of non-capital funding in in FY 2014. The FY 2012 funding was set at 2.95%.

Explanation of Funding Changes

The SBIR/STTR amount is adjusted to mandated percentages for non-capital funding.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
SBIR/STTR	0	21,457	+21,457

In FY 2012, $17,915,000 and $2,412,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology (STTR) programs, respectively. SBIR/STTR funding is set at 3.2% of non-capital funding in FY 2014. FY 2012 was set at 2.95%.

Construction
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Long Baseline Neutrino Experiment	4,000	4,025	0
Muon to Electron Conversion Experiment	24,000	24,147	35,000
Total, Construction	28,000	28,172	35,000

Overview

The Muon to Electron Conversion Experiment (Mu2e) will be built at Fermilab and is an important component of the Intensity Frontier subprogram. It will utilize a proton beam to produce muons to study their conversion to electrons in order to determine if charged leptons can change identity in flight like neutrinos do. This process is forbidden In the Standard Model, so observation of events of this type would be a clear signal of new physics.

The Mu2e cost estimate has been revised and CD-1 was approved on July 11, 2012. Preliminary engineering design for Mu2e has commenced. The PED funds requested in FY 2013–2014 will be used to complete the engineering design, and the construction funds requested in FY 2014 will be used to initiate long-lead procurement of technical materials in order to reduce cost and schedule risk. The project is planned to be baselined (CD-2) in FY 2014.

The HEP program has been developing the Long Baseline Neutrino Experiment (LBNE) project, with the Homestake Mine in South Dakota as a possible site for a far detector. The National Science Foundation was a potential partner in development and operations of the LBNE far detector but has chosen not to participate. During FY 2011 and early FY 2012, DOE worked to refine the scientific scope that can be achieved by DOE alone. In the spring of 2012, the Daya Bay Reactor Neutrino experiment, a U.S.-China collaboration reported a new measurement of an important (and previously unknown) neutrino parameter that determines the physics “reach” of experiments such as LBNE. Original LBNE designs had accommodated a value as much as ten times smaller than that reported by the Daya Bay collaboration, requiring much larger detectors to be certain of achieving physics goals. Knowledge of this parameter has allowed the current LBNE conceptual design to be re-optimized. The LBNE project team developed a conceptual design during FY 2012 that includes a new neutrino beam at Fermilab pointed at the Homestake Mine in South Dakota and an approximately 10 kiloton liquid argon detector on the surface at Homestake. This conceptual design received CD-1 approval on December 10, 2012. DOE is continuing to review this project mindful of ongoing community planning exercises.

Explanation of Funding Changes

The increase of PED funding for Mu2e takes into account the planned profiles. Mu2e and LBNE received PED funding in FY 2012.

Construction funding for Mu2e will increase in FY 2014 as construction (TEC) funding replaces the FY 2012 PED and OPC/R&D funding.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Long Baseline Neutrino Experiment	4,000	0	-4,000

No PED is requested in FY 2014.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Muon to Electron Conversion Experiment	24,000	35,000	+11,000
Funding is provided for continuing project engineering and design activities and to initiate long-lead procurements and construction.			
Total, Construction	28,000	35,000	+7,000

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Capital equipment over $500,000, including major items of equipment (MIEs)	63,295	—	50,222
General plant projects (GPP) (under $10 million)	7,475	—	14,548
Accelerator improvement projects (AIP)	0	—	6,200
Total, Capital Operating Expenses	70,770	—	70,970

Capital Equipment over $500,000 (including MIEs)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Major items of equipment (TEC over $2 million)					
Intensity Frontier Experimental Physics					
NOνA					
TEC	204,468	143,748	41,240	—	0
OPC	73,532	73,532	0	—	0
TPC	278,000	217,280	41,240	—	0
MicroBooNE[a]					
TEC	14,760	2,903	6,000	—	0
OPC	5,140	5,140	0	—	0
TPC	19,900	8,043	6,000	—	0
Reactor Neutrino Detector at Daya Bay					
TEC	32,700	32,200	500	—	0
OPC	2,800	2,800	0	—	0
TPC	35,500	35,000	500	—	0

[a] The MicroBooNE Project received CD-2/3a approval for its performance baseline and long-lead procurements on September 27, 2011. CD-3b approval for all fabrication was on March 29, 2012. The TPC is $19,900,000.

	(dollars in thousands)				
	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Belle-II[a]					
TEC	10,970	0	0	—	8,000
OPC	5,030	0	1,030	—	0
TPC	16,000	0	1,030	—	8,000
Muon g-2 Experiment[b]					
TEC	32,150	0	0	—	2,000
OPC	7,850	0	0	—	7,000
TPC	40,000	0	0	—	9,000
Cosmic Frontier Experimental Physics					
HAWC[c]					
TEC	3,000	0	1,500	—	0
OPC	0	0	0	—	0
TPC	3,000	0	1,500	—	0
Large Synoptic Survey Telescope (LSSTcam) Camera[d]					
TEC	160,800	0	0	—	22,000
OPC	12,200	1,900	5,500	—	0
TPC	173,000	1,900	5,500	—	22,000
Total MIEs					
TEC			49,240	—	32,000
OPC			6,530	—	7,000
TPC			55,770	—	39,000
Other capital equipment projects under $2 million TEC			14,055	—	18,222
Total, Capital equipment (excludes MIE OPC)			63,295	—	50,222

[a] This project is not yet baselined. Critical Decision CD-1 for the Belle-II Project's Conceptual Design was approved on September 18, 2012. Initial long-lead procurement was approved (CD-3a) on November 8, 2012.

[b] Critical Decision CD-0 for the Muon g–2 Project was approved on September 18, 2012. The TPC range is $30,000,000 to $60,000,000.

[c] The HAWC project falls below the $10,000,000 TPC threshold that requires a CD-0. The TPC as well as the OPC/TEC split may change.

[d] This project is not yet baselined and the OPC/TEC split is not yet determined. This project received CD-1 on April 12, 2012.

Intensity Frontier Experimental Physics MIEs:

The *NuMI Off-axis Neutrino Appearance (NOνA) Project* will use the NuMI beam from Fermilab to directly observe and measure the transformation of muon neutrinos into electron neutrinos over a distance of 810 km (500 miles). The project also includes improvements to the Fermilab proton accelerator to increase the intensity of the neutrino NuMI beam to the detector in Ash River, Minnesota. The occurrence of neutrino flavor changes is expected to be much rarer than the phenomenon under study with MINOS. The baseline was approved in September 2008 with a TPC of $278,000,000. A total of $55,000,000 was provided under the Recovery Act to advance the project. Funding planned for the outyears was reduced to maintain the TPC. The NOvA Project will complete fabrication in FY 2014.

The MicroBooNE Project Fabrication began in FY 2012. This project will build a multi-hundred ton liquid-argon neutrino detector to be used in the Booster neutrino beam at Fermilab for the measurement of low energy neutrino cross-sections. These cross sections will be measured at lower neutrino energy than MINERνA and will be important for future neutrino oscillation experiments such as T2K. This experiment will also be an important demonstration of the efficacy of large-scale liquid argon time projection chambers as neutrino detectors. This is a new technology with improved track resolution and background discrimination.

Reactor Neutrino Detector, located in Daya Bay, China, has been fabricated in partnership with research institutes in China. This experiment uses anti-neutrinos produced by commercial power reactors to measure a fundamental parameter to help resolve ambiguities in neutrino properties and help set future directions of neutrino research. The TPC is $35,500,000. An Independent Project Review for CD-4B has been conducted and CD-4B was approved August 20, 2012. Data-taking began December 2010 with a subset of the detectors and an important, world-leading measurement of the oscillation properties of electron antineutrinos was published in March 2012.

The *Belle-II Project* will fabricate detector subsystems for the upgraded Belle detector located at the Japanese B-Factory, which is currently being upgraded to deliver higher luminosity. This project is not yet baselined. Critical Decision CD-1 for the Conceptual Design was approved on September 18, 2012. Initial long-lead procurement was approved (CD-3a) on November 8, 2012. The TPC range is $12,000,000 to $16,000,000.

The *Muon g-2 Project* is a new MIE in FY 2014. This experiment seeks to improve the measurement of the muon anomalous magnet moment, which is sensitive to new physical interactions such as supersymmetry. The project will utilize a storage ring from a previous experiment at Brookhaven National Laboratory with upgraded detectors to be located at Fermilab in order to utilize the high intensity proton beam available there to produce the needed muons. Critical Decision CD-0 was approved on September 18, 2012. The preliminary estimated cost range for this project is $30,000,000 to $60,000,000. FY 2014 funding will fully fund project design, the transfer of the BNL storage rings to Fermilab and the testing and reassembly of those rings.

Cosmic Frontier Experimental Physics MIEs:

The *High Altitude Water Cherenkov (HAWC)* detector is an experiment in Mexico that will survey the sky for sources of TeV gamma-rays in the 10–100 TeV range. HAWC's wide field of view and continuous duty cycle will provide unique capabilities that are complementary to other gamma-ray experiments. The project is being carried out in collaboration with NSF and Mexican research institutes. MIE funding for the fabrication started in FY 2012. The total DOE cost is $3,000,000 and the estimated completion date is in FY 2014.

The *Large Synoptic Survey Telescope Camera (LSSTcam*) is a digital camera for a next-generation, wide-field, ground-based optical and near-infrared observatory, located in Chile, and is designed to provide deep images of half the sky every few nights. It will open a new window on the universe and address a broad range of astronomical topics with an emphasis on enabling precision studies of the nature of dark energy. LSST was identified by the National Research Council's (NRC) Astro2010 decadal survey panel as its highest priority ground-based astrophysics initiative. The project is carried out in collaboration with NSF, along with private and foreign contributions. DOE will provide the camera for the facility. CD-1 for the LSSTcam project was approved in April 2012, with an estimated total DOE cost range of $120,000,000–$175,000,000 and estimated completion date of FY 2021.

General Plant Projects (GPP) (TEC under $10 million)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Liquid Argon Test Facility	6,583	69	4,347	—	2,167
MC-1 Building	9,000	0	500	—	1,000
Muon Campus Beamline Enclosure	9,700	0	0	—	3,700
Other projects under $5 million TEC	n/a	n/a	2,628	—	7,681
Total, General Plant Projects (GPP)			7,475	—	14,548

Accelerator Improvement Projects (AIP)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Muon Campus Cryogenics	8,800	0	0	—	4,200
Recycler RF Upgrades	8,100	0	0	—	1,000
Other projects under $5 million TEC	n/a	n/a	0	—	1,000
Total, AIP			0	—	6,200

Construction Project Summary

Construction Projects

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Long Baseline Neutrino Experiment					
TEC	TBD	0	4,000	4,025	0
OPC	TBD	34,434	17,000	—	10,000
TPC	TBD	34,434	21,000	—	10,000
Muon to Electron Conversion Experiment					
TEC	223,000	0	24,000	24,147	35,000
OPC	26,177	13,177	8,000	8,049	0
TPC	249,177	13,177	32,000	32,196[a]	35,000
Total, Construction					
TEC			28,000	28,172	35,000
OPC			25,000	—	10,000
TPC			53,000	—	45,000

Construction Project Outyears

(dollars in thousands)

	FY 2015	FY 2016	FY 2017	FY 2018	Outyears to Completion
Muon to Electron Conversion Experiment					
TEC/TPC	32,000	44,000	45,000	23,000	0

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC, and TPC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $25,000,000 ($20,000,000 TEC and $5,000,000 OPC) is assumed instead.

Other Supporting Information

Funding Summary

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	391,329	—	383,609
Facilities Operations			
Scientific User Facilities Operations	201,921	—	226,812
Other Facilities	45,788	—	43,186
Total, Facilities Operations	247,709	—	269,998
Projects			
Major Items of Equipment	55,770	—	39,000
Other Projects	21,193	—	15,894
Construction[a]	53,000	—	45,000
Total, Projects	129,963	—	99,894
Other	1,532	—	23,020
Total, High Energy Physics	770,533	—	776,521

Scientific User Facility Operations

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Fermilab Accelerator Complex	119,544	—	156,438
FACET	7,500	—	9,000
B-Factory	10,031	—	4,600
LHC Detector Support and Operations	64,846	—	56,774
Total, Scientific User Facilities Operations	201,921	—	226,812

[a] Includes Other Project Costs funding for LBNE and Mu2e.

Facilities Users and Hours

	FY 2012 Actual	FY 2013 Annualized CR Estimate	FY 2014 Request Estimate
Fermilab Accelerator Complex[a]			
Achieved operating hours	4,236	—	N/A
Planned operating hours	2,650	—	4,500
Optimal hours (estimated)	2,650	—	4,500
Percent of optimal hours	159.8%	—	100%
Unscheduled downtime percentage	N/A	—	N/A
Total number of users	1,400	—	1,400
FACET			
Achieved operating hours	2,363	—	N/A
Planned operating hours	2,380	—	2,800
Optimal hours (estimated)	2,800	—	2,800
Percent of optimal hours	84.4%	—	100%
Unscheduled downtime percentage	N/A	—	N/A
Total number of users	48	—	48
B-Factory			
Total number of users	200	—	100
Total Facilities			
Achieved operating hours	6,599	—	N/A
Planned operating hours	5,030	—	7,300
Optimal hours (estimated)	5,450	—	7,300
Percent of optimal hours (funding weighted)	155.4%	—	100%
Unscheduled downtime percentage	N/A	—	N/A
Total number of users	1,648	—	1,548

[a] Only NuMI runs FY 2012 and beyond.

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	225	—	280
Number of laboratory groups	45	—	40
Number of permanent Ph.D.'s (FTEs)	1,045	—	955
Number of postdoctoral associates (FTEs)	450	—	410
Number of graduate students (FTEs)	555	—	490
Number of Ph.D.'s awarded	105	—	105

High Energy Physics
Funding Profile by Subprogram and Activity

Non-Comparable Structure[a]

	(dollars in thousands)	
	FY 2012 Current	FY 2014 Request
Proton Accelerator-Based Physics		
Research	126,562	0
Facilities	296,170	0
Total, Proton Accelerator-Based Physics	422,732	0
Electron Accelerator-Based Physics		
Research	10,816	0
Facilities	11,061	0
Total, Electron Accelerator-Based Physics	21,877	0
Non-Accelerator Physics		
Research	70,000	0
Projects	13,393	0
Total, Non-Accelerator Physics	83,393	0
Theoretical Physics		
Research		
Grants Research	27,746	0
National Laboratory Research	24,720	0
Computational HEP	11,036	0
Other	3,463	0
Total, Theoretical Physics	66,965	0
Advanced Technology R&D		
Accelerator Science	42,459	0
Accelerator Development	76,968	0
Other Technology R&D	28,139	0
Total, Advanced Technology R&D	147,566	0

[a] The Office of Science received OMB and Congressional approval to restructure the High Energy Physics program. The execution initiated in FY 2013; the FY 2014 Budget Request is the initial presentation. The restructure aligns with the long-range plan developed by the HEPAP subpanel, Particle Physics Project Prioritization Panel, in their report *U.S. Particle Physics: Scientific Opportunities A Strategic Plan for the Next Ten Years*.

	(dollars in thousands)	
	FY 2012 Current	FY 2014 Request
Energy Frontier Experimental Physics		
Research	0	96,129
Facility Operations and Experimental Support	0	58,558
Total, Energy Frontier Experimental Physics	0	154,687
Intensity Frontier Experimental Physics		
Research	0	53,562
Facility Operations and Experimental Support	0	180,481
Projects	0	37,000
Total, Intensity Frontier Experimental Physics	0	271,043
Cosmic Frontier Experimental Physics		
Research	0	62,364
Facility Operations and Experimental Support	0	12,022
Projects	0	24,694
Total, Cosmic Frontier Experimental Physics	0	99,080
Theoretical and Computational Physics		
Research		
Theory	0	51,196
Computational HEP	0	8,474
Total, Research	0	59,670
Projects	0	3,200
Total, Theoretical and Computational Physics	0	62,870
Advanced Technology R&D		
Research		
HEP General Accelerator R&D	0	57,856
HEP Directed Accelerator R&D	0	23,500
Detector R&D	0	23,947
Total, Research	0	105,303
Facility Operations and Experimental Support	0	17,150
Total, Advanced Technology R&D	0	122,453
Accelerator Stewardship		
Research	0	6,581
Facility Operations and Experimental Support	0	3,350

	(dollars in thousands)	
	FY 2012 Current	FY 2014 Request
Total, Accelerator Stewardship	0	9,931
SBIR/STTR	0	21,457
Subtotal, High Energy Physics	742,533	741,521
Construction		
Long Baseline Neutrino Experiment	4,000	0
Muon to Electron Conversion Experiment	24,000	35,000
Total, Construction	28,000	35,000
Total, High Energy Physics[a]	770,533	776,521

[a] SBIR/STTR funding:

- FY 2012 Appropriation: SBIR $17,915,000 and STTR $2,412,000 (transferred out of HEP in FY 2012 Current column)
- FY 2014 Request: SBIR $18,775,000 and STTR $2,682,000

11-SC-41, Muon to Electron Conversion Experiment (Mu2e), Fermi National Accelerator Laboratory, Batavia, Illinois Project Data Sheet (PED and Construction)

1. Summary and Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-1 that was approved on July 11, 2012 with a preliminary cost range of $200,000,000–$310,000,000 and CD-4 of FY 2021.

A Federal Project Director has been assigned to this project.

This Project Data Sheet is for PED and construction. It does not include a new start for the Budget Year.

This PDS is an update of the FY 2013 PDS.

The initial cost estimate developed in FY 2011 was deemed too high for proceeding to CD-1, and the project team was charged with developing a scope with a lower cost. The effort was completed successfully and CD-1 was approved on July 11, 2012. The lower-cost scope has one-third the proton beam power which enables a significantly simpler configuration of accelerators and beam lines, eliminates entirely the use of the Fermilab Accumulator Ring and permits the Accumulator Ring's existing electromagnets to be reused elsewhere at great cost savings for the project, and significantly reduces the amount of concrete shielding necessary for radiation protection.

This budget Request supports the continuation of the preliminary engineering design phase for setting the project performance baseline (with CD-2) during FY 2014. Critical Decision CD-3A is planned for initiating advance procurements in FY 2014 consisting of superconducting solenoid magnet conductor, solenoid prototypes and site preparation work, using construction and/or PED funds.

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	PED Complete	CD-2	CD-3A	CD-3B	CD-4	D&D Start	D&D Complete
FY 2011	11/24/2009	4Q FY 2010	4Q FY 2012	TBD	N/A	TBD	TBD	TBD	TBD
FY 2012	11/24/2009	4Q FY 2011	4Q FY 2013	TBD	N/A	TBD	TBD	TBD	TBD
FY 2013	11/24/2009	4Q FY 2012	4Q FY 2014	4Q FY 2013	N/A	4Q FY 2014	4Q FY 2018	N/A	N/A
FY 2014	11/24/2009	7/11/2012	2Q FY 2015	2Q FY 2014[a]	3Q FY 2013	4Q FY 2015[a]	2Q FY 2021[a]	N/A	N/A

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3A – Approve Limited Construction
CD-3B – Approve Full Construction
CD-4 – Approve Start of Operations or Project Closeout
D&D Start – Start of Demolition & Decontamination (D&D) work
D&D Complete – Completion of D&D work

[a] Schedule estimates are preliminary, based on CD-1, since this project has not received CD-2 approval.

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC Except D&D	OPC, D&D	OPC, Total	TPC
FY 2011	35,000	TBD	TBD	10,000	TBD	TBD	TBD
FY 2012	36,500	TBD	TBD	18,777	TBD	TBD	TBD
FY 2013	44,000	N/A	N/A	24,177	0	24,177	68,177
FY 2014	61,000[a]	162,000	223,000	26,177	0	26,177	249,177[a b]

4. Project Description, Scope, and Justification

Mission Need

The conversion of a muon to an electron in the field of a nucleus provides a unique window for discovery of charged lepton flavor symmetry violation and allows access to new physics at very high mass scales. The Particle Physics Project Prioritization Panel (P5) recommended this type of experiment for the Intensity Frontier of particle physics. This project provides accelerator beam and experimental apparatus to identify unambiguously neutrinoless muon-to-electron conversion events.

Scope and Justification (11-SC-41, Muon to Electron Conversion Experiment)

This project will construct a new beamline for protons using the existing 8 GeV Booster Synchrotron at Fermilab: a system for producing, transporting and stopping secondary muons (from the proton beam); an experimental detector, a low-mass magnetic spectrometer that can measure the electron momentum with a resolution of order 0.15%; and a new conventional facility to house the secondary production target, muon-stopping beamline, and the detector.

The project is being conducted in accordance with the project management requirements in DOE 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

[a] The TEC, PED and TPC totals reflect funding through FY 2012 and the FY 2013 Request level, plus planned amounts in FY 2014. These totals and the project schedule will be reviewed and revised as necessary after FY 2013 funding is finalized.
[b] This project has not received CD-2 approval. No construction, excluding long-lead procurement, will be performed until the project performance baseline has been validated and CD-3 has been approved.

5. Financial Schedule

	(dollars in thousands)		
	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
PED			
FY 2012	24,000	24,000	0
FY 2013	24,147[a]	20,000[b]	20,000
FY 2014	15,000	15,000	20,000
FY 2015	2,000	2,000	21,000
Total, PED	61,000	61,000	61,000
Construction			
FY 2014	20,000[c]	20,000	6,000
FY 2015	30,000	30,000	20,000
FY 2016	44,000	44,000	35,000
FY 2017	45,000	45,000	35,000
FY 2018	23,000	23,000	30,000
FY 2019	0	0	21,000
FY 2020	0	0	10,000
FY 2021	0	0	5,000
Total, Construction	162,000	162,000	162,000

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC and TPC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $25,000,000 ($20,000,000 TEC and $5,000,000 OPC) is assumed instead.
[b] The FY 2013 amount reflects the FY 2013 Request level and does not reflect the final FY 2013 level.
[c] $20,000,000 is requested for long lead procurements for the superconducting magnet systems and civil construction.

(dollars in thousands)

	Appropriations	Obligations	Costs
TEC			
FY 2012	24,000	24,000	0
FY 2013	24,147[a]	20,000[b]	20,000
FY 2014	35,000	35,000	26,000
FY 2015	32,000	32,000	41,000
FY 2016	44,000	44,000	35,000
FY 2017	45,000	45,000	35,000
FY 2018	23,000	23,000	30,000
FY 2019	0	0	21,000
FY 2020	0	0	10,000
FY 2021	0	0	5,000
Total, TEC	223,000	223,000	223,000
Other Project Costs (OPC)			
OPC except D&D			
FY 2010	4,777	4,777	3,769
FY 2011	8,400	8,400	8,940
FY 2012	8,000	8,000	6,740
FY 2013	8,049[a]	5,000[b]	6,728
Total, OPC	26,177	26,177	26,177

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC and TPC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $25,000,000 ($20,000,000 TEC and $5,000,000 OPC) is assumed instead.

[b] The FY 2013 amount reflects the FY 2013 Request level and does not reflect the final FY 2013 level.

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Project Cost (TPC)			
FY 2010	4,777	4,777	3,769
FY 2011	8,400	8,400	8,940
FY 2012	32,000	32,000	6,740
FY 2013	32,196[a]	25,000[b]	26,728
FY 2014	35,000	35,000	26,000
FY 2015	32,000	32,000	41,000
FY 2016	44,000	44,000	35,000
FY 2017	45,000	45,000	35,000
FY 2018	23,000	23,000	30,000
FY 2019	0	0	21,000
FY 2020	0	0	10,000
FY 2021	0	0	5,000
Total, TPC	249,177[c]	249,177	249,177

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
PED			
Design	40,000	31,000	N/A
Contingency	21,000	13,000	N/A
Total, PED	61,000	44,000	N/A

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. TheTEC, OPC and TPC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $25,000,000 ($20,000,000 TEC and $5,000,000 OPC) is assumed instead.

[b]The FY 2013 amount reflects the FY 2013 Request level and does not reflect the final FY 2013 level.

[c] This project has not yet received CD-2 approval.

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction			
Site Work	2,000	N/A	N/A
Construction	17,000	N/A	N/A
Equipment	99,000	N/A	N/A
Contingency	44,000	N/A	N/A
Total, Construction	162,000	N/A	N/A
Total, TEC	223,000	44,000	N/A
Contingency, TEC	65,000	13,000	N/A
Other Project Cost (OPC)			
OPC except D&D			
R&D	2,500	150	N/A
Conceptual Planning	4,350	7,750	N/A
Conceptual Design	12,727	12,000	N/A
Contingency	6,600	4,277	N/A
Total, OPC	26,177	24,177	N/A
Contingency, OPC	6,600	4,277	N/A
Total, TPC	249,177	68,177	N/A
Total, Contingency	71,600	17,277	N/A

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	Total
FY 2011	TEC	5,000	30,000	0	0	0	0	0	0	35,000
	OPC	10,000	0	0	0	0	0	0	0	10,000
	TPC	15,000	30,000	0	0	0	0	0	0	45,000
FY 2012	TEC	0	24,000	12,500	0	0	0	0	0	36,500
	OPC	12,777	6,000	0	0	0	0	0	0	18,777
	TPC	12,777	30,000	12,500	0	0	0	0	0	55,277

Request Year		Prior Years	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	Total
		(dollars in thousands)								
FY 2013	TEC	0	24,000	20,000	0	0	0	0	0	44,000
	OPC	13,177	6,000	5,000	0	0	0	0	0	24,177
	TPC	13,177	30,000	25,000	0	0	0	0	0	68,177
FY 2014	TEC	0	24,000	24,147	35,000	32,000	44,000	45,000	23,000	223,000
	OPC	13,177	8,000	8,049	0	0	0	0	0	26,177
	TPC	13,177	32,000	32,196[a]	35,000	32,000	44,000	45,000	23,000	249,177

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	FY 2021
Expected Useful Life	10 years
Expected Future Start of D&D of this capital asset	FY 2031

Operations and maintenance of this experiment will become part of the existing Fermilab accelerator facility. Annual related funding estimates are for the incremental cost of five years of full operation, utilities, maintenance and repairs with the accelerator beam on. Five subsequent years are planned for further analysis of the data while the detector and beam line are maintained in a minimal maintenance state (with annual cost of approximately 3% of full operations) to preserve availability for future usage with much smaller annual cost.

(Related Funding Requirements)

(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	3,100	N/A	16,000	N/A
Utilities	2,400	N/A	12,400	N/A
Maintenance & Repair	100	N/A	600	N/A
Recapitalization	0	N/A	0	N/A
Total	5,600	N/A	29,000	N/A

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC and TPC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $25,000,000 ($20,000,000 TEC and $5,000,000 OPC) is assumed instead.

9. Required D&D Information

Area	Square Feet
Area of new construction	Approximately 25,000 SF
Area of existing facilities being replaced	N/A
Area of any additional space that will require D&D to meet the “one-for-one” requirement	N/A (see below)

The one-for-one replacement has been met through banked space. A waiver from the one-for-one requirement to eliminate excess space at Fermilab to offset the Mu2e project was approved by DOE Headquarters on November 12, 2009. The waiver identified and transferred to Fermilab sufficient excess space to accommodate the new Mu2e facilities from space that was banked at other DOE facilities.

10. Acquisition Approach

The acquisition approach is fully documented in the Acquisition Strategy approved as part of CD-1. This is a high-level summary of material from that document.

DOE has awarded the prime contract for the Mu2e project to the Fermi Research Alliance (FRA), the Fermilab Management and Operating (M&O) contractor, rather than have the DOE compete a contract for fabrication to a third party. FRA has a strong relationship with the high energy physics community and its leadership, including many Fermilab scientists and engineers. This arrangement will facilitate close cooperation and coordination between the Mu2e scientific collaboration and an experienced team of project leaders managed by Fermilab. Fermilab will have primary responsibility for oversight of all subcontracts required to execute the project. These subcontracts are expected to include the purchase of components from third party vendors as well as subcontracts with university groups to fabricate detector subsystems.

The largest procurements will be the magnet systems and the civil construction. The superconducting solenoid magnets are divided into three systems that could be procured independently but which must ultimately perform as a single integrated magnetic system. Two of the systems are similar to systems that have been successfully built in private industry, so the engineering design and fabrication for two of the solenoids may be subcontracted to third party vendors, if a planned study of industrial vendor capabilities confirms that the technical risks are acceptable. The third solenoid is relatively unique, and no good industrial analog exists. This solenoid will be designed and fabricated at Fermilab, though most of the parts will be procured from third party vendors.

There will be two major subcontracts for the civil construction for Mu2e. An architecture and engineering (A&E) contract will be placed on a firm-fixed-price basis for Preliminary (Title I) Design, and Final (Title II) Design with an option for construction (Title III) support. The general construction subcontract will be placed on a firm-fixed-price basis. It is expected that the design specifications will be sufficiently detailed to allow prospective constructors to formulate firm-fixed-price offers without excessive contingency and allowances.

All subcontracts will be competitively bid and awarded based on best value to the government. Chicago Office provides contract oversight for FRA’s plans and performance. Project performance metrics for FRA are included in the M&O contractor’s annual performance evaluation and measurement plan.

Nuclear Physics
Funding Profile by Subprogram and Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Medium Energy Nuclear Physics			
Research	35,216	—	36,304
Operations	78,222	—	95,344
SBIR/STTR and Other	2,084	—	18,214
Total, Medium Energy Nuclear Physics	115,522	—	149,862
Heavy Ion Nuclear Physics			
Research	39,259	—	35,386
Operations	163,158	—	165,224
Total, Heavy Ion Nuclear Physics	202,417	—	200,610
Low Energy Nuclear Physics			
Research	52,752	—	49,590
Operations	31,537	—	28,023
Facility for Rare Isotope Beams	22,000	—	55,000
Total, Low Energy Nuclear Physics	106,289	—	132,613
Nuclear Theory			
Theory Research	34,547	—	34,109
Nuclear Data Activities	6,785	—	7,713
Total, Nuclear Theory	41,332	—	41,822
Isotope Development and Production for Research and Applications			
Research	4,827	—	4,648
Operations	14,255	—	14,883
Total, Isotopes	19,082	—	19,531
Subtotal, Nuclear Physics	484,642	500,431	544,438
Construction			
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	50,000	50,306	25,500
Total, Nuclear Physics[a]	534,642	550,737[b]	569,938

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $11,233,092 and STTR $1,512,147 (transferred out of NP in FY 2012 Current column)
- FY 2014 Request: SBIR $12,530,000 and STTR $1,787,000

[b] FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act," 1977
Public Law 101-101, "1990 Energy and Water Development Appropriations Act," establishing the Isotope Production and Distribution Program Fund
Public Law 102-468, "Energy Policy Act of 1992"
Public Law 103-316, "1995 Energy and Water Development Appropriations Act," amending the Isotope Production and Distribution Program Fund to provide flexibility in pricing without regard to full-cost recovery
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

One of the enduring mysteries of the universe asks the question, "What, really is matter?" or more precisely, "What are the units that matter is made of, and how do they fit together to give matter the properties we observe?". Primarily, the mass of the matter we are familiar with comes from the nuclei of atoms. The mission of the Nuclear Physics (NP) program is to discover, explore, and understand all forms of nuclear matter. The fundamental particles that compose nuclear matter—quarks and gluons—are relatively well understood, but exactly how they fit together and interact to create different types of matter in the universe, familiar and unfamiliar, is still largely unknown.

The quest to understand the properties and behavior of matter requires both theoretical and experimental examination. In the theoretical approach, the interaction of quarks and gluons in nuclear matter, described by a theory referred to as Quantum Chromodynamics (QCD), is examined by scientists using today's most advanced computers to develop approximate solutions to the precise mathematical description of this interaction. On the experimental side, scientists accumulate experimental data about the behavior of quarks and gluons as well as protons, neutrons, and nuclei in a variety of settings. Most of the experiments today require large accelerator facilities that slam bits of matter into each other at speeds approaching the speed of light. The careful integration and comparison of the observed experimental results with theoretical calculations provides both insight into the behavior of matter and the information needed to test the validity of theoretical models. Nuclear physics seeks to understand matter in all of its manifestations—not just the familiar forms of matter we see around us, but also such exotic forms as the matter that existed in the first moments after the creation of the universe and the matter that exists today inside neutron stars—and to understand why matter takes on the particular forms that it does.

Nuclear physics focuses on three broad, yet tightly interrelated frontiers: Quantum Chromodynamics, Nuclei and Nuclear Astrophysics, and Fundamental Symmetries and Neutrinos. Quantum Chromodynamics seeks to develop a complete understanding of how quarks and gluons assemble themselves into protons and neutrons and how the resulting quark structure of protons and neutrons is modified in the interior of light and heavy nuclei. Nuclei and Nuclear Astrophysics seeks to understand how protons and neutrons combine to form atomic nuclei, including some now being observed for the first time, and how these nuclei have arisen during the 13.7 billion years since the birth of the cosmos. Fundamental Symmetries and Neutrinos seeks to develop a better understanding of the fundamental properties of the neutron and of the neutrino—the nearly undetectable fundamental particle produced by the weak force interactions that was first indirectly observed in nuclear beta decay experiments.

At the heart of the NP program are groups of highly trained scientists who conceive, plan, execute, and interpret transformative experiments carried out at nuclear physics facilities. NP supports scientists at both universities and national laboratories and is involved in a variety of international collaborations. The program provides more than 90 percent of the nuclear science research funding in the U.S. with approximately 80 Ph.D. degrees granted annually to students for research supported by the program. NP research at national laboratories is guided by DOE's mission and priorities and helps develop the core expertise needed to achieve the goals of the NP program. National laboratory scientists work and collaborate with academic scientists and other national laboratory experimental and theoretical researchers to collect and analyze data and to construct, support, and maintain the detectors and facilities used in experiments. The national laboratories also provide state-of-the-art resources for detector and accelerator R&D for future upgrades and new facilities. This research develops knowledge, technologies, and trained scientists to design and build next-generation NP accelerator facilities and is also of relevance to machines being developed by other domestic and international programs.

The complementary user facilities and equipment necessary to advance the U.S. nuclear science supported by NP are large and complex, and they account for about 50 percent of the NP budget. Three national user facilities are currently supported, each with unique capabilities: the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL); the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility (TJNAF); and the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL). These major scientific facilities provide particle beams for a user community of more than 3,000 research scientists world-wide. Approximately 38 percent of the users are from institutions outside of the U.S.; these institutions provide very significant benefits to the U.S. program through contributed capital, human capital, experimental equipment, and intellectual exchange. A number of other SC programs, DOE offices (National Nuclear Security Administration [NNSA] and Nuclear Energy), Federal agencies (National Science Foundation [NSF], National Aeronautics and Space Administration [NASA], and Department of Defense), and industries also use NP user facilities to carry out their own research programs.

Involving students in the development and construction of NP facilities and advanced instrumentation, along with the development of accelerator technology and computational techniques, supports workforce development. These facilities and techniques also provide collateral benefits such as the creation of new technologies with applications in industry. For example, superconducting radio frequency (SRF) particle acceleration has provided technological advances for an increasingly broad range of applications including materials research, cancer therapy, food safety, bio-threat mitigation, waste treatment, and commercial fabrication.

Basic and Applied R&D Coordination

The Isotope Development and Production for Research and Applications subprogram (Isotope Program) produces commercial and research isotopes that are important for basic research and applications and supports research for the development of new or improved production and separation techniques of stable and radioactive isotopes. NP has taken significant steps in aligning the federal, industrial, and research stakeholders of the Isotope Program with each other and with the nuclear science research community. To ascertain current and future demands of the research community, NP continues to develop working groups and relationships with NNSA and other Federal agencies and offices (e.g., National Institutes of Health [NIH], Office of Science and Technology Policy [OSTP], NASA, and National Security Council [NSC]), to foster interactions between researchers and Isotope Program staff; to obtain information from visits to DOE, NNSA, and international isotope production sites; to attend scientific community exhibitions and conferences; and to develop strategic plans and priorities with community input. Program priorities are also guided by National Academy studies and assessments by the Nuclear Science Advisory Committee (NSAC). Examples include conducting a Federal workshop to identify isotope demand and supply across a broad range of Federal agencies in support of research and applications within their areas of responsibility, playing a lead role in an interagency working group for prioritizing requested allocations of helium-3 and seeking alternative supplies, leading the joint DOE/NIH federal working group to develop a strategic plan and priorities for medical isotope production, participating in the OSTP interagency working group and the Organization for Economic Cooperation and Development (OECD) international working group to address the supply of molybdenum-99, and working with industry to ensure availability of isotopes of strategic and economic importance to the Nation.

NP also supports a competitive program of targeted awards in Applications of Nuclear Science and Technology. While the primary goal of these efforts is to pursue forefront nuclear science research and development important to the NP mission, they are also inherently cross-cutting and relevant to applications and help bridge the gap between basic research and applied science. Projects include nuclear physics research relevant to the development of advanced fuel cycles for next generation nuclear power reactors; advanced cost-effective accelerator technology and particle detection techniques for medical diagnostics and treatment; and research in developing neutron, gamma, and particle beam sources with applications in cargo screening and nuclear forensics. The proposals are peer reviewed with participation from the applied sciences community, including other DOE offices as appropriate.

Program Accomplishments and Milestones

TJNAF discovers missing particles, narrowing explanations of the nature of nuclear matter. Recently the CEBAF Large Angle Spectrometer (CLAS) experiment at TJNAF discovered five unstable particles, known as N* baryon resonances. These composite particles, which are dominantly composed of three quarks, are predicted to exist by Lattice Quantum Chromodynamics (QCD) calculations on some of today's most advanced computers. Lattice QCD is a mathematical technique for determining approximate predictions of QCD, a theory which describes nuclear matter and its behavior. Since these missing resonances had long eluded discovery, doubt was cast on earlier models leading to a conjecture that di-quarks—a hypothetical strong pairing of two of the three quarks known to inhabit the interior of baryons—might prevent some specific N* baryon resonances from existing. The advanced experimental capability provided by the CLAS experiment resolved the issue by finding some of these previously missing N* resonances, which eliminated the di-quark conjecture. The new particles discovered by CLAS have now been included in the Particle Data Group 2012 Review of Particle Properties.

RHIC probes the perfect liquid. Following the discovery of a new state of matter, a perfect quark-gluon liquid at the Relativistic Heavy Ion Collider (RHIC), a key question has been, "How perfect is the perfect liquid at RHIC?" NP researchers have achieved major scientific and technological advances toward answering this question. Scientists were able to disentangle the effects of fluctuations in the geometrical overlap of two colliding nuclei by studying collisions of gold and copper, two nuclei very different in size. Researchers also successfully used an advanced device called EBIS (Electron Beam Ion Source) to inject uranium nuclei for collisions in RHIC. Uranium nuclei are naturally football shaped, and the difference in observed experimental data when uranium nuclei collide tip-to-tip versus middle-to-middle can tell scientists whether their understanding of how nuclear matter flows during nucleus-nucleus collisions is correct. First-ever results on high energy uranium-uranium collisions were reported at the Quark Matter 2012 Conference showing conclusively that geometrical effects in uranium-uranium collisions can be detected. These results and technical advances provide scientists a powerful new tool to probe the liquid that is thought to have existed shortly after the birth of the universe and to understand its perfection.

Magic numbers provide insight toward a comprehensive theory of nuclear structure: Magic numbers refer to specific numbers of protons or neutrons that provide additional stability to nuclei and provide unique benchmarks for nuclear theory. A nucleus with a magic number of protons or neutrons behaves like a closed core which is not modified when single protons or neutrons are added. Nuclear theory makes very detailed predictions of the energies and properties of such single-particle excited states associated with an extra nucleon beyond the magic numbers. A very important set of nuclear benchmarks involves the excited states of ^{133}Sn (tin), which adds one neutron to the double-magic nucleus ^{132}Sn (magic in both neutron and proton number). Using a beam of radioactive ^{132}Sn, researchers at Oak Ridge National Laboratory (ORNL) recently produced and measured, with high precision, the energies of the complete set of the expected single-particle states in ^{133}Sn for the very first time. Particularly important is a newly identified state that lies above the energy where neutrons typically boil off the nucleus if it becomes excited. The position of this newly observed state indicates the strength of the spin-orbit force in nuclei, a key input to theoretical models which attempt to predict how nuclei configure themselves as protons and neutrons are added. These long-awaited data provide a stringent test and constraint for any comprehensive theory of nuclear structure.

New horizons on the nuclear landscape. There are 288 stable or nearly stable nuclei that occur in nature, comprising 99.9 percent of the matter in the visible world around us. Some 3,000 more have been synthesized in laboratories. These nuclear species have been mapped onto a chart of nuclides—the periodic table of the nuclear physics world. Until recently, the boundaries marking the edge of where nuclei can exist in this nuclear landscape—where the addition of one more proton or one more neutron will cause the nucleus to fall apart—has been highly uncertain, especially for heavier elements. Research using a technique known as nuclear density functional theory carried out at the University of Tennessee and ORNL using one of the world's most powerful supercomputers now predicts that the number of bound nuclides with atomic numbers between 2 and 120 is around 7,000. These findings represent a major advance in our understanding of nuclear stability and the ultimate limits of nuclear existence. Understanding the stability of nuclides is important to many applications and to natural phenomena such as the stellar processes that create the matter around us.

Further progress on producing isotopes for cancer treatment. Actinium-225 is an alpha-emitting isotope identified as a high priority by the National Institutes of Health that shows significant potential in the treatment of cancers such as leukemias and lymphomas, but inhibiting the realization of this potential has been the inadequate availability of actinium-225. The Isotope Program-sponsored research on accelerator-based production of actinium-225 that showed it is technically possible to produce more than ten times the current annual supply of actinium-225 in the matter of a few days. These quantities are sufficient to support the essential clinical trials and ultimately the clinical applications of this isotope.

Higher efficiency atom trapping allows world-wide analysis of water aquifers and ice cores. The Atom Trap Trace Analysis (ATTA) technique developed at ANL to search for new physics beyond the Standard Model has been adapted to date samples of ground water as old as a million years. Laser trapping of single atoms has been enabling new studies in geophysics, water resource management, and ocean science. Krypton-81 is an extremely rare and long lived isotope present in the atmosphere. When water loses contact with air, the concentration of the krypton-81 isotope in water begins to decline. New technological advances allow the trapping of single atoms of krypton-81 in a sample, and therefore the ability to determine its concentration and so the age of the sample. This approach enables its potential use in a comprehensive world-wide analysis of water aquifers and ice cores for geological studies; recently analyzed samples are from Yellowstone National Park, the Great Artesian Basin in Australia, and the Guarani aquifer in Brazil. This new capability, developed as a by-product of NP supported research, has created a new community of interdisciplinary researchers with complementary expertise supported by NSF, the U.S. Geological Survey, and the International Atomic Energy Agency (IAEA). ANL hosted an international workshop on Tracer Applications of Noble Gas Radionuclides in 2012 to advance new opportunities and foster research partnerships.

Milestone	**Date**
Obtain Critical Decision-2/3A for the Facility for Rare Isotope Beams (FRIB) to establish the technical, schedule, and cost baselines of this next generation facility for nuclear structure and nuclear astrophysics that is being constructed at MSU, and initiate civil construction.	3rd Qtr, FY 2013
Conduct a broad review of university and national laboratory research efforts within the Nuclear Physics program and assess the performance of individual groups.	4th Qtr, FY 2013
Complete a Committee of Visitor's review of the Nuclear Physics program.	2nd Qtr, FY 2013

The first two milestones are partially carried over from FY 2012.

Program Planning and Management

To ensure that funding is allocated optimally, NP has developed a rigorous and comprehensive process for strategic planning and priority setting that relies heavily on input from groups of outside experts. At a high level, NP works closely with the NSF to jointly charge the Nuclear Science Advisory Committee (NSAC) to provide recommendations regarding the highest priority scientific opportunities. NP develops strategic plans for the field with input from the scientific community via long range plans produced by NSAC every five to six years. In April 2012, DOE and NSF charged NSAC to review the implementation of the priorities and recommendations of the 2007 Long Range Plan in light of projected budgetary constraints; NSAC's report in response to this charge was issued in January 2013[a].

At the program execution level, all activities within the subprograms are peer reviewed by external scientific experts, and performance and productivity are assessed on a regular basis. Priority is given to research activities supporting the most exciting and internationally competitive scientific opportunities.

University grants are proposal driven in response to grant solicitation notices. Funding is competitively awarded according to Federal guidelines, and the quality and productivity of university grants are peer reviewed on a three-year basis with progress reports required annually.

Laboratory research groups are reviewed on a four-year basis, with progress reports required annually to ensure laboratory research efforts maintain a high level of productivity on competitive mission-driven science. As part of NP's peer review process, biennial science and technology reviews of the national user facilities and isotope production facilities are conducted to assess operations, performance, and scientific productivity. These results influence budget decisions and NP's assessment of laboratory performance in the annual Office of Science (SC) laboratory appraisals. The institutions are held accountable for responding to the peer review recommendations. Annual reviews of instrumentation projects focus on scientific merit, technical status and feasibility, cost and schedule, and effectiveness of management approach. Performance of instrumentation projects is also assessed on a monthly and quarterly basis.

NP strategic plans are also influenced by National Academies' reports and White House OSTP and NSC Interagency Working Group (IWG) efforts. NP participates in a federal working group with the NIH, along with the SC Biological and Environmental Research program, to better coordinate radioisotope production and to address other issues important to nuclear medicine. The National Academies new decadal study of nuclear science was released in June 2012;[b] the report re-iterated the importance of a strong nuclear science program to the Nation and endorsed the recommendations of the 2007 NSAC Long Range Plan. In order to optimize interagency activities, on an as-needed basis, the program establishes interagency working groups to tackle issues of common interest and to enhance communication. NP is currently involved in four OSTP or NSC IWGs: Forensic Science, Critical Materials, Molybdenum-99 Production, and Helium-3.

NP takes this input into account in its budget requests, making decisions to maximize scientific impact, productivity, quality, and cost-effectiveness within available resources. Funding decisions in this budget request are influenced by the results of these periodic peer reviews of the university and national laboratory research efforts, and facility and project performance.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Support fundamental research to discover, explore, and understand all forms of nuclear matter.
- *Facility Operations*: Maximize the reliability, dependability, and availability of the NP scientific user and isotope production facilities.
- *Future Facilities*: Build future facilities or upgrades to existing facilities and experimental capabilities to ensure the continuing productivity of the NP scientific user and isotope production facilities. All construction projects and MIEs are within 10% of their specified cost and schedule baselines.
- *Scientific Workforce*: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers which is knowledgeable in nuclear science.

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[a] http://science.energy.gov/~/media/np/nsac/pdf/20130201/2013_NSAC_Implementing_the_2007_Long_Range_Plan.pdf

[b] http://www8.nationalacademies.org/onpinews/newsitem.aspx?recordid=13438

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Medium Energy	28%	72%	0%	0%
Heavy Ion	17%	82%	1%	0%
Low Energy	37%	21%	42%	0%
Nuclear Theory	100%	0%	0%	0%
Isotopes	24%	76%	0%	0%
Construction	0%	0%	100%	0%
Total, Nuclear Physics	32%	55%	13%	0%

Performance Measures

Performance Goal (Measure)	**NP Facility Operations**—Average achieved operation time of NP user facilities as a percentage of total scheduled annual operation time.		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 80%	≥ 80%	≥ 80%
Result	Met		
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		

Performance Goal (Measure)	**NP Nuclear Structure**—Investigate new regions of nuclear structure, study interactions in nuclear matter like those occurring in neutron stars, and determine the reactions that created the nuclei of atomic elements inside stars and supernovae.		
Fiscal Year	**2012**	**2013**c	**2014**
Target	N/A	Complete initial measurements with high resolving power tracking array, GRETINA, for sensitive studies of structural evolution and production of superheavy elements.	Perform mass measurements and nuclear reaction studies to infer weak interaction rates in nuclei in order to constrain models of supernovae and stellar evolution.
Result	N/A		
Endpoint Target	Increase the understanding of the existence and properties of nuclear matter under extreme conditions, including that which existed at the beginning of the universe.		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012-2014 Annual Performance Plan & Report.

Explanation of Funding and Program Changes

The FY 2014 requested increase of $35,296,000 over FY 2012 is dominated by an increase to continue construction of FRIB at Michigan State University (MSU). The request also supports continued operations of the NP user facilities—RHIC and ATLAS—as well as the initiation of beam development and commissioning activities at CEBAF. Partially offsetting the increases is a decrease for the 12 GeV CEBAF Upgrade as construction ramps down.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Medium Energy Nuclear Physics	115,522	149,862	+34,340

$14,317,000 of the increase from FY 2012 is for the required NP contribution to the SBIR/STTR programs; the FY 2012 SBIR/STTR funds have already been transferred out of the amount shown in the FY 2012 Current column.

The balance of the increase primarily reflects the transition of key staff from the 12 GeV CEBAF Upgrade project back to CEBAF operations funding to support early operations and commissioning of the facility as the project nears completion. The temporary movement of staff from operations to the project allowed more cost-effective implementation of the project, and it is critical that these personnel transition back to operations to commission and operate the upgraded facility. In addition, power and cryogen usage will increase when pre-operations and commissioning begin, Other Project Costs for the 12 GeV Upgrade project increase as planned, and funding is requested for fabrication of Instrumentation for the 12 GeV scientific program. Research groups at universities and laboratories are focused on the implementation of the 12 GeV CEBAF Upgrade project, completion of the analysis of data on the quark structure of nucleons and nuclei from the recently completed 6 GeV program at TJNAF, and the program at RHIC to determine the origin of the proton spin.

Heavy Ion Nuclear Physics	202,417	200,610	-1,807

Funding supports 2,770 hours of operations at RHIC, which is the minimum needed for a 2-species run and is made possible partially by a leaner operations staff. Core research at universities and laboratories decreases and is focused on the highest priority efforts at RHIC and LHC to determine the properties of the quark-gluon plasma. Support for the STAR Heavy Flavor Tracker MIE decreases as planned, as the project is completed.

Low Energy Nuclear Physics	106,289	132,613	+26,324

The increase is dominated by the ramp-up of the FRIB project profile to support construction activities and maintain project performance. Core research efforts at universities and laboratories to advance knowledge of the structure of nuclei and operations of ATLAS decrease and are focused on the highest priority activities. Support for R&D of a neutrinoless double beta decay experiment prototype ramps down as planned.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Nuclear Theory	41,332	41,822	+490
Theoretical activities underpinning experimental efforts throughout the NP program are focused on high priority activities. Support for the Nuclear Data stewardship program and the Scientific Discovery through Advanced Computing (SciDAC-3) awards are maintained.			
Isotope Development and Production for Research and Applications	19,082	19,531	+449
Support is provided to maintain research efforts, university production capabilities, and mission readiness of the Isotope production and processing facilities at Brookhaven, Oak Ridge, and Los Alamos National Laboratories.			
Construction	50,000	25,500	-24,500
FY 2014 construction funding decreases for the 12 GeV CEBAF Upgrade project based on the current planned profile, which is revised as a result of the reduced FY 2012 appropriation. A full re-assessment of the project baseline will be conducted in FY 2013.			
Total, Nuclear Physics	534,642	569,938	+35,296

Medium Energy Nuclear Physics
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	35,216	—	36,304
Operations (TJNAF)	78,222	—	95,344
SBIR/STTR and Other[a]	2,084	—	18,214
Total, Medium Energy Nuclear Physics	115,522	—	149,862

[a] SBIR/STTR funding (covers the entire NP program):

- FY 2012 Transferred: SBIR $11,233,092 and STTR $1,512,147 (transferred out of NP in FY 2012 Current column)
- FY 2014 Request: SBIR $12,530,000 and STTR $1,787,000

Overview

The Medium Energy Nuclear Physics subprogram focuses primarily on experimental tests of the mathematical description of how quarks and gluons in nuclear matter interact, referred to as Quantum Chromodynamics (QCD), with an emphasis on the behavior of quarks inside protons and neutrons. Specific questions addressed include:

- What is the internal landscape of the protons and neutrons (collectively known as nucleons)?
- What does QCD predict for the properties of strongly interacting matter?
- What governs the transition of quarks and gluons into pions (hadronic subatomic particle) and nucleons?
- What is the role of gluons and gluon self-interactions in nucleons and nuclei?

Various experimental approaches are pursued to determine the distribution of up, down, and strange quarks and their antiquarks in nucleons as well as the roles of the gluons that bind the quarks; the effects of the quark and gluon spins within the nucleon; and the effect of the nuclear environment on the quarks and gluons. The subprogram also produces and studies higher-mass "excited states" of hadrons (composite particles, including nucleons, made of quarks, antiquarks, and gluons) predicted by QCD in order to determine how the theory leads to the observed properties of these strongly interacting particles.

Funding supports both research and operations of the subprogram's primary research facility, CEBAF at TJNAF, as well as medium energy research that is carried out at RHIC. CEBAF provides high quality beams of polarized electrons that allow scientists to extract information on the quark and gluon structure of protons and neutrons; it also uses polarized electrons to make precision measurements to search for processes that violate a fundamental symmetry of nature, called parity, in order to reveal physics beyond what is currently known within the Standard Model. These are capabilities that are unique in the world. The increase in beam energy provided by the 12 GeV CEBAF Upgrade opens up exciting new scientific opportunities, and will secure continued U.S. world leadership in this area of physics. Additional research is carried out at RHIC, which provides colliding beams of spin-polarized protons, a capability unique to RHIC, to understand the origin of the spin of the proton, another important QCD frontier. Research support for both facilities includes laboratory and university personnel needed to implement and execute experiments and to conduct the data analysis necessary to extract the physics results. Compelling, special focus experiments that require different capabilities are supported at the High Intensity Gamma Source (HIGS) at Triangle Universities Nuclear Laboratory, Fermi National Accelerator Laboratory (Fermilab), and specific facilities in Europe. Efforts are supported at the Research and Engineering Center at the Massachusetts Institute of Technology (MIT), which has specialized infrastructure capabilities used to develop and fabricate advanced instrumentation and accelerator equipment.

The SBIR/STTR and Other category within this subprogram includes all of the mandated SBIR/STTR funding for the NP program, as well as funding to meet other NP obligations, such as the annual Lawrence Awards and Fermi Awards for honorees selected by DOE for outstanding contributions to science.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	35,216	36,304	+1,088
The FY 2014 Request maintains the highest priority research preparations for the 12 GeV program, as well as continued analysis of 6 GeV data and data from polarized proton beam runs at RHIC.			
Operations	78,222	95,344	+17,122
The increase supports critical operations staff as they transition from the 12 GeV Upgrade project back to the base operations budget. These staff are essential for the operations of CEBAF. Increased funding is provided for Other Project Costs as planned as part of the 12 GeV CEBAF Upgrade project profile to support the increased power and cryogen costs associated with the initiation of commissioning and beam development activities in FY 2014. Increased funding is also requested for scientific instrumentation that is needed for the 12 GeV research program.			
SBIR/STTR and Other	2,084	18,214	+16,130
The increase represents NP's required FY 2014 contributions to the SBIR/STTR programs. The SBIR/STTR funding set-aside of 2.95% in FY 2012 increases to 3.05% in FY 2013 and 3.2% in FY 2014. FY 2012 SBIR/STTR funding has already been transferred to the SBIR/STTR program.			
Total, Medium Energy Nuclear Physics	115,522	149,862	+34,340

Research

Overview

Research groups at TJNAF, BNL, ANL, LBNL, and LANL, and about 160 scientists and 125 graduate students at 32 universities carry out research and conduct experiments at CEBAF, RHIC, and elsewhere, and participate in the development and fabrication of advanced instrumentation, including state-of-the-art detectors that also have applications in medical imaging instrumentation and homeland security. TJNAF staff research efforts include developing experiments, acquiring data, and performing data analysis in the three existing CEBAF experimental Halls A, B, and C. Additionally, a scientific group is being developed to utilize the new experimental capabilities of Hall D being constructed as part of the 12 GeV CEBAF Upgrade project. Scientists also are conducting research to identify and develop the scientific opportunities and goals for next generation facilities. An active visiting scientist program at TJNAF and bridge positions with regional universities are also supported as a cost-effective approach to augmenting scientific expertise at the laboratory and boosting research experience opportunities.

ANL scientists continue targeted experiments at TJNAF and are leading an experiment at Fermilab to distinguish the different quark contributions to the structure of the proton. ANL scientists are also using their unique laser atom-trapping technique to make a precision measurement of the atomic electric dipole moment in order to research possible explanations for the excess of matter over antimatter in the universe. Research groups at BNL, LBNL, ANL, and LANL with important responsibilities in the RHIC program are supported within this subprogram to play lead roles in determining the spin structure of the proton through development and fabrication of advanced instrumentation as well as data acquisition and analysis efforts. At LANL, scientists and collaborators are also completing analysis of data from the MiniBooNE experiment at Fermilab, which has shown an intriguing discrepancy between anti-neutrino and neutrino data and may unveil new physics beyond the Standard Model. Researchers at MIT are developing high current, polarized electron sources.

Accelerator R&D research proposals from universities and laboratories are evaluated by peer review through a single competition for funding under the Medium Energy and Heavy Ion subprograms.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Efforts focused on completing the highest priority 6 GeV experiments at CEBAF prior to installation of the 12 GeV Upgrade and on support of the RHIC spin program.	35,216
FY 2013	The FY 2013 Request proposed $35,524,000. Research funding in FY 2013 is reduced overall by 5.8% relative to FY 2012; the decrease is partially offset by a small shift of a lab research effort from the Heavy Ion subprogram. Efforts are focused on analysis of 6 GeV experiments, the implementation of instrumentation needed for the 12 GeV experimental program at TJNAF, the formation of a research group for the new experimental hall in the 12 GeV CEBAF project, and on collecting experimental data at RHIC with polarized proton beams. Support for accelerator R&D is reduced by 5.8% relative to FY 2012 and addresses high priority technological advances in superconducting radiofrequency technology, cryogenics, and other areas of importance to next-generation NP facilities.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Efforts will focus on the new 12 GeV experimental program at TJNAF such as the implementation of instrumentation and development of the Hall D experimental group, as well as continued analysis of 6 GeV experimental data and RHIC polarized proton beam data. Support for short and mid-term accelerator R&D continues.	36,304

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Research	16,941	—	18,368
National Laboratory Research			
TJNAF Research	7,050	—	6,852
Other National Laboratory Research	10,390	—	10,255
Total, National Laboratory Research	17,440	—	17,107
Other Research			
Accelerator R&D Research	835	—	829
Total, Research	35,216	—	36,304

Operations

Overview

CEBAF is a unique scientific user facility with unparalleled capabilities using polarized electron beams to study the contributions of quarks and gluons to the properties of hadrons, and a user community with a strong international component.

Accelerator Operations support is provided for the accelerator physicists that operate the facility as well as for maintenance, power costs, capital infrastructure investments, and accelerator improvements. Investments in accelerator improvement projects are aimed at increasing the productivity, cost-effectiveness, and reliability of the facility. Support is provided to maintain efforts in developing advances in superconducting radiofrequency (SRF) technology relevant to improving the operations of the existing machine. The core competency in SRF technology plays a crucial role in many DOE projects and facilities outside of nuclear physics and has broad applications in medicine and homeland security. For example, SRF research and development at TJNAF has led to improved land-mine detection techniques and carbon nanotube and nano-structure manufacturing techniques for constructing super-lightweight composites such as aircraft fuselages. TJNAF also has a core competency in cryogenics and has developed award-winning techniques that have led to more cost-effective operations at TJNAF and several other Office of Science facilities. Accelerator capital equipment investment is targeted toward instrumentation needed to support the laboratory's core competencies in SRF and cryogenics. TJNAF accelerator physicists help train the next generation of accelerator physicists, enabled in part by a close partnership with the NP-supported Center for Accelerator Science at Old Dominion University (ODU). Experimental Support is provided for the scientific and technical staff as well as for materials and services for integration, assembly, modification, and disassembly of large and complex CEBAF experiments. Capital equipment investments for experimental support at TJNAF provide scientific instrumentation for the major experiments, including data acquisition computing and supporting infrastructure.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	CEBAF ran near the optimal level at 6 GeV until the planned shutdown in May 2012 as part of the 12 GeV CEBAF Upgrade project plan. Operations focused on efforts to implement the highest priority experiments before the completion of the current 6 GeV experimental program, including a precision measurement of the weak charge of the proton to help constrain new physics beyond the Standard Model, an important experiment to search for missing excited states of the neutron, and experiments that are helping to develop the laboratory's research program using the 12 GeV CEBAF Upgrade.	78,222
FY 2013	The FY 2013 Request proposed $80,271,000. FY 2013 funding supports maintenance and improvements in the existing facility in preparation for post-construction operations, beam study activities, instrumentation implementation, and installation of the 12 GeV project. The growth in operations funding relative to FY 2012 is dominated by the initiation of pre-operations funding for the 12 GeV CEBAF Upgrade project, which is part of the baselined Total Project Cost.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	FY 2014 funding increases significantly as staff are transitioned from the construction project back to base operations support in order to start commissioning and operating the upgraded CEBAF machine and equipment. Increased support is needed for power and cryogens as the facility turns on and begins pre-operations, beam study activities, and commissioning. Other project costs increase in support of the 12 GeV CEBAF project in accordance with the planned project profile. Support is provided to continue the implementation of instrumentation for the planned scientific research program.	95,344

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
TJNAF Accelerator Operations	50,052	—	58,394
12 GeV Other Project Costs (OPC)	0	—	4,500
TJNAF Experimental Support	28,170	—	32,450
Total, Operations (TJNAF)	78,222	—	95,344

Heavy Ion Nuclear Physics
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	39,259	—	35,386
Operations	163,158	—	165,224
Total, Heavy Ion Nuclear Physics	202,417	—	200,610

Overview

The Heavy Ion Nuclear Physics subprogram focuses on studies of nuclear matter at extremely high densities and temperatures that are directed primarily at answering the overarching questions defining one of the three nuclear physics frontiers—Quantum Chromodynamics (QCD). The fundamental questions addressed include:

- What are the phases of strongly interacting matter, and what roles do they play in the cosmos?
- What governs the transition of quarks and gluons into pions and nucleons?
- What determines the key features of QCD, and what is their relation to the nature of gravity and space-time?

At the Relativistic Heavy Ion Collider (RHIC) facility, scientists continue to pioneer the laboratory study of condensed quark-gluon matter at the extreme temperatures characteristic of the infant universe. The intellectual goal is to explore and understand unique manifestations of QCD in this many-body environment and their influence on the universe's evolution. Complementary research capability is also provided at the Large Hadron Collider (LHC) at CERN. In the debris of collisions at RHIC and at the LHC, researchers have seen signs of the same quark-gluon plasma that is believed to have existed shortly after the Big Bang. With careful measurements, scientists are accumulating data which offers insights into the processes early in the creation of the universe, and how protons, neutrons, and other bits of normal matter developed from that plasma. Important avenues of investigation are directed at learning more about the physical characteristics of the quark-gluon plasma including exploring the energy loss mechanism for quarks and gluons traversing the plasma, determining the speed of sound in the plasma and locating the critical point for the transition between the plasma and normal matter.

The RHIC facility places heavy ion research at the frontier of nuclear physics. RHIC serves two large-scale international experiments called PHENIX and STAR. Operation of RHIC in FY 2014 will take advantage of at least a 10-fold enhancement in the heavy ion beam collision rate using the recently completed stochastic cooling systems and the Electron Beam Ion Source (EBIS). New and ongoing detector upgrades coupled with the enhanced collision rate will contribute further scientific results and understanding. The RHIC facility is uniquely flexible, providing a full range of colliding nuclei at variable energies spanning the transition to the new state of matter discovered at RHIC. Short and mid-term accelerator R&D is conducted at RHIC in a number of areas including the cooling of high-energy hadron beams based on a new concept called Coherent Electron Cooling; high intensity polarized electron sources; and high-energy, high-current energy recovery linear (ERL) accelerators. The RHIC facility is used by about 1,200 DOE, NSF, and foreign agency-supported researchers annually.

Participation in the heavy ion program at the LHC at CERN provides U.S. researchers the opportunity to investigate new states of matter under substantially different initial conditions than those provided by RHIC, providing complementary information regarding the matter that existed during the infant universe. U.S. scientists, in collaboration with international scientists, successfully conducted the first heavy ion experiments in 2010 and 2011 using the ALICE, CMS, and ATLAS detectors, confirming that the same quark-gluon plasma is seen at the higher energy. In addition to playing a lead role in the fabrication of a large electromagnetic calorimeter detector installed in FY 2010 in the ALICE experiment, U.S. researchers are making important scientific contributions to the emerging results from all three LHC experiments.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	39,259	35,386	-3,873
The decrease reflects the planned ramp-down and final year of funding for the fabrication of the STAR HFT MIE at RHIC to detect particles containing charm quarks, a measurement essential to determine the properties of the quark-gluon plasma discovered at RHIC. Core research activities are decreased and focused on the highest priority efforts at RHIC and the LHC.			
Operations	163,158	165,224	+2,066
The increase provides 2,770 hours of RHIC operations, an increase of 970 hours over the FY 2013 planned run. Direct support for General Purpose Equipment at BNL is eliminated.			
Total, Heavy Ion Nuclear Physics	202,417	200,610	-1,807

Research

Overview

Heavy ion research groups at BNL, LBNL, LANL, ORNL, and LLNL, and about 120 scientists and 100 graduate students at 28 universities are supported to analyze data from RHIC and participate in a modest program at the LHC.

The university and national laboratory research groups provide the scientific personnel and graduate students needed for running the RHIC and LHC heavy ion experiments; analyzing data; publishing results; conducting R&D of next-generation detectors; planning for future experiments; and designing, fabricating, and operating the RHIC and LHC heavy ion detectors. BNL also provides project management oversight for the fabrication of the STAR HFT MIE. BNL and LBNL provide computing infrastructure for terabyte-scale data analysis and state-of-the-art facilities for detector and instrument development. At LBNL, the large scale computational system, Parallel Distributed Systems Facility (PDSF), is a major resource used for the analysis of RHIC and LHC data in alliance with the National Energy Research Scientific Computing Center (NERSC), which is supported by the SC's Advanced Scientific Computing Research program. LLNL computing resources are also made available for LHC data analysis.

Accelerator R&D research proposals for short and mid-term accelerator R&D from universities and laboratories are evaluated by peer review through a single competition for funding under the Heavy Ion and Medium Energy subprograms.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Heavy ion research efforts were maintained and the NP commitment to the international ALICE and CMS experiments at the LHC were fulfilled. The PHENIX Forward Vertex Detector (FVTX) MIE received its final funding under the Recovery Act in FY 2009 and was completed in December 2011. Important for both the heavy ion and spin programs, this detector will provide new vertex tracking capabilities to PHENIX. The STAR Heavy Flavor Tracker (HFT), an MIE initiated in FY 2010, will provide direct reconstruction of short-lived particles containing heavy quarks; its schedule and budget baseline were established and fabrication began in October 2011.	39,259
FY 2013	The FY 2013 Request proposed $38,178,000. The FY 2013 request reduces support for heavy ion research efforts at universities and national laboratories by 5.8% relative to FY 2012. Researchers will participate at RHIC and the LHC in the collection and analysis of data, operations of newly completed scientific instrumentation, and scientific leadership essential for the implementation of the STAR HFT MIE. NP commitments for required management and operating costs to the international ALICE and CMS experiments are met. Offsetting the decrease is an increase in funding relative to FY 2012 for fabrication of the STAR HFT consistent with the approved baseline. Funding is reduced for Accelerator R&D focused on high priority activities targeted towards developing technological advances for improving the operations of current facilities and the development of next-generation facilities.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Researchers participate in the collection and analysis of data from RHIC with newly completed scientific instrumentation and in the conduct of R&D for innovative detector designs and planning for future experiments. NP provides scientific leadership to the international ALICE, CMS, and ATLAS experiments and commitments for required management and operating costs are met. The final year of funding is provided for the fabrication of the STAR HFT as it nears completion and a transition to operations is initiated. Mid- and short-term accelerator R&D continues at the FY 2013 level.	35,386

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Research	14,279	—	13,468
National Laboratory Research			
BNL RHIC Research	11,638	—	7,530
Other National Laboratory Research	11,192	—	12,847
Total, National Laboratory Research	22,830	—	20,377
Other Research			
Accelerator R&D Research	2,150	—	1,541
Total, Research	39,259	—	35,386

Operations

Overview

Support is provided for the operations, power costs, capital infrastructure investments, and accelerator improvement projects of the RHIC accelerator complex at BNL. This includes the Electron Beam Ion Source (EBIS), the Booster, and AGS accelerators that together serve as the injector for RHIC. RHIC operations allow for parallel and cost-effective operations of the Brookhaven Linac Isotope Producer Facility (BLIP), supported by NP for the production of research and commercial isotopes critically needed by the Nation, and for the NASA Space Radiation Laboratory Program for the study of space radiation effects applicable to human space flight. Through operations of the RHIC complex, important core competencies are nurtured in accelerator physics techniques to improve RHIC performance and support the NP mission; these core competencies also provide collateral benefits to applications in industry, medicine, homeland security, and other scientific projects outside of NP. RHIC accelerator physicists are leading the effort to address technical feasibility issues of relevance to a next-generation collider, including beam cooling techniques and energy recovery linacs. These physicists also play an important role in the training of next generation of accelerator physicists, with support of graduate students and post-doctoral associates.

In addition to the accelerator complex, the operation, maintenance, improvement, and enhancement of the RHIC experimental complex, including the STAR and PHENIX detectors, the experimental halls, and the RHIC Computing Facility are included in this activity. Instrumentation advances by this community have led to practical applications in medical imaging and homeland security.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	RHIC operated for 3,072 hours (75 percent utilization), an increase above planned operations due to the highest ever reliability of the machine and lower power costs than had been anticipated. Operations focused on the highest priority scientific opportunities and goals of the heavy ion program, with very modest support provided for continued R&D of luminosity enhancement technologies. Operations workforce decreased compared to FY 2011 due to voluntary reductions and retirements of some laboratory staff, and one-time reductions in materials and supplies which allowed the maximum running possible within available funding.	163,158
FY 2013	The FY 2013 Request proposed $158,571,000. RHIC operations are supported for an estimated 1,360 hour operating schedule (33 percent utilization) in FY 2013, a decrease of 1,030 hours from that planned in FY 2012. Increases required to restore one-time cuts made in FY 2012 and for projected staff salary and benefits increases contribute to the reduction in operating hours. Effective operation will be achieved by combining FY 2013–FY 2014 running into a single back-to-back run bridging the two fiscal years. Minimal support is continued for accelerator R&D activities focused on maintaining and improving the current operations of the facility. Support for lab-wide GPE is reduced to the FY 2011 level.	—
FY 2014	RHIC operations provide for 2,770 beam hours (68 percent utilization) in support of the planned RHIC research program, which is partially made possible due to reductions in operations staff. Efforts continue to increase the heavy ion and proton-proton beam luminosity for enhanced scientific productivity. Newly completed electron lenses should improve polarized proton luminosity. General purpose equipment at the laboratory is no longer directly supported by NP.	165,224

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
RHIC Operations			
RHIC Accelerator Operations	124,669	—	128,777
RHIC Experimental Support	35,489	—	36,447
Total, RHIC Operations	160,158	—	165,224
Other Operations (BNL GPE)	3,000	—	0
Total, Operations	163,158	—	165,224

Low Energy Nuclear Physics
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	52,752	—	49,590
Operations (ATLAS, HRIBF, and other)	31,537	—	28,023
Facility for Rare Isotope Beams	22,000	—	55,000
Total, Low Energy Nuclear Physics	106,289	—	132,613

Overview

The Low Energy Nuclear Physics subprogram is the most diverse within the NP portfolio, supporting research activities aligned with scientific thrusts focusing primarily on answering the overarching questions associated with two science areas: Nuclei and Nuclear Astrophysics, and Fundamental Symmetries and Neutrinos.

Questions associated with the Nuclei and Nuclear Astrophysics frontier include:

- What is the nature of the nuclear force that binds protons and neutrons into stable nuclei and rare isotopes?
- What is the origin of simple patterns in complex nuclei?
- What is the nature of neutron stars and dense nuclear matter?
- What is the origin of the elements in the cosmos?
- What are the nuclear reactions that drive stars and stellar explosions?

Questions addressed in the Fundamental Symmetries and Neutrinos frontier, which uses neutrinos and neutrons as primary probes, include:

- What is the nature of the neutrinos, what are their masses, and how have they shaped the evolution of the universe?
- Why is there now more matter than antimatter in the universe?
- What are the unseen forces that were present at the dawn of the universe but disappeared from view as the universe evolved?

One major goal of this subprogram is to develop a comprehensive description of nuclei using beams of stable and rare isotopes to yield new insights and reveal new nuclear phenomena. A second is to measure the cross sections of the nuclear reactions powering stars and leading to spectacular stellar explosions responsible for the synthesis of the elements.

This subprogram also seeks to measure or set a limit on the neutrino mass and to determine if the neutrino is its own anti-particle (a Majorana particle). Neutrino properties are believed to play an important role in the evolution of the cosmos. Beams of cold and ultracold neutrons are used for precision measurements of parity-violating processes and beta-decay parameters and to investigate the dominance of matter over antimatter in the universe, addressing fundamental questions in nuclear and particle physics, astrophysics, and cosmology.

Two NP national scientific user facilities have been pivotal in making progress on these scientific frontiers, serving a combined international community of approximately 700 scientists. ATLAS is used to study questions of nuclear structure by providing high-quality beams of all the stable elements up to uranium as well as selected beams of short-lived nuclei for experimental studies of nuclear properties under extreme conditions and reactions of interest to nuclear astrophysics. HRIBF, which ceased operations April 15, 2012, provided beams of short-lived radioactive nuclei used to study exotic nuclei that do not normally exist in nature. HRIBF was also used to explore reactions of interest to nuclear astrophysics and isotope production.

Progress in nuclear structure and nuclear astrophysics depends increasingly upon the availability of rare isotope beams. While ATLAS has some capabilities for these studies, one of the highest priorities for the NP program is support for the construction of a facility with world-leading capabilities for short-lived radioactive beams, the Facility for Rare isotope Beams (FRIB). FRIB is a next-generation machine that will advance understanding of rare nuclear isotopes and the evolution of the cosmos by providing beams of rare isotopes with neutron and proton numbers far from those of stable nuclei in order to test the limits of nuclear existence.

NP supports the LBNL 88-Inch Cyclotron jointly with the National Reconnaissance Office (NRO) and the U.S. Air Force (USAF).

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	52,752	49,590	-3,162
The decrease reflects the last year of support for the fabrication of the Majorana Demonstrator prototype; commissioning of the prototype begins in FY 2014. Offsetting this decrease is support provided to contribute to the operation of the recently completed Karlsruhe Tritium Neutrino (KATRIN) experiment to measure the mass of the neutrino in tritium beta decay, and to maintain, operate, and enhance the newly completed GRETINA detector. Funding for core research in nuclear structure, nuclear astrophysics, neutron physics, and neutrino physics maintains the highest priority efforts. Research for the final analysis of HRIBF data is completed at the end of FY 2013 and scientific staff transition to other nuclear structure/astrophysics research efforts.			
Operations	31,537	28,023	-3,514
The decrease reflects the transfer of NP dewatering activities at the Homestake mine to the DOE High Energy Physics (HEP) program; HEP provides support for dewatering activities in FY 2014. A modest increase is provided to maintain critical staff and operations at the ATLAS national user facility.			
Facility for Rare Isotope Beams	22,000	55,000	+33,000
Federal funding ramps up for the continued execution of FRIB construction. The request supports continued construction activities of the facility at the MSU according to project plans. The FRIB project will be baselined in FY 2013.			
Total, Low Energy Nuclear Physics	106,289	132,613	+26,324

Research

Overview

Low Energy research groups are supported at ANL, BNL, LBNL, LANL, LLNL, and ORNL and university grants support about 125 scientists and 100 graduate students at 41 universities. About two-thirds of the supported university scientists conduct nuclear structure and astrophysics research primarily using specialized instrumentation at the ATLAS national user facility (and previously, HRIBF), as well as smaller accelerator facilities at two university-based Centers of Excellence. The subprogram also supports a number of other targeted areas of research, and DOE-supported scientists have a lead role in developing important accelerator- and non-accelerator-based projects:

- NP is the steward for double beta decay experiments within the Office of Science. These experiments will search for evidence that the neutrino is its own antiparticle and aim at measuring or setting a limit on the effective Majorana neutrino mass. This includes the CUORE experiment at the Gran Sasso Laboratory in Italy, where the U.S. has a major role, and the Majorana Demonstrator R&D effort to demonstrate feasibility of a future ton-scale neutrino-less double beta decay experiment with germanium detectors. In the future, NP will assess opportunities with next-generation double beta decay experiments. U.S. university scientists participating in the German-led KATRIN experiment aim to achieve a direct determination of the mass of the electron neutrino by measuring the beta decay spectrum of tritium.
- The Fundamental Neutron Physics Beamline (FNPB) at the Spallation Neutron Source will deliver cold and ultra-cold neutrons at the highest (pulsed) intensities in the world for studying the fundamental properties of the neutron, providing experimental tests of the Standard Model.
- The neutron Electric Dipole Moment Experiment (nEDM) MIE, an R&D intensive and technically challenging discovery experiment, was terminated indefinitely in FY 2012. A modest R&D effort aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment, consistent with recent NSAC recommendations, continues.

Accelerator operations are supported at two university Centers of Excellence with specific goals and unique physics programs: the Cyclotron Institute at Texas A&M University (TAMU) and accelerator facilities at the Triangle Universities Nuclear Laboratory (TUNL) at Duke University. At the University of Washington, infrastructure is supported to develop scientific instrumentation projects and provide technical and engineering training opportunities.

Applications for Nuclear Science and Technology, which is also funded under the Nuclear Theory subprogram, supports competitively awarded basic nuclear physics research that also has practical applications to other fields, including medicine, next-generation nuclear reactors, and homeland security.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	HRIBF researchers worked on completing analyses of data obtained through FY 2012, and began transitioning to other efforts. The ATLAS research program achieved its highest priority scientific goals. The nEDM MIE was terminated, and the CUORE MIE funding profile ramped down as planned for its final year of funding. Funding supported continuation of the Majorana Demonstrator R&D effort and transitioning to operations of new instrumentation projects as they came on-line, including GRETINA, experiments at the Fundamental Neutron Physics Beamline (FNPB), and the international KATRIN experiment.	52,752

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $50,354,000. University and laboratory research efforts, including support for the nuclear structure and nuclear astrophysics community to conduct research at ATLAS and support the development of FRIB, is reduced by 5.8% relative to FY 2012. In addition, the closure of HRIBF results in reduced research funding, the final year of funding for the CUORE MIE was provided in FY 2012, and the Majorana R&D effort receives its final year of funding, a decrease relative to FY 2012. Partially offsetting these decreases are increases in several areas, including operations and maintenance of the recently completed GRETINA MIE. Modest funding for R&D on the electric dipole moment of the neutron aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment continues, consistent with the recent NSAC review of priorities in the U.S. neutron science portfolio. Funding for Applications of Nuclear Science and Technology is reduced 5.8% relative to FY 2012.	—
FY 2014	University and laboratory nuclear structure and nuclear astrophysics efforts focus on research at ATLAS, university Centers of Excellence, and support for the development of advanced instrumentation to use new scientific capabilities that will be provided by FRIB. Implementation of scientific instrumentation for neutrino physics and R&D for a next generation double beta decay experiment continue with the start of commissioning of the Majorana Demonstrator; and support is provided for operations, maintenance, and enhancement of the GRETINA detector; operations of the KATRIN experiment; and operation costs for the CUORE MIE. The neutron program at the FNPB focuses on the fundamental properties of the neutron, and a modest R&D effort on the feasibility of setting a world leading limit on the electric dipole moment of the neutron (nEDM) continues	49,590

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Research	20,588	—	20,295
National Laboratory Research			
National Laboratory User Facility Research	8,823	—	4,669
Other National Laboratory Research	23,341	—	24,626
Total, National Laboratory Research	32,164	—	29,295
Total, Research	52,752	—	49,590

Operations

Overview

ATLAS provides stable and selected radioactive beams and utilizes specialized instrumentation for scientists to conduct research on nuclear structure and nuclear astrophysics. It is the premiere stable beam facility in the world. The Californium Rare Ion Breeder Upgrade (CARIBU) at ATLAS provides limited capabilities to produce radioactive ion beams until FRIB, the most advanced facility for rare ion beams in the world, becomes operational near the turn of the decade.

The ATLAS facility nurtures a core competency in accelerator science with superconducting radio frequency cavities for heavy ions that are relevant to the next generation of high-performance proton and heavy-ion linacs. This competency is important to the Office of Science mission and international stable and radioactive ion beam facilities. Capital equipment investments support the fabrication and implementation of small-scale instrumentation at the facility. ANL accelerator physicists and research scientists are also working closely with researchers at Michigan State University on developing the scientific program for FRIB.

Operation of HRIBF was supported through April 15, 2012 to provide unique capabilities for the production of intense radioactive beams by the Isotope-Separator-On-Line (ISOL) technique and for reaccelerating medium mass nuclei to the Coulomb barrier. Core competencies developed through this research include high power target design and ISOL ion beam production techniques that will have importance for FRIB and other rare isotope beam facilities. Efforts in 2013 and outyears focus on disposition of equipment at the facility.

Limited operations of the 88-Inch Cyclotron at LBNL are supported in partnership with the NRO and the USAF to meet national security needs and for a small in-house research program.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	ATLAS provided 6,140 beam hours with cost-effective 7 day-a-week operations. Support was provided for the scientific and technical personnel required to operate the facility, and capital and accelerator investments focused on increasing the reliability and efficiency of operations, including helium compressors and cryogenic system upgrades. HRIBF had limited, but very successful, operations to complete the highest priority experiments prior to its closure on April 15, 2012; equipment disposition planning activities commenced in FY 2012. One-time support was provided for sustaining operations at the Homestake Mine in conjunction with the High Energy Physics (HEP) program.	31,537
FY 2013	The FY 2013 Request proposed $27,072,000. ATLAS operations and experimental support funding levels provide 4,000 hours of operations, 80% of the maximum 5,000 hours possible with the scheduled installation of facility upgrades in FY 2013. Accelerator and capital investments support continuation of the energy and efficiency upgrade of ATLAS and the development of an electron beam ion source in order to conduct experiments with more neutron rich nuclei. Most of the increase for ATLAS Operations reflects a one-time FY 2012 transfer to the Isotope subprogram for R&D in support of the development of a californium-252 target for CARIBU. Support is provided for D&D planning activities at HRIBF. Support continues at the same level as FY 2012 for joint operations of the 88-Inch Cyclotron with the NRO and USAF. The overall funding reduction relative to FY 2012 is largely due to one-time NP funding for dewatering and sustaining operations at the Homestake Mine in FY 2012.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	ATLAS provides an estimated 5,500 hours of beam time (89% utilization) at approximately constant level of effort; additional demands will be placed on this national user facility as it attempts to serve some of the user community from HRIBF. Accelerator and capital investments continue the energy and efficiency upgrade and the development of an electron beam ion source. Funding continues for the implementation of equipment disposition activities at HRIBF.	28,023

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
User Facility Operations			
ATLAS Operations	16,048	—	17,255
HRIBF Operations[a]	6,825	—	0
HRIBF Equipment Disposition	0	—	6,479
Total, User Facility Operations	22,873	—	23,734
Other Operations	8,664	—	4,289
Total, Operations	31,537	—	28,023

[a] A portion of the FY 2012 funding was utilized for equipment disposition activities; HRIBF operations ceased April 15, 2012.

Facility for Rare Isotope Beams (FRIB)

Overview

FRIB will provide intense beams of rare isotopes for world-leading research opportunities in nuclear structure, nuclear astrophysics, and fundamental symmetry studies that will advance knowledge of the origin of the elements and the evolution of the cosmos. It offers a facility for exploring the limits of nuclear existence and identifying new phenomena, with the possibility that a broadly applicable theory of the structure of nuclei will emerge. It will offer new glimpses into the origin of the elements by providing a better insight into the structure of exotic nuclei that, until now, have been created only in nature's most spectacular supernova explosions. Experiments on fundamental symmetries will be conducted through the creation and study of certain exotic isotopes. Although motivated by discovery science, the knowledge gained will also develop competencies relevant to national security applications.

The science which underlies the FRIB mission is a core competency of nuclear physics: understanding how protons and neutrons combine to form various nuclear species; understanding how long chains of different nuclear species survive; and understanding how one nuclear species decays into another and what is emitted when that happens. Forefront knowledge and capability in this competency is essential, both for U.S. leadership in this scientific discipline and to provide the knowledge and workforce needed for numerous activities and applications relevant to national security and economic competitiveness.

Michigan State University (MSU) is undertaking a comprehensive effort to design, construct, and operate FRIB, which includes utilizing core competencies developed by several NP-supported national laboratory groups. FRIB is based on a heavy-ion linac with a minimum energy of 200 MeV per nucleon for all ions at beam power of 400 kW. The facility will include a production area, three-stage fragment separator, three ion stopping stations, and post accelerator capabilities.

Critical Decision 1 (CD-1), Approve Alternative Selection and Cost Range, was signed on September 1, 2010. The preliminary total project cost (TPC) range that DOE has been planning is $500,000,000 to $550,000,000, not including the MSU cost share of $94,500,000. The TPC and cost profile are preliminary and will not be finalized until CD-2, Approve Performance Baseline, planned for 3rd Quarter, FY 2013.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funds support continued engineering and design efforts aimed at developing FRIB, and long-lead procurements to reduce project risks. The Total Project Cost and duration will be evaluated in the process of achieving CD-2, Approve Performance Baseline, planned for FY 2013.	22,000
FY 2013	The FY 2013 Request proposed $22,000,000. Efforts begun in FY 2012 continue, and engineering and design efforts aimed at achieving CD-3, "Approve Construction Start" are pursued.	—
FY 2014	Federal funding ramps up to support construction activities and major procurements in FY 2014. CD-3b (Approve Start of All Construction) is planned and will allow construction of technical components as well as civil construction.	55,000

Design and Construction Schedule

The project performance baseline will be obtained in FY 2013. Previous dates contained in this table are preliminary estimates. Changes in the planned funding profile in FY 2012 and FY 2013 have been evaluated and the project will be baselined in FY 2013; the dates for future critical decisions will be updated based on the approved baseline.

	CD-0	CD-1	Design Complete	CD-2 / 3A	CD-3B	CD-4
FY 2011	02/09/2004	4Q FY 2010	TBD	TBD	TBD	FY 2017–2019
FY 2012	02/09/2004	9/1/2010	TBD	4Q FY 2012	TBD	FY 2018–2020
FY 2013	02/09/2004	9/1/2010	TBD	TBD	TBD	TBD
FY 2014	02/09/2004	9/1/2010	TBD	3Q FY 2013	TBD	TBD

CD-0–Approve Mission Need
CD-1–Approve Alternative Selection and Cost Range
CD-2–Approve Performance Baseline
CD-3–Approve Start of Construction
CD-4–Approve Start of Operations or Project Closeout

Funding Profile History (DOE Only)

This table does not include MSU's cost share, which is estimated to total $51,700,000 by the end of FY 2013.

(dollars in thousands)

Request Year		FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	Outyears	Total
FY 2011	TEC	0	0	10,000	TBD	TBD	TBD	TBD	TBD
	OPC	7,000	12,000	0	TBD	TBD	TBD	TBD	TBD
	TPC	7,000	12,000	10,000	TBD	TBD	TBD	TBD	TBD
FY 2012	TEC	0	0	10,000	30,000	TBD	TBD	TBD	TBD
	OPC	7,000	12,000	0	0	TBD	TBD	TBD	TBD
	TPC	7,000	12,000	10,000	30,000	TBD	TBD	TBD	TBD
FY 2013	TEC	0	0	10,000	22,000	22,000	TBD	TBD	TBD
	OPC	7,000	12,000	0	0	0	TBD	TBD	TBD
	TPC	7,000	12,000	10,000	22,000	22,000	TBD	TBD	TBD
FY 2014	TEC	0	0	10,000	22,000	—	55,000	TBD	TBD
	OPC	7,000	12,000	0	0	—	0	TBD	TBD
	TPC	7,000	12,000	10,000	22,000	—	55,000	TBD	TBD

Nuclear Theory
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Theory Research	34,547	—	34,109
Nuclear Data Activities	6,785	—	7,713
Total, Nuclear Theory	41,332	—	41,822

Overview

The Nuclear Theory subprogram provides the theoretical support needed to interpret the wide range of data obtained from the experimental nuclear science subprograms and to advance new ideas and hypotheses that identify potential areas for future experimental investigations. Nuclear Theory addresses all three of NP's scientific frontiers. One major theme of theoretical research is the development of an understanding of the mechanisms and effects of quark confinement and deconfinement. A quantitative description of these phenomena, QCD, is one of this subprogram's greatest intellectual challenges. New theoretical and computational tools are also being developed to describe nuclear many-body phenomena; these approaches will likely also see important applications in condensed matter physics and in other areas of the physical sciences. Another major research area is nuclear astrophysics, which includes efforts to understand the origins of the elements (e.g., via supernovae) and the consequences that neutrino masses have for nuclear astrophysics and for the current Standard Model of elementary particles and forces.

This subprogram supports one of the program's university Centers of Excellence, the Institute for Nuclear Theory (INT) at the University of Washington. Starting in FY 2010, five-year topical collaborations within the university and national laboratory communities were established to address high-priority topics in nuclear theory that merit a concentrated theoretical effort. The Nuclear Theory subprogram also operates the Nuclear Data program through the National Nuclear Data Center (NNDC), which collects, evaluates, and disseminates nuclear physics data for basic nuclear research and for applied nuclear technologies. The extensive nuclear databases maintained and continually updated by the Nuclear Data program are an international resource consisting of carefully organized scientific information gathered from over 100 years of worldwide low-energy nuclear physics experiments.

Much of the research supported by the Nuclear Theory subprogram requires extensive access to leading-edge supercomputers. One area that has a particularly pressing demand for large, dedicated computational resources is lattice quantum chromodynamics (LQCD). LQCD calculations are critical for understanding and interpreting many of the experimental results from RHIC, LHC, and CEBAF. A joint five-year HEP/NP LQCD-ext project, started in FY 2010, follows previous efforts that address the computational requirements of lattice QCD research. The national LQCD computing capability was further augmented by NP Recovery Act funding, which provided a dedicated LQCD computer at TJNAF that made extensive use of graphics processor units (GPUs). This relatively inexpensive GPU-based cluster has greatly increased the U.S. national capacity for LQCD research.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Theory Research	34,547	34,109	-438
Funding maintains the final year of the current theory topical centers, the LQCD-ext project (joint with the Office of High Energy Physics), university and national laboratory research efforts, and third year awards for SciDAC-3 projects.			
Nuclear Data Activities	6,785	7,713	+928
Nuclear Data activities are focused on the highest priority efforts. Increased funding supports awards in Applications of Nuclear Science and Technology, which is also partially supported within the Low Energy Program.			
Total, Nuclear Theory	41,332	41,822	+490

Theory Research

Overview

The Nuclear Theory subprogram supports the research programs of approximately 160 university scientists and 120 graduate students at 45 universities as well as nuclear theory groups at seven national laboratories (ANL, BNL, LANL, LBNL, LLNL, ORNL, and TJNAF). This research has the goals of improving our fundamental understanding of nuclear physics, interpreting the results of experiments carried out under the auspices of the experimental nuclear physics program, and identifying and exploring important new areas of research. It is aligned with the experimental program through the program performance milestones established by NSAC. In FY 2010, NP implemented three new topical collaborations through 5-year awards to bring together theorists to address specific high-priority theoretical challenges: JET (QCD in the heavy-ion environment); NuN (neutrinos and nucleosynthesis in hot and dense matter); and TORUS (low-energy nuclear reactions for unstable isotopes). A midterm review of the three topical collaborations was conducted in September2012.

The research effort supported by the Nuclear Theory subprogram is strengthened by interactions with NSF-supported theory efforts, the HEP program, and other national nuclear theory programs. International collaborations by nuclear theorists are supported by three reciprocal visitor programs: Japan-U.S. (JUSTIPEN), France-U.S. (FUSTIPEN), and Germany-U.S. (GAUSTEQ).

SciDAC is a collaborative program with ASCR that partners scientists and computer experts in research teams to address major scientific challenges that require supercomputer facilities at the current technological limits. The NP SciDAC program operates on a five year cycle, and supports computationally intensive research projects jointly with other SC and DOE offices in areas of mutual interest. SciDAC-3 awards were made for the first year in FY 2012.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Support continued for university and laboratory nuclear theory research efforts, the second-generation LQCD project in partnership with HEP, and the third-year of the topical theory collaborations. SciDAC programs throughout SC were re-competed in FY 2012 as SciDAC-3. NP is supporting three new computational nuclear theory projects under SciDAC-3 in collaboration with ASCR and NNSA.	34,547
FY 2013	The FY 2013 Request proposed $31,770,000. Support for university and laboratory theoretical efforts required for the interpretation of experimental results obtained at NP facilities is reduced by 5.8% relative to FY 2012. A specific focus will be to provide theoretical support for the research program at the upgraded CEBAF 12 GeV facility and the planned FRIB facility in order to fully exploit their physics potentials and to advance theoretical concepts that motivate future experiments at these facilities and elsewhere, including in the relatively new NP area of fundamental symmetries. Funding for SciDAC research under the SciDAC-3 program continues flat with the FY 2012 level. The fourth year for the topical theory collaborations is supported and some funding for these efforts shifts from universities to national laboratories, as planned.	—
FY 2014	Funding supports university and laboratory theoretical efforts required for the interpretation of experimental results obtained at NP facilities. Efforts will continue to focus on the research program at the upgraded CEBAF 12 GeV facility, the research program at the planned FRIB facility, and topics related to fundamental symmetries. Funding supports ongoing research efforts, the SciDAC-3 grants, and the final year of the topical theory collaborations, as planned.	34,109

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Research	16,301	—	15,407
National Laboratory Research	15,836	—	16,702
SciDAC	2,410	—	2,000
Total, Theory Research	34,547	—	34,109

Nuclear Data

Overview

The Nuclear Data effort involves the work of several national laboratories and universities, and is guided by the DOE-managed National Nuclear Data Center (NNDC) at BNL. The NNDC coordinates the work of the U.S. Nuclear Data Network, a group of DOE-supported individual nuclear data professionals located in universities and national laboratories that perform assessments, validate and estimate uncertainties, and develop modern online dissemination capabilities. The databases developed and maintained by the Nuclear Data program cover over 100 years of nuclear science research with between 1,500 and 6,000 nuclear data retrievals on a daily basis. Data retrievals increased to over 9,000 per day following the Japanese earthquake and tsunami. The NNDC participates in the International Data Committee of the IAEA and is an important national and international resource.

Independent of the core Nuclear Data activities, funding is also provided to support efforts in Applications of Nuclear Science and Technology, including efforts relevant to nuclear fuel cycle research. The funding is split between the Low Energy subprogram and the Nuclear Data program pending competitive peer review and award.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding for ongoing work of the National Nuclear Data Program continued and NNDC data servers were upgraded.	6,785
FY 2013	The FY 2013 Request proposed $6,933,000. Funding for the Nuclear Data program is reduced 5.8% relative to FY 2012. Efforts will be focused on updating online databases containing experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature. The NNDC plans to hold a major nuclear data conference, ND2013, during FY 2013. Funding for Applications of Nuclear Science and Technology is reduced 5.8% relative to FY 2012.	—
FY 2014	Funding for NNDC efforts increase to support key staff in order to maintain the viability of the program. Efforts focus on updating online databases containing experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature and on maintaining computing infrastructure needed to support important efforts across the NNDC.	7,713

Isotope Development and Production for Research and Applications
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	4,827	—	4,648
Operations	14,255	—	14,883
Total, Isotope Development and Production for Research and Applications	19,082	—	19,531

Overview

The Isotope Development and Production for Research and Applications subprogram (Isotope Program) supports the production, distribution, and development of production techniques for radioactive and stable isotopes in short supply and critical to the Nation. Isotopes are commodities of strategic importance for the Nation that are essential for energy exploration and innovation, medical applications, national security, and basic research. An important goal of the program is to make key isotopes more readily available to meet U.S. needs. To achieve this goal, the program provides facilities and capabilities for the production of research and commercial stable and radioactive isotopes, scientific and technical staff associated with general isotope research and production, and a supply of critical isotopes. The subprogram also supports R&D efforts associated with developing new and more cost-effective and efficient production and processing techniques, and on the production of isotopes needed for research purposes. The R&D activities also provide collateral benefits for training, contributing to workforce development, and helping to ensure a future U.S.-based expertise in the fields of nuclear chemistry and radiochemistry. These disciplines are foundational not only to radioisotope production but to many other critical aspects of basic and applied nuclear science as well.

The Isotope Program, which operates a revolving fund, maintains its financial viability by utilizing a combination of appropriations and revenues from the sale of isotopes and services. These resources are used to maintain the staff, facilities, and capabilities at user-ready levels and to support peer-reviewed research and development activities related to the production of isotopes. Commercial isotopes are priced to provide full cost recovery or the market price (whichever is higher). Investments in new capabilities are made to meet the growing demands of the Nation and foster research in applications that will support national security and the health and welfare of the public.

Isotopes are critical national resources that are used to improve the accuracy and effectiveness of medical diagnoses and therapy, enhance national security, improve the efficiency of industrial processes, and provide precise measurement and investigative tools for materials, biomedical, environmental, archeological, and other research. Some examples are:

- strontium-82 use for cardiac imaging;
- germanium-68 use for calibrating the growing number of positron imaging scanners;
- actinium-225 and bismuth-213 use in cancer and infectious disease therapy research;
- strontium-90 use for cancer therapy;
- selenium-75 use in industrial radiography;
- arsenic-73 use as a tracer for environmental research;
- silicon-32 use in oceanographic studies related to climate modeling;
- californium-252 for well logging, medicine, homeland defense, and energy security; and
- nickel-63 use as a component in molecular sensing devices and helium-3 (He-3) as a component in neutron detectors, both for applications in homeland defense.

Stable and radioactive isotopes are vital to the mission of many Federal agencies including the National Institutes of Health (NIH), the National Institute of Standards and Technology, the Environmental Protection Agency, the Department of Agriculture, the Department of Homeland Security (DHS), NNSA, and DOE Office of Science programs. NP continues to work in close collaboration with these organizations to develop strategic plans for isotope production and to establish effective communication to better forecast isotope needs and leverage resources. For example, a five-year production strategy has been generated with the NIH that identifies the isotopes and projected quantities needed by the medical community in the context of the Isotope Program capabilities. In addition, NP initiated a workshop, attended by representatives of all federal agencies that require stable and radioactive isotopes to support research and applications within their realms of responsibility, to provide a comprehensive assessment of national needs for isotope products and services. Another example is participation in the OSTP working group on molybdenum-99 (Mo-99). While the Isotope Program is not responsible for the production of Mo-99, it recognizes the importance of this isotope for the Nation and is working closely with NNSA, the lead entity responsible for domestic Mo-99 production, and is offering technical and management support. NP is participating in the international High-Level Group on the Security of Supply of Medical Isotopes lead by the Organisation for Economic Co-operation and Development (OECD). NP participates in the Certified Reference Material Working Group which assures material availability for nuclear forensics applications that support national security missions. Finally, NP plays a lead role in a federal working group on the He-3 supply issue involving NNSA, the DHS, the Department of Defense, NIH, and many other agencies. While the Isotope Program role in He-3 is limited to packaging and distribution of the isotope, the program does play a lead role in working with all of the federal agencies in forecasting demand for the gas and its allocation. The objective of the working group is to ensure that the limited supply of He-3 will be distributed to the highest priority applications and basic research.

The National Isotope Development Center (NIDC) is a virtual center that interfaces with the user community and manages the coordination of isotope production across the facilities and business operations involved in the production, sale, and distribution of isotopes. The NIDC includes the Isotope Business Office which is located at ORNL.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	4,827	4,648	-179
Support is provided for competitively awarded university and laboratory research in developing or improving production techniques for critical isotopes.			
Operations	14,255	14,883	+628
Funding maintains constant effort for the Isotope Production Facility, the Brookhaven Linac Isotope Producer, processing capabilities at ORNL, and the NIDC. Funding is provided to support university-based operations in support of isotope production.			
Total, Isotope Development and Production for Research and Applications	19,082	19,531	+449

Research

Overview

Research is supported to develop new or improved production or separation techniques for high priority isotopes in short supply. Examples of isotope needs requiring research to meet national needs include positron-emitting radionuclides to support the rapidly growing area of medical imaging using positron emission tomography (PET), isotopes that support medical research used to diagnose and treat diseases spread through acts of bioterrorism, alpha-emitting radionuclides that exhibit great potential in disease treatment, research isotopes for various biomedical applications, enriched stable isotopes, and alternative isotope supplies for national security applications and advanced power sources. Priorities in research isotope production are informed by guidance from NSAC. One of the high priorities is to conduct R&D aimed at re-establishing a U.S. capability for stable isotope production. Isotope Program research also provides training opportunities for workforce development in the areas of nuclear chemistry and radiochemistry. These disciplines are essential to the long-term health of the fields of radioisotope production and applications. All R&D activities are peer reviewed.

Support is provided for scientists at BNL, LANL, ORNL, INL, PNNL, and ANL and for investigators at universities and in industry to perform peer-reviewed experimental research. The supported work includes research on target design, enhanced processing and separation techniques, radiochemistry, material conversions, and other related services. Researchers provide unique expertise and facilities for data analysis and utilize reactor and accelerator capabilities throughout the DOE complex and at university sites. Isotopes produced by the NP Isotope Program are sold at reduced rates to investigators to make them more affordable for research applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Based on the FY 2011 Funding Opportunity Announcement, 4 projects received FY 2012 funding to support research into new and improved technologies for production of radioisotopes and enriched stable isotopes. Laboratory research groups were established at those sites at which production capabilities exist.	4,827
FY 2013	The FY 2013 Request proposed $4,453,000. Funding for competitively awarded research and development is reduced by 5.8%; support for laboratory research groups at LANL, BNL and ORNL will continue at the same funding level as FY 2012. There is an additional reduction relative to FY 2012 as a result of the one-time R&D project for ATLAS that was funded in FY 2012.	—
FY 2014	Support maintains research and development competitive awards and laboratory research groups at LANL, BNL, and ORNL. Development of production techniques for alpha-emitters is of high priority, as is R&D aimed at re-establishing a domestic capability for research quantities of stable isotopes.	4,648

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
National Laboratory Research	3,677	—	3,415
University Research	1,150	—	1,233
Total, Research	4,827	—	4,648

Operations

Overview

The Isotope Program is steward of the Isotope Production Facility (IPF) at Los Alamos National Laboratory (LANL) and the Brookhaven Linac Isotope Producer (BLIP) facility at BNL and provides support for hot cell facilities for processing and handling irradiated materials and purified products at ORNL, BNL, and LANL. Facilities at other national laboratories are used as needed, such as the Idaho National Laboratory reactor for the production of cobalt-60 and the Pacific Northwest National Laboratory for processing and packaging strontium-90.

Funding is provided for the scientists and engineers needed to support operational readiness of the Isotope Program facilities and includes modest facility maintenance and investments in new facility capabilities. In addition, the program supports isotope production capabilities at a few universities, other national laboratories, and reactor facilities throughout the Nation to promote a reliable supply of domestic isotopes. Facilities at Washington University, the University of California at Davis, the University of Washington, and the Missouri University Research Reactor can provide cost-effective opportunities to partner in order to increase the availability of isotopes. Partnerships with industrial counterparts are pursued to leverage resources.

The National Isotope Data Center (NIDC) interfaces with the user community and manages the coordination of isotope production across the facilities and business operations involved in the production, sale, and distribution of isotopes. The NIDC oversees public outreach for the program and maintains a website for the program at www.isotopes.gov. The NIDC also coordinates all transportation efforts and quality control issues among all of the production sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Support was provided for the infrastructure and maintenance of facilities, core competencies in isotope production and development at university and laboratory accelerator and reactor facilities, and the NIDC. Isotopes produced included commercial isotope production initiated to meet customer demand (e.g., gadolinium-153, strontium-89, neptunium-236, carbon-14, and tin-117m) and high priority isotopes identified by NSAC (e.g., astatine-211, actinium-225, and berkelium-249).	14,255
FY 2013	The FY 2013 Request proposed $14,255,000. Mission readiness for isotope production at university and laboratory accelerator and reactor facilities, and support for the NIDC are maintained within flat funding with FY 2012. The isotopes that will be chosen for production will represent a balance of commercial isotopes that must be produced in order to maintain the program’s livelihood, and high priority research isotopes identified by NSAC and the Federal workshop held in FY 2012.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Support continues at constant effort for infrastructure and maintenance of facilities, core competencies in isotope production and development, and for the NIDC. National Laboratory operations are maintained at constant effort relative to FY 2013 and focused on essential activities required to maintain aging facilities in operational conditions. An increase in university operations is associated with supporting routine production of isotopes that had been developed in prior years through grants awarded by the Isotope Program. The isotopes that will be chosen for production will represent a balance of commercial isotopes, and high priority research isotopes identified by NSAC and the Federal workshop held in FY 2012. Production of actinium-225, a promising alpha-emitter for the treatment of cancer, will be initiated in quantities sufficient to address applications and research important to the Nation.	14,883

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Operations	150	—	355
Isotope Production Facility (IPF) Operations	941	—	969
Brookhaven Linear Isotope Producer (BLIP) Operations	520	—	536
National Isotope Data Center (NIDC)	2,278	—	2,346
Other National Laboratory Operations	10,366	—	10,677
Total, Operations	14,255	—	14,883

Construction
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	50,000	50,306	25,500

Overview

This funding provides for project engineering and design (PED) and construction needed to meet overall objectives of the Nuclear Physics program. Currently the only line item construction project supported is the 12 GeV CEBAF Upgrade at TJNAF, which was identified in the 2007 NSAC Long-Range Plan as the highest priority for the U.S. Nuclear Physics program to enable scientists to address one of the mysteries of modern physics—the mechanism of quark confinement.

Explanation of Funding Changes

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	50,000	25,500	-24,500

The FY 2014 request reflects the current planned profile. A baseline change will be required as a result of the FY 2012 appropriation, which provided $50,000,000; $16,000,000 less than the baseline profile. A full assessment of the project baseline will be conducted later in FY 2013.

During FY 2014, the new cryomodules will be installed in the accelerator tunnel; the Hall D experimental equipment will be procured, fabricated, and installed; and Halls B and C experimental equipment will be upgraded.

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Capital equipment over $500,000, including major items of equipment (MIE)	13,970	—	19,258
General plant projects (GPP) (under $10 million)	2,000	—	2,000
Accelerator improvement projects (AIP)	3,622	—	5,215
Total, Capital Operating Expenses	19,592	—	26,473

Capital Equipment over $500,000, including MIEs

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Major items of equipment (TEC over $2 million)					
STAR Heavy Flavor Tracker, BNL					
TEC	15,200	6,800	4,050	—	950
OPC	280	280	0	—	0
TPC	15,480[a]	7,080	4,050	—	950
Cryogenic Underground Observatory for Rare Events (CUORE), LBNL					
TEC	7,586	7,400	186	—	0
OPC	1,114	764	350	—	0
TPC	8,700	8,164	536	—	0
Total, MIEs					
TEC			4,236	—	950
OPC			350	—	0
TPC			4,586	—	950
Other capital equipment projects under $2 million TEC			9,734	—	18,308
Total, Capital Equipment (excludes MIE OPC)			13,970	—	19,258

[a] The baselined TPC includes an additional $1,100,000 of support for engineering and technical activities supported by the base RHIC research program, for a total project cost of $16,580,000.

Heavy Ion Nuclear Physics MIEs

STAR Heavy Flavor Tracker (HFT), BNL: This MIE will fabricate a high-precision tracking and vertexing device based on ultra-thin silicon pixel and pad detectors in the STAR detector. It received CD-2/3 approval in October 2011. The project is scheduled for completion in FY 2015.

Low Energy Nuclear Physics MIEs

Cryogenic Underground Observatory for Rare Events (CUORE), LBNL: This MIE fabricates the U.S. contribution to the Italian-led CUORE experiment to measure fundamental neutrino properties. It received CD-2/3 approval in December 2009, final funding in FY 2012, and is scheduled to finish in FY 2015. This is a joint DOE/NSF project with NSF contributing additional funds.

General Plant Projects (TEC under $10 million)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Other general plant projects under $5 million TEC	n/a	n/a	2,000	—	2,000

Accelerator Improvement Projects (AIP)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
RHIC Low Energy Electron Cooling	8,000	0	0	—	2,300
Other accelerator improvement projects under $5 million TEC	n/a	n/a	3,622	—	2,915
Total, AIP			3,622	—	5,215

Construction Projects Summary

Construction Projects

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF					
TEC	287,500	170,428	50,000	50,306	25,500
OPC	22,500	10,500	0	—	4,500
TPC[a]	310,000	180,928	50,000	50,306[b]	30,000

Construction Project Outyears

(dollars in thousands)

	FY 2015 Request	FY 2016 Request	FY 2017 Request	FY 2018 Request	Outyears to Completion
12 GeV CEBAF Upgrade, TJNAF					
TEC	5,000	3,000	0	0	0
OPC	5,000	0	0	0	0
TPC	10,000	3,000	0	0	0

[a] The TPC and the completion date will change as a result of the reduced FY 2012 funding; a full assessment of the project baseline will be conducted later in FY 2013.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. Pending finalization of FY 2013 funding levels, however, the TEC, OPC and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $40,572,000 for TEC, $2,500,000 for OPC, and $43,072,000 for TPC is assumed instead.

Other Supporting Information

Funding Summary

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	168,800	—	166,800
Scientific User Facilities Operations	261,253	—	277,823
Other Facility Operations	22,919	—	25,651
Projects			
Major Items of Equipment	4,586	—	950
Facility for Rare Isotope Beams[a]	22,000	—	55,000
Construction Projects (12 GeV Upgrade TEC)	50,000	—	25,500
Total Projects	76,586	—	81,450
Other[b]	5,084	—	18,214
Total Nuclear Physics	534,642	550,737	569,938

Scientific User Facility Operations and Research

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
CEBAF (TJNAF)			
Operations[c]	78,222	—	95,344
Facility research/MIEs	12,194	—	10,725
Total CEBAF	90,416	—	106,069
RHIC (BNL)			
Operations	160,158	—	165,224
Facility research/MIEs	11,638	—	7,530
Total RHIC	171,796	—	172,754

[a] FRIB is funded with operating expense dollars through a Cooperative Agreement with MSU.
[b] Includes SBIR/STTR funding in FY 2013 and FY 2014.
[c] CEBAF Operations includes $2,500,000 in 12 GeV Other Project Costs in FY 2013, and $4,500,000 in FY 2014.

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
HRIBF (ORNL)			
Operations[a]	6,825	—	0
Facility research/MIEs	3,673	—	0
Total HRIBF	10,498	—	0
ATLAS (ANL)			
Operations	16,048	—	17,255
Facility research/MIEs	5,150	—	4,669
Total ATLAS	21,198	—	21,924
Scientific User Facilities			
Operations	261,253	—	277,823
Facility research/MIEs	32,655	—	22,924
Total, Scientific User Facility Operations and Research	293,908	—	300,747

Facilities Users and Hours

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
CEBAF (TJNAF)[b]			
Achieved operating hours	3,729	—	N/A
Planned operating hours	3,870	—	0
Optimal hours	3,940	—	0
Percent of optimal hours	95%	—	N/A
Unscheduled downtime	10%	—	N/A
Number of users	1,390	—	1,375

[a] Operations of HRIBF as a National User Facility ceased on April 15, 2012. Funding in FY 2012 was used for equipment disposition planning, transitioning staff, and limited operations to complete the highest priority experiments prior to closure.

[b] Optimal hours for CEBAF reflect the maximum possible due to the shutdown schedule for the 12 GeV CEBAF Upgrade project. During FY 2013 and FY 2014, there will be no research hours while the 12 GeV upgrade is commissioned. In FY 2014, approximately 2,100 hours of operations are supported for beam development and commissioning.

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
RHIC (BNL)			
Achieved operating hours	3,072	—	N/A
Planned operating hours	2,390	—	2,770
Optimal hours	4,100	—	4,100
Percent of optimal hours	75%	—	68%
Unscheduled downtime	15%	—	N/A
Number of users	1,200	—	1,200
ATLAS (ANL)[a]			
Achieved operating hours	6,140	—	N/A
Planned operating hours	5,900	—	5,500
Optimal hours	6,200	—	6,200
Percent of optimal hours	99%	—	89%
Unscheduled downtime	8%	—	N/A
Number of users	395	—	430
Total Facilities			
Achieved operating hours	12,941	—	N/A
Planned operating hours	12,160	—	8,270
Optimal hours	14,240	—	10,300
Percent of optimal hours (funding weighted)	83%	—	70%
Unscheduled downtime	11%	—	N/A
Number of users	2,985	—	3,005

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	220	—	205
Average size per year	$320,000	—	$340,000
Number of laboratory projects	34	—	33
Number of permanent Ph.D.'s (FTEs)	743	—	710
Number of postdoctoral associates (FTEs)	338	—	300
Number of graduate students (FTEs)	551	—	515
Number of Ph.D.'s awarded	104	—	85

[a] The maximum number of hours ATLAS can operate in FY 2013 is 4,200 hours due to downtime for installation of upgrades.

06-SC-01, 12 GeV CEBAF Upgrade, Thomas Jefferson National Accelerator Facility
Newport News, Virginia
Project Data Sheet is for PED/Construction

1. Summary and Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-3, Approve Start of Construction, which was signed on September 15, 2008, with a Total Project Cost (TPC) of $310,000,000 and a planned CD-4, Approve Project Completion, in the third quarter of FY 2015.

The previous Federal Project Director (FPD) took another position and the Deputy FPD to the 12 GeV project was promoted to the FPD position. He has a training plan and is being mentored as he works toward certification Level 3 from his current certification at Level 1.

This project data sheet (PDS) does not include a new start for the budget year; it is an update of the FY 2013 PDS.

A baseline change will be required as a result of the FY 2012 appropriation, which provided $50,000,000 for this project, $16,000,000 less than the baseline profile. As a result of this directed change, the project will be undergoing a review in FY 2013 to rebaseline the project's cost, schedule, and scope. The directed deviation from the baselined cost profile will increase the TPC, extend the project schedule, and could reduce project scope. The rebaselining effort is also currently planned to reflect any impacts resulting from the final FY 2013 appropriations. The available project contingency shrank in part due to delays and impacts caused by the FY 2012 funding. Risks change from month to month, and include issues with the procurement and installation of components, schedule, and impacts of funding uncertainty. For each moderate and high risk, a mitigation plan is developed in order to optimize successful project completion.

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4A	CD-4B	D&D
FY 2007	3/31/2004	1Q FY 2007	4Q FY 2009	4Q FY 2007	4Q FY 2008	N/A	1Q FY 2014	N/A
FY 2008	3/31/2004	2/14/2006[a]	4Q FY 2009	4Q FY 2007	4Q FY 2008	N/A	1Q FY 2015	N/A
FY 2009	3/31/2004	2/14/2006	4Q FY 2009	11/9/2007	4Q FY 2008	N/A	3Q FY 2015	N/A
FY 2010	3/31/2004	2/14/2006	4Q FY 2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2011	3/31/2004	2/14/2006	1Q FY 2010	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2012	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2013	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2014[b]	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline

[a] CD-1 was approved on 2/14/2006. Engineering and design activities started in 4Q FY 2006 after Congress approved the Department of Energy's request to reprogram $500,000 within the FY 2006 funding for Nuclear Physics, per direction contained in H.Rpt 109–275.
[b] The CD-4B date does not reflect the impact resulting from the reduced FY 2012 funding, which will be assessed at a rebaseline review in FY 2013.

CD-3 – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout
D&D– Demolition & Decontamination (D&D) work

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC Except D&D	OPC, D&D	OPC, Total	TPC
FY 2007	21,000	TBD	TBD	11,000	TBD	TBD	TBD
FY 2008	21,000	TBD	TBD	10,500	TBD	TBD	TBD
FY 2009	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2010	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2011	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2012	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2013	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2014[a]	21,000	266,500	287,500	22,500	N/A	22,500	310,000

4. Project Description, Scope, and Justification

Mission Need

The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility is the world-leading facility for the experimental study of the structure of matter governed by the "strong force." An energy upgrade of CEBAF has been identified by the nuclear science community as a compelling scientific opportunity. In particular, the Nuclear Science Advisory Committee (NSAC) stated in the 1996 Long Range Plan that "…the community looks forward to future increases in CEBAF's energy, and to the scientific opportunities that would bring." In the 2007 Long Range Plan, NSAC concluded that completion of the 12 GeV CEBAF Upgrade project was the highest priority for the Nation's nuclear science program.

Scope and Justification for 06-SC-01, 12 GeV CEBAF Upgrade

The 12 GeV CEBAF Upgrade directly supports the Nuclear Physics mission and addresses the objective to measure properties of the proton, neutron, and simple nuclei for comparison with theoretical calculations to provide an improved quantitative understanding of their quark substructure.

The scope of the project includes upgrading the electron energy capability of the main accelerator from 6 GeV to 12 GeV, building a new experimental hall (Hall D) and associated beam-line, and enhancing the capabilities of the existing experimental halls to support the most compelling nuclear physics research.

[a] A Work-for-Others agreement was approved by DOE that provides $9,000,000 appropriated by the Commonwealth of Virginia to leverage the federal investment for an upgrade of the Jefferson Lab's research facilities. The additional funding reduced project risks associated with cost and schedule. Any adjustments to the federal government's share of the TPC as a result of the funding from this Work-for-Others activity will be evaluated by the SC Office of Project Assessment during the rebaseline review in FY 2013 that assesses the impacts of reduced FY 2012 funding. The TPC does not reflect the impact resulting from the reduced FY 2012 funding.

CD-4A Key Performance Parameters

Subsystem	Technical Definition of Completion
Accelerator	12 GeV capable 5.5 pass machine installed
	11 GeV capable beamline to existing Halls A, B, and C installed
	12 GeV capable beamline to new Hall D tagger area installed
	Accelerator commissioned by transporting a ≥ 2 nA electron beam at 2.2 GeV (1pass)
Conventional Facilities	New Experimental Hall D and the Counting House ≥ 10,500 square feet.

CD-4B Key Performance Parameters

Subsystem	Technical Definition of Completion
Hall B	Detector operational: events recorded with a ≥ 2 nA electron beam at > 6 GeV beam energy (3 pass)
Hall C	Detector operational: events recorded with a ≥ 2 nA electron beam at > 6 GeV beam energy (3 pass)
Hall D	Detector operational: events recorded with a ≥ 2 nA electron beam at > 6 GeV beam energy (3 pass)

Key Performance Parameters to achieve CD-4 are phased between the accelerator and conventional facilities (CD-4A) and the experimental equipment in Halls B, C, and D (CD-4B). The deliverables defining completion are identified in the Project Execution Plan and have not changed since CD-2. Mitigation plans exist for identified risks to help ensure successful project completion after a rebaseline due to the directed change.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Total Estimated Cost (TEC)				
PED				
FY 2006	500	500	0	88
FY 2007	7,000	7,000	0	6,162
FY 2008	13,377[a]	13,377	0	9,108
FY 2009	123[a]	123	0	5,370
FY 2010	0	0	0	265
FY 2011	0	0	0	7
Total, PED	21,000	21,000	0	21,000

[a] The baseline FY 2008 PED funding was reduced by $123,000 as a result of a FY 2008 rescission. This reduction was restored in FY 2009 to maintain the TEC and project scope.

	(dollars in thousands)			
	Appropriations	Obligations	Recovery Act Costs	Costs
Construction				
FY 2009	28,500	28,500	0	5,249
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,642
FY 2011[a]	35,928	35,928	25,889	40,801
FY 2012	50,000	50,000	5,203	45,537
FY 2013	50,306[b]	40,572	1,549	48,000
FY 2014	25,500	25,500	0	34,000
FY 2015	1,000	1,000	0	9,271
Total, Construction	266,500	266,500	65,000	201,500
TEC				
FY 2006	500	500	0	88
FY 2007	7,000	7,000	0	6,162
FY 2008	13,377	13,377	0	9,108
FY 2009	28,623	28,623	0	10,619
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,907
FY 2011	35,928	35,928	25,889	40,808
FY 2012	50,000	50,000	5,203	45,537
FY 2013	50,306[b]	40,572	1,549	48,000
FY 2014	25,500	25,500	0	34,000
FY 2015	1,000	1,000	0	9,271
Total, TEC	287,500	287,500	65,000	222,500

[a] The baseline FY 2011 funding was reduced by $72,000 as a result of a FY 2011 rescission.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. Pending finalization of FY 2013 funding levels, however, the TEC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $40,572,000 for TEC is assumed instead.

	(dollars in thousands)			
	Appropriations	Obligations	Recovery Act Costs	Costs
Other Project Cost (OPC)				
OPC except D&D				
FY 2004	700	700	0	77
FY 2005	2,300	2,300	0	2,142
FY 2006	4,000	4,000	0	3,508
FY 2007	2,500	2,500	0	2,751
FY 2008	1,000	1,000	0	1,802
FY 2009	0	0	0	155
FY 2010	0	0	0	62
FY 2013	—[a]	2,500	0	1,500
FY 2014	4,500	4,500	0	3,500
FY 2015	5,000	5,000	0	7,003
Total, OPC	22,500	22,500	0	22,500
Total Project Cost				
FY 2004	700	700	0	77
FY 2005	2,300	2,300	0	2,142
FY 2006	4,500	4,500	0	3,596
FY 2007	9,500	9,500	0	8,913
FY 2008	14,377	14,377	0	10,910
FY 2009	28,623	28,623	0	10,774
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,969
FY 2011	35,928	35,928	25,889	40,808
FY 2012	50,000	50,000	5,203	45,537
FY 2013	50,306[a]	43,072	1,549	49,500
FY 2014	30,000	30,000	0	37,500
FY 2015	6,000	6,000	0	16,274
Total, TPC[b]	310,000	310,000	65,000	245,000

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $40,572,000 for TEC, $2,500,000 for OPC, and $43,072,000 for TPC is assumed instead.

[b] The TPC does not reflect the impact resulting from the reduced FY 2012 funding, which will be assessed at a rebaseline review in FY 2013.

6. Details of Project Cost Estimate

	(dollars in thousands)		
	Current Total Estimate	Previous Total Estimate	Original Validated Estimate
Total Estimated Cost (TEC)			
PED			
Design	21,000	21,000	19,200
Contingency	0	0	1,800
Total, PED	21,000	21,000	21,000
Construction Phase			
Construction	30,306	29,507	27,450
Accelerator/Experimental Equipment/ Management	225,059	210,058	174,150
Contingency	11,135	26,935	64,900
Total, Construction	266,500	266,500	266,500
Total, TEC	287,500	287,500	287,500
Contingency, TEC	11,135	26,935	66,700
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Design	3,445	3,445	3,500
R&D	7,052	7,052	6,400
Start-up	11,836	9,394	7,450
Contingency	167	2,609	5,150
Total, OPC	22,500	22,500	22,500
Contingency, OPC	167	2,609	5,150
Total, TPC[a]	310,000	310,000	310,000
Total, Contingency	11,302	29,544	71,850

[a] The TPC does not reflect the impact resulting from the reduced FY 2012 funding, which will be assessed at a rebaseline review in FY 2013.

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2007 (PED only)	TEC	19,000	2,000	0	0	0	0	0	0	21,000
	OPC	11,000	0	0	0	0	0	0	0	11,000
	TPC	30,000	2,000	0	0	0	0	0	0	32,000
FY 2008 (PED only)	TEC	21,000	0	0	0	0	0	0	0	21,000
	OPC	10,500	0	0	0	0	0	0	0	10,500
	TPC	31,500	0	0	0	0	0	0	0	31,500
FY 2009[a] (Performance Baseline)	TEC	20,877	28,623	59,000	62,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	59,000	62,000	66,000	43,000	18,000	2,000	310,000
FY 2010[b]	TEC	20,877	93,623	22,000	34,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	93,623	22,000	34,000	66,000	43,000	18,000	2,000	310,000
FY 2011	TEC	20,877	93,623	20,000	36,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	93,623	20,000	36,000	66,000	43,000	18,000	2,000	310,000
FY 2012	TEC	20,877	93,623	20,000	36,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	93,623	20,000	36,000	66,000	43,000	18,000	2,000	310,000
FY 2013	TEC	20,877	93,623	20,000	35,928[c]	50,000	40,572	26,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	93,623	20,000	35,928	50,000	43,072	34,000	2,000	310,000

[a] The FY 2009 Congressional Budget was the first project data sheet to reflect the CD-2 Performance Baseline which was approved in November 2007.

[b] The project received $65,000,000 from the American Recovery and Reinvestment Act of 2009 which advanced a portion of the baselined FY 2010 and FY 2011 planned funding. The FY 2010 and FY 2011 amounts reflect a total of $65,000,000 in reductions to the originally planned baselined funding profile to account for the advanced Recovery Act funding.

[c] The baseline FY 2011 funding was reduced by $72,000 as a result of the FY 2011 rescission.

Request Year		Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
		(dollars in thousands)								
FY 2014	TEC	20,877	93,623	20,000	35,928	50,000	50,306	25,500	1,000	287,500
	OPC	10,500	0	0	0	0	—	4,500	5,000	22,500
	TPC[a]	31,377	93,623	20,000	35,928	50,000	50,306[b]	30,000	6,000	310,000

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	3Q FY 2016
Expected Useful Life (number of years)	15
Expected Future start of D&D for new construction (fiscal quarter)	N/A

(Related Funding Requirements)

(dollars in thousands)

	Annual Costs		Life cycle costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	150,000	150,000	2,250,000[c]	2,250,000
Maintenance	Included above	Included above	Included above	Included above
Total, Operations & Maintenance	150,000	150,000	2,250,000	2,250,000

9. Required D&D Information

	Square Feet
Area of new construction	31,500
Area of existing facility(ies) being replaced	N/A
Area of any additional D&D space to meet the "one-for-one" requirement	31,500

The "one-for-one" requirement is met by offsetting 31,500 square feet of the 80,000 square feet of banked space that was granted to Jefferson Laboratory in a Secretarial waiver.

[a] The TPC does not reflect the estimated impact resulting from the reduced FY 2012 funding, which will be assessed at a rebaseline review in FY 2013.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $40,572,000 for TEC, $2,500,000 for OPC, and $43,072,000 for TPC is assumed instead.

[c] The total operations and maintenance (O&M) is estimated at an average annual cost of approximately $150,000,000 (including escalation) over 15 years. Almost 90% of the O&M cost would still have been required had the existing accelerator not been upgraded and instead continued operations at 6 GeV.

10. Acquisition Approach

The Acquisition Strategy was approved February 14, 2006 with CD-1 approval. All acquisitions are managed by Jefferson Science Associates with appropriate Department of Energy oversight. Cost, schedule, and technical performance are monitored using an earned-value process that is described in the Jefferson Lab Project Control System Manual and consistent with DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets. The procurement practice uses firm fixed-price purchase orders and subcontracts for supplies, equipment, and services and makes awards through competitive solicitations. Project and design management, inspection, coordination, tie-ins, testing and checkout witnessing, and acceptance are performed by Jefferson Laboratory and Architectural-Engineering subcontractors as appropriate.

Workforce Development for Teachers and Scientists
Funding Profile by Subprogram and Activity

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Activities at the DOE Laboratories			
Science Undergraduate Laboratory Internships	6,500	—	7,300
Community College Internships	552	—	700
Graduate Student Research Program (formerly Office of Science Graduate Fellowship)	5,000	—	2,000
Visiting Faculty Program	1,179	—	1,300
Albert Einstein Distinguished Educator Fellowship	1,200	—	1,200
National Science Bowl®	2,700	—	2,800
Technology Development and On-Line Application	620	—	550
Evaluation Studies	300	—	300
Outreach	300	—	300
Laboratory Equipment Donation Program	149	—	50
Total, Workforce Development for Teachers and Scientists	18,500	18,613	16,500

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act of 1977"
Public Law 101-510, "DOE Science Education Enhancement Act of 1991"
Public Law 103-382, "The Albert Einstein Distinguished Educator Fellowship Act of 1994"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

The Workforce Development for Teachers and Scientists (WDTS) program mission is to help ensure that DOE has a sustained pipeline of skilled and diverse science, technology, engineering, and mathematics (STEM) workers. This is accomplished through support of undergraduate internships, graduate thesis research, and visiting faculty programs at the DOE laboratories; the Albert Einstein Distinguished Educator Fellowship for K–12 STEM teachers, which is administered by WDTS for DOE and for a number of other federal agencies; and Nation-wide, middle- and high-school science competitions that annually culminate in the National Science Bowl® in Washington D.C. These investments help develop the next generation of scientists and engineers to support the DOE mission, administer its programs, and conduct its research.

WDTS activities rely significantly on DOE's 17 laboratories, which employ more than 30,000 workers with STEM backgrounds. The DOE laboratory system provides access to leading scientists; world-class scientific user facilities and instrumentation; and large-scale, multidisciplinary research programs unavailable in universities or industry. WDTS leverages these assets to develop and train students and educators, with the intent that they continue the pursuit of work relevant to the DOE mission in their future studies and careers.

Program Accomplishments and Milestones

In FY 2012, the WDTS program initiated improvements to enhance the research experiences of the student interns and visiting faculty it supports at the DOE laboratories, strengthen program management and execution, increase program transparency, and leverage technology to improve program operations. Consistent with the goals described in *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report,*[a] WDTS programs focus on DOE's unique STEM workforce needs.

Undergraduate Student Internship Programs. In 2012, management and execution processes for the undergraduate student internship programs sited at DOE laboratories (Science Undergraduate Laboratory Internships [SULI] and the Community College Internships [CCI]) were improved in several ways. To help promote the development of skills that interns will need for STEM careers, participant deliverables were revised and made uniform across all participating DOE laboratories; these now include research papers, project reports, posters, and oral presentations. Changes also include clearer eligibility requirements; application essay questions with improved relevance to STEM studies and careers; and new processes by which laboratories select interns from the applicant pool. Program management now also includes a preliminary Federal (WDTS staff) applicant eligibility and compliance review prior to release of applications to host laboratories.

Visiting Faculty Program (VFP). In 2012, the VFP was revised to help ensure that faculty members (largely from colleges and universities traditionally underrepresented in STEM fields) and DOE laboratory researchers engage in important, impactful, and mutually beneficial research projects. The most important change is a new requirement that a faculty applicant and a laboratory principal investigator—who become the co-principal investigators on the research project—develop a research project plan, which becomes part of the faculty member's application. Prior to selection of participants in the VFP, these research plans are merit reviewed using similar processes and criteria to those applied throughout the Office of Science. In July 2012, a VFP workshop was held to review this new application process following the experience gained after the first year of implementation. There was agreement from the laboratory education directors and the VFP participants that the requirement of a short proposal engages both faculty applicants and laboratory investigators early in the process of collaboration and significantly improves the research experiences for both. Effecting early connections between prospective faculty applicants and laboratory principal investigators is one of the most important functions of the laboratory education directors with respect to the VFP. WDTS and the laboratory education directors continue to develop and share best-practices.

Milestone	Date
Peer review of the WDTS activities sited at the DOE Laboratories—SULI, CCI, and VFP—is completed.	2nd Qtr, FY 2013
Phase in of the new online application and review systems for SULI, CCI, and VFP is completed.	2nd Qtr, FY 2013
A Federal Advisory Committee Act Committee of Visitors (COV) review of WDTS program activities is commissioned.	4th Qtr, FY 2013

Program Planning, Evaluation, and Management

Consistent with Office of Science practices for program management and execution and aligned with the President's management priorities[b] WDTS uses evaluation and evidenced-based decision making to improve program management and execution and to set priorities. The 2010 WDTS COV,[c] which reviewed the WDTS activities, recommended enhancing activities that reviewed as Excellent or Very Good and redirecting funds from activities that reviewed as Fair or Poor. As a result, from the time of the COV review to the present, funding for some activities (notably SULI and CCI) was increased; one activity (VFP) was restructured using input from the scientific community and from the DOE laboratories that host the program participants; and six activities were gradually phased out. A second COV review will be held

[a] http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc_federal_stem_education_coordination_report.pdf

[b] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

[c] http://science.energy.gov/sc-2/committees-of-visitors/

in late 2013. In addition to the standard charge (assess the efficacy and quality of the processes used to solicit, review, recommend, monitor, and document application, proposal, and award actions; and assess the quality of the resulting portfolio), the COV will be asked to comment on the changes that have taken place since the 2010 COV, the new directions of the program, and the plans for data collection and program assessment as they relate to workforce development programs.

In FY 2012, the first peer review of the WDTS laboratory programs (i.e., the offices of the laboratory education directors) provided a comparative assessment of the management and execution of the SULI, CCI, and VFP activities across the DOE laboratory complex. The peer review focused on leadership, management, and best practices at the host DOE laboratories. This includes program planning and execution, resource allocation, fostering synergy with those who serve as student advisors and faculty collaborators, and outreach to prospective participants.

In response to the recommendation of the 2010 COV for increased interaction and cooperation between WDTS staff and Office of Science research program staff, two actions have been taken. First, the Office of Science STEM Working Group of Ph.D. level program managers from the SC program offices was used more extensively to increase interactions with the SC programs. The Working Group coordinates STEM workforce activities across the Office of Science and with the DOE technology programs and also provides a forum for sharing best practices in workforce development program management, particularly management of programs at the DOE laboratories. Second, two Ph.D. level program managers from the Office of Science now serve as team leads for WDTS activities.

The Office of Science, in collaboration with the DOE technology programs, represents the Department of Energy on the interagency Committee on STEM Education (CoSTEM) established under the National Science and Technology Council. In response to the 2010 reauthorization of the America COMPETES Act, CoSTEM was formed to coordinate federal STEM education activities and programs and specifically charged to establish and maintain an inventory of federally sponsored STEM education programs and develop a 5-year STEM education strategic plan. As part of these efforts the federal agencies are identifying and sharing best practices for STEM programs, which will inform processes used by the WDTS programs. In December 2011, CoSTEM released the *Federal Science, Technology, Engineering, and Mathematics (STEM) Education Portfolio*, an inventory and analysis of federally supported STEM education programs across 13 agencies. In February 2012, CoSTEM released the *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report*, a report to Congress on status of the establishment of a Federal strategic plan on STEM education programs.

In addition to CoSTEM efforts, WDTS coordinates with other Federal agencies such as National Science Foundation, National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration to develop interagency efforts in STEM workforce development and education and to carry out jointly funded programs.

Program Goals and Funding

WDTS activities support the following Office of Science performance expectation area:

- *Scientific Workforce:* Contribute to STEM workforce development through the support of undergraduate internships, a graduate student thesis research program, and visiting faculty programs at the DOE laboratories; the Albert Einstein Distinguished Educator Fellowship; and the National Science Bowl®.

Goal Areas

	Research	Facility Operations	Future Facilities	Scientific Workforce
Workforce Development for Teachers and Scientists	0%	0%	0%	100%

Performance Measures

Performance Goal (Measure)	**WTDS Science Undergraduate Laboratory Internship (SULI)**—Percentage of SULI students who report in their exit survey that they have increased their preparedness for a STEM career as a result of the program		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	N/A	≥ 90%	≥ 90%
Result	N/A		
Endpoint Target	Encourage undergraduate students to enter STEM careers especially relevant to the DOE mission by providing research experiences at DOE national laboratories under the direction of scientific and technical laboratory staff who serve as research advisors and mentors		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012–2014 Annual Performance Plan and Report.

Explanation of Funding and Program Changes

The Graduate Student Research Program (formerly the DOE Office of Science Graduate Fellowship program) has been restructured following experience with the first cohort of the SCGF, the desire to take full advantage of the opportunities afforded by the DOE laboratories, and the need to address the unique future workforce requirements of those laboratories. The program will provide graduate thesis research opportunities at DOE laboratories in collaboration with DOE laboratory scientists.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Science Undergraduate Laboratory Internships	6,500	7,300	+800
The number of undergraduate students supported increases from 645 in FY 2012 to approximately 700 in FY 2014.			
Community College Internships	552	700	+148
The number of community college students supported decreases from 80 in FY 2012 to approximately 70 in FY 2014; FY 2012 funding was augmented with prior year funds from terminated activities, thus allowing additional students to participate.			
Graduate Student Research Program [formerly DOE Office of Science Graduate Fellowship (SCGF)]	5,000	2,000	-3,000
Funding in FY 2012 continued 70 SCGF Fellows in the third and final year of their Fellowship initiated with the FY 2010 appropriation. Prior year funding from terminated activities was used to fully fund for three years a small FY 2012 cohort. Funding in FY 2014 supports graduate students to perform part of their thesis research at DOE laboratories in collaboration with DOE laboratory scientists. Approximately 100 students will be supported in FY 2014. Actual numbers of students will be determined following peer review of applications.			

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Visiting Faculty Program	1,179	1,300	+121
No significant change. Funding supports approximately 50 faculty and 20 students in FY 2012 and FY 2014. Actual numbers of faculty and students will be determined following peer review of applications.			
Albert Einstein Distinguished Educator Fellowship	1,200	1,200	0
No change; funding supports 6 Fellows.			
National Science Bowl®	2,700	2,800	100
Funding is increased to help defray increased housing, transportation, and other logistical expenses for the national event.			
Technology Development and On-Line Application	620	550	-70
Funding is provided to support modernization of on-line applications systems for application, review, data collection, and evaluation of WDTS programs. Small decrease reflects completion of some activities.			
Evaluation Studies	300	300	0
No change; funding is provided for the collection and analysis of data and other materials, including pre- and post-participation questionnaires, participant deliverables, and longitudinal participant tracking.			
Outreach	300	300	0
No change; funding is provided to support outreach activities to broaden participation in DOE laboratory programs—undergraduate student internships, graduate student thesis research, and visiting faculty programs.			
Laboratory Equipment Donation Program	149	50	-99
Funding is reduced, reflecting efficiencies in program management and termination of the pilot program to provide laboratory equipment to middle schools and high schools. Funding continues support for the transfer of excess laboratory equipment to faculty at higher educational institutions for DOE-related research.			
Total, Workforce Development for Teachers and Students	18,500	16,500	-2,000

Activities at the DOE Laboratories

Overview

Activities at the DOE Laboratories include the Science Undergraduate Laboratory Internships, the Community College Internships, the Graduate Student Research Program (formerly DOE Office of Science Graduate Fellowship), and the Visiting Faculty Program. These activities provide opportunities for participants to engage in research requiring specialized instrumentation; large-scale, multidisciplinary efforts; and/or the scientific user facilities. Undergraduate internships and the Visiting Faculty Program are aligned with the CoSTEM Strategic Federal Coordination Objectives[a] for undergraduate education and for support of those traditionally underrepresented in STEM fields.

The **Science Undergraduate Laboratory Internships (SULI)** program goal is to encourage undergraduate students to enter STEM careers especially relevant to the DOE mission by providing research experiences at DOE national laboratories under the direction of scientific and technical laboratory staff who serve as research advisors and mentors. With its long history, the SULI program places undergraduate students in paid internships in science and engineering research activities at DOE laboratories, working with laboratory staff scientists or engineers on projects related to ongoing research programs. Appointments are for 10 weeks during the summer term and 16 weeks during the fall and spring terms.

The **Community College Internships (CCI)** program goal is to encourage community college students to pursue technical careers relevant to the DOE mission by providing technical training experiences at DOE laboratories under the direction of laboratory staff who serve as advisors and mentors. The CCI program places students in paid internships in technologies supporting laboratory work under the supervision of a laboratory technician or researcher.

The **Graduate Student Research Program** goal is to strengthen and enhance graduate student preparedness for science, technology, engineering, or mathematics (STEM) careers especially relevant to the Office of Science mission by providing graduate thesis research opportunities at DOE laboratories. The program provides research awards for graduate students to pursue part of their graduate thesis research at a DOE laboratory in areas that address scientific challenges relevant to the Office of Science mission. Graduate students pursuing Ph.D. degrees in areas of physics, chemistry, materials sciences, biology (non-medical), mathematics, computer or computational sciences, or specific areas of environmental sciences that are aligned with the mission of the Office of Science are eligible for research awards to conduct part of their graduate thesis research at a DOE laboratory in collaboration with a DOE laboratory scientist. Research award terms will range from 3 months to 1 year. Approximately 100 awards will be made in FY 2014 with the exact number dependent on the distribution of terms requested in successful proposals.

The **Visiting Faculty Program (VFP)** goal is to increase the research competitiveness of faculty members and their students at institutions historically underrepresented in the research community in order to expand the workforce that addresses DOE mission areas. Through direct collaboration with research staff at DOE host laboratories, VFP appointments provide an opportunity for faculty and students to develop skills applicable to programs at their home institutions; this helps increase the STEM workforce in DOE science mission areas at institutions historically not part of the DOE enterprise.

[a] http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc_federal_stem_education_coordination_report.pdf

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	SULI supported 645 students.	6,500
	CCI supported 80 students.	552

Fiscal Year	Activity	Funding (dollars in thousands)
	SCGF supported 70 fellows whose Fellowships were initiated with the FY 2010 appropriation and an additional 80 fellows whose Fellowships were fully funded for three years using the American Recovery and Reinvestment Act. Prior year funds resulting from terminated activities were used to fully fund a cohort of 49 Fellows for FY 2012–2014; SC received Congressional approval prior to the solicitation for this cohort.	5,000
	VFP supported 50 faculty and 25 students.	1,179
FY 2013	The FY 2013 Request proposed $7,300,000 for SULI to support approximately 700 students.	—
	The FY 2013 Request proposed $700,000 for CCI to support approximately 70 students.	—
	The FY 2013 Request proposed no funding for the SCGF program as originally formulated.	—
	The FY 2013 Request proposed $1,300,000 for VFP to support approximately 50 faculty and 20 students.	—
FY 2014	SULI will support approximately 700 students.	7,300
	CCI will support approximately 70 students.	700
	The Graduate Student Research Program will support approximately 100 graduate students for periods of 3 months to 1 year to conduct a part of their thesis research at DOE laboratories.	2,000
	VFP will support approximately 50 faculty and 20 students.	1,300

Albert Einstein Distinguished Educator Fellowship

Overview

The Albert Einstein Distinguished Educator Fellowship Act of 1994 gives the Department of Energy responsibility for administering a program of professional development fellowships for elementary and secondary school mathematics and science teachers. WDTS manages the Einstein Fellowship for the federal government and encourages participation by other federal agencies. Selected teachers spend eleven months in a Congressional office or a Federal agency. Typically, the Office of Science supports 6 Fellows each year; 4 are placed in Congressional offices and 2 are placed in the Office of Science. Other Offices within DOE also participate; other participating agencies include the National Science Foundation, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration. The Fellows provide their educational expertise, years of teaching experience, and personal insights to these offices and often are involved in the advancement of science, mathematics, and technology education programs.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	The FY 2012 appropriation supported 6 Fellows.	1,200
FY 2013	The FY 2013 request proposed $1,200,000 to support 6 Fellows.	—
FY 2014	The FY 2014 request supports 6 Fellows.	1,200

National Science Bowl

Overview

The DOE National Science Bowl® is a nationwide academic competition testing students' knowledge in all areas of science, including energy. High school and middle school students are quizzed in a fast-paced, question-and-answer format. Since 1991, more than 335,000 students have participated in regional and national competitions.

The number of regional events held annually remains nearly constant, with approximately 70 high school and approximately 40 middle school teams participating in the national competition in recent years. Regional science bowl winning teams receive an all-expenses paid trip to Washington D.C. to compete at the national competition in April or May. Competing teams are composed of four students, one alternate, and a teacher who serves as an advisor and coach.

In 2012, 4,700 middle school and 10,450 high school students participated in the competitions, with 41 middle school and 69 high school teams (550 students) participating in the finals in Washington, DC. More than 5,000 volunteers also participated in the local and national competitions. In 2013, Alaska will host a regional middle school competition, bringing National Science Bowl® events to all fifty states.

In response to a recommendation from the 2010 WDTS Committee of Visitors to seek broader geographic coverage for the NSB, the geographic boundaries of the regional competitions were defined by using state/county/city boundaries for the first time. Formerly underrepresented geographic areas were assigned to a specific regional Science Bowl competition.

The DOE National Science Bowl® is aligned with the CoSTEM Strategic Federal Coordination Objective[a] for STEM engagement.

[a] http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc_federal_stem_education_coordination_report.pdf

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding is provided for travel and housing costs for regional winning teams to attend the national event; for other logistical expenses for the national event; and for upgrades to the NSB online registration system to accommodate increased numbers of participants and out-of-date technologies.	2,700
FY 2013	The FY 2013 Request proposed $2,800,000 for increased travel and housing costs and for other logistical expenses for the national event.	—
FY 2014	Funding is maintained to support a constant number of regional teams each year at the national finals competition.	2,800

Technology Development and On-line Application Systems

Overview

This activity continues modernization of on-line systems to support on-line applications and review, data collection, and evaluation for the WDTS programs. A project to develop, build, and launch new online application and program support systems was initiated to improve program management, execution, and evaluation by WDTS program staff and by DOE laboratory staff. A study of stakeholder needs was completed to determine system requirements, identify optimized views of required elements and data, and define a project plan and build schedule for a 2012 launch—in time for the 2013 summer internship programs. The new online systems will enable better management of application and participant information and the collection and archiving of participant deliverables (research reports, etc.). An important component of the systems is the ability to support regular evaluation of program performance and impact. A phased approach will be used to develop and build the systems. Following completion of the systems for SULI, CCI, and VFP for use beginning in 2013, the systems for the National Science Bowl®, the Albert Einstein Distinguished Educator Fellowship, and the Graduate Student Research Program will be updated or developed.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding in FY 2012 supported a redesign to integrate the on-line applications, participant deliverables, and questionnaires that participants complete; to bring the transactional web properties into alignment with the programmatic procedures, policies and protocols; and to provide users a facile interface.	620
FY 2013	The FY 2013 Request proposed $550,000 to continue on-going work.	—
FY 2014	Funding in FY 2014 continues on-going work.	550

Evaluation Studies

Overview

The Evaluation Studies activity supports work to assess whether WDTS programs meet established goals through the use of collection and analysis of data and other materials, including pre- and post-participation questionnaires, participant deliverables, and longitudinal participant tracking.

The 2010 Committee of Visitors found little evaluation of activities across WDTS but noted that the data collection and evaluation plans under development provided some innovative options for gathering workforce information and for tracking participants. In FY 2014, evaluation plans for each WDTS activity will be completed.

Evaluation Studies is aligned with Congressional recommendations in the GPRA Modernization Act of 2010, the President's management priorities,[a] and the 2008 Congressionally-mandated Academic Competitiveness Council initiative, which emphasized the need for federal programs (including STEM education programs) to demonstrate their effectiveness through rigorous evaluation. WDTS works cooperatively with Office of Science programs, other DOE programs, and other federal agencies through the National Science and Technology Council Committee on STEM Education (CoSTEM) to share best practices for STEM program evaluation to ensure the implementation of evaluation processes that are appropriate to the nature and scale of the program effort.

[a] http://www.whitehouse.gov/sites/default/files/omb/memoranda/2012/m-12-14.pdf

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	FY 2012 funding supports the reassessment of the evaluation plans to measure the effectiveness of WDTS investments in STEM workforce development.	300
FY 2013	The FY 2013 Request proposed $300,000 to begin the evaluation plans for all WDTS activities.	—
FY 2014	FY 2014 funding completes the evaluation plans for all WDTS activities and begins data archiving and curation.	300

Outreach

Overview

WDTS engages in outreach activities, some in cooperation with other federal agencies, to broaden participation in and enhance the student internships, the graduate student thesis research program, and the Visiting Faculty Program. The method most widely used by prospective program participants to obtain information about WDTS is the WDTS website (http://science.energy.gov/wdts/). Therefore, in order to facilitate outreach to prospective participants, the WDTS website was completely revised in FY 2012 to allow students and faculty access to current, consistent, and accurate information for all WDTS activities, including program descriptions, opportunities, and eligibility requirements. Website content is now also optimized for mobile devices, such as smart phones, often used by the demographic groups targeted by WDTS programs. Active outreach is also via the web using live webinar virtual meetings to highlight the programs, their opportunities, and the WDTS internship experience.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	FY 2012 funding continued ongoing Outreach activities.	300
FY 2013	The FY 2013 Request proposed $300,000 to continue the ongoing activity.	—
FY 2014	Funding continues the ongoing activity.	300

Laboratory Equipment Donation Program

Overview

The Laboratory Equipment Donation Program provides excess laboratory equipment to faculty at educational institutions. Through the Energy Asset Disposal System, DOE sites identify excess equipment. Colleges and universities can then search for equipment of interest and apply via the website. The equipment is free, but the receiving institution pays for shipping costs.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	FY 2012 funding continued the ongoing program.	149
FY 2013	The FY 2013 Request proposed $50,000 to continue the ongoing program. A reduction in funding reflects increases in efficiency and the elimination of eligibility for middle schools and high schools based on a suggestion by the 2010 Committee of Visitors.	—
FY 2014	Funding continues the ongoing program.	50

Science Laboratories Infrastructure
Funding Profile by Subprogram and Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Infrastructure Support			
Oak Ridge Landlord	5,493	5,527	5,951
Payments in Lieu of Taxes	1,385	1,393	1,385
Facilities and Infrastructure	0	0	900
Total, Infrastructure Support	6,878	6,920	8,236
Construction			
Utilities Upgrade at FNAL (13-SC-70)	0	0	34,900
Utility Infrastructure Modernization at TJNAF (13-SC-71)	0	0	29,200
Science and User Support Building at SLAC (12-SC-70)	12,086	12,160	25,482
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)	12,024	12,098	0
Energy Sciences Building at ANL (10-SC-71)	40,000	40,245	0
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)	15,500	15,595	0
Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II, at LBNL (09-SC-72)	12,975	13,054	0
Technology and Engineering Development Facility at TJNAF (09-SC-74)	12,337	12,413	0
Total, Construction	104,922	105,565	89,582
Total, Science Laboratories Infrastructure	111,800	112,485	97,818

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 102-468, "Energy Policy Act of 1992"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

The Science Laboratories Infrastructure (SLI) program mission is to support scientific and technological innovation at the Office of Science (SC) laboratories by funding and sustaining mission-ready infrastructure and fostering safe and environmentally responsible operations. The program provides the infrastructure necessary to support world leadership by the SC national laboratories in the area of basic scientific research now and in the future.

SLI's primary focus is on long-term modernization of SC laboratory infrastructure to ensure the mission readiness of SC laboratories. Through this program, SC is ensuring that its laboratories have state-of-the-art facilities and utilities that are flexible, reliable, and sustainable, with environmentally stable research space and high performance computing space needed to support scientific discovery. Facility designs ensure safe, collaborative, and interactive work environments and allow for the integration of basic and applied research and development. Projects in many cases include funds for removal of aged and outdated facilities that are being replaced by new ones. New and renovated buildings and utilities include the latest temperature and humidity controls, clean power, and isolation from vibration and electromagnetic interference where needed. Other small facility decontamination and decommissioning and cleanup projects not included in the SLI construction program are funded with laboratory overhead. SLI maintains and regularly updates a portfolio of potential future projects across all 10 SC laboratories to provide modernized mission-ready infrastructure as needed.

In addition to the construction program, SLI's Infrastructure Support program provides SC stewardship responsibilities for the Oak Ridge Reservation and the Federal facilities in the City of Oak Ridge, Tennessee, and Payments in Lieu of Taxes (PILT) to local communities around the Argonne, Brookhaven, and Oak Ridge National Laboratories. Beginning in FY 2013, SLI will provide funding to support facilities and infrastructure for the Office of Scientific and Technical Information (OSTI) at Oak Ridge and the New Brunswick Laboratory (NBL) at the Argonne Site. These activities were previously budgeted in SC Program Direction.

Program Accomplishments and Milestones

In FY 2012, two SLI projects were recognized by the Secretary of Energy for excellence in project management. The DOE Secretary's Award of Excellence was awarded to the *Physical Sciences Facility (PSF) project at Pacific Northwest National Laboratory (PNNL)* and the DOE Secretary's Improvement Award was presented to the *Modernization of Laboratory Facilities (MLF) project at Oak Ridge National Laboratory (ORNL)*. Both of these projects were approved for project closeout and accepted for occupancy in FY 2011.

Demolition of Building 51 and Bevatron Project at Lawrence Berkeley National Laboratory (LBNL) was completed in FY 2012 on schedule and within budget. The project, which eliminated a legacy accelerator and freed up approximately three acres of much-needed land at the site for programmatic use, has been nominated for recognition for a DOE project management excellence award.

The Technology and Engineering Development Facility (TEDF) at Thomas Jefferson National Accelerator Facility (TJNAF). On March 22, 2012 this project received CD-4A, Approve Start of Operations—New Construction, after the on-time completion of the 30,000 square foot addition to Test Lab for Superconducting Radio Frequency (SRF) space and completion of the new 70,000 square foot Technology and Engineering Development building for engineering and fabrication functions. TJNAF obtained LEED® Gold Certification for this newly constructed building.

The Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II at Lawrence Berkeley National Laboratory. Beneficial Occupancy on Building 74 of this project was completed on August 28, 2012.

The Research Support Building and Infrastructure Modernization (RSB) at SLAC National Accelerator Laboratory (SLAC). Construction on the Operations Support Building (Bldg. 028) was completed 3-months ahead of schedule on October 31, 2011. Work involved a significant renovation in the first quarter of FY 2012 and the addition of enclosed offices and open work-stations to the 20,000 square-foot building. The construction also added ADA compliant access, restrooms, break rooms, huddle rooms, and utility rooms (mechanical, electrical, IT, etc.). SLAC obtained LEED® Gold Certification for this newly renovated building.

The Interdisciplinary Science Building (ISB), Phase I project at Brookhaven National Laboratory (BNL). Construction of this new 87,700 square foot laboratory building is substantially complete, on schedule, and within budget. Beneficial Occupancy was achieved on February 27, 2013.

Milestone	Date
Approve start of construction for the balance of the Research Support Building project at SLAC	3rd Qtr. FY 2013
Approve project completion for the Interdisciplinary Science Building project at BNL	3rd Qtr. FY 2013
Approve performance baseline and start of construction for the Science and User Support Building project at SLAC	3rd Qtr. FY 2013

Milestone	Date
Approve start of operations for the renovated Test Lab and project completion of the Technology and Engineering Development Facility project at TJNAF	2nd Qtr. FY 2014
Approve project completion for the Renovate Science Laboratories—Phase II project at BNL	3rd Qtr. FY 2014

Program Planning and Management

SLI's portfolio of infrastructure modernization construction projects has been established in full collaboration with the SC Deputy Director for Field Operations and the Deputy Director for Science Programs. SLI reviews the priorities for new construction projects each year in concert with the Director of Science and the Deputy Director for Science Programs in order to assure project starts are consistent with current and future science mission priorities. SLI relies on the SC Annual Laboratory Plans for this annual review. These plans integrate scientific planning with infrastructure and operational planning by directly tying proposed investments to identified mission capability gaps. The plans provide a concise picture of the mission readiness of each laboratory, the capability gaps, and the investments necessary to fill those gaps.

SLI's construction projects are rigorously managed in accordance with the requirements of DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, as well as Office of Science policies and procedures, including Independent Project Reviews. SLI program managers work closely with the SC Budget and Project Assessment offices during project planning and execution. As a result, performance of SLI construction projects has been on track with commitments. To date, all on-going SLI infrastructure modernization construction projects have received successful reviews by the SC Office of Project Assessment and all planned milestones and Critical Decision (CD) approvals have been met.

Program Goals and Funding

Revitalizing facilities and providing modern laboratory infrastructure is critical to ensuring the continued mission readiness of SC laboratories. Mission readiness of a laboratory's facilities and infrastructure is defined as the capability of those assets to effectively support the scientific mission assigned to the laboratory. The current and future mission readiness of each SC laboratory is evaluated using a peer review process that focuses on the ability of each laboratory infrastructure element to meet the needs of scientific research. Through the SLI program, capital investments are provided to make needed improvements. The goal of SLI's construction program is to provide the modern laboratory infrastructure needed to deliver advances in science the Nation requires to remain competitive in the 21st century and to correct longstanding deficiencies while ensuring laboratory infrastructure provides a safe and quality workplace.

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Infrastructure Support	0%	0%	100%	0%
Line Item Construction	0%	0%	100%	0%
Total, Science Laboratories Infrastructure	0%	0%	100%	0%

Explanation of Funding and Program Changes

Two ongoing SLI construction projects received final year funding in FY 2012—the Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II project at Lawrence Berkeley National Laboratory; and the Technology and Engineering Development Facility project at Thomas Jefferson National Accelerator Facility. Furthermore, three ongoing construction projects are scheduled to receive final year funding with the requested FY 2013 budget: the Renovate Science Laboratories project at Brookhaven National Laboratory; the Energy Sciences Building project at Argonne National Laboratory; and the Research Support Building and Infrastructure Modernization project at the SLAC National Accelerator Laboratory.

In FY 2014, SLI will continue funding for three ongoing construction projects: the Science and User Support

Building project at SLAC, the Utilities Upgrade project at the Fermi National Accelerator Laboratory, and the Utility Infrastructure Modernization project at TJNAF. In FY 2014, SLI's Infrastructure Support subprogram will continue funding to accommodate and support facilities and infrastructure activities at the Office of Scientific and Technical Information facility at Oak Ridge and the NBL facility at the Argonne Site.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Infrastructure Support	6,878	8,236	+1,358
Funding increases to accommodate the transfer of funding for facilities and infrastructure support at the OSTI facility at Oak Ridge and the NBL facility at the Argonne site that were previously funded under SC Program Direction. Increased funding also supports reservation road repairs, critical maintenance needs, and other landlord responsibilities at the Oak Ridge Reservation and other DOE facilities in Oak Ridge.			
Line Item Construction	104,922	89,582	-15,340
Two ongoing SLI construction projects received final funding in FY 2012, and three ongoing construction projects received final funding in FY 2013. The conclusion of funding is offset in FY 2014 by funding provided for the continuation of the Science and User Support Building project at SLAC, the Utilities Upgrade project at FNAL, and the Utility Infrastructure Modernization project at TJNAF.			
Total, Science Laboratories Infrastructure	111,800	97,818	-13,982

Infrastructure Support
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Oak Ridge Landlord	5,493	5,527	5,951
Payments in Lieu of Taxes	1,385	1,393	1,385
Facilities and Infrastructure	0	0	900
Total, Infrastructure Support	6,878	6,920	8,236

Overview

The Infrastructure Support subprogram provides SC stewardship responsibilities for the Oak Ridge Reservation and DOE facilities and Office of Scientific and Technical Information in the city of Oak Ridge, Tennessee and facilities infrastructure support for New Brunswick Laboratory at the Argonne site. Infrastructure Support also provides Payments in Lieu of Taxes to local communities around the Argonne, Brookhaven, and Oak Ridge National Laboratories.

Explanation of Funding Changes

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Oak Ridge Landlord	5,493	5,951	+458
Funding increases to accommodate the transfer of funding for facilities and infrastructure support at OSTI ($200,000) that was previously funded under SC Program Direction. The increase also supports reservation road repairs and other critical maintenance needs at the Oak Ridge Reservation and other DOE facilities in Oak Ridge.			
Payments in Lieu of Taxes	1,385	1,385	0
Funding is maintained at the current level.			
Facilities and Infrastructure	0	900	+900
Funding increases to accommodate the transfer of funding for facilities and infrastructure support at NBL. This funding was previously funded under SC Program Direction.			
Total, Infrastructure Support	6,878	8,236	+1,358

Oak Ridge Landlord

Overview

Funding supports landlord responsibilities, including infrastructure for the 24,000 acre Oak Ridge Reservation, Office of Scientific and Technical Information, and DOE facilities in the city of Oak Ridge, Tennessee. Activities include maintenance of roads, grounds, and other infrastructure; support and improvement of environmental protection, safety, and health; routine infrastructure maintenance at OSTI; and Payment in Lieu of Taxes to Oak Ridge communities. Landlord responsibilities exclude the Y-12 plant, ORNL, and the East Tennessee Technology Park.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding provided for activities to ensure continuity of operations and minimize interruptions due to infrastructure or other system failures.	5,493
FY 2013	The FY 2013 Request proposed $5,934,000 to support Oak Ridge Reservation Landlord responsibilities and to ensure continuity of operations and minimize interruptions due to infrastructure or other system failures. Funding also initiated support of OSTI facility and infrastructure expenses transferred from SC Program Direction.	5,527
FY 2014	The FY 2014 request provides funding for activities to ensure continuity of operations and minimize interruptions due to infrastructure or other system failures. Funding also initiates support for OSTI facility and infrastructure expenses transferred from SC Program Direction.	5,951

Payments in Lieu of Taxes

Overview

The Department is authorized to provide discretionary payments to state and local government authorities for real property that is not subject to taxation because it is owned by the United States and operated by the Department. Under this authorization, PILT is provided to communities around the Argonne and Brookhaven National Laboratories to compensate for lost tax revenues for land removed from local tax rolls. PILT payments are negotiated between the Department and local governments based on land values and tax rates.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding supports the Department's authorization to provide PILT payments to communities around Argonne and Brookhaven National Laboratories.	1,385
FY 2013	The FY 2013 Request proposed $1,385,000 to support the Department's authorization to provide PILT payments to communities around the Argonne and Brookhaven National Laboratories.	1,393
FY 2014	The FY 2014 request provides funding for PILT payments to communities around the Argonne and Brookhaven National Laboratories.	1,385

Facilities and Infrastructure

Overview

Funding within this activity is provided for maintenance of general purpose infrastructure at the New Brunswick Laboratory (NBL), located on the site of the Argonne National Laboratory.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	In FY 2012, these activities were funded by SC Program Direction.	0
FY 2013	The FY 2013 Request proposed $900,000 to initiate support of NBL facilities and infrastructure previously funded under SC Program Direction.	0
FY 2014	Funding provided to support of NBL facilities and infrastructure previously funded under SC Program Direction.	900

Construction
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Construction			
Utilities Upgrade at FNAL (13-SC-70)	0	0	34,900
Utility Infrastructure Modernization at TJNAF (13-SC-71)	0	0	29,200
Science and User Support Building at SLAC (12-SC-70)	12,086	12,160	25,482
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)	12,024	12,098	0
Energy Sciences Building at ANL (10-SC-71)	40,000	40,245	0
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)	15,500	15,595	0
Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II, at LBNL (09-SC-72)	12,975	13,054	0
Technology and Engineering Development Facility at TJNAF (09-SC-74)	12,337	12,413	0
Total, Construction	104,922	105,565	89,582

Overview

The SLI Construction program funds line item projects to maintain and enhance the general purpose infrastructure at SC laboratories. SLI's infrastructure modernization construction projects are focused on the accomplishment of long-term science goals and strategies at each SC laboratory.

Explanation of Funding Changes

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Utilities Upgrade at FNAL (13-SC-70)	0	34,900	+34,900

The reliability of FNAL's current industrial cooling water and high-voltage electrical distribution systems is suffering due to increased pipe break and electrical failures. Also, current and future accelerator and experimental facilities at FNAL will exhaust the capacity of the existing utility systems and additional stresses to the system will exacerbate these problems. The Utilities Upgrade project will upgrade the laboratory's industrial cooling water and high voltage electrical system, which will mitigate environmental liability, improve reliability, and enable FNAL to effectively perform high energy physics research.

This project received CD-1 approval on November 15, 2010.

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
The FY 2014 Request fully funds this project to reduce procurement risk.			
Utility Infrastructure Modernization at TJNAF (13-SC-71)	0	29,200	+29,200

The Utility Infrastructure Modernization project at TJNAF will replace/upgrade existing utility systems that continue to experience failures that could limit the laboratory's performance abilities. This project will upgrade and increase capacity of the process cooling, cryogenic, electrical power distribution, and communication systems. These upgrades will improve performance and reliability of ongoing SC research programs including Continuous Electron Beam Accelerator Facility and its 12 GeV Upgrade, along with the Free Electron Laser.

This project received CD-1 approval on October 14, 2010.

The FY 2014 Request fully funds this project to reduce procurement risk.

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Science and User Support Building at SLAC (12-SC-70)	12,086	25,482	+13,396

SLAC's Linac Coherent Light Source (LCLS) and Stanford Synchrotron Radiation Light Source (SSRL), through a common user support office, engage, train, and support a new generation of scientific users working in a range of disciplines in physical sciences, engineering, and biology, whose skills bridge x-ray and laser physics capabilities. With the success of the LCLS, SLAC is benefiting from a large influx of visitors and users and expects the demand to use SLAC's research facilities will continue to grow. The Science and User Support Building project will provide the expanded user space needed to ensure that world-class research conducted is supported by mission-ready facilities. This project will replace aging structures with a newly constructed building that will serve as the main entrance to the laboratory and bring together SLAC's visitor's, users, and administrative services.

This project received CD-1 approval on May 11, 2012.

FY 2014 funding supports the continuation of construction activities per the planned profile in the Preliminary Project Execution Plan.

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)	12,024	0	-12,024

The Research Support Building and Infrastructure Modernization project improves accelerator research capabilities and efficiency by collocating Particle Physics, SSRL, and LCLS functions. Additionally, the Accelerator Main Control Center, located within the Research Support Building, will contribute to the co-location of accelerator scientists and strengthen ties and interactions between control room operators and related areas of research and support functions as well as provide them a stronger connection to the main campus.

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
CD-3A approval to start construction on Building 28 and Building 52 was received on December 10, 2010. Construction on Building 28 was completed on October 31, 2011 and construction on Building 52 is in progress and is expected to be completed in FY 2013. CD-3B to start construction on Building 41 is expected to be approved in FY 2013.			
Final funding for this project was requested in FY 2013.			
Energy Sciences Building at ANL (10-SC-71)	40,000	0	-40,000
The Energy Science Building project replaces some of the oldest and least effective research space with new, environmentally stable, and specialized multi-disciplinary laboratory space. This integration will enable multi-functionality and enhance capabilities of research funded through the Basic Energy Science (BES) program including biomolecules; superconductors and magnets; catalysts with intricately structured surfaces; and hybrid solar cells integrating nanoscale dyes, semiconductors, and electrolytes.			
This project received CD-3 approval on June 15, 2011 and is planned for project closeout in FY 2014.			
Final funding for this project was requested in FY 2013.			
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)	15,500	0	-15,500
This project provides upgrades to several laboratory buildings at BNL. Building 510 (the Physics Department) is essential to research supported by the SC Office of Nuclear and Office of High Energy Physics as it is home to scientists from the PHENIX and STAR collaborations at the Relativistic Heavy Ion Collider (RHIC) facility and is the center for the U.S. ATLAS group that works at the Large Hadron Collider at CERN. This building also accommodates research related to the MINOS experiment at Fermilab and the Long Baseline Neutrino Experiment. Building 555 (the Chemistry Department) is essential to research supported by the BES program as it is the primary site for wet chemistry and is linked to BNL's Center for Functional Nanomaterials, the National Synchrotron Light Source (NSLS), and the future NSLS-II. The Renovate Science Labs, Phase II project will improve the working environment of scientists by modernizing the laboratory space in these two buildings which will boost operational efficiency, save energy through more efficient buildings, and provide facilities that meet ES&H codes to improve safety.			
This project received CD-3B approval on June 15, 2011 and is planned to receive approval for project closeout in FY 2014.			
Final funding for this project was requested in FY 2013.			

(dollars in thousands)

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II, at LBNL (09-SC-72)	12,975	0	-12,975
This project received final funding in FY 2012 and is planned to receive approval for project closeout in FY 2015.			
Technology and Engineering Development Facility at TJNAF (09-SC-74)	12,337	0	-12,337
This project received final funding in FY 2012 and is planned to receive approval for project closeout in FY 2014.			
Total, Construction	104,922	89,582	-15,340

Supporting Information

Capital Operating Expenses

<u>**Capital Operating Expenses**</u>

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
General plant projects under $5 million	100	—	100

Construction Projects Summary

Construction Projects

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Utilities Upgrade at FNAL (13-SC-70)					
TEC	34,900[a]	0	0	0	34,900
OPC[b]	1,100	1,100	0	0	0
TPC	36,000[a]	1,100	0	0	34,900
Utility Infrastructure Modernization at TJNAF (13-SC-71)					
TEC	29,200[a]	0	0	0	29,200
OPC[b]	700	700	0	0	0
TPC	29,900[a]	700	0	0	29,200
Science & User Support Building at SLAC (12-SC-70)					
TEC	64,000[a]	0	12,086	12,160[c]	25,482
OPC[b]	1,000	500	0	0	300
TPC	65,000[a]	500	12,086	12,160[c]	25,782
Research Support Building and Infrastructure Modernization at SLAC (10-SC-70)					
TEC	96,000	47,594	12,024	12,098[d]	0
OPC[b]	1,400	705	215	216[d]	230
TPC	97,400	48,299	12,239	12,314[d]	230

[a] This project has not received CD-2 approval; therefore, preliminary cost estimates are shown for TEC and TPC.

[b] Other Project Costs shown are funded through laboratory overhead.

[c] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and subsequent appropriation assumptions have not been adjusted to reflect this FY 2013 level; the FY 2013 Request level of $21,629,000 is assumed instead.

[d] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and subsequent appropriation assumptions have not been adjusted to reflect this FY 2013 level; the FY 2013 Request level of $36,382,000 for TEC, $250,000 for OPC, and $36,632,000 for TPC is assumed.

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Energy Sciences Building at ANL (10-SC-71)					
TEC	95,000	22,970	40,000	40,245[a]	0
OPC[b]	956	956	0	0	0
TPC	95,956	23,926	40,000	40,245[a]	0
Renovate Science Laboratories, Phase II, at BNL (10-SC-72)					
TEC	50,000	19,970	15,500	15,595[c]	0
OPC[b]	800	800	0	0	0
TPC	50,800	20,770	15,500	15,595[c]	0
Seismic Life-Safety, Modernization, and Replacement of General Purpose Buildings, Phase II, at LBNL (09-SC-72)					
TEC	94,560	81,585	12,975	13,054[d]	0
OPC[b]	2,480	2,256	74	74	0
TPC	97,040	83,841	13,049	13,128[d]	0
Technology and Engineering Development Facility at TJNAF (09-SC-74)					
TEC	72,143	59,806	12,337	12,413[d]	0
OPC[b]	1,000	1,000	0	0	0
TPC	73,143	60,806	12,337	12,413[d]	0
Total, Construction					
TEC			104,922	105,565	89,582
OPC[b]			289	290	530
TPC			105,211	105,855	90,112

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and subsequent appropriation assumptions have not been adjusted to reflect this FY 2013 level; the FY 2013 Request level of $32,030,00 is assumed instead.

[b] Other Project Costs shown are funded through laboratory overhead.

[c] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and subsequent appropriation assumptions have not been adjusted to reflect this FY 2013 level; the FY 2013 Request level of $14,530,000 is assumed instead.

[d] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and subsequent appropriation assumptions have not been adjusted to reflect this FY 2013 level. Final funding for this project was received in FY 2012.

Construction Project Outyears

	(dollars in thousands)				
	FY 2015 Request	FY 2016 Request	FY 2017 Request	FY 2018 Request	Outyears to Completion
Science & User Support Building at SLAC (12-SC-70)					
TEC	4,803	0	0	0	0
OPC[a]	200	0	0	0	0
TPC	5,003	0	0	0	0

[a] Other Project Costs shown are funded through laboratory overhead.

Other Supporting Information

Indirect Costs and Other Items of Interest for the Office of Science

General Plant Projects

General Plant Projects are construction projects that are less than $10 million and necessary to adapt facilities to new or improved production techniques, to effect economies of operation, and to reduce or eliminate health, fire, and security problems. The following table displays total GPP funding across the Office of Science by site.

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Ames Laboratory	1,152	—	600
Sandia National Laboratories	1,700	—	0
SLAC National Accelerator Laboratory	1,000	—	0
Fermi National Accelerator Laboratory	7,175	—	14,548
Oak Ridge Institute for Science and Education	700	—	500
Oak Ridge Office	100	—	100
Pacific Northwest National Laboratory	1,483	—	0
Princeton Plasma Physics Laboratory	465	—	400
Thomas Jefferson National Acceleratory Facility	2,000	—	2,000
Total, GPP	15,775	—	18,148

Institutional General Plant Projects

Institutional General Plant Projects are construction projects that are less than $10 million and cannot be allocated to a specific program. IGPPs fulfill multi-programmatic and/or inter-disciplinary needs and are funded through site overhead. The following table displays total IGPP funding across all SC laboratories by site.

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Argonne National Laboratory	16,998	—	21,435
Brookhaven National Laboratory	7,541	—	7,750
Lawrence Berkeley National Laboratory	5,730	—	6,000
Oak Ridge National Laboratory	8,517	—	20,000
Pacific Northwest National Laboratory	7,340	—	13,160
SLAC National Accelerator Laboratory	5,477	—	6,850
Total, IGPP	51,603	—	75,195

Facilities Maintenance and Repair

General purpose infrastructure includes multiprogram research laboratories, administrative and support buildings, as well as cafeterias, power plants, fire stations, utilities, roads, and other structures. Together, the SC laboratories have over 1,400 operational buildings and real property trailers, with nearly 20 million gross square feet of space.

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. Facilities Maintenance and Repair activities funded by this budget are displayed below.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance)

Generally, facilities maintenance and repair expenses are funded through an indirect overhead charge. In some cases, however, a laboratory may charge maintenance directly to a specific program. One example would be when maintenance is performed in a building used only by a single program. Such direct-funded charges are not directly budgeted.

(dollars in thousands)

	FY 2012 Actual Costs	FY 2012 Planned Costs	FY 2013 Planned Costs	FY 2014 Planned Costs
Brookhaven National Laboratory	6,623	5,696	—	6,028
Fermilab National Accelerator Facility	68	122	—	142
Notre Dame Radiation Laboratory	180	171	—	117
Oak Ridge National Laboratory	16,514	15,388	—	17,714
Oak Ridge Office	2,941	5,100	—	3,123
Office of Scientific and Technical Information	355	355	—	373
SLAC National Accelerator Laboratory	3,049	838	—	5,269
Thomas Jefferson National Accelerator Facility	83	63	—	68
Total, Direct-Funded Maintenance and Repair	29,813	27,733	—	32,834

Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance)

Facilities maintenance and repair activities funded indirectly through overhead charges at SC laboratories are displayed below. Since this funding is allocated to all work done at each laboratory, the cost of these activities is allocated to SC and other DOE organizations, as well as other Federal agencies and other entities doing work at SC laboratories. Maintenance reported to SC for non-SC laboratories is also shown. The figures below are total projected expenditures across all SC laboratories.

(dollars in thousands)

	FY 2012 Actual Costs	FY 2012 Planned Costs	FY 2013 Planned Costs	FY 2014 Planned Costs
Ames Laboratory	1,343	1,147	—	1,272
Argonne National Laboratory	62,728	50,755	—	51,200
Brookhaven National Laboratory	36,952	36,742	—	36,743
Fermi National Accelerator Laboratory	16,221	16,178	—	17,158
Lawrence Berkeley National Laboratory	16,437	17,200	—	18,300
Lawrence Livermore National Laboratory	2,719	2,719	—	2,828

	(dollars in thousands)			
	FY 2012 Actual Costs	FY 2012 Planned Costs	FY 2013 Planned Costs	FY 2014 Planned Costs
Los Alamos National Laboratory	117	117	—	121
Oak Ridge Institute for Science and Education	954	413	—	447
Oak Ridge National Laboratory	58,397	58,712	—	61,014
Oak Ridge National Laboratory facilities at Y-12	819	602	—	779
Pacific Northwest National Laboratory	3,887	4,300	—	2,922
Princeton Plasma Physics Laboratory	6,228	6,045	—	6,587
Sandia National Laboratories	2,548	2,548	—	2,649
SLAC National Accelerator Laboratory	11,105	17,424	—	11,224
Thomas Jefferson National Accelerator Facility	5,452	4,450	—	5,500
Total, Indirect-Funded Maintenance and Repair	225,907	219,352	—	218,744

Report on FY 2012 Expenditures for Maintenance and Repair

This report responds to legislative language set forth in Conference Report (H.R. Conf. Rep. No. 108-10) accompanying the Consolidated Appropriations Resolution, 2003 (Public Law 108-7) (pages 886-887), which requests the Department of Energy provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2012 to the amount planned for FY 2012, including Congressionally-directed changes.

Total Costs for Maintenance and Repair

	(dollars in thousands)	
	FY 2012 Actual Costs	FY 2012 Planned Costs
Ames Laboratory	1,343	1,147
Argonne National Laboratory	62,728	50,755
Brookhaven National Laboratory	43,575	42,438
Fermi National Accelerator Laboratory	16,289	16,300
Lawrence Berkeley National Laboratory	16,437	17,200
Lawrence Livermore National Laboratory	2,719	2,719
Los Alamos National Laboratory	117	117
Notre Dame Radiation Laboratory	180	171
Oak Ridge Institute for Science and Education	954	413
Oak Ridge National Laboratory	74,911	74,100
Oak Ridge National Laboratory facilities at Y-12	819	602
Oak Ridge Office	2,941	5,100
Office of Science and Technical Information	355	355

	(dollars in thousands)	
	FY 2012 Actual Costs	FY 2012 Planned Costs
Pacific Northwest National Laboratory	3,887	4,300
Princeton Plasma Physics Laboratory	6,228	6,045
Sandia National Laboratories	2,548	2,548
SLAC National Accelerator Laboratory	14,154	18,262
Thomas Jefferson National Accelerator Facility	5,535	4,513
Total, Maintenance and Repair	255,720	247,085

13-SC-70, Utilities Upgrade, Fermi National Accelerator Laboratory (FNAL), Batavia, Illinois
Project Data Sheet is for PED and Construction

1. Summary and Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-1, *Approve Alternative Selection and Cost Range*, which was approved on November 15, 2010. The preliminary Total Estimated Cost (TEC) range for this project is $31,300,000 to $34,900,000. The preliminary Total Project Cost (TPC) range for this project is $32,400,000 to $36,000,000.

This PDS is an update of the data sheet submitted in FY 2013 and includes a new start for the budget year, which was also requested in FY 2013.

The preliminary funding schedule has been updated to reflect full project funding in FY 2014.

A Federal Project Director with a certification level II has been assigned to this project.

This PDS includes a new CD-2/3A, Approve Performance Baseline and Approve Long Lead Procurement.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	PED Complete	CD-2	CD-3A	CD-3B	CD-4
FY 2013	9/18/2009	11/15/2010	1Q FY 2014	4Q FY 2013[a]	N/A	3Q FY 2014[a]	3Q FY 2015[a]
FY 2014	9/18/2009	11/15/2010	4Q FY 2014	3Q FY 2014[a]	3Q FY 2014[a]	2Q FY 2015[a]	4Q FY 2016[a]

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2/3A – Approve Performance Baseline and Approve Long Lead Procurement
CD-3B – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC[b] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2013	4,450	30,450[c]	34,900[c]	1,100	0	1,100	36,000[c]
FY 2014	4,450	30,450[c]	34,900[c]	1,100	0	1,100	36,000[c]

4. Project Description, Justification, and Scope

Mission Need

DOE is a leading sponsor of research in particle physics and FNAL remains focused on particle physics while progressing research efforts to neutrino physics at the intensity frontier. Maintaining a dependable base from which science research

[a] This project is pre-CD-2 and schedule estimates are preliminary.
[b] Other project costs (OPC) are funded through laboratory overhead.
[c] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $31,300,000 to $34,900,000. The preliminary TPC range for this project is $32,400,000 to $36,000,000.

can be accomplished is dependent upon robust, redundant, maintainable, and flexible utility systems. Existing FNAL facilities are subjected to decreased reliability as pipe breaks and electrical equipment failures become more common. FNAL also currently has design concepts established for a group of neutrino projects including the Muon to Electron Conversion Experiment (Mu2e) funded through the SC High Energy Physics (HEP) program. These and future accelerator and experimental facilities at FNAL will exhaust the capacity capabilities of the existing utility systems.

Scope and Justification (13-SC-70, Utilities Upgrade at FNAL)

The backbone of Fermilab's utility systems is its industrial cooling water (ICW) and high voltage electrical systems. Without these systems, science at Fermilab cannot exist. The Utilities Upgrade project at FNAL will upgrade both of these systems and significantly extend their useful lifespans.

The ICW system consists of ponds, pumping stations, and approximately 72,000 feet of underground network piping, supplying process cooling and fire protection water throughout the laboratory's 6,800 acre site. As most of the system was installed during the construction of the lab, almost 40 years ago most components of the system have reached the end of their useful life. The fragile state of the piping and valves currently in service, reduction in flows by biofouling, and frequent pipe failures jeopardize the reliability and maintainability of the ICW system. The current system requires frequent and unscheduled repairs which are complicated by insufficient and often malfunctioning isolation valves, enlarging the disabled area being repaired. Reliable process cooling and fire protection water service cannot be provided to current accelerator and experimental facilities areas as well as those areas slated for development of future facilities unless substantial re-investment in the lab's ICW system is provided. The new system will include state of the art materials to mitigate the existing conditions such as biofouling (zebra mussels) and valves to properly isolate various locations of the system. These improvements will significantly extend the useful life of the system.

The high voltage electrical system consists of substations, switches, and transformers. Various elements of the high voltage distribution system are rated as poor based on their current condition, are unreliable, and will continue to deteriorate with age. Future science at Fermilab is dependent upon a robust, redundant, maintainable, and flexible high voltage electrical distribution system for both programmatic and conventional power needs. The master substation and numerous oil switches and transformers across the site were installed during the original construction of the laboratory in the early 1970s. Much of this equipment is now beyond its useful life, and substantial reinvestment in this system is required for continued science in support of the Fermilab mission. This project will mitigate environmental liability (e.g. oil switches replaced with air switches), improve reliability, and allow FNAL to effectively perform high energy physics research. Furthermore, this project will upgrade and expand these utilities to provide a flexible base to serve existing facilities and provide the backbone from which future projects will build to serve new facilities. Many parts of the system are no longer manufactured, limiting system maintenance options. New state of the art transformers and substations will be provided to extend system life. This will establish a stable base from which to serve both programmatic and conventional requirements across the site.

Key Performance Parameters

Description	Threshold Value (Minimum)	Objective Value (Maximum)
High-Voltage Electrical (H/V) Upgrade	Replace Master Substation Building and associated components Replace all oil switches with new air switches	Threshold value plus: Replace feeder cable > 25 years old Replace all end-of-life unit substations Perform all Master Substation Modifications to improve system reliability, which includes replacing the 345kV oil circuit breaker and performing various yard modifications

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Industrial Cooling Water (ICW) Upgrade	Install new backbone piping network from Casey's Pond to the Main Ring ICW system	Threshold value plus: Install new Backfeed Loop System to improve reliability and to provide greater sectionalization of the ICW system, including installing new ICW transmission mains, upgrading primary and secondary pumphouses, and automating transfer of stored water in east ponds into the ICW system

FY 2014 funds will be used for preliminary and final design, for procurement of long-lead items, to start and complete construction work, and for project management and support activities.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
PED[a]			
FY 2014	4,450	4,450	4,450
Construction			
FY 2014	30,450	30,450	10,000
FY 2015	0	0	13,000
FY 2016	0	0	7,450
Total, Construction	30,450	30,450	30,450
TEC			
FY 2014	34,900	34,900	14,450
FY 2015			13,000
FY 2016	0	0	7,450
Total, TEC[b]	34,900	34,900	34,900

[a] All design will be completed in less than 18 months.

[b] This project has not received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range is $31,300,000 to $34,900,000. The preliminary TPC range is $32,400,000 to $36,000,000.

(dollars in thousands)

	Appropriations	Obligations	Costs
Other Project Cost (OPC)[a]			
OPC except D&D			
FY 2010	390	390	390
FY 2011	710	710	710
Total, OPC	1,100	1,100	1,100
Total Project Cost (TPC)			
FY 2010	390	390	390
FY 2011	710	710	710
FY 2012	0	0	0
FY 2013	0	0	0
FY 2014	34,900	34,900	14,450
FY 2015	0	0	13,000
FY 2016	0	0	7,450
Total, TPC[b]	36,000	36,000	36,000

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
PED[c]			
Design	3,560	3,560	N/A
Contingency	890	890	N/A
Total, PED	4,450	4,450	N/A

[a] Other Project Costs are funded through laboratory overhead.
[b] This project has not received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range is $31,300,000 to $34,900,000. The preliminary TPC range is $32,400,000 to $36,000,000.
[c] All design will be completed in less than 18 months.

	(dollars in thousands)		
	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction			
Construction	24,360	24,360	N/A
Contingency	6,090	6,090	N/A
Total, Construction	30,450	30,450	N/A
Total, TEC[a]	34,900	34,900	N/A
Contingency, TEC	6,980	6,980	N/A
Other Project Cost (OPC)[b]			
OPC except D&D			
Conceptual Planning	500	500	N/A
Conceptual Design	400	400	N/A
Contingency	200	200	N/A
Total, OPC	1,100	1,100	N/A
Contingency, OPC	200	200	N/A
Total, TPC[a]	36,000	36,000	N/A
Total, Contingency	7,180	7,180	N/A

7. Funding Profile History

(dollars in thousands)

Request Year		FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2013	TEC	0	0	0	2,500	32,400	0	34,900[a]
	OPC[b]	390	710	0	0	0	0	1,100
	TPC	390	710	0	2,500	32,400	0	36,000[a]
FY 2014	TEC	0	0	0	0	34,900	0	34,900[a]
	OPC[b]	390	710	0	0	0	0	1,100
	TPC	390	710	0	0	34,900	0	36,000[a]

[a] This project has not received approval of CD-2; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range is $31,300,000 to $34,900,000. The preliminary TPC range is $32,400,000 to $36,000,000.
[b] Other Project Costs are funded through laboratory overhead.

8. Related Operations and Maintenance Funding Requirements

Project is an upgrade and expansion of existing utility systems. No additional operations and maintenance funding is required.

9. Required D&D Information

The project is an upgrade and expansion of existing utility systems and will not require offsetting demolition of excess facilities.

10. Acquisition Approach

Acquisition for this project will be performed by the Management and Operating (M&O) Contractor, Fermi Research Alliance, LLC (FRA). FRA's standard procurement practice is to use firm fixed-price purchase orders and subcontracts for supplies, equipment, and services and to make awards through competitive solicitations.

Various acquisition alternatives will be considered for this project, including a design-build approach and/or a design-bid-build approach. As the M&O contractor, FRA is responsible for its subcontracts. Fermi Site Office provides contract oversight for FRA's plans and performance. Project performance metrics for FRA are included in the M&O contractor's annual performance evaluation and measurement plan.

13-SC-71, Utility Infrastructure Modernization,
Thomas Jefferson National Accelerator Facility (TJNAF), Newport News, Virginia
Project Data Sheet is for PED and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-1, *Approve Alternative Selection and Cost Range*, which was approved October 14, 2010. The preliminary Total Estimated Cost (TEC) range for this project is $24,300,000 to $29,200,000. The preliminary Total Project Cost (TPC) range for this project is $25,000,000 to $29,900,000.

This PDS is an update of the data sheet submitted in FY 2013 and includes a new start for the budget year, which was also requested in FY 2013.

The preliminary funding schedule has been updated to reflect full project funding in FY 2014.

A Federal Project Director at the appropriate level has been assigned to this project.

This PDS includes a new CD-3A, *Approve Procurement of Long-Lead Items*, to purchase critical components of utility systems as quickly as possible.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	PED Complete	CD-2	CD-3A	CD-3B	CD-4
FY 2013	9/18/2009	10/14/2010	4Q FY 2013	4Q FY 2013	N/A	4Q FY 2013	4Q FY 2015
FY 2014[a]	9/18/2009	10/14/2010	4Q FY 2014	3Q FY 2014	1Q FY 2014	3Q FY 2014	4Q FY 2016

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline
CD-3A – Approve Procurement of Long-Lead Items
CD-3B – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC[b] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2013	900	28,300[c]	29,200[c]	700	0	700	29,900[c]
FY 2014	900	28,300[c]	29,200[c]	700	0	700	29,900[c]

[a] This project is pre-CD-2 and schedule estimates are preliminary.
[b] Other Project Costs are funded through laboratory overhead.
[c] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $24,300,000 to $29,200,000. The preliminary TPC range for this project is $25,000,000 to $29,900,000.

4. Project Description, Justification, and Scope

Mission Need

DOE is an important sponsor of research in nuclear physics and TJNAF maintains a central and unique role in the field of nuclear physics as a world leader in hadronic physics and superconducting accelerator technologies. At TJNAF, the accelerator science core capability has an immediate need for investment to ensure the laboratory utilities infrastructure can continue to support the superconducting radio frequency (SRF) mission in the research, development, and production of cryomodules.

Existing utility, cryogenic, power distribution, cooling water, and communication systems at TNJAF continue to experience failures at increasing rates, which limits the laboratory's ability to support SC research programs. For example, the current cryogenic capacity is inadequate to support the needs in the Test Lab, which is the key facility for SRF development and production activities. This limits various SRF activities and research supported by the Nuclear Physics (NP) and High Energy Physics (HEP) programs. In addition, the current power distribution system does not have the necessary redundancy to maintain operation of critical systems during power outages. The most critical shortfall is the inability to use an alternative power feed to restart the Central Helium Liquefier (CHL), a critical component to maintaining constant cryogenic temperatures in the accelerator cryomodules that prevent degradation of accelerator performance and costly repairs. These inadequacies reduce reliability and could jeopardize the laboratory's capability to support ongoing research performed by NP and HEP.

Scope and Justification (13-SC-71, Utility Infrastructure Modernization at TJNAF)

The Utility Infrastructure Modernization project will address the performance gaps at TJNAF that limit its ability to provide a work environment that meets safety goals, current code standards and operational efficiency goals. The project will address these gaps by upgrading the electrical distribution, process cooling, cryogenics, and communications systems, replacing aging infrastructure and providing needed additional capability. The scope of the project includes replacement of primary and secondary electrical distribution feeders, replacement of cooling tower cells to significantly extend the useful expected life of the process cooling system, expansion of the Cryogenics Test Facility with additional cryogenics equipment, and an expandable communications pathway for the campus.

The cryogenic, power distribution, cooling water, and communication systems are 20–40 years old, dating back to the previous owner. The cryogenic system has insufficient capacity and, despite gains over the past several years on significantly improving the efficiency of major system components, there remains a need for overall system efficiency optimization. The lack of adequate cryogenic capacity is a limiting factor on scheduling SRF activities. The sizing of the systems to mitigate the effects of the limiting factors will be fully integrated during the final design process. Cryogenic system operation at TJNAF accounts for over 90% of annual electricity costs. Therefore, efficiency gains in this system will significantly contribute to a reduction in overall operating costs.

The cooling water distribution system is suffering frequent failures and has insufficient capacity to support optimal experimental program scheduling, computer center heat loads, and future expected growth. Since 2008, failures of the cooling water distribution system have caused several weeks of down time for the Free Electron Laser facility. Cooling towers are well past their efficient life-cycle utilization and are requiring ever increasing amounts of maintenance. In addition, addressing this gap would achieve an estimated 10% energy savings.

Subsurface communications systems are outdated and unreliable. Because some of these systems are over 40 years old, replacement components are often unavailable. Phone switch parts are difficult to locate and no additional cabling capacity is available for telecommunications or data lines. Inadequate capacity is impacting the ability to install communications to support staff growth and replace degraded cables as necessary. Consequently, instances of phone outages are impacting the efficiency of operations. The underground copper wiring is also past its service life. In addition, installation of an

Emergency Broadcast System is necessary to meet safety goals and improve response efficiency. In order to meet the growth in communication requirements, both in size and type, new upgraded cabling will be necessary.

The proposed solutions under this project to address the utility system performance gaps at TJNAF are relatively straight-forward and include upgrades and expansion of cryogenic, electrical power distribution, cooling water, and communication systems.

Key Performance Parameters

Description	Threshold Value (Minimum)	Objective Value (Maximum)
Electrical Distribution System	Replace accelerator primary and secondary feeders with copper (upgrade from aluminum to copper)	Threshold value plus: Increase size of the tie line between substations
Process Cooling	Replace and extend system life of existing cooling towers at North and South Access. Construct a 2,500 square foot addition to the TEDF chiller plant building and a 800 ton chiller for the computer center	Threshold value plus: Replace the ESR cooling tower (life extension) Replace Building 92 cooling tower (life extension) Add a 1 MW UPS system for the computer center
Cryogenics Test Facility	1,000 square foot addition	2,500 square foot addition Upgrade cryogenic piping and support systems
Communications System Upgrade	Create an expandable pathway for a fiber ring around the campus to eliminate single points of failure for this core ring.	Threshold value plus: Establish redundant network path for major facilities. Establish 2 demarcation communication utility facilities from off-site

FY 2014 funds will be used for preliminary and final design, for procurement of long-lead items, to start and complete construction work, and for project management and support activities.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
PED[a]			
FY 2014	900	900	900

[a] All design will be complete in less than 18 months

(dollars in thousands)

	Appropriations	Obligations	Costs
Construction			
FY 2014	28,300	28,300	12,490
FY 2015	0	0	10,150
FY 2016	0	0	5,660
Total, Construction	28,300	28,300	28,300
TEC			
FY 2014	29,200	29,200	13,390
FY 2015	0	0	10,150
FY 2016	0	0	5,660
Total, TEC[a]	29,200	29,200	29,200
Other Project Cost (OPC)[b]			
OPC except D&D			
FY 2010	400	400	400
FY 2011	300	300	300
Total OPC	700	700	700
Total Project Cost (TPC)			
FY 2010	400	400	400
FY 2011	300	300	300
FY 2012	0	0	0
FY 2013	0	0	0
FY 2014	29,200	29,200	13,390
FY 2015	0	0	10,150
FY 2016	0	0	5,660
Total, TPC[a]	29,900	29,900	29,900

[a] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $24,300,000 to $29,200,000. The preliminary TPC range for this project is $25,000,000 to $29,900,000.

[b] Other Project Costs (OPC) are funded through laboratory overhead.

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
PED[a]			
Design	800	800	N/A
Contingency	100	100	N/A
Total, PED	900	900	N/A
Construction			
Other Construction	22,640	22,640	N/A
Contingency	5,660	5,660	N/A
Total Construction	28,300	28,300	N/A
Total, TEC[b]	29,200	29,200	N/A
Contingency, TEC	5,760	5,760	N/A
Other Project Cost (OPC)[c]			
OPC except D&D			
Conceptual Planning	700	700	N/A
Startup	0	0	N/A
Total, OPC	700	700	N/A
Total, TPC[a]	29,900	29,900	N/A
Total, Contingency	5,760	5,760	N/A

7. Funding Profile History

(dollars in thousands)

Request Year		FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2013	TEC	0	0	0	2,500	26,700	0	29,200[a]
	OPC[b]	400	300	0	0	0	0	700
	TPC	400	300	0	2,500	26,700	0	29,900[a]

[a] All design will be complete in less than 18 months

[b] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $24,300,000 to $29,200,000. The preliminary TPC range for this project is $25,000,000 to $29,900,000.

[c] Other Project Costs are funded through laboratory overhead.

FY 2014	TEC	0	0	0	0	29,200	0	29,200[a]
	OPC[b]	400	300	0	0	0	0	700
	TPC	400	300	0	0	29,200	0	29,900[a]

8. Related Operations and Maintenance Funding Requirements

This project is an upgrade and expansion of existing utility systems. No additional operations and maintenance funding is required.

9. Required D&D Information

This project will construct up to 5,000 square feet of new space through additions to a chiller plant building and the Cryogenics Test Facility. The space increase from these additions has been offset by space previously banked at TJNAF in order to meet the one-for-one replacement requirement.

10. Acquisition Approach

Acquisition for this project will be performed by TJNAF. TJNAF's standard procurement practice is to use firm fixed-price purchase orders and subcontracts for supplies, equipment and services, and to make awards through competitive solicitations. Drawings and specifications will be sufficiently detailed to allow prospective small business design and construction firms to effectively participate in procurements. This practice was employed during the design and construction of prior projects at TJNAF and has proven to be very effective for the projects as well as for small business vendors. As the Management and Operating (M&O) contractor, TJNAF is responsible for its subcontracts. Thomas Jefferson Site Office provides contract oversight for TJNAF's plans and performance. Project performance metrics for TJNAF are included in the M&O contractor's annual performance evaluation and measurement plan.

The Acquisition Strategy and Acquisition Plan will reflect the addition of CD-3A, *Approve Procurement of Long-Lead Items*. This new critical decision will support accelerator upgrade commissioning activities and facilitate project completion.

As appropriate, critical procurements will be evaluated according to pre-defined criteria for ranking prospective vendors competing for an award. An evaluation plan will include a technical review of each proposal as well as a review of business and cost factors (e.g., past performance, management, and environment, health, and safety factors).

12-SC-70, Science and User Support Building
SLAC National Accelerator Laboratory (SLAC), Menlo Park, California
Project Data Sheet is for PED and Construction

1. Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-1, *Approve Alternative Selection and Cost Range*, which was approved May 11, 2012. The estimated preliminary Total Estimated Cost (TEC) range for this project is $59,000,000 to $64,000,000. The estimated preliminary Total Project Cost (TPC) range for this project is $60,000,000 to $65,000,000.

The preliminary funding schedule has been updated to reflect planned FY 2013 funding under the Continuing Resolution, and funding extending into FY 2015 as a result of overall program restraints. As a result, CD-4 has been extended until 3Q FY 2017.

A Federal Project Director with a certification level II has been assigned to this project.

This Project Data Sheet (PDS) does not include a new start for the budget year.

This PDS is an update of the FY 2013 PDS.

2. Design, Construction, and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	PED Complete	CD-2/3	CD-4	D&D Start	D&D Complete
FY 2012	8/26/2010	2Q FY 2012	4Q FY 2013	TBD	TBD	TBD	TBD
FY 2013	8/26/2010	3Q FY 2012	2Q FY 2013	2Q FY 2013	4Q FY 2016	3Q FY 2012	4Q FY 2016
FY 2014	8/26/2010	5/11/2012	2Q FY 2014	3Q FY 2013[a]	3Q FY 2017[a]	3Q FY 2012[a]	4Q FY 2016[a]

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2/3 – Approve Performance Baseline; Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout
D&D Start – Start of Demolition & Decontamination (D&D) work
D&D Complete – Completion of D&D work

[a] This project is pre-CD-2 and the estimated schedule is preliminary.

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC Construction	TEC, Total	OPC[a] Except D&D	OPC, D&D	OPC, Total	TPC
FY 2012	5,000	59,000[b]	64,000[b]	1,000	TBD	1,000	65,000[b]
FY 2013	5,000	59,000[b]	64,000[b]	1,000	0	1,000	65,000[b]
FY 2014	5,000	59,000[b]	64,000[b]	1,000	0	1,000	65,000[b]

4. Project Description, Justification, and Scope

Mission Need

SLAC is an Office of Science laboratory that supports a large national and international community of scientific users performing cutting edge research in support of the Department of Energy mission. SLAC is home to research activities in materials and chemical sciences that build on ultrafast and advanced synchrotron techniques. SLAC also operates beamlines for structural biology and supports efforts in particle physics and particle astrophysics. SLAC operates and is strongly positioned by the Linac Coherent Light Source (LCLS) and the Stanford Synchrotron Radiation Light Source (SSRL).

The demand to use SLAC's unique research facilities is rapidly increasing. This has resulted in a critical gap in SLAC's mission capability due to inadequate centralized support for its user community and lack of modern, collaborative infrastructure to support a world-class research program.

The SLAC Science and User Support building (SUSB) will close the mission capability gap and ensure that the world-class research conducted by SLAC scientific staff and users is supported by modern, mission-ready facilities. Located at the entrance to the Laboratory, this building will be the first stop for all users and visitors to SLAC, and will bring together many of the Laboratory's user, visitor, and administrative services. This will enhance scientific productivity and collaboration that better supports the laboratory's cutting-edge discoveries and exceptional user research program.

Scope and Justification (12-SC-70, Science and User Support Building at SLAC)

This project will construct a building that will house a centrally located user support hub; the visitor's center; a new cafeteria; office space needed to centralize SLAC communications, security, and laboratory administration; and a state-of-the-art auditorium and conference space. The Science and User Support Building will replace the aging structure that currently holds Panofsky Auditorium and the cafeteria built in 1962, the same year SLAC was founded. In order to meet the congressional mandates for replacement, the project plans to demolish the Panofsky Auditorium building (approximately 19,000 gsf) and use banked excess for the balance. Note that the project does not yet have CD-2 approval, so some assumptions may change.

Key Performance Parameters

Description	Minimum Threshold	Maximum Threshold
Multistory Office Building	58,000 gross square feet	72,000 gross square feet

[a] Other Project Costs are funded through laboratory overhead.

[b] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary TPC range for this project is $60,000,000 to $65,000,000.

FY 2014 construction funding will support construction activities on this project, including project management and all associated support functions.

The project will be conducted in accordance with the project management requirements in DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Costs
Total Estimated Cost (TEC)			
PED			
FY 2012	5,000	5,000	1,150
FY 2013	0	0	3,850
Total, PED	5,000	5,000	5,000
Construction			
FY 2012	7,086	7,086	0
FY 2013	12,160[a]	21,629	15,000
FY 2014	25,482	25,482	35,000
FY 2015	4,803	4,803	9,000
Total, Construction	59,000	59,000	59,000
TEC			
FY 2012	12,086	12,086	1,150
FY 2013	12,160[a]	21,629	18,850
FY 2014	25,482	25,482	35,000
FY 2015	4,803	4,803	9,000
Total, TEC[b]	64,000	64,000	64,000

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $21,629,000 is assumed instead.

[b] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary TPC range for this project is $60,000,000 to $65,000,000.

(dollars in thousands)

	Appropriations	Obligations	Costs
Other Project Cost (OPC)[a]			
OPC except D&D			
FY 2011	500	500	500
FY 2012	0	0	0
FY 2013	0	0	0
FY 2014	300	300	300
FY 2015	200	200	200
Total, OPC except D&D	1,000	1,000	1,000
Total Project Cost (TPC)			
FY 2011	500	500	500
FY 2012	12,086	12,086	1,150
FY 2013	12,160[b]	21,629	18,850
FY 2014	25,782	25,782	35,300
FY 2015	5,003	5,003	9,200
Total, TPC[c]	65,000	65,000	65,000

6. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
PED			
Design	4,150	4,150	N/A
Contingency	850	850	N/A
Total, PED	5,000	5,000	N/A

[a] Other Project Costs are funded through laboratory overhead.
[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $21,629,000 is assumed instead.
[c] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary TPC range for this project is $60,000,000 to $65,000,000.

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction			
Construction	46,000	46,000[a]	N/A
D&D	1,200	1,200[a]	N/A
Contingency	11,800	11,800	N/A
Total, Construction	59,000	59,000	N/A
Total, TEC[b]	64,000	64,000	N/A
Contingency, TEC	12,650	12,650	N/A
OPC[c]			
Other OPC	500	500	N/A
Start-Up	300	300	N/A
Contingency	200	200	N/A
Total, OPC	1,000	1,000	N/A
Total, TPC[b]	65,000	65,000	N/A
Total, Contingency	12,850	12,850	N/A

7. Funding Profile History

(dollars in thousands)

Request Year		FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2012	TEC	0	12,086	TBD	TBD	TBD	TBD
	OPC[c]	500	300	200	0	0	1,000
	TPC	500	12,386	TBD	TBD	TBD	TBD
FY 2013	TEC	0	12,086	21,629	30,285	0	64,000[b]
	OPC[c]	500	0	0	300	200	1,000
	TPC	500	12,086	21,629	30,585	200	65,000[b]

[a] The Previous Total Estimate updated to show D&D costs separate from new construction costs.
[b] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $60,000,000 to $65,000,000 is the TPC; The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary Total Project Cost (TPC) range for this project is $60,000,000 to $65,000,000.
[c] Other Project Costs are funded through laboratory overhead.

Request Year		(dollars in thousands) FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2014	TEC	0	12,086	12,160[a]	25,482	4,803	64,000[b]
	OPC[c]	500	0	0	300	200	1,000
	TPC	500	12,086	12,160[a]	25,782	5,003	65,000[b]

8. Related Operations and Maintenance Funding Requirements

Not Applicable.

9. Required D&D Information

The Science and User Support Building will replace the aging 14,000 gross square foot structure that currently holds the Panofsky Auditorium and the cafeteria, built in 1962, the same year SLAC was founded. In order to meet the congressional mandates for one-for-one replacement, the project plans to demolish the Panofsky Auditorium building and cafeteria; and use SC's banked excess space at SLAC for the balance. Note that the project does not yet have CD-2 approval, so some assumptions may change.

10. Acquisition Approach

SLAC as the Management and Operating (M&O) contractor will have the primary responsibility for oversight of design and construction subcontracts, LEED, commissioning, and estimating services necessary to execute this project scope. Design will be performed by an architect-engineer (A-E) with the subcontract managed by the SLAC operating contractor. Final design and construction will occur concurrently using the design-build project delivery method. SLAC Site Office provides contract oversight for SLAC's plans and performance. Project performance metrics for SLAC are included in the M&O contractor's annual performance evaluation and measurement plan.

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $21,629,000 is assumed instead.

[b] This project has not received CD-2 approval; funding estimates are consistent with the high end of the preliminary cost ranges. The preliminary TEC range for this project is $59,000,000 to $64,000,000. The preliminary Total Project Cost (TPC) range for this project is $60,000,000 to $65,000,000.

[c] Other Project Costs are funded through laboratory overhead.

Safeguards and Security
Funding Profile by Subprogram and Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Protective Forces	35,370	—	38,141
Security Systems	10,902	—	13,319
Information Security	5,118	—	4,164
Cyber Security	15,536	—	17,599
Personnel Security	5,108	—	5,143
Material Control and Accountability	2,121	—	2,397
Program Management	6,418	—	6,237
Total, Safeguards and Security	80,573	81,066	87,000

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 102-468, "Energy Policy Act of 1992"
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

The Safeguards and Security (S&S) program mission is to support Departmental research at Office of Science (SC) laboratories by ensuring appropriate levels of protection against unauthorized access, theft or destruction of Department assets, and hostile acts that may cause adverse impacts on fundamental science, national security, or the health and safety of DOE and contractor employees, the public, and the environment.

Global information sharing and open scientific collaboration are essential for the successful pursuit of scientific research and the achievement of scientific breakthroughs. As a result, SC laboratory campuses and networks have been designed to facilitate ready exchange of and access to scientific information. This openness presents security challenges across the SC national laboratory system. The SC S&S program is designed to ensure that appropriate measures are in place to address these challenges. Specifically, the program has established the following priorities: to protect special, source, and other nuclear materials, radioactive materials, and classified and sensitive information at SC laboratories; to provide physical controls at SC national laboratory facilities to mitigate other security risks, including risks to valuable assets and laboratory employees; to provide cyber security controls for SC national laboratory information systems to protect data while enabling the mission; and to ensure that site security programs result in the secure workplace required to facilitate scientific advances.

The S&S program is organized into seven functional areas: Protective Forces, Security Systems, Information Security, Cyber Security, Personnel Security, Material Control and Accountability, and Program Management.

Program Planning and Management

S&S partners closely with DOE site offices and laboratory management to ensure close integration of security measures with laboratory operations. SC security program planning is based on physical security risk assessments that have been completed at each site. This approach provides an information baseline for use in integrating S&S considerations, facilitating management evaluation of program elements, determining appropriate resources, and establishing a cost-benefit basis for analyses and comparison. In partnership with S&S Program Managers, SC site offices and laboratories assess the local threat to mission specific assets and implement baseline security elements to mitigate risk. The result of these efforts is a resource proposal and a site specific S&S Baseline Level of Protection. This Baseline Level of Protection:

- Relies on national standards and rigorous peer reviews where possible, appropriately aligns risk tolerance and acceptance with fiscal constraints, and recognizes the diversity in the SC site missions and assets.
- Provides for the scalability of requirements, defines clear roles and responsibilities, and aligns accountability for performance with the appropriate Federal and contractor management.
- Encourages the use of technology where appropriate.

An essential step in implementing the S&S Baseline Level of Protection is to undertake a physical security risk assessment, which is required at each SC site to provide the basis for implementation and for funding requests.

Explanation of Funding and Program Changes

The FY 2014 request will maintain security throughout DOE sites and support continued progress toward the Baseline Level of Protection. The program will also continue implementation of technologies to incrementally reduce reliance on the use of personnel for routine access control and other security services. The increased FY 2014 request supports infrastructure investments in access control systems, upgrades necessary to meet Homeland Security Presidential Directive-12 (HSPD-12) requirements at laboratories, and the cyber security enhancements needed to ensure laboratories are properly protected against emerging threats and persistent attacks against SC Information Technology systems. In addition, the FY 2014 request includes funding to fully support SC's portion of the new Protective Forces Contract at Oak Ridge National Laboratory (ORNL), and the additional protection needed to secure the Category 1 Special Nuclear Material in Building 3019 at ORNL.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Protective Forces	35,370	38,141	+2,771
The increased request provides funding to fully support SC's portion of the new Protective Force Contract at ORNL. The increased funds will be used to pay for technical surveillance counter measures, use of the paramilitary training facility, emergency support for special response teams, and access to a classified network for security operations.			
Security Systems	10,902	13,319	+2,417
Risk assessments completed as part of the Security Baseline Level of Protection identified security system upgrades to improve security system operations by either augmenting or replacing staff FTEs through entry control automation. This allows for site-specific incremental savings without increasing risk. These savings partially offset increases to support implementation of technology upgrades and infrastructure investments in automated access control systems. The request also provides funding for upgrades necessary to meet the requirements for a common identification standard for federal employees and contractors at SC laboratories, mandated under HSPD-12.			

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Information Security	5,118	4,164	-954
Funding decreases to accommodate laboratory and program priorities. Funding at this level will maintain proper document marking, storage, and protection of information.			
Cyber Security	15,536	17,599	+2,063
The increased request provides funding to support the cyber security enhancements needed to ensure that laboratories are properly protected against emerging threats made evident by persistent attacks against SC IT systems. Funding will be used to support threat assessments, risk management, configuration management, and network management.			
Personnel Security	5,108	5,143	+35
Funding increases to accommodate the additional facility users and visitors, including foreign nationals, anticipated as a result of the expanded interest in SC laboratory programs.			
Material Control and Accountability (MC&A)	2,121	2,397	+276
Funding increases to accommodate changes in site specific MC&A programs.			
Program Management	6,418	6,237	-181
Funding decreases to accommodate laboratory and program priorities. Funding at this level maintains direction, oversight and administration, and security program planning.			
Total, Safeguards and Security	80,573	87,000	+6,427

Protective Forces

Overview

The Protective Forces element supports security officers, access control officers, and security policy officers assigned to protect S&S interests. Activities within this element include access control and security response operations as well as physical protection of the Department's critical assets and SC facilities. In addition, activities to maintain operations are aimed at providing effective response to emergency situations, random prohibited article inspections, security alarm monitoring, and performance testing of the protective force response to various event scenarios.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding in FY 2012 maintains the necessary protective forces and the equipment, facilities, and training needed to ensure effective performance.	35,370
FY 2013	The FY 2013 Request was for $33,750,000 to maintain the current security posture at a level that is consistent with SC laboratory needs.	—
FY 2014	The FY 2014 request provides funding to fully support SC's portion of the new Protective Forces Contract at Oak Ridge and maintains protection levels, equipment, facilities, and training needed to ensure effective performance at all SC laboratories.	38,141

Security Systems

Overview

The Security Systems element provides physical protection of Departmental material, equipment, property, and facilities, including buildings, fences, barriers, lighting, sensors, surveillance devices, entry control devices, access control systems, and power systems operated and used to support the protection of DOE property, classified information, and other interests of national security.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding maintains the systems currently in place, including S&S personnel required to operate and service them.	10,902
FY 2013	The FY 2013 Request proposed $13,685,000 to support investments in federal access control systems and upgrades (e.g., badge card readers and access system software and hardware) needed to meet HSPD-12 requirements.	—
FY 2014	Funding in FY 2014 will support the federal access control systems and upgrades needed to meet HSPD-12 requirements and implementation of technologies that will incrementally reduce reliance on the use of personnel for routine access control, employee verification, and other security services.	13,319

Information Security

Overview

The Information Security element provides support to ensure that sensitive and classified information is accurately and consistently indentified, reviewed, marked, protected, transmitted, stored, and ultimately destroyed. Specific activities within this element include management, planning, training, and oversight for maintaining security containers and combinations, marking documents, and administration of control systems, operations security, special access programs, technical surveillance countermeasures, and classification and declassification determinations.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding provided for personnel, equipment, and systems necessary to ensure sensitive and classified information is properly safeguarded at SC laboratories.	5,118
FY 2013	The FY 2013 Request proposed $4,344,000 to accommodate laboratory and program priorities.	—
FY 2014	Funding will maintain Information Security efforts to ensure proper document marking, storage, and protection of information.	4,164

Cyber Security

Overview

The Cyber Security element provides appropriate risk management tools and controls for sensitive or classified information which is electronically processed, transmitted, or stored. Risk management controls ensure that information systems, including the information contained within the systems, maintain confidentiality, integrity, and availability in a manner consistent with the SC Research mission and possible threats.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding in FY 2012 provides for activities to protect SC laboratory computer resources and data.	15,536
FY 2013	The FY 2013 Request proposed $18,422,000 to address emerging cyber security threats.	—
FY 2014	The increased FY 2014 request supports the cyber security enhancements needed to ensure laboratories are properly protected against emerging threats from persistent attacks against SC Information Technology systems. Funding supports threat assessments, risk management, and configuration and network management.	17,599

Personnel Security

Overview

The Personnel Security element encompasses the processes for employee suitability and security clearance determinations at each site to ensure that individuals are trustworthy and eligible for access to classified information or matter. This element also includes the management of security clearance programs, adjudications, security education and awareness programs for Federal and contractor employees, and processing and hosting approved foreign visitors.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding supports the necessary laboratory personnel to grant individual access to classified matter and/or special nuclear material and to allow foreign national's access to SC facilities, consistent with agency procedures. Funding also supports security investigations for federal field personnel and security awareness programs for employees.	5,108
FY 2013	The FY 2013 Request proposed $ 5,000,000 to maintain support for Personnel Security at SC laboratories.	—
FY 2014	FY 2014 funding will maintain support and Personnel Security efforts at SC laboratories.	5,143

Material Control and Accountability

Overview

The Material Control and Accountability (MC&A) element provides assurance that Departmental materials are properly controlled and accounted for at all times. This element supports administration, including testing performance and assessing the levels of protection, control, and accountability required for the types and quantities of materials at each facility; documenting facility plans for materials control and accountability; assigning authorities and responsibilities for MC&A functions; and establishing programs to detect and report occurrences such as material theft, the loss of control or inability to account for materials, or evidence of malevolent acts.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding provides for establishing, controlling, and tracking inventories of special and other nuclear materials at SC laboratories. Activities supported by these funds include measurements, quality assurance, accounting, containment, surveillance, and physical inventories of materials.	2,121
FY 2013	The FY 2013 Request proposed $2,173,000 to provide resources for essential requirements.	—
FY 2014	Funding in FY 2014 maintains proper protection of material at SC laboratories.	2,397

Program Management

Overview

The Program Management element coordinates the management of Protective Forces, Security Systems, Information Security, Personnel Security, Cyber Security, and Material Control and Accountability to achieve and ensure appropriate levels of protections are in place.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding provides for the oversight, administration, and planning for security programs at SC laboratories.	6,418
FY 2013	The FY 2013 Request proposed $6,626,000 to maintain efforts to ensure security procedures and policy support the SC Research mission.	—
FY 2014	FY 2014 funding will maintain direction, oversight, administration, and security program planning. Funding decreases to accommodate changes in laboratory and program priorities.	6,237

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
General Plant Projects under $5M	350	—	0

Other Supporting Information

Estimates of Security Cost Recovered by Science, Safeguards and Security

In addition to the direct funding received from the Safeguards and Security Program, sites recover Safeguards and Security costs related to Work for Others (WFO) activities from WFO customers, including the cost of any unique security needs directly attributable to the customer. Estimates of those costs are shown below.

(dollars in thousands)

	FY 2012 Costs	FY 2013 Planned Costs	FY 2014 Planned Costs
Ames National Laboratory	240	—	220
Argonne National Laboratory	1,100	—	1,070
Brookhaven National Laboratory	700	—	700
Lawrence Berkeley National Laboratory	733	—	733
Oak Ridge Institute for Science and Education	600	—	509
Oak Ridge National Laboratory	4,900	—	5,000
Pacific Northwest National Laboratory	5,200	—	4,800
Princeton Plasma Physics Laboratory	70	—	50
SLAC National Accelerator Laboratory	48	—	81
Total, Security Cost Recovered	13,591	—	13,163

Science Program Direction
Funding Profile by Category

	(dollars in thousands/whole FTEs)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Headquarters			
Salaries and Benefits	51,849	—	55,071
Travel	1,750	—	2,116
Support Services	6,988	—	8,427
Other Related Expenses	12,050	—	15,534
Total, Headquarters	72,637	—	81,148
Full Time Equivalents	320	—	330
Office of Scientific and Technical Information			
Salaries and Benefits	5,845	—	6,042
Travel	74	—	65
Support Services	1,129	—	1,286
Other Related Expenses	1,275	—	1,007
Total, Office of Scientific and Technical Information	8,323	—	8,400
Full Time Equivalents	43	—	48
Field Offices			
Chicago Office			
Salaries and Benefits	22,791	—	23,590
Travel	329	—	275
Support Services	3,407	—	1,666
Other Related Expenses	4,022	—	4,313
Total, Chicago Office	30,549	—	29,844
Full Time Equivalents	171	—	180

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
	(dollars in thousands/whole FTEs)		
Oak Ridge Office			
Salaries and Benefits	26,650	—	25,181
Travel	372	—	268
Support Services	2,719	—	2,964
Other Related Expenses	6,247	—	5,668
Total, Oak Ridge Office[a]	35,988	—	34,081
Full Time Equivalents[b]	225	—	217
Ames Site Office			
Salaries and Benefits	456	—	439
Travel	16	—	22
Support Services	0	—	0
Total, Ames Site Office	472	—	461
Full Time Equivalents	3	—	3
Argonne Site Office			
Salaries and Benefits	3,259	—	3,756
Travel	60	—	102
Support Services	118	—	118
Other Related Expenses	9	—	20
Total, Argonne Site Office	3,446	—	3,996
Full Time Equivalents	20	—	24

[a] The FY 2014 Request includes the transfer of $700,000 from the Office of Science/Oak Ridge to other DOE programs for Vendor Inquiry Payment Electronic Reporting System (VIPERS)/Vendor Invoice Approval System (VIAS) support, which is now funded through the Working Capital Fund i-Manage business line.

[b] The FY 2014 Request includes the transfer of 3 Oak Ridge FTEs from the Office of Science to the Office of Environmental Management.

	(dollars in thousands/whole FTEs)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Berkeley Site Office			
Salaries and Benefits	3,633	—	3,745
Travel	58	—	60
Support Services	284	—	304
Other Related Expenses	27	—	50
Total, Berkeley Site Office	4,002	—	4,159
Full Time Equivalents	22	—	22
Brookhaven Site Office			
Salaries and Benefits	4,113	—	4,306
Travel	118	—	115
Support Services	520	—	614
Other Related Expenses	156	—	165
Total, Brookhaven Site Office	4,907	—	5,200
Full Time Equivalents	27	—	27
Fermi Site Office			
Salaries and Benefits	2,297	—	2,372
Travel	53	—	75
Support Services	53	—	45
Other Related Expenses	22	—	62
Total, Fermi Site Office	2,425	—	2,554
Full Time Equivalents	16	—	16
New Brunswick Laboratory			
Salaries and Benefits	3,894	—	4,299
Travel	74	—	100
Support Services	329	—	514
Other Related Expenses	1,917	—	1,035
Total, New Brunswick Laboratory	6,214	—	5,948
Full Time Equivalents	29	—	29

(dollars in thousands/whole FTEs)

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Oak Ridge National Laboratory Site Office			
Salaries and Benefits	4,167	—	5,560
Travel	50	—	66
Support Services	213	—	399
Other Related Expenses	225	—	26
Total, Oak Ridge National Laboratory Site Office	4,655	—	6,051
Full Time Equivalents	27	—	43
Pacific Northwest Site Office			
Salaries and Benefits	4,747	—	4,798
Travel	133	—	125
Support Services	29	—	159
Other Related Expenses	204	—	122
Total, Pacific Northwest Site Office	5,113	—	5,204
Full Time Equivalents	35	—	34
Princeton Site Office			
Salaries and Benefits	1,507	—	1,543
Travel	40	—	45
Support Services	73	—	52
Other Related Expenses	86	—	123
Total, Princeton Site Office	1,706	—	1,763
Full Time Equivalents	10	—	10
SLAC Site Office			
Salaries and Benefits	2,443	—	2,431
Travel	44	—	9
Support Services	116	—	130
Other Related Expenses	42	—	10
Total, SLAC Site Office	2,645	—	2,580
Full Time Equivalents	14	—	15

	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Thomas Jefferson Site Office			
Salaries and Benefits	1,788	—	1,792
Travel	37	—	39
Support Services	6	—	43
Other Related Expenses	87	—	37
Total, Thomas Jefferson Site Office	1,918	—	1,911
Full Time Equivalents	12	—	12
Total Field Offices			
Salaries and Benefits	81,745	—	83,812
Travel	1,384	—	1,301
Support Services	7,867	—	7,008
Other Related Expenses	13,044	—	11,631
Total, Field Offices	104,040	—	103,752
Full Time Equivalents	611	—	632
Total PD			
Salaries and Benefits	139,439	—	144,925
Travel	3,208	—	3,482
Support Services	15,984	—	16,721
Other Related Expenses	26,369	—	28,172
Total, PD	185,000	186,132	193,300
Full Time Equivalents	974	989	1,010

(dollars in thousands/whole FTEs)

FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 111-358 "America COMPETES Reauthorization Act of 2010"

Overview

The Office of Science's (SC) Program Direction (PD) mission is to support and sustain a skilled and motivated Federal workforce to develop and oversee SC investments in world-leading scientific research and scientific user facilities. SC investments deliver new scientific discoveries and technological innovations to solve our Nation's energy and environmental challenges, and enable the United States to maintain its global competitiveness. Providing easy public access to DOE's scientific findings further leverages the Federal science investment and advances the scientific enterprise.

Program Direction strives to provide an efficient, cost-effective corporate infrastructure for program management, business management, and stewardship of the resources necessary for SC to execute its mission. Carrying out SC's mission requires highly skilled scientific and technical program and project managers, as well as experts in areas such as acquisition, finance, legal, construction and infrastructure management, human resources, and environmental, safety, and health oversight. SC's Federal workforce plans, executes, and manages science programs that meet critical national needs. National challenges in energy, environmental stewardship, and nuclear security, as well as continued U.S. innovation and scientific competitiveness, all rely upon transformational basic research. Oversight of DOE's basic research portfolio by the Office of Science, which includes grants and contracts supporting about 25,000 researchers located at some 300 universities and 17 national laboratories, as well as supervision of major construction projects, is a Federal responsibility. SC also enables world-leading research by providing and maintaining state-of-the-art scientific user facilities—the large machines of modern science—supporting nearly 29,000 users. These facilities offer unique capabilities and place U.S. researchers and industries at the forefront of science, technology, and innovation. With adequate staffing levels and a workforce with appropriate skills, education, and experience, SC is an effective and efficient steward that utilizes taxpayer dollars for maximum national benefit.

Headquarters (HQ):

SC HQ personnel are Federal Staff who provide policy and strategic management for the SC enterprise. As part of this, the Headquarters:

- Strategically maintains a balanced research portfolio that includes high-risk, high-reward research to maximize the program's potential to achieve mission goals and objectives.
- Conducts scientific program planning, execution, and management across a broad spectrum of scientific disciplines and program offices; and communicates research interests and priorities to the scientific community.
- Assures rigorous external merit review of research proposals, selection of appropriate peer review experts, development of award recommendations informed by peer review, and regular evaluation of research programs. SC typically manages over 6,000 laboratory, university, non-profit, and private industry research awards and receives between 5,000 and 6,000 new and renewal proposals annually, requiring over 15,000 peer reviews.
- Provides oversight and management of the Science Laboratories Infrastructure program and the maintenance and operational integrity of 10 SC laboratories.
- Provides policy and strategic management in the areas of information technology, grants and contracts, and budget for the SC enterprise.

Site Offices:

SC Site Office personnel are Federal staff charged with maintaining the business and management infrastructure required to support the scientific mission at 10 SC national laboratories. This includes conducting day-to-day business transactions of contract management activities, approvals to operate hazardous facilities, safety and security oversight, leases, property transfers, sub-contracts above defined thresholds, sub-awards, and activity approvals required by laws, regulations, and DOE policy. As part of this, the Site Offices:

- Maintain a comprehensive contract management program to assure contractual mechanisms, supporting over $3 billion per year of SC mission work performed by SC contractors at 10 national laboratories, are effectively managed consistent with guidelines and regulations.
- Evaluate complex integrated laboratory activities including nuclear, radiological, and other complex hazards.
- Provide Federal project directors to facilitate execution of line item and other construction projects.

Integrated Support Center (ISC):

The ISC, physically located at the Chicago and Oak Ridge Offices, provides the backbone for the business infrastructure supporting the entire SC enterprise, including headquarters. These functions include legal and technical support; financial management; grant and contract processing; safety, security, and health management; labor relations, intellectual property and patent management; environmental compliance; facility infrastructure operations and maintenance; and information systems development and support. As part of this, the ISC:

- Serves as a legal DOE allottee that manages multi-appropriation, multi-program allotments for all SC national laboratories with responsibility for over 90% of SC funds.
- Provides support to SC and other DOE programs for solicitations and funding opportunity announcements, as well as the negotiation, award, administration, and closeout of contracts and financial assistance awards using certified contracting officers and professional acquisition staff.

Office of Scientific and Technical Information (OSTI):

OSTI fulfills both the Department's legislative mandate to provide public access to the unclassified results of DOE's research program as well as the White House Open Government Directive to encourage collaboration and increase transparency (http://energy.gov/open). OSTI's collection from the mid-1990s to date is available on-line. In FY 2012, OSTI served over 300 million web transactions for DOE's R&D information, which represents a 20% increase from FY 2011. As part of its activities, OSTI:

- Collects, protects, and provides secure access to DOE's classified research outcomes. OSTI works closely with National Nuclear Security Administration laboratories and facilities to collect classified R&D information and to provide secure access through the Enterprise Secure Network.
- Has built, on behalf of DOE, broad collaborations within the United States and internationally to enable a single point of access to nearly 400 million pages of scientific information.

Program Milestones

Voluntary Early Retirement Authority/Voluntary Separation Incentive Payments (VERA/VSIP). In early FY 2012, as part of cost reduction and long term strategies to continuously provide an appropriate mix of employee skills, experience, and institutional knowledge, SC was given authority to offer VERA/VSIP to eligible employees in selected job series in OSTI and the Field Offices. Both organizations require systems and processes that respond quickly and adapt to the rapidly-changing science and technology environment in which they operate. While the outcome of the VERA/VSIP effort enabled PD to operate within the FY 2012 Appropriation, it also supported the plan by OSTI and the Field Offices to refine and partially restructure their organizations to maintain this adaptability. The workload commensurate with the total Science appropriation has not reduced; therefore, selected vacancies as a result of VERA/VSIP are being backfilled with lower-graded, developmental positions. Of the SC workforce, 43% are either currently retirement-eligible or will be retirement-eligible in less than 5 years. As such, it is essential that SC fully implement its succession strategy to assure qualified staff are available to support the continuing workload and maintain appropriate safety and security mandates.

Hiring Controls. In FY 2012, SC implemented strict hiring controls, limiting backfill hires to only the most essential positions and requiring deputy director approval for any new vacancy announcements. While this has prevented SC from fully implementing its succession strategy, it has allowed SC to maintain the flexibility necessary to operate successfully in an uncertain budget environment.

Major Programmatic Shifts or Changes

- FY 2014 is an increase of $8,300,000, or 4.5% from FY 2012 and supports a total FTE level of 1,010, backfill hiring for essential SC positions, full succession strategy implementation, and targeted recruitment efforts based on contemporary skill requirements.
- In addition to cost reductions as an outcome of VERA/VSIP, SC operated with reductions in travel as well as reduced support services and discretionary other related costs in FY 2012.
- The SC Information Technology Modernization Plan (ITMP) was authorized by the Director on July 10, 2012. This plan will modernize the SC infrastructure, deliver service at reduced operating costs, and simplify the acquisition process by consolidating IT support service contracts, while improving cyber security and providing new technologies to enhance collaboration and mobile computing to enable access to SC information to those who need it, when they need it, and where they need it. The overarching goal of the ITMP is to provide excellent customer service within existing budgets.
- The FY 2014 Request includes the transfer of $700,000 from the Office of Science to other DOE programs for support of the Vendor Inquiry Payment

Electronic Reporting System and the Vendor Invoice Approval System. These systems are now part of the DOE Working Capital Fund i-Manage business line, and each DOE organization will be assessed an equitable share of the software requirements consistent with other corporate financial systems.

- The reorganization of the Oak Ridge Office was implemented on July 1, 2012. The Oak Ridge Office provides direct programmatic oversight and authority on behalf of the Office of Science for the Oak Ridge National Laboratory (ORNL). The FY 2014 Request includes the transfer of 3 FTEs from the SC-Oak Ridge Assistant Manager for Environment, Safety and Health to the Office of Environmental Management-Oak Ridge Engineering Division.
- *President's Council of Advisors on Science and Technology (PCAST).* Per Executive Order 13539, as amended December 19, 2011, "The Department of Energy shall provide such funding and administrative and technical support as the PCAST may require." In FY 2012, on behalf of DOE, SC assumed functional responsibility and administrative management for PCAST activities. PCAST is a Federal Advisory Committee group of the nation's leading scientists and engineers who directly advise the President and the Executive Office of the President and make policy recommendations in the many areas where understanding of science, technology, and innovation is key to strengthening our economy and forming policy that works for the American people. The FY 2014 Request provides support for PCAST salary and benefits (1 FTE), travel by committee members, meeting planning support, and other related expenses totaling $800,000.

Explanation of Funding and Program Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Salaries and Benefits	139,439	144,925	+5,486

The FY 2014 Request for 1,010 FTEs supports scientific oversight, project management, essential operations support associated with science program portfolio management, and administration of PCAST. This FTE level is an increase in 36 FTEs from the FY 2012 level and allows for SC to fully implement its succession strategy. Implementation of the SC succession strategy is critical to long term mission success as SC expects an increase in retirements over the next several years. Of the SC workforce, 43% is either currently retirement-eligible, or will be retirement-eligible in less than 5 years. The percentage is higher in certain key scientific and technical job series such as 800–Engineering and Architecture (55%) and 1300–Physical Sciences (46%). The additional 36 FTEs would be used to hire additional staff primarily in these areas, mainly at developmental grade levels, to minimize the risk of institutional knowledge loss in the next several years.

Salaries and Benefits represent 75.0% of the FY 2014 PD Request. The pay raise and support for expenses such as increases in health coverage costs and retirement allocations in the Federal Employees Retirement System are included.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Travel	3,208	3,482	+274

Staff travel is required to ensure scientific management, compliance, safety oversight, and external review of research funding across all SC programs, since SC senior program managers are not co-located with grantees or at national laboratories. Travel is also required for facility visits where the use of electronic telecommunications is not practical for mandated on-site inspections and operations reviews.

Travel is also included to support meetings of the PCAST, scheduled for 6 times per year with additional meetings called at the discretion of the President. PCAST is an advisory group to the President and Executive Office of the President.

SC Federal Advisory Committee travel is supported, which includes 173 representatives from universities, national laboratories, and industry, representing a diverse balance of disciplines, professional experience, and geography. Each of the six advisory committees provides valuable, independent advice to the Department regarding the complex scientific and technical issues that arise in the planning, management, and implementation of SC programs.

Travel represents 1.8% of the PD Request and is an 8.5% increase from the FY 2012 level (4.2% annualized growth). The FY 2014 Request maintains travel for essential scientific program oversight and mandatory site visits for health and safety inspection. The increase supports required travel for PCAST activities.

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Support Services	15,984	16,721	+737

Essential support for multiple levels of technical expertise and business services will sustain the following: maintenance, operation, and cyber security management of SC mission-specific information technology systems and infrastructure as well as SC-corporate Enterprise Architecture and Capital Planning Investment Control management; administration of the Small Business Innovation Research/Small Business Technology Transfer program; grants and contract processing and close-out activities; accessibility to DOE's corporate multi-billion dollar R&D program through information systems managed and administered by OSTI; operations and maintenance of the Searchable Field Work Proposal system to provide HQ and Field organizations a tool to search and monitor field work proposals; selected routine administrative services including travel processing and Federal staff training and education to maintain appropriate certification and update skills; select reports or analyses directed toward improving the effectiveness, efficiency, and economy of services and processes; and safeguards and security oversight functions.

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Support Services represent 8.6% of the FY 2014 PD Request and a 4.6% increase from the FY 2012 level (2.3% annualized growth). The FY 2014 Request funds essential information technology infrastructure and safety management support, as well as training for the SC workforce. The overall increase, primarily in Automated Data Processing, results from the implementation of the SC Information Technology Modernization Plan (ITMP); a common operating environment across SC Headquarters and Integrated Support Center (Chicago and Oak Ridge).			
Other Related Expenses	26,369	28,172	+1,803
SC contribution to the Department's Working Capital Fund (WCF) provides for common administrative services at HQ including: rent and building operations, telecommunications, network connectivity, supplies, printing/graphics, mail, purchase card surveillance, overseas office support, health centers, and interagency transfer fees associated with E-gov initiatives. In addition to increases to support salary and benefit costs for staff administering the WCF, also included are fixed requirements in the Field Offices not funded through the WCF associated with rent, utilities, and telecommunications, building and grounds maintenance, computer/video maintenance and support, equipment leases, purchases, maintenance, and site-wide health care units. Also funded are SC-wide assessments for payroll processing and the Corporate Human Resource Information System. Other Related Expenses (ORE) represent 14.6% of the FY 2014 PD Request and a 6.8% increase from the FY 2012 levels (3.4% annualized growth). The FY 2014 Request supports mandatory increases in fixed costs, rent, and other WCF requirements. WCF costs encompass 42.1% of the Other Related Expenses (ORE) Request. The overall increase in ORE is not the result of any particular item, but reflects modest increases in WCF requirements as well as other areas corresponding to the increase in FTEs supported by the FY 2014 Request.			
Total Funding Change, Science Program Direction	185,000	193,300	+8,300

(dollars in thousands)

Support Services by Category

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Technical Support			
Development of specifications	263	—	482
System review and reliability analyses	787	—	682
Surveys or reviews of technical operations	0	—	560
Total, Technical Support	1,050	—	1,724
Management Support			
Automated data processing	3,103	—	7,176
Training and education	886	—	680
Reports and analyses, management, and general administrative services	10,945	—	7,141
Total, Management Support	14,934	—	14,997
Total, Support Services	15,984	—	16,721

Other Related Expenses by Category

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Other Related Expenses			
Rent to GSA	698	—	658
Rent to others	3,398	—	2,466
Communications, utilities, and miscellaneous	2,035	—	2,252
Printing and peproduction	25	—	0
Other services	4,709	—	5,604
Operation and maintenance of equipment	989	—	963
Operation and maintenance of facilities	1,362	—	1,182
Supplies and materials	512	—	651
Equipment	4,963	—	2,543
Working Capital Fund	7,678	—	11,853
Total, Other Related Expenses	26,369	—	28,172

Isotope Production and Distribution Program Fund

Program Overview and Benefits

The Department of Energy's Isotope Program produces and sells radioactive and stable isotopes, byproducts, surplus materials, and related isotope services world-wide and operates under a revolving fund established by the 1990 Energy and Water Appropriations Act (Public Law 101–101), as modified by Public Law 103–316. The combination of an annual direct appropriation and collections from isotope sales are deposited in the Isotope Production and Distribution Program Fund; both are needed to maintain the Isotope Program's viability. This revolving fund allows continuous and smooth operations of isotope production, sales, and distribution independent of the federal budget cycle and fluctuating sales revenue. An independent cost review of the fund's revenues and expenses is conducted annually.

The annual appropriation is requested as Isotope Development and Production for Research and Applications in the Office of Science Nuclear Physics program. Appropriated funds are used to maintain mission-readiness of facilities by supporting the core scientists and engineers needed to carry out the Isotope Program and the maintenance of isotope facilities to assure reliable production. In addition, the appropriation provides support for R&D activities associated with the development of new production and processing techniques for isotopes, operations support for the production of research isotopes, and support for the training of new personnel in isotope production. Each site's production expenses for processing and distributing isotopes are offset by revenue generated from sales. About 80 percent of the resources in the revolving fund are used for operations, maintenance, isotope production, and R&D for new isotope production techniques, with roughly 20 percent available for process improvements, unanticipated changes in volume, and purchases of small capital equipment, such as assay equipment and shipping containers needed to ensure on-time deliveries.

The Department has supplied isotopes and related services since the Atomic Energy Act of 1954 specified the role of the U.S. government in isotope distribution. Substantial national and international scientific, medical, and research infrastructure has relied upon the use of isotopes and is strongly dependent on the Department's products and services. Isotopes are now used for hundreds of applications that benefit society every day such as diagnostic medical imaging, cancer therapy, smoke detectors, neutron detectors for homeland security applications, explosives detection, oil exploration, and tracers for climate-related research. For example, radioisotopes are used in the diagnosis or treatment of about one third of all patients admitted to hospitals[a]. Each year, nearly 18 million nuclear medicine imaging and therapeutic procedures are performed on patients at the approximately 5,000 nuclear medicine centers in the United States[b]. Such nuclear procedures are among the safest and most effective diagnostic tests available and enhance patient care by avoiding exploratory surgery and other invasive procedures. In FY 2012, the Isotope Program organized the first Federal workshop to assess stakeholder requirements in order to optimize the utilization of resources and assure the greatest availability of isotopes.

Isotopes are primarily produced and processed at three facilities stewarded by the Isotope Program: the Isotope Production Facility (IPF) at Los Alamos National Laboratory, the Brookhaven Linac Isotope Producer (BLIP) at Brookhaven National Laboratory, and processing facilities at Oak Ridge National Laboratory (ORNL). IPF and BLIP provide accelerator production capabilities, while the High Flux Isotope Reactor (HFIR) at ORNL provides reactor production capability. HFIR has the highest neutron flux available for isotope production in the U.S. In addition, production and distribution activities are supported at the Advanced Test Reactor at the Idaho National Laboratory and by the Pacific Northwest National Laboratory. The Isotope Program is broadening production capability by including university accelerator and reactor facilities which can provide cost-effective and unique production capabilities, including at the University of Washington, Washington University, the University of California at Davis, and the Missouri University Research Reactor.

[a] http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/med-use-radactiv-mat-fs.html

[b] http://interactive.snm.org/docs/whatisnucmed2.pdf

The resources available in the revolving fund in FY 2012 totaled $46.7 million. This consists of $19.1 million from FY 2012 appropriations and collections of $27.6 million. Collections in FY 2012 included sales of californium-252, selenium-75, and strontium-82. Californium-252 has a variety of industrial and medical applications, selenium-75 is used as a radiography source, and strontium-82 has gained world-wide acceptance for use in heart imaging. In FY 2012, the Isotope Program served about 150 customers including major pharmaceutical companies, industrial users, and approximately 100 researchers at hospitals, national laboratories, other Federal agencies, universities, and private companies, with the sale of approximately 190 different radioactive and stable isotopes. Among the isotopes produced, seven are high-volume and moderately priced isotopes; the remaining are low-volume research isotopes, which are more expensive to produce. The Isotope Pricing Policy was revised and issued in FY 2012 to provide clear guidelines on pricing practices. Commercial isotopes are priced to recover full cost or the market price (whichever is higher).

For FY 2014, the Department foresees more than moderate growth in isotope demand.

<u>Program Accomplishments</u>

New isotope production capabilities are being established at Duke University, Texas A&M University, Washington University, University of Wisconsin, and Oak Ridge National Laboratory as a result of grants awarded in FY 2012 under an Isotope Production solicitation. Capabilities will be established to produce astatine-211 (an alpha emitter under investigation for cancer therapy applications); copper-64 (medical therapeutic and diagnostic applications); yttrium-86, zirconium-89, copper-62, and iodine-124 (medical diagnostic applications); and curium-248 (physics research applications). Each award has a duration of either one or two years and all work will be completed in FY 2014.