DOE/MA-0274
Volume 3 of 4

Congressional Budget Request

General Science and Research
Uranium Enrichment
Geothermal Resources Development Fund
Power Marketing Administrations
Departmental Administration

Volume 3

FY 1989

U.S. Department of Energy
Assistant Secretary,
Management and Administration
Office of the Controller

February 1988

DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

URANIUM ENRICHMENT

GEOTHERMAL RESOURCES DEVELOPMENT FUND

POWER MARKETING ADMINISTRATIONS

DEPARTMENTAL ADMINISTRATION

VOLUME 3

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DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1987 ACTUAL	FY 1988 ESTIMATE	FY 1989 REQUEST
APPROPRIATIONS BEFORE THE ENERGY AND WATER DEVELOPMENT SUBCOMMITTEES:			
ENERGY SUPPLY RESEARCH AND DEVELOPMENT..	$1,258,137	$1,860,087	$1,969,760
URANIUM ENRICHMENT......................	1,209,494	950,000	1,184,000
GENERAL SCIENCE AND RESEARCH............	326,596	355,108	364,986
ISOTOPE PRODUCTION AND DISTRIBUTION FUND	509	89	16,243
BASIC RESEARCH USER FACILITIES..........	473,206	574,945	972,613
ATOMIC ENERGY DEENSE ACTIVITIES.........	7,481,852	7,749,364	8,100,000
DEPARTMENTAL ADMINISTRATION.............	226,874	164,243	177,814
ALASKA POWER ADMINISTRATION.............	2,881	3,026	3,159
BONNEVILLE POWER ADMINISTRATION.........	432,259	165,000	136,000
SOUTHEASTERN POWER ADMINISTRATION.......	19,647	27,400	36,267
SOUTHEASTERN - CONTINUING FUND..........	3,772	---	---
SOUTHWESTERN POWER ADMINISTRATION.......	25,337	16,648	15,389
WESTERN AREA POWER ADMINISTRATION.......	238,008	249,515	298,413
WESTERN AREA POWER EMERGENCY FUND.......	225	24	---
FEDERAL ENERGY REGULATORY COMMISSION....	99,079	100,000	106,760
NUCLEAR WASTE FUND......................	499,000	360,000	448,832
GEOTHERMAL RESOURCES DEVELOPMENT FUND...	72	72	75
SUBTOTAL, APPROPRIATIONS BEFORE THE ENERGY AND WATER DEVELOPMENT SUBCOMMITTEES.........................	12,296,948	12,575,521	13,830,311

DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1987 ACTUAL	FY 1988 ESTIMATE	FY 1989 REQUEST
APPROPRIATIONS BEFORE THE INTERIOR AND RELATED AGENCIES SUBCOMMITTEES:			
ALTERNATIVE FUELS PRODUCTION............	437	---	---
CLEAN COAL TECHNOLOGY...................	---	50,000	525,000
FOSSIL ENERGY RESEARCH AND DEVELOPMENT..	293,171	326,975	166,992
NAVAL PETROLEUM AND OIL SHALE RESERVES..	122,177	159,663	185,071
ENERGY CONSERVATION.....................	232,362	309,517	89,359
ENERGY REGULATION.......................	23,400	21,565	20,772
EMERGENCY PREPAREDNESS..................	6,044	6,172	6,154
STRATEGIC PETROLEUM RESERVE.............	147,433	164,162	173,421
STRATEGIC PETROLEUM ACCOUNT.............	---	438,744	1,017,907
ENERGY INFORMATION ACTIVITIES...........	60,301	61,398	62,856
SUBTOTAL, INTERIOR AND RELATED AGENCIES SUBCOMMITTEES.........................	885,325	1,538,196	2,247,532
SUBTOTAL, ENERGY AND WATER DEVELOPMENT SUBCOMMITTEES.........................	12,296,948	12,575,521	13,830,311
SUBTOTAL, DEPARTMENT OF ENERGY..........	13,182,273	14,113,717	16,077,843
PERMANENT - INDEFINITE APPROPRIATIONS:			
PAYMENTS TO STATES......................	912	1,839	1,909
TOTAL, DEPARTMENT OF ENERGY.............	$13,183,185	$14,115,556	$16,079,752

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1987 FTE USAGE	FY1988 -FY87	FY1988 CONGR REQ	FY1989 -FY88	FY1989 CONGR REQ
ENERGY & WATER SUBCOMMITTEE					
HEADQUARTERS	4,697	264	4,961	73	5,034
FIELD	9,356	58	9,414	-75	9,339
SUBCOMMITTEE TOTAL	14,053	322	14,375	-2	14,373
INTERIOR SUBCOMMITTEE					
HEADQUARTERS	1,181	66	1,247	-111	1,136
FIELD	882	25	907	-140	767
SUBCOMMITTEE TOTAL	2,063	91	2,154	-251	1,903
GRAND TOTAL	16,116	413	16,529	-253	16,276
ADJUSTMENT		-263	-263	-209	-472
ADJUSTED TOTAL	16,116	150	16,266	-462	15,804

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1987 FTE USAGE	FY1988 -FY87	FY1988 CONGR REQ	FY1989 -FY88	FY1989 CONGR REQ
10:ENERGY SUPPLY RESEARCH AND DEV	922	14	936	10	946
HEADQUARTERS	644	7	651	10	661
FIELD	278	7	285	0	285
15:URANIUM ENRICHMENT	59	8	67	0	67
HEADQUARTERS	48	8	56	0	56
FIELD	11	0	11	0	11
20:GENERAL SCIENCE AND RESEARCH	42	-3	39	7	46
HEADQUARTERS	42	-3	39	7	46
25:ATOMIC ENERGY DEFENSE ACTIVITI	2,782	88	2,870	40	2,910
HEADQUARTERS	492	62	554	21	575
FIELD	2,290	26	2,316	19	2,335
30:DEPARTMENTAL ADMINISTRATION	3,333	133	3,466	6	3,472
HEADQUARTERS	1,756	79	1,835	6	1,841
FIELD	1,577	54	1,631	0	1,631
34:ALASKA POWER ADMINISTRATION	36	-1	35	0	35
FIELD	36	-1	35	0	35
36:BONNEVILLE POWER ADMIN	3,398	-18	3,380	-50	3,330
FIELD	3,398	-18	3,380	-50	3,330
38:SOUTHEASTERN POWER ADMIN	38	2	40	0	40
FIELD	38	2	40	0	40
42:SOUTHWESTERN POWER ADMIN	192	-6	186	0	186
FIELD	192	-6	186	0	186
46:WAPA - POWER MARKETING	1,160	-21	1,139	0	1,139
FIELD	1,160	-21	1,139	0	1,139
50:WAPA - COLORADO RIVER BASIN	219	21	240	0	240
FIELD	219	21	240	0	240
52:FEDERAL ENERGY REGULATORY COMM	1,562	97	1,659	0	1,659
HEADQUARTERS	1,562	97	1,659	0	1,659
54:NUCLEAR WASTE FUND	307	8	315	-15	300
HEADQUARTERS	152	14	166	29	195
FIELD	155	-6	149	-44	105
56:GEOTHERMAL RESOURCES DEV FUND	1	0	1	0	1
HEADQUARTERS	1	0	1	0	1
63:CLEAN COAL TECHNOLOGY	0	45	45	13	58
HEADQUARTERS	0	21	21	5	26
FIELD	0	24	24	8	32
65:FOSSIL ENERGY RESEARCH AND DEV	709	-6	703	-133	570
HEADQUARTERS	141	-3	138	-10	128
FIELD	568	-3	565	-123	442
70:NAVAL PETROL & OIL SHALE RES	89	6	95	0	95
HEADQUARTERS	17	5	22	0	22
FIELD	72	1	73	0	73
75:ENERGY CONSERVATION	320	32	352	-109	243
HEADQUARTERS	197	30	227	-84	143
FIELD	123	2	125	-25	100
80:EMERGENCY PREPAREDNESS	64	7	71	0	71
HEADQUARTERS	64	7	71	0	71
81:ECONOMIC REGULATION	288	-13	275	-22	253
HEADQUARTERS	288	-13	275	-22	253
85:STRATEGIC PETROLEUM RESERVE	147	0	147	0	147
HEADQUARTERS	28	-1	27	0	27
FIELD	119	1	120	0	120
90:ENERGY INFORMATION ACTIVITIES	446	20	466	0	466
HEADQUARTERS	446	20	466	0	466
94:ADVANCES FOR CO-OP WORK	2	0	2	0	2
FIELD	2	0	2	0	2
GRAND TOTAL	16,116	413	16,529	-253	16,276
ADJUSTMENT		-263	-263	-209	-472
ADJUSTED TOTAL	16,116	150	16,266	-462	15,804

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VOLUME III

NUCLEAR PHYSICS

DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

NUCLEAR PHYSICS

VOLUME 3

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DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
OFFICE OF ENERGY RESEARCH

OVERVIEW

NUCLEAR PHYSICS PROGRAM

The Nuclear Physics Program and the BRUF-NP Program of the Department of Energy (DOE) have the lead responsibility for Federal support of nuclear physics research and provide about 80 percent of the funding for the field. The primary goal of these programs is to understand the structure and interactions of atomic nuclei. A second goal, using the specialized knowledge, techniques and apparatus available to the program, is to understand how the fundamental forces and particles of nature manifest themselves in nuclear matter. Nuclear processes determine the essential physical characteristics of our universe and the composition of the matter which forms it. An understanding of nuclei and nuclear phenomena is essential to any basic understanding of the world around us and has had enormous influence over other branches of science and technology, such as nuclear power, nuclear weapons and nuclear medicine. Only slightly less well known are nuclear techniques for geophysical exploration, testing of materials and archeological dating and siting. The inclusion of the nuclear data program within Nuclear Physics tacitly recognizes the inseparable aspects of the basic and applied nature of nuclear research.

Over the years, many theoretical models have been developed to describe the structure of the nucleus and its behavior. These models have progressed from simple mechanical models of surface vibrations and rotations to sophisticated descriptions of meson-nucleon interactions. Scientists now know that nucleons (neutrons and protons, and constituents of the nucleus) are composed of smaller constituents called quarks. Based on the ways quarks are confined together in groups of three to make nucleons, or groups of two to make mesons, a more fundamental theory of the strong force called quantum chromodynamics is emerging. Nuclear physics use of extended nuclear matter as a substrate for investigation of quark effects provides a complementary approach for addressing scientific problems in common with those of high energy physics. Growing interactions with astrophysics include measurements or calculations of supernovae, neutron stars, solar neutrinos, heavy cosmic rays, and the nuclear abundances produced by stellar processes. Of particular interest is the ability of relativistic heavy ion collisions to create a quark-gluon plasma, simulating a stage of evolution of the universe that disappeared ten millionths of a second after the big bang start of the universe.

The strategy of the program is to address key scientific questions with new theories, equipment and facilities while maintaining an effective balance between competing and diverse program elements. Essential guidance is provided by the Nuclear Physics Program Plan, with continuing advice from the Nuclear Science Advisory Committee (NSAC). Key elements of the plan are reflected in this budget.

The program is centered around an active experimental research program which is continually evaluated and revised to focus on the most basic scientific questions. Necessary for proper conduct of this research are efforts in nuclear theory, design and fabrication of sophisticated detectors, and development of creative and skilled personnel. Central to the program are the construction, operation and maintenance of the accelerator facilities which provide the beams of particles upon which the experiments are based. In some areas of nuclear physics, questions are addressed by accelerators at Universities dedicated to in-house research, or smaller facilities at some national laboratories. However, many of the newly emerging fundamental problems in nuclear science require large modern facilities designed for the research use of the entire nuclear community.

The Nuclear Physics Program supports the basic research in the field. In FY 1989 it will maintain a vigorous research program, focusing on current problems of high scientific and technological interest and pointing towards exploitation of the new major facilities. Special emphasis is placed on effective use of the upgraded accelerators at the University of Washington and Yale University, the ATLAS superconducting heavy ion facility at Argonne National Laboratory (ANL), and Tandem/AGS high energy heavy ion beams at Brookhaven National Laboratory (BNL). Adjustments within the program will be made to accommodate the resurgence of American student interest in nuclear physics and to revitalize the theory program to reflect more accurately the highest program priorities and new scientific areas. In addition, much good science can be accomplished with selected smaller improvements of existing facilities such as the South Target Hall internal target experiment at the MIT/Bates Electron Linac. The program will reduce research levels or terminate research at some existing facilities as research efforts transfer to the new facilities. Other national laboratory and university accelerators will be operated for maximum program effectiveness with selected capital equipment detector projects to optimize facility productivity.

Research and development in support of next generation accelerators is included in the Nuclear Physics Program. Efforts will continue at Brookhaven National Laboratory for the purpose of providing a solid scientific and technical basis for the proposed Relativistic Heavy Ion Collider (RHIC). The R&D necessary to optimize the RHIC project is currently being conducted. A Nuclear Sciences Advisory Committee (NSAC) review has confirmed the high scientific merit of the research to be performed at RHIC. Recent recognition of the extremely high magnetic fields created in the collision process identifies exciting new areas of research in addition to the core program of quark-gluon plasma investigations.

A growing fraction, now about 75 percent, of the scientists supported by the Nuclear Physics Program conduct research, including theoretical support, at the large facilities supported by the BRUF-NP Program, or are active participants in the design and fabrication of the experimental facilities at the Continuous Electron Beam Accelerator Facility (CEBAF). Along with their colleagues funded by the National Science Foundation, these physicists determine the content of the research programs and define operational priorities at the

National facilities. To construct, operate, and maintain these large National user facilities, the BRUF-NP Program is requesting $122,712,000 in FY 1989. More than 200 scientists do experiments at the Bevalac at the Lawrence Berkeley Laboratory each year and a similar number make use of the Tandem/AGS at the Brookhaven National Laboratory. More than 325 visiting scientists annually use the multiple beams available at the LAMPF facility at the Los Alamos National Laboratory for one or more experiments. Over 650 physicists have demonstrated interest in possible future use of the Continuous Electron Beam Accelerator Facility by joining the CEBAF user's group, and 100 of them are actively participating in the design of experiments. The close coupling of the research supported by this program, and the facilities supported by the BRUF-NP Program demands extraordinary coordination efforts between the two programs to be effective in achieving the scientific results for which these two programs are funded. While the importance of maintaining a proper balance between the Nuclear Physics research and the operation of the facilities is recognized, the separation of these activities serves to clearly delineate the resources needed to effectively carry out the research on the one hand and to operate and construct the major national laboratories on the other.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

LEAD TABLE

NUCLEAR PHYSICS

Activity	FY 1987 Actual	FY 1988 Approp.	FY 1989 Base	FY 1989 Request	Program Change Request vs Base: Dollar	Program Change Request vs Base: Percent
Operating Expenses						
Medium Energy Nuclear Physics Physics	$32,658	$35,490	$35,490	$37,550	$+ 2,060	+ 6%
Heavy Ion Nuclear Physics	36,428	40,950	40,950	43,288	+ 2,338	+ 6%
Low Energy Nuclear Physics	24,036	26,195	26,195	26,300	+ 105	0%
Nuclear Theory	10,000	10,500	10,500	11,000	+ 500	+ 5%
Subtotal Operating Expenses	103,122	113,135	113,135	118,138	+ 5,003	+ 4%
Capital Equipment	14,790	16,575	16,575	17,450	+ 875	+ 5%
Construction	4,330	5,200	5,200	5,800	+ 600	+ 11%
Total	$122,242 b/	$134,910 b/	$134,910 b/	$141,388 b/	$+ 6,478	+ 5%
Operating Expenses	(103,122)a/	(113,135)	(113,135)	(118,138)	+ 5,003	+ 4%
Capital Equipment	(14,790)	(16,575)	(16,575)	(17,450)	+ 875	+ 5%
Construction	(4,330)	(5,200)	(5,200)	(5,800)	+ 600	+ 11%

Staffing (FTEs).............(Reference General Science Program Direction)

Authorization: Section 209, P.L. 95-91.

a/ Total has been reduced by $2,198,000 ($442,000 Medium Energy; $350,000 Heavy Ion; $1,406,000 Low Energy) reprogrammed to Energy Supply for SBIR.
b/ $92,677,000 in FY 1987, $110,190,000 in FY 1988, and $122,712,000 in FY 1989 has been transferred to the Basic Research User Facilities appropriation.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

SUMMARY OF CHANGES

Nuclear Physics

FY 1988 Appropriation..	$ 134,910
- Funding required to maintain a constant overall level of program activity............	+ 5,396
<u>Medium Energy Nuclear Physics</u>	
- Conduct medium energy physics research at FY 1988 level of activity, with increased level of research effort in electromagnetic physics................................	+ 640
<u>Heavy Ion Nuclear Physics</u>	
- Continue Heavy Ion research at approximately constant level of activity, with slight increase for experiments and data analysis..	+ 700
<u>Low Energy Nuclear Physics</u>	
- Continue nuclear data program and low energy physics research at reduced level and maintain approximately constant level of activity for accelerator based research......	- 942
<u>Nuclear Theory</u>	
- Continue program at approximately constant level of effort...........................	+ 80
<u>Capital Equipment</u>	
- Maintain overall level of effort and provide for general purpose equipment to meet laboratory-wide needs of Lawrence Berkeley Laboratory...............................	+ 212

Construction

- Continue AIP and GPP projects at smaller facilities..................................	+ 392
FY 1989 Congressional Budget Request..	$ 141,388

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: MEDIUM ENERGY NUCLEAR PHYSICS

The Nuclear Physics program supports the basic research necessary to identify and understand the fundamental features of atomic nuclei and their interactions. The Medium Energy Nuclear Physics subprogram supports research at accelerator facilities with sufficient primary beam energy to produce pi mesons (pions) using projectiles no more massive than alpha particles. Two national accelerator facilities are dedicated to the Medium Energy subprogram--the Clinton P. Anderson Meson Physics Facility (LAMPF) at Los Alamos National Laboratory supported by the BRUF-NP Program and the Bates Linear Accelerator Center operated by the Massachusetts Institute of Technology. In addition, the subprogram supports nuclear physics experiments at accelerators operated by other DOE programs (e.g., High Energy Physics and Basic Energy Sciences) and at other unique domestic or foreign facilities. Research at these accelerator facilities involves a nationwide community of scientists from over 100 American institutions, of which over 90% are universities. At proton facilities, support is provided for wide-ranging research activities on the scattering of protons and pions, weak interactions, muonic and pionic atoms, selective excitation of proton/neutron states, and giant resonances. At electron facilities, support is provided for high resolution studies of the electric and magnetic structure of nuclei, the motion of pions inside nuclei, and the role of excited states of nucleons in nuclear structure.

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Total, Medium Energy Nuclear Physics......	$ 32,658	$ 35,490	$ 37,550	+ 6

II. B. Major Laboratory and Facility Funding

Los Alamos National Laboratory.............	$ 6,267	$ 6,505	$ 6,600	+ 1
Massachusetts Institute of Technology.......	9,024	9,440	9,350	- 1
Other National Laboratories.................	5,442	5,880	6,280	+ 7

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
MEDIUM ENERGY NUCLEAR PHYSICS			
LAMPF-Based Research	Carry out broad research program at this proton facility including the following specific activities:		
	Continue use of Clamshell spectrometer for elastic, inelastic, and double-charge-exchange pion scattering, and start experiments using new neutron facility.	Continue use of Clamshell and neutron facility, and initiate research program using medium resolution spectrometer.	Continue use of Clamshell Spectrometer, and neutron facility and medium resolution spectrometer, and initiate nucleon-nucleus program using high intensity polarized proton beam.
	Continue data taking phase of first major neutrino oscillation experiment at LAMPF using beam stop as source of neutrinos.	Complete data taking phase of neutrino oscillation experiment and develop conceptual design by broad-based university-laboratory collaboration of Large Cherenkov Detector (LCD) for neutrino experiments for critical tests of the Standard Model.	Analyze data from oscillation experiment and continue preparation activities on LCD for neutrino experiments.
	Expand use of Time-of-Flight Isochronous (TOFI) spectrometer by adding outside users.	Continue use of TOFI facility for nuclear spectroscopy.	Continue use of TOFI facility for nuclear mass measurements.
	Expand activities in ten-instituion collaboration to prepare detection facility for highly-sensitive search for the rare decay of the muon into a positron and a gamma ray (MEGA).	Complete MEGA preparations and start taking data.	Continue data taking phase of MEGA experiment and present preliminary results.
	($10,580)	($10,675)	($10,815)

Program Activity	FY 1987	FY 1988	FY 1989
Bates-Based Activities	Carry out comprehensive research program at this electron facility including the following specific activities:		
	Use new polarized electron capability for studies of parity violation.	Complete data taking phase of parity experiment and start next round of experiments requiring polarized electrons.	Begin multi-arm coincidence measurements utilizing the polarized electron beam.
	Carry out selected coincidence experiments at higher energies permitted by accelerator improvements.	Continue program of coincidence experiments not requiring continuous beams. Initiate Class IV computer upgrade at the Laboratory for Nuclear Science.	Prepare for out-of-plane spectrometer measurements (delta experiment). Continues computer upgrade at the Laboratory for Nuclear Science.
	Do high energy experiments using South Hall spectrometers as well as the high precision energy loss spectrometer.	Emphasize high momentum transfer experiments in South Hall.	Continue high resolution cross section measurements utilizing energy-loss spectrometer and coincidence measurements utilizing South Hall spectrometers.
	Initiate R&D program on pulse stretcher ring system to enhance duty factor including operation with polarized beams.	Initiate fabrication of the Bates Internal Target Experiment (BITE) in the South Hall including a pulse stretcher ring for use with polarized and unpolarized gas jet targets.	Design internal gas-jet target system for use in BITE and continue fabrication of BITE components in the South Hall.
	Operate 850 MeV electron accelerator and experimental facilities 3000 hours for nuclear physics research.	Operate accelerator and facilities about 2500 hours for nuclear physics research.	Operate accelerator and facilities about 2000 hours for nuclear physics research.

Program Activity	FY 1987	FY 1988	FY 1989
Bates Based Activities (Cont'd)	Provide beam for 40 experiments involving 140 scientists from 40 institutions.	Provide beam for approximately 35 experiments involving about 135 scientists.	Provide beam for approximately 30 experiments involving about 125 scientists.
	Finish installation of polarized electron source and install improved accelerator components to help increase the maximum beam energy to more than 1 GeV.	Provide beam energies above 1 GeV for experiments requiring the highest energies.	Operate accelerator at 1 GeV for required experiments during selected operating cycles during the year.
	($9,160)	($9,708)	($9,935)
Research at Other Sites	Carry out experiments at facilities supported by other DOE programs or at other unique U.S. or foreign facilities, including activities as follow:		
	Continue preparations for rare kaon decay experiments at the AGS.	Start data taking phase of rare kaon decay experiment and continue preparations for experiments using new kaon beams at the AGS.	Continue data taking phase of rare kaon decay experiment and start taking data using new kaon beam line
	Begin deuteron photodisintegration experiment in the Nuclear Physics at SLAC (NPAS) program.	Carry out deep inelastic scattering experiments in the NPAS program.	Continue electron scattering experiments using NPAS and start preparations for experiments using gas jet target in PEP ring at SLAC.
	Establish superconducting materials and components research activities at CEBAF.	Expand accelerator research activities at CEBAF.	Continue activities in superconducting research area at CEBAF.

Program Activity	FY 1987	FY 1988	FY 1989
Research at Other Sites (Cont'd)	Complete preparations for experiments using the upgraded Low Energy Antiproton Ring (LEAR) facility.	Utilize upgraded LEAR facility for high intensity antiproton experiments.	Complete data taking using LEAR facility.
	Start data taking phase of the double beta decay experiment in the St. Gotthard Tunnel in the Alps.	Continue data taking phase of the St. Gotthard double beta decay experiment.	Complete germanium phase of St. Gotthard double beta decay experiment and initiate xenon phase.
	Complete installation and begin tests of the Laser Electron Gamma Source (LEGS) on the National Synchrotron Light Source at BNL.	Start first round of experiments on the LEGS facility.	Expand experimental program to full planned operating level using the LEGS facility.
	Operate the nuclear physics injector (NPI) and End Station A spectrometers at SLAC for 700 hours. Provide beams of six GeV electrons for experiments involving 50 scientists from 18 institutions.	Operate NPI and facilities at SLAC for 1000 hours. Provide beams of six GeV electrons for experiments involving about 50 scientists. Run only highest priority experiments in coordination with startup of SLC program for High Energy Physics.	Operate NPI and facilities at SLAC for 1000 hours. Provide beams of six GeV electrons for experiments involving about 50 scientists.
	($12,918)	($15,107)	($16,800)

I. Preface: HEAVY ION NUCLEAR PHYSICS

The Heavy Ion Research subprogram is aimed at understanding the behavior of nuclear matter over an ever increasing range of excitation energy, nuclear density, angular momentum, and deformation. These conditions are created in collisions between nuclear targets and nuclear beams. The heavy ion beams used for these studies are produced by highly sophisticated accelerators located at three large universities and four national laboratories. Studies include the high spin behavior of cold nuclear matter causing severe deformation and eventually fission. At low bombarding energies, nuclear orbiting phenomena are studied. Especially intriguing are close encounters of the heaviest nuclei which lead to unexplained spontaneous positron production. The nuclear dynamics of complex phenomena including deep-inelastic scattering and projectile fragmentation are studied at medium bombarding energies. At higher energies, exploration is made of the nuclear matter equation of state for hot dense nuclear matter. At ultra-relativistic energies, a search is beginning for the new state of matter known as the quark-gluon plasma which would require a new facility in the future called the Relativistic Heavy Ion Collider (RHIC).

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Total, Heavy Ion Nuclear Physics..........	$ 36,428	$ 40,950	$ 43,288	+ 5

II. B. Major Laboratory and Facility Funding

	FY 1987	FY 1988	FY 1989	% Change
Argonne National Laboratory.................	$ 5,300	$ 5,330	$ 5,520	+ 4
Brookhaven National Laboratory..............	4,698	7,510	9,090	+ 21
Lawrence Berkeley Laboratory................	8,812	9,250	9,498	+ 3
Los Alamos National Laboratory..............	860	880	910	+ 3
Oak Ridge National Laboratory...............	8,040	8,120	8,405	+ 4

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
HEAVY ION NUCLEAR PHYSICS			
LBL Bevalac Research	Conduct research at the Bevalac using relativistic heavy ion beams to study the dynamics of high energy heavy ion collisions as revealed by pion production, kaon production and final state fragment yields. Commission the Dilepton Spectrometer to probe the properties of nuclei under extreme conditions of temperature and density at the earliest stages of the collision process as measured by electron-positron pair production. Conduct CERN experiments with ultra-relativistic oxygen beams in the first of two 17 day runs and begin data analysis.	Continue the experimental programs on collision dynamics especially using upgraded detector systems for the HISS superconducting magnetic spectrometer. Begin support of HISS-based EOS time projection chamber detector. Continue the experimental program with the Dilepton Spectrometer by measuring electron-positron production for heavier systems (e.g., Ca + Ca) Continue the second round of CERN experiments using sulfur beams and analyze the data for nuclear stopping giving information on unexplored areas of hot dense nuclear matter.	Continue experiments with HISS to study fission and fragmentation of very heavy beams. Continue fabrication of EOS detector. Continue experiments with the Dilepton Spectrometer to explore high energy dynamics at the earliest stages of nuclear collisions. Develop concepts for detection equipment for experiments measuring the equation of state of nuclear matter. Continue and complete the analyses of the CERN experiments. Continue development of detectors for proposed AGS dilepton experiment.

Program Activity	FY 1987	FY 1988	FY 1989
LBL Bevalac Research (Cont'd)	($5,482)	Also initiate proto-typing of detectors for proposed AGS dilepton experiment. ($5,840)	($5,984)
BNL Tandem/AGS Research	Finish commissioning the spectrometer and associated equipment for experiment E-802 and begin experimental program. Begin assembly and testing of a time projection chamber for experiment E-810 and calorimeters and drift chambers for experiment E-814. Initiate R&D for the Relativistic Heavy Ion Collider at a $3M level. ($4,698)	Analyze data from initial running of E-802 and continue experimental program. Complete first phase of testing time projection chamber for experiment E-810 and begin experimental program. Continue testing of components of E-814 with beam. Continue RHIC R&D on major accelerator systems at about $6M. Transfer effort of scientists from Tandem research to other programs. ($7,510)	Continue data taking on improved and evolving experiment E-802 and complete analysis of initial data. Include with the E-802 effort nuclear scientists now doing heavy ion research that previously have had their program and funding from low energy physics. Initiate the data-taking phase of E-810. Complete assembly and testing of E-814 and begin experimental program. Begin support of a new experiment designed to measure correlated lepton-antilepton production. Continue R&D towards a Relativistic Heavy Ion Collider (RHIC) at about $6M. ($9,090)
National Laboratory Activities	At the ANL ATLAS, provide 3750 hours of operation for a broad based program in nuclear physics with light to medium-mass heavy-ion beams with energies in the 5-15 million electron volt per nucleon energy range. At the LBL 88" Cyclotron, provide 4000 hours of operation with light to	Provide 3750 hours of ATLAS operation for nuclear physics experiments. Begin testing the Phase I positive-ion injector. Provide 4000 hours of operation of the 88" Cyclotron for the nuclear physics program with an improved ECR ion source. Provide 3900 hours of	Provide 3750 hours to ATLAS operation for nuclear physics experiments. Support installation of new beam line for the fragment mass analyzer. Provide 4000 hours of operation of the 88" Cyclotron and continue development of the ECR ion source. Provide 3900 hours of

Program Activity	FY 1987	FY 1988	FY 1989
National Laboratory Activities (Cont'd)	medium mass beams in the energy range of 5-25 million electron volts per nucleon for a broad based nuclear physics program. At the ORNL HHIRF, provide 3700 hours of accelerator operation for a broad based research program with light to medium mass beams in the 5-25 million electron volts per nucleon energy range. Begin installation of reconfigured accelerator tubes.	operation of HHIRF for nuclear and atomic physics programs. Complete installation of reconfigured accelerator tubes.	HHIRF operation for nuclear physics program and atomic physics research programs. Operate upgraded accelerator tubes with greater reliability and increasing voltage. Reduce coupled Tandem/Cyclotron operation as Tandem performance improves.
	At ANL, conduct experimental program with light and medium mass heavy ion beams from ATLAS in the 5-15 million electron volt per nucleon range. Emphasize the study of fusion and peripheral reactions near the Coulomb barrier, the behavior of nuclei at high spin and high excitation energy, and the properties of compound nucleus decay.	Continue the experimental program at ATLAS using the completed gamma-ray detector system. Extend experimental program on heavy ion reaction mechanisms near the Coulomb barrier to heavier mass systems. Begin programmatic support of the Fragment Mass Analyzer Detector.	Continue the experimental program at ATLAS with emphasis on reactions near the Coulomb barrier using the heavier mass projectiles available from the improved injector. Begin design and testing of detector systems for the Fragment Mass Analyzer for an experimental program on nuclei far from stability.
	At the LBL 88" cyclotron, fully exploiting the capabilities of the new ECR source, conduct experimental program with light and medium mass heavy ion beams in the 5-25 million electron volt per nucleon range. Emphasize the study of nuclear disintegration processes, the transition from statistical to preequilibrium decay, the behavior of	At the 88" cyclotron, continue the experimental program on high spin states using the completed gamma-ray detector system, HERA. Continue experimental programs on the study of heavy ion nuclear reaction processes and the production and properties of nuclei far from stability.	Continue the experimental program at the 88" cyclotron with fully implemented full solid angle gamma-ray facility and study superdeformed bands at very high spin. Continue technological research on Electron Cyclotron Resonance (ECR) ion sources using strong fields and high frequencies.

Program Activity	FY 1987	FY 1988	FY 1989
National Laboratory Activities (Cont'd)	nuclei at high spin and high excitation energy, and the production of nuclei far from stability.		
	At the ORNL Holifield facility, conduct experimental program with light and medium mass heavy ion beams in the 5-25 million electron volt per nucleon range. Study the decay properties of the basic modes of nuclear excitation, the properties of separated isotopes far from stability, the dynamics of nuclear collisions, and the properties of nuclei at high spin and high excitation energy. Operate calorimeters in data runs for CERN experiment WA-80 and begin analysis of the data.	At HHIRF, continue experimental programs on the decay modes of nuclear giant resonance vibration, projectile breakup of medium mass beams, and the structure of nuclei far from stability. Continue physics analysis of CERN WA-80 data for nuclear stopping and possible nuclear matter phase changes at ultra-relativistic energies. Begin design and proto-typing of detectors for proposed dilepton experiment at AGS.	Continue the experimental program at HHIRF with empahsis on improved capabilities with gamma-ray detection and a more fully implemented heavy-ion, light-ion detector system. Complete data analysis of CERN WA-80 experiment and continue development of equipment for proposed dilepton experiment at AGS.
	At LANL, operate spectrometer for CERN Experiment NA-34.	At LANL, continue running and analysis for CERN NA-34 and begin constructing calorimeter for BNL Tandem/AGS experiment E-814.	At LANL, complete analysis of CERN NA-34 and begin installation of participant calorimeter at BNL for experiment E-814.
	($17,195)	($17,740)	($18,349)
University Activities	Continue support of the upgrade project at Yale University to convert the existing tandem into an ESTU heavy ion facility. At the University of Washington, complete the installation of the	Commission upgraded tandem accelerator at Yale University and provide light heavy ion beams for a broad experimental program in nuclear physics. Begin the in-house experimental program on the	Provide light heavy ion beams for experiments using the upgraded facilities at Yale University. Provide light heavy ion beams for in-house experiments at the University of Washington using the

Program Activity	FY 1987	FY 1988	FY 1989
University Activities (Cont'd)	superconducting linac booster testing the accelerator system and begin experimental research program. Support the completion of the state-of-Texas funded superconducting cyclotron and begin phaseout of the existing convention cyclotron.	University of Washington upgraded accelerator system. Provide light and medium mass heavy ion beams up to 125 MeV/amu for the experimental program at Texas A&M University.	superconducting linac booster. Provide light and medium mass heavy ion beams for experimental programs at Texas A&M University.
	Carry out independent and collaborative user-group research programs at the LBL Bevalac, LBL 88" Cyclotron, ANL ATLAS, ORNL HHIRF, and BNL Tandem/AGS accelerators and at other heavy ion accelerators in the U.S. and Europe. About 30 university user-groups participate in the heavy ion physics experiments at these facilities.	Continue university user-group efforts to provide the core research programs at the National Facilities. Begin the in-house program on interaction symmetries at the Yale Tandem, the in-house program on giant resonance excitation and sub-barrier fusion at the upgraded University of Washington accelerator system, and the in-house heavy ion programs on the new superconducting cyclotron at Texas A&M.	Continue university user-group research programs and enhance detector R&D efforts. Continue nuclear physics research programs at the Yale Tandem on investigating nuclei far from stability. Use the higher energies of the University of Washington superconducting linac booster to study pre-equilibrium particle emission, in particular the study of Fermi jets. Exploit the new capabilities of the Texas A&M superconducting cyclotron to study subthreshold pion production.
	($9,053)	($9,860)	($9,865)

I. Preface: LOW ENERGY NUCLEAR PHYSICS

This subprogram emphasizes experimental investigations of nuclear structure, nuclear decay parameters, and low energy reaction mechanisms. These studies also include general tests of fundamental theories and symmetries, as well as more specific and detailed studies of reactions involved in stellar and cosmologic processes. University-based research is an important feature of the Low Energy program. The facilities required are relatively small and appropriate for siting on university campuses. The university-based programs permit excellent hands-on training of nuclear experimentalists, many of whom contribute after obtaining Ph.D.s to nuclear technology development of interest to the DOE. Beginning in FY 1988, this subprogram also includes the DOE Nuclear Data program, which was included in the Basic Energy Sciences program prior to FY 1988. The Nuclear Data program includes nuclear data measurement and nuclear data compilation, and evaluation activities important for nuclear technologies.

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Total, Low Energy Nuclear Physics.........	$ 24,036	$ 26,195	$ 26,300	0

II. B. Major Laboratory and Facility Funding

Ames National Laboratory....................	$ 200	$ 205	$ 210	+ 2
Argonne National Laboratory.................	2,820	2,940	3,045	+ 3
Brookhaven National Laboratory..............	4,295	4,385	3,845	- 13
Idaho National Engineering Laboratory.......	310	335	350	+ 4
Lawrence Berkeley Laboratory................	1,945	2,050	2,155	+ 5
Lawrence Livermore National Laboratory......	210	225	235	+ 4
Los Alamos National Laboratory..............	1,210	1,255	1,325	+ 5
Oak Ridge National Laboratory...............	4,475	4,665	4,880	+ 5

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
LOW ENERGY NUCLEAR PHYSICS			
Activities at University Facilities	Conduct low energy nuclear physics research at four university accelerator facilities: Duke University (Triangle University Nuclear Laboratory), Texas A&M University, University of Washington, and Yale University. This includes: nuclear structure, nuclear decay parameters, low-energy light-ion reaction mechanisms, general tests of fundamental symmetries (such as parity), and detailed studies of reactions pertinent to astrophysics and cosmology.	Exploit new capabilities of the upgraded accelerator facilities: at Texas A&M the new state-funded K500 superconducting cyclotron), at the University of Washington (the superconducting LINAC booster), and at Yale University (the stretched tandem). Continue research with funding priorities guided by results of recent review of the low energy accelerator facilities.	Continue utilization of upgraded facilities. At the University of Washington, use the intense polarized beam with LINAC beams for research into parity violations in light nuclei. Use the proton spectrometer at Texas A&M initially for (d, He-2) studies of spin-flip, charge-exchange reactions. Use the new polarized ion source at Duke, with the cryogenic polarized target, to perform much improved measurements of spin-spin effects in neutron-nucleus reactions and to begin time-reversal invariance tests.

Program Activity	FY 1987	FY 1988	FY 1989
Activities at University Facilities (Cont'd)	Provide support (together with Heavy Ion Physics) for the operation and maintenance of the four university accelerator facilities. Bring into operation the superconducting LINAC booster at the University of Washington.	Provide support (together with Heavy Ion Physics) for the operation and maintenance of the four university accelerator facilities, with an appropriate increase in support for the University of Washington booster and Texas A&M cyclotron. Complete construction of the proton spectrometer at Texas A&M. Complete the construction of a new powerful polarized ion source at Duke University.	Provide support for university laboratory accelerator facilities at about the same level. Begin additions to the proton spectrometer facility at Texas A&M to prepare it for use in high-resolution (n,p) charge-exchange studies for neutrons in the previously little-studied 125-172 MeV energy range. Enhance the cryogenic target facility at Duke University by adding the capability for studying the interaction of polarized neutrons with a solid polarized target of He-3.
	($4,523)	($4,752)	($4,940)
National Laboratory Accelerator Activities	Conduct low energy nuclear physics research and operations at three national laboratory accelerators: ANL ATLAS, LBL, 88-INCH CYCLOTRON, ORNL HHIRF. At LBL, the exotic nuclide Ge-61 has been observed via its beta-delayed proton emission. At ORNL, installation of a nuclear orientation target facility to permit more sophisticated experiments to study nuclear structure at the UNISOR on-line separator has begun.	Continue low energy research and operations at ANL, LBL, and ORNL at about same level of effort. At LBL, selected gamma-ray production cross sections will be measured for use in the interpretation of spectra obtained from observatories in space. At ORNL, the nuclear orientation target will be brought into operation.	Continue low energy research and operations at ANL, LBL, and ORNL. At LBL, high intensity He-3 beams will be used with the RAMA on-line separator to attempt to observe the decay of nuclides which are adjacent to, or are defining of, the proton drip-line in the sd-shell. At ORNL, nuclear structure studies at the UNISOR will be greatly enhanced by the use of the nuclear orientation capability to determine the electromagnetic properties of gamma-ray transitions.
	($4,295)	($4,470)	($4,630)

Program Activity	FY 1987	FY 1988	FY 1989
Research at Reactors	Conduct a joint BNL-University research effort at the BNL High Flux Beam Reactor HFBR using the filtered low energy beam for average resonance capture experiments and the TRISTAN on-line mass separator as complementary tools for the study of the nuclear structure of the neutron-rich nuclides far from stability. Initiate support for U.S. (NBS) participation in a collaborative experiment at the ILL high-flux reactor in Grenoble, France to perform a definitive measurement of the neutron lifetime. ($965)	Continue the research by the Participating Research Team at the BNL HFBR at about the same level. Use the complementary filtered beam and TRISTAN facilities to test a new global parameterization of nuclear structure. Develop picosecond lifetime techniques to be able to measure transition rates in nuclei far from stability. The neutron lifetime measurement experiment at ILL will continue. ($925)	Continue support of the BNL-led effort to obtain a systematic understanding of nuclear structure in heavy nuclei, and its evolution with N, Z, A, and the number of valence protons and neutrons. Continue ion source development, particularly for studies of astrophysical interest. The neutron lifetime measurement at ILL should be completed, but research efforts are expected to transfer to the new Ultra-cold neutron source at the NBS for measurement of the neutron dipole moment. ($976)
Other Research	Continue experiment by LANL to determine the high-energy solar neutrino flux integrated over the last several million years by isolating and measuring Tc-98 in deeply buried molybdenum ore. Initiate US/Foreign collaborations in solar neutrino experiments: with the USSR (Gallium metal detector in the Caucasus), the Europeans (Gallium chloride detector in the Appenines), the Japanese (Large light water Cerenkov detector in their Kamioka mine), and the Canadians (Design study for heavy-water Cerenkov	Continue support of the LANL experiment with the first results expected from the molybdenum-ore experiment. The 60-ton gallium-metal gallium experiment in the USSR is expected to begin operation. The European GALLEX experiment will be completing acquisition of Gallium chloride and installation of equipment in the Gran Sasso tunnel. Administer SBIR contracts.	Continue solar neutrino research at about same level of effort. Analyze first results from the joint US/European 35-ton gallium-chloride experiment. Transfer support for BNL nuclear group from low energy Tandem based research to relativistic heavy ion reactions at the Tandem/AGS facility in Heavy Ion subprogram. Administer SBIR contracts.

Program Activity	FY 1987	FY 1988	FY 1989
Other Research (Cont'd)	detector). Analyze 11 neutrino events in Kamioka detector from the Supernova 1987A. Administer SBIR contracts. ($3,934)	($5,025)	($4,374)
Nuclear Data Measurements	Conduct neutron cross section measurement programs at the Oak Ridge Electron Linear Accelerator ORELA, at the ANL Fast Neutron Generator FNG, at the LANL WNR facility, at the NBS accelerators, and at several university accelerators (Colorado School of Mines, University of Lowell, University of Michigan, Ohio University, and Duke University/TUNL.) These measurements are keyed to the improvement of the Evaluated Nuclear Data File ENDF, which is the prime data base for use by the fission, fusion, and other nuclear technologists. ($6,223)	Continue the nuclear data measurement cross sections at about the same level of effort. Complete the transfer of support from NE for the ANL Fast Neutron Generator (FNG). Measurements at the FNG will concentrate on cross sections requested by the Office of Fusion Energy; in particular, total and scattering cross sections of structural materials, and cross sections for the production of long-lived radioactivity from them. Complete the construction of the large, segmented, full- solid-angle gamma-ray detector to be used at the ORELA as a photon-multiplicity detector. ($6,408)	Continue nuclear data measurement program at about same level. Measurements will begin at the ORELA using the photon-multiplicity detector to provide unadjusted differential measurements of capture cross sections and capture-to-fission ratios which meet the accuracy requirements of reactor designers, beginning with U-235 and Pu-239. ($6,595)
Nuclear Data Compilation and Evaluation	Continue the two major activities: (1) updating of the Evaluated Nuclear Structure and Decay File ENSDF, from which the Nuclear Data Sheets are produced for use by the nuclear research community; (2) evaluation of data, mainly neutron cross sections, for inclusion in the next version of	Continue at the same level the two major activities that comprise a reasonably balanced nuclear data program that satisfies current nuclear data needs of both basic researchers and technologists. The evaluation of the neutron cross section data for inclusion in ENDF-6	Continue nuclear data compilation and evaluation at the same level. ENDF-6 is expected to be nearing completion; a significant advance over previous versions should result from the inclusion of recent data measured for the purpose, and from improvements in nuclear models

Program Activity	FY 1987	FY 1988	FY 1989
Nuclear Data Compilation and Evaluation (Cont'd)	the Evaluated Nuclear Data File ENDF-6, which is the primary data base for use by nuclear technologists. Both activities are coordinated by the National Nuclear Data Center (NNDC) at BNL; with the coordination of the 50% foreign contributions to the ENSDF evaluation provided by the Nuclear Data Section of the IAEA. The completion of a simultaneous evaluation (with treatment of correlations) of the standard cross sections used in the ENDF data base is expected by the end of the year. ($4,096)	will continue. The LBL group published the Table of Radioactive Isotopes, a 1056-page reference book, containing detailed radiation data in a convenient format tailored to the requirements of medical researchers, biologists, designers and monitors of nuclear reactors. ($4,615)	and evaluation methods. The cycle time for the evaluation of the A-chains for the ENSDF file is expected to be shortened as the evaluators take advantage of their experience with computerized methods and as the LBL group resumes its evaluation effort. ($4,785)

I. Preface: NUCLEAR THEORY

The purpose of research in theoretical nuclear physics is to obtain a unified description of atomic nuclei and relate this description to elementary constituent particles and the fundamental forces connecting them. The long-range objectives of nuclear theory are to obtain a comprehensive understanding of the foundations of nuclear matter at the most fundamental level, in terms of the properties of the constituent quarks and gluons. These objectives are approached by interpreting results from nuclear physics experiments, and by predicting phenomena and relationships to test this description. The understanding of nuclear phenomena is prerequisite for a description of the material foundations of the universe, including astrophysics phenomena such as formation of the elements in stars and supernovae. Much of nuclear theory requires extensive use of supercomputer capabilities.

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Nuclear Theory.............................	$ 10,000	$ 10,500	$ 11,000	+ 5

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory.................	$ 895	$ 910	$ 945	+ 4
Brookhaven National Laboratory.............	940	955	990	+ 4
Lawrence Berkeley Laboratory................	815	880	915	+ 4
Los Alamos National Laboratory.............	990	1,005	1,045	+ 4
Oak Ridge National Laboratory..............	825	835	865	+ 4

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
Nuclear Theory	Improve calculations of nuclear structure and reactions and develop connections between the models developed by different theorists. Continue the development of the description of nuclei in terms of their constituent quarks and gluons. Develop improved equations for relativistic heavy-ion collisions and astrophysics. Increase emphasis on electron scattering theory to guide experimental program of the Continuous Electron Beam Accelerator Facility (CEBAF).	Increase attention to the role of spin in nuclear forces to describe the results of experiments using new polarized beams at DOE-supported facilities. Provide a deeper understanding of the equations describing nuclear matter. Concentrate theory of nuclear phase transitions on the formation of quark-gluon plasmas as related to experiments that would be carried out on a future Relativistic Heavy Ion Collider (RHIC).	Emphasize investigations of quark-gluon descriptions of nuclear structure and of very high energy density forms of nuclear matter in preparation for future experimental investigations at CEBAF and RHIC, and other next generation machines. Do calculations to better understand nuclear astrophysical processes. Establish a major Theory Institute with participation of broadly based Nuclear Physics programs. Continue broad program of theoretical research on properties of atomic nuclei, understanding of nuclear forces, and phase transitions in nuclear matter.
	($10,000)	($10,500)	($11,000)

I. Preface: CAPITAL EQUIPMENT

Capital equipment funds are needed to provide for particle detection systems and for data acquisition and analysis systems. These funds are essential for effective utilization of nuclear physics accelerator facilities. In addition, the program has landlord responsibility for providing general purpose capital equipment at the Lawrence Berkeley Laboratory.

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Capital Equipment	$ 14,790	$ 16,575	$ 17,450	+ 5

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory	$ 4,045	$ 4,800	$ 5,000	+ 4
Lawrence Berkeley Laboratory	2,072	2,190	2,200	+ 1
Los Alamos National Laboratory	2,033	2,325	2,125	- 9
Argonne National Laboratory	1,730	1,755	1,900	+ 8
Massachusetts Institute of Technology/Bates	1,145	1,200	1,200	0
Oak Ridge National Laboratory	1,358	960	930	- 3
Continuous Electron Beam Accelerator Facility	500	1,000	970	- 3
University Laboratories	500	900	1,000	+ 11
Lawrence Berkeley Laboratory GPE	1,170	1,300	1,400	+ 8
All Other	237	145	725	+400

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
CAPITAL EQUIPMENT			
BNL	Complete construction of Experiment 802. Develop Time Projection Chamber (TPC) for Experiment 810. Begin running with partial setup of Experiment 814 using uranium scintillating calorimeters and NaI crystals transferred from CERN. Install some elements of the tagging spectrometer at the Laser Electron Gamma Source (LEGS) facility in the NSLS X-ray ring. Begin engineering	Complete construction of prototype TPC for Experiment 810 and perform test runs. Complete fabrication of all detectors and data acquisition systems for Experiment 814, and begin initial physics running of the experiment. Procure major components of the kaon beam line. Construct a new beam line for Experiment 814. Complete installation of tagging spectrometer for the LEGS facility	Add a second spectrometer arm to Experiment 802 which will enable the apparatus to handle higher mass projectiles and to operate at higher laboratory angles. Perform major running of Experiment 814 after final installation and testing of all detectors. Install a frequency quadrupled laser system at LEGS to expand the gamma-ray energy range. Complete

Program Activity	FY 1987	FY 1988	FY 1989
BNL (Cont'd)	design of a 1-2 GeV/c kaon beam line at the AGS. Modify beam lines at the AGS for heavy ion running. ($4,045)	and begin initial experiments. Begin replacement of central computer at the National Nuclear Data Center. ($4,800)	construction of the kaon beam line and begin initial experiments. Construct beam line for new AGS heavy ion experiment. Complete modernization of central computer at NNDC. ($5,000)
LBL	Complete large area drift chambers for the HISS spectrometer. Start construction of highly segmented time-of-flight (TOF) wall and a high multiplicity trigger for HISS. Construct drift chamber for experiment at the CERN Low Energy Antiproton Ring. Build compact multiplicity detector for the dilepton spectrometer (DLS). Test prototype three-stage telescope detectors for Reverse Kinematics Facility at the Bevalac. Complete the central BGO ball of the 4-pi gamma-ray detector (called HERA) at the 88-Inch Cyclotron. ($2,072)	Design and fabricate a prototype Time Projection Chamber (TPC) for the HISS spectrometer to measure central collisions with the heaviest and most energetic projectiles available from the Bevalac. Install new TOF wall and multiplicity trigger at HISS. Add a multi-segmented calorimeter system to the DLS to increase electron/pion rejection power. Install reverse Kinematics Facility. Replace several VAX data analysis computers at the Bevalac with a single, more powerful facility. ($2,190)	Construct the production TPC for the HISS magnet at the Bevalac, fabricating field cage, pad plane, and electronics. Begin running HISS with new TOF wall and trigger. Finish installation of calorimeter system at the DLS. Begin use of completed Reverse Kinematics Facility. Complete upgrade at the Bevalac data analysis facility. Install ultra-fast data analysis computer at the HERA facility. ($2,200)
LANL	Complete installation of large superconducting solenoid magnet and perform full scale prototyping of electron and photon spectrometers for the MEGA experiment, which searches for a very rare decay mode of the muon. Complete engineering design	Complete construction of one-half of MEGA detectors and perform in-beam testing to optimize system design. Machine magnet steel, procure vacuum chambers, and begin component assembly of the Medium Resolution Spectrometer. Complete construction,	Complete construction of the MEGA detector, collect initial data, and begin analysis. Commission Medium Resolution Spectrometer and begin research use with the new intense polarized proton beam. Acquire high density mass storage devices

Program Activity	FY 1987	FY 1988	FY 1989
LANL (Cont'd)	and initiate procurement of magnets for the Medium Resolution Spectrometer. Begin initial testing of neutron time of flight facility. Upgrade VAX 8600 data analysis system. ($2,033)	procure data acquisition system, and begin research operation of the full 600-m neutron time of flight facility. ($2,325)	and add new processor to the data analysis facility. Procure and install hardware, including separators, choppers, and phase space compression devices, for improving the quality of pion and muon beams. ($2,125)
ANL	Start design and construction of the Fragment Mass Analyzer for highly selective detection of rare particles from heavy ion reactions at ATLAS. Complete installation of phase-space control system with ion-buncher detectors for all ATLAS beam transport lines. Replace obsolete data acquisition and playback computer system in Area II. ($1,730)	Install major components of the Fragment Mass Analyzer. Add second data acquisition system DAPHNE and playback computer system to Area III. ($1,755)	Start construction of a new experimental system for positron studies needed to exploit the intense beams of very heavy ions available from the new positive ion injector at ATLAS. Complete construction of the Fragment Mass Analyzer and begin initial experiments. ($1,900)
MIT/Bates and ORNL	Carry out various projects such as construction of a liquid hydrogen target for use at high beam power. Procure 60 barium floride scintillation detectors for a high-energy gamma-ray facility. ($2,503)	Make improvements to the polarized electron source, install beam halo monitoring system, install new focal-plane detectors on the OHIPS electron spectrometer. Complete the second half of the heavy-ion/light-ion detector and provide data analysis system for CERN experiment WA 80. ($2,160)	Design and construct an out-of-plane magnetic spectrometer system and equipment for internal target experiment. Upgrade velocity selector capability. ($2,130)

III. CAPITAL EQUIPMENT (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
CEBAF	Procure RF and cryogenic testing equipment for evaluating superconducting RF cavities. ($500)	Procure equipment for the RF cryogenic laboratory such as cryogenic plumbing and gas storage systems, procure electrical testing equipment, install an array-vector processor to speed design of experimental equipment and accelerator components. ($1,000)	Procure a magnet measurement system, purchase shop equipment such as a large milling machine, procure cryogenic support equipment, and upgrade the VAX computer system to 30 MFLOP capacity. ($ 970)
University Laboratories	Complete construction of the high-intensity polarized ion source at TUNL (located at Duke University), which enables an expanded program of study of spin-dependent interactions. ($500)	Initiate construction of a variety of experimental equipment at Texas A&M University, Yale University, University of Washington, and TUNL, e.g., charged particle array, 2-pi neutron ball, radiative capture setup, plastic wall gamma-ray detector system, and proton spectrometer. ($900)	Continue instrumentation initiative at university laboratories with construction of charged particle time-of-flight system, detectors for large scattering chamber, magnetic spectrometer, high energy gamma detector and polarized solid He-3 target. ($1,000)
LBL	Provide general purpose equipment at Lawrence Berkeley Laboratory, for which the Nuclear Physics program has landlord responsibility, such as spectrum analyzers and corona detectors for the electronics engineering group, film thickness measuring instruments for the mechanical shops, radiation detection equipment for LBL's environmental	Provide general purpose equipment such as data processing equipment used in administrative functions, equipment for the Computing Division, computer aided design and engineering (CAD/CAM) work stations, a chest x-ray machine, and an emergency power plant.	Provide general purpose equipment such as a firetruck and forklifts for the Motor Vehicle group, disk drives for the Administration Division computer, refrigerators and freezers for the cafeteria, optical mass storage system for the Central Computing Facility, a high temperature kiln and a scatter plate interferometer for the

III. CAPITAL EQUIPMENT (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
LBL (Cont'd)	health and safety groups, and a UNIX work station for the informational services group. ($1,170)	($1,300)	Engineering Division. ($1,400)
Other	Provide equipment for the Nuclear Physics Injector (NPI) program at SLAC and for the Oak Ridge Associated Universities on-line isotope separator (UNISOR) project. ($237)	Provide equipment for UNISOR, NPI injector at SLAC and other small programs. ($145)	Provide equipment for NPI injector at SLAC and equipment for UNISOR. ($725)
TOTAL CAPITAL EQUIPMENT	$14,790	$16,575	$17,450

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

Nuclear Physics

Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1988 Appropriated	FY 1989 Request	Remaining Balance	TEC
89-R-201	Accelerator Improvements and Modifications	---	---	2,600	---	2,600
88-R-201	Accelerator Improvements and Modifications	---	2,300	---	---	2,300
GP-E-300	General Plant Projects	---	---	3,200	---	3,200
GP-E-300	General Plant Projects	---	2,900	---	---	2,900
Total, Nuclear Physics Construction			$ 5,200	$ 5,800		XXX

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Nuclear Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 89-R-201 Accelerator Improvements and Modifications
Various locations

Project TEC: $ 2,600
Start Date: 2nd Qtr. FY 1989
Completion Date: 2nd Qtr. FY 1991

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1989	$ 2,600	$ 2,600	$ 1,600
1990	0	0	700
1991	0	0	300

3. Narrative:

(a) Accelerator Improvement Projects provide for additions, modifications, and improvements to research accelerators and ancillary experimental facilities. The requested projects are necessary to maintain and improve reliability and efficiency of operations and to provide new experimental capabilities as required for execution of planned nuclear physics research programs. Funds for these projects are needed annually to provide increased performance levels and increased serviceability, thereby decreasing facility downtime, improving the productivity and cost effectiveness of the program.

(b) A description and listing of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheets. Some of these may be located on non-Government owned property. The following is a list of the proposed FY 1989 funding for the various locations:

Argonne National Laboratory (ATLAS)	$ 1,500
Lawrence Berkeley Laboratory	600
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	500
Total Estimated Costs..................	$ 2,600

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Nuclear Physics

IV. B. Plant Funded Construction Project

1. Project title and location: GP-E-300 General Plant Projects
Various locations

Project TEC: $ 3,200
Start Date: 2nd Qtr. FY 1989
Completion Date: 2nd Qtr. FY 1991

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1989	$ 3,200	$ 3,200	$ 700
1990	0	0	1,800
1990	0	0	700

3. Narrative:

(a) General Plant Projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required at the Lawrence Berkeley Laboratory, and the Massachusetts Institute of Technology (Bates Linear Accelerator Center). GPP projects focus on general laboratory facilities whereas the AIP projects focus on the technical facilities.

(b) These projects are required for the general maintenance, modification and improvement of the overall laboratory plant and include minor new construction, capital alterations and additions, and improvements to buildings and utility systems. These projects are essential for maintaining the productivity, increasing the operational cost effectiveness, and ensuring that necessary support services are available to the research program at the DOE-owned facilities.

(c) A description and listing of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheets. Some of these may be located on non-Government owned property. The following is a list of the proposed FY 1989 funding for the various locations:

Lawrence Berkeley Laboratory	$ 2,600
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	600
Total Estimated Cost....................	$ 3,200

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
BASIC RESEARCH USER FACILITIES
OFFICE OF ENERGY RESEARCH

OVERVIEW

BASIC RESEARCH USER FACILITIES-NUCLEAR PHYSICS PROGRAM (BRUF-NP)

The Nuclear Physics Program and the BRUF-NP Program of the Department of Energy (DOE) have the lead responsibility for Federal support of nuclear physics research and provide about 80 percent of the funding for the field. The primary goal of these programs is to understand the structure and interactions of atomic nuclei. A second goal, using the specialized knowledge, techniques and apparatus available to the program, is to understand how the fundamental forces and particles of nature manifest themselves in nuclear matter. Nuclear processes determine the essential physical characteristics of our universe and the composition of the matter which forms it. An understanding of nuclei and nuclear phenomena is essential to any basic understanding of the world around us and has had enormous influence over other branches of science and technology, such as nuclear power, nuclear weapons and nuclear medicine. Only slightly less well known are nuclear techniques for geophysical exploration, testing of materials and archeological dating and siting.

Over the years, many theoretical models have been developed to describe the structure of the nucleus and its behavior. These models have progressed from simple mechanical models of surface vibrations and rotations to sophisticated descriptions of meson-nucleon interactions. Scientists now know that nucleons (neutrons and protons, the constituents of the nucleus), are composed of smaller constituents called quarks. Based on the ways quarks are confined together in groups of three to make nucleons, or groups of two to make mesons, a more fundamental theory of the strong force called quantum chromodynamics is emerging. Nuclear physics use of extended nuclear matter as a substrate for investigation of quark effects provides a complementary approach for addressing scientific problems in common with those of high energy physics. Growing interactions with astrophysics include measurements or calculations of supernovae, neutron stars, solar neutrinos, heavy cosmic rays, and nuclear abundances produced by stellar processes. Of particular interest is the ability of relativistic heavy ion collisions to create a quark-gluon plasma, simulating a stage of evolution of the universe that disappeared ten millionths of a second after the big bang start of the universe.

The strategy of the program is to address key scientific questions with new theories, equipment and facilities while maintaining an effective balance between competing and diverse program elements. Essential guidance is provided by the Nuclear Physics Program Plan, with continuing advice from the Nuclear Science Advisory Committee (NSAC). Key elements of the plan are reflected in this budget.

The program is centered around an active experimental research program which is continually evaluated and revised to focus on the most basic scientific questions. Necessary for proper conduct of this research are efforts in nuclear theory, design and fabrication of sophisticated detectors, and development of creative and skilled personnel. Central to the program are the construction, operation and maintenance of the accelerator facilities which provide the beams of particles upon which the experiments are based. In some areas of nuclear physics, questions are addressed by accelerators at Universities dedicated to in-house research, or smaller facilities at some national laboratories. However, many of the newly emerging fundamental problems in nuclear science require large modern facilities designed for the research use of the entire nuclear community.

The Basic Research User Facilities Nuclear Physics Program will operate and maintain the following complex user facilities: LAMPF at Los Alamos National Laboratory, the Bevalac at Lawrence Berkeley Laboratory, and the Tandem/AGS at Brookhaven National Laboratory. It will also support the construction of the new major facilities which are required to address the most important scientific questions. To meet this later objective CEBAF construction was started in FY 1987.

The BRUF-NP Program is structured to construct, maintain, and operate the large user facilities which are essential to carry out the Nuclear Physics experimental program. The beams of particles provided by complex accelerators are the primary vehicle by which scientists learn about the structure and forces acting within atomic nuclei. The BRUF-NP program provides support for the technical staff and craftsmen, the maintenance personnel, accelerator operators, power costs, and instrumentation for the operation and construction of the large facilities. Moderate use is made of AIP, GPP, and capital equipment funds in order to maintain the facilities in the most effective operating conditions and to modernize the apparatus. Although nuclear physics research is not supported by the program, R&D activity designed to optimize efficient operations and to plan for advanced technical activities is carried out by the BRUF-NP program. Construction and operation of these large, complex and expensive facilities requires sustained, central federal support since they are far too large and costly to expect any single non-federal research institution to provide such facilities for the benefit of the scientific community.

The Nuclear Physics Program in the General Science and Research appropriation is requesting $141,388,000 for support of research at universities and for use of the national facilities. In addition, many of the nuclear scientists supported by the National Science Foundation programs, funded at about $40 million, are users of these facilities. More than 200 scientists do experiments at the Bevalac at the Lawrence Berkeley Laboratory each year and a similar number make use of the Tandem/AGS at the Brookhaven National Laboratory. More than 325 visiting scientists annually use the multiple beams available at the LAMPF facility at the Los Alamos National Laboratory for one or more experiments. Over 650 physicists have demonstrated interest in possible future use of the Continuous Electron Beam Accelerator Facility (CEBAF) by joining the CEBAF user's group, and 100 of them are actively participating in the design of experiments. An estimated 80 percent of experimental nuclear scientists will base their research at these four major facilities. The users are actively involved in the definition of the facility operations and setting of priorities for new capabilities. They are participants in design and construction of large detectors. Formally and informally, their inputs largely determine the research atmospheres of the laboratories. While the importance of maintaining a proper balance between the Nuclear Physics research and the operation of the facilities is recognized, the separation of these activities serves to clearly delineate the resources needed to effectively carry out the research on the one hand and to operate and construct the major national facilities on the other.

DEPARTMENT OF ENERGY
BASIC RESEARCH USER FACILITIES
FY 1989 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

LEAD TABLE

Basic Research User Facilities - Nuclear Physics (BRUF - NP)

Activity	FY 1987 Actual	FY 1988 Approp.	FY 1989 Base	FY 1989 Request	Program Change Request vs Base: Dollar	Program Change Request vs Base: Percent
Operating Expenses						
Medium Energy Nuclear Physics Physics.....................	$47,900	$48,460	$48,460	$49,600	$+ 1,140	+ 2%
Heavy Ion Nuclear Physics....	23,922	24,330	24,330	25,362	+ 1,032	+ 4%
Subtotal Operating Expenses...	71,822	72,790	72,790	74,962	+ 2,172	+ 3%
Capital Equipment.............	1,085	1,100	1,100	1,050	- 50	- 5%
Construction..................	19,770	36,300	36,300	46,700	+10,400	+ 29%
Total.....................	$92,677	$110,190	$110,190	$122,712	$+ 12,522	+ 11%
Operating Expenses............	(71,822)	(72,790)	(72,790)	(74,962)	+ 2,172	+ 3%
Capital Equipment.............	(1,085)	(1,100)	(1,100)	(1,050)	- 50	- 5%
Construction..................	(19,770)	(36,300)	(36,300)	(46,700)	+10,400	+ 29%

Staffing (FTEs)..............(Reference General Science Program Direction)

Authorization: Section 209, P.L. 95-91.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
BASIC RESEARCH USER FACILITIES
(dollars in thousands)

SUMMARY OF CHANGES

Basic Research User Facilities - Nuclear Physics (BRUF-NP)

FY 1988 Appropriation	$ 110,190
- Funding required to maintain a constant overall level of program activity	+ 4,466
Medium Energy Nuclear Physics	
- Conduct Medium Energy physics operations at slightly less than FY 1988 level of activity	- 798
Capital Equipment	
- Reduce overall Capital Equipment activities slightly from FY 1988 level	- 94
Construction	
- Continue AIP and GPP at reduced level of effort	- 712
- Continue Continuous Electron Beam Accelerator Facility (CEBAF) project	+ 9,660
FY 1989 Congressional Budget Request	$ 122,712

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
BASIC RESEARCH USER FACILITIES
(dollars in thousands)

KEY ACTIVITY SUMMARY

BASIC RESEARCH USER FACILITIES - NUCLEAR PHYSICS (BRUF - NP)

I. Preface: (BRUF - NP) MEDIUM ENERGY NUCLEAR PHYSICS

The Medium Energy BRUF-NP subprogram supports operations at accelerator facilities with sufficient primary beam energy to produce pi mesons (pions) using projectiles no more massive than alpha particles. Operation of the Clinton P. Anderson Meson Physics Facility (LAMPF) at Los Alamos National Laboratory is supported entirely under this subprogram, as is the "light ion operation" of the Bevalac at Lawrence Bekeley Laboratory (LBL). R&D activities required for the construction of the Continuous Electron Beam Accelerator Facility (CEBAF) and preparation for operation of the laboratory are also carried out under this subprogram.

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
R&D..	$ 6,250	$ 5,250	$ 5,000	- 5
Operations.................................	41,650	43,210	44,600	+ 3
Total, BRUF-NP Medium Energy Nuclear Physics.................................	$ 47,900	$ 48,460	$ 49,600	+ 2

II. B. Major Laboratory and Facility Funding

Los Alamos National Laboratory/LAMPF........	$ 40,600	$ 41,325	$ 42,650	+ 3
Lawrence Berkeley Laboratory/Bevalac........	1,050	885	950	+ 7
Continuous Electron Beam Accelerator Facility.......................	6,250	6,250	6,000	- 4

Program Activity	FY 1987	FY 1988	FY 1989
R&D			
CEBAF R&D	Test prototype industrial accelerator superconducting cavities to establish a reliable baseline design. Complete cryogenics systems designs.	Carry out tests on four industrial cryostats in order to confirm the compatibility of integrated accelerator components.	Complete a cryomodule, the basic unit of accelerator structure which can be cooled to superconducting temperatures.
	Establish the instrumentation and control system architecture for the accelerator.	Complete a computer model for the accelerator. Develop and test other accelerator components.	Develop the thermionic injector for the accelerator. Implement a magnetic measurement capability for the components of the beam transport system. Carry out final testing of the prototype RF separator system. Develop electron beam monitoring techniques.
	Emphasize activities for most effective design of experimental equipment. ($6,250)	Complete design of the large experimental spectrometer. ($5,250)	Carry out detailed development for spectrometer and detector systems. ($5,000)
OPERATIONS			
LAMPF Operations	Operate high intensity 800 MeV proton accelerator and experimental facilities 3000 hours for nuclear physics research with an average of seven simultaneous secondary beams of pions, muons, protons, and neutrinos for nuclear physics and scientific research.	Operate accelerator and facilities about 2700 hours for nuclear physics research with about seven secondary beams.	Operate accelerator and facilities about 2800 hours for nuclear physics research with about seven secondary beams operating simultaneously.

III. (BRUF-NP) MEDIUM ENERGY NUCLEAR PHYSICS (Cont'd)

LAMPF Operations (Cont'd)	Provide beam for approximately 75 nuclear physics experiments involving about 300 scientists. Operate neutron time-of-flight facility and continue support for installation of a polarized ion source with much higher intensity than the present polarized source. ($40,600)	Provide beam for approximately 58 nuclear physics experiments involving about 290 scientists. Commission medium resolution spectrometer and continue support for installation of polarized ion source. ($41,325)	Provide beam for approximately 60 nuclear physics experiments involving about 330 scientists. Start operation of high intensity polarized ion source and begin beam line for neutrino research facility including a Large Cherenkov Detector (LCD) being fabricated by a consortium of university and national laboratory scientists. ($42,650)
Other Operations	Provide operations funds for the LBL Bevalac to support the medium energy research activities (350 hours). ($1,050)	Continue operations support for the Bevalac medium energy research activities (300 hours). Provide for startup of laboratory operations at CEBAF. ($1,885)	Continue operations support for the Bevalac medium energy research activities (350 hours). Provide for startup of laboratory operations at CEBAF. ($1,950)

I. Preface: (BRUF-NP) HEAVY ION NUCLEAR PHYSICS

The Heavy Ion Research subprogram contained in BRUF-NP is aimed at understanding the behavior of nuclear matter over an ever increasing range of excitation energy and nuclear density. These conditions are created in collisions between nuclear targets and nuclear beams. The heavy ion beams are produced by two highly sophisticated accelerators located at national laboratories. Areas of research at these two relativistic heavy ion facilities involve measurements of projectile fragmentation, particularly those related to the production of secondary beams of unstable nuclear species, and the exploration of the nuclear matter equation of state for hot dense nuclear matter. At ultra-relativistic energies, a search is beginning for the new state of matter known as the quark-gluon plasma which will require, in the future, a new facility called the Relativistic Heavy Ion Collider (RHIC).

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
Total, BRUF-NP Heavy Ion Nuclear Physics................................	$ 23,922	$ 24,330	$ 25,362	+ 4

II. B. Facility Operations Funding

Brookhaven National Laboratory.............	$ 6,980	$ 7,195	$ 7,710	+ 7
Lawrence Berkeley Laboratory................	16,942	17,135	17,652	+ 3
	--------	--------	--------	---------
Total, BRUF-NP Heavy Ion Nuclear Physics................................	$ 23,922	$ 24,330	$ 25,362	+ 4

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
(BRUF-NP) HEAVY ION NUCLEAR PHYSICS			
BNL/Tandem/AGS Operations	Complete commissioning of the Tandem/AGS accelerator system and provide oxygen and silicon beams for the initial round of relativistic heavy ion experiments. Terminate operation of the Tandem for low energy nuclear physics. ($6,980)	Operate the Tandem/AGS accelerator system to produce 700 hours (7 weeks) of oxygen and sulfur beams for the relativistic heavy ion experiments. Complete installation of beam lines for experiments E-802 and E-814. ($7,195)	Operate Tandem/AGS accelerator system to produce 8 weeks of oxygen and sulfur beams for the approved relativistic heavy ion experiments. Begin installation of new beam line for proposed dilepton spectrometer experiment. ($7,710)
LBL Bevalac Operations	Provide beams of any ion through uranium with energies up to 2.1 billion electron volts per nucleon for a broad based research program in heavy ion nuclear physics, nuclear chemistry, atomic physics, and astrophysics. One third of the beam time is provided for a biomedical research program. Provide 3000 hours of beam time to over 200 university and national laboratory users. ($16,942)	Continue to provide relativistic heavy ion beams for the research program. Provide up to 2900 hours of beam time for the research program. Emphasize provision of beams in the 100-400 MeV/amu range and secondary beams of unstable species. ($17,135)	Continue to provide up to 2900 hours of beam time for the research program. Make full utilization of the specialized low energy, kaon, and secondary radioactive beam lines. Begin to phase out the independent research program of the SuperHILAC. ($17,652)

I. Preface: (BRUF-NP) CAPITAL EQUIPMENT

Capital equipment funds are needed to provide for instrumentation to improve and maintain performance at all of the major Nuclear Physics accelerators supported by the Nuclear Physics program. These funds are required to maintain effective utilization of these national accelerator facilities operated by the Nuclear Physics program.

II. A. Summary Table

Program Activity	FY 1987	FY 1988	FY 1989	% Change
(BRUF-NP) Capital Equipment................	$ 1,085	$ 1,100	$ 1,050	- 5

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory.............	$ 50	$ 200	$ 150	- 25
Lawrence Berkeley Laboratory...............	535	400	400	0
Los Alamos National Laboratory.............	500	500	500	0

III. Activity Descriptions

Program Activity	FY 1987	FY 1988	FY 1989
(BRUF-NP) CAPITAL EQUIPMENT			
BNL	Upgrade components of the AGS switchyard for heavy ion running. ($50)	Install instrumentation for heavy ion operation of the AGS accelerator and beam lines. ($200)	Provide heavy ion instrumentation for beam lines. ($150)
LBL	Install liquid nitrogen reclaimer to recover cold nitrogen gas from the Bevatron vacuum systems. Add beam diagnostics to the local injector and transfer line beam transport systems. Install cryogenic pumping on beam lines. Provide instrumentation to improve beam delivery at the biomedical facility. ($535)	Install liquid nitrogen reclaimer at the SuperHILAC. Install high-sensitivity external beamline instrumentation in the transfer line. Provide low level RF electronics at the SuperHILAC. Fabricate new instrumentation for beam monitoring on the biomedical beam line. ($400)	Upgrade auxiliary power supplies at the Bevatron. Improve the electronics for the Adam ion source at the SuperHILAC. Build instrumentation for the scanning magnet radiotherapy beam-delivery system at the Bevatron. ($400)

III. (BRUF-NP) CAPITAL EQUIPMENT (Cont'd)

Program Activity	FY 1987	FY 1988	FY 1989
LANL	Provide upgraded instrumentation for the LAMPF control systems. ($500)	Convert Central Control Room computer to a VAX cluster and remove the obsolete SEL-840. Initiate replacement of obsolete remote analog data systems. ($500)	Replace power supplies within the beam switchyard. Continue replacement of remote analog data systems. ($500)
TOTAL (BRUF-NP) CAPITAL EQUIPMENT	$ 1,085	$ 1,100	$ 1,050

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
BASIC RESEARCH USER FACILITIES
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

Basic Research User Facilities - Nuclear Physics (BRUF-NP)

Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1988 Appropriated	FY 1989 Request	Remaining Balance	TEC
89-R-501	Accelerator Improvements and Modifications	---	---	1,700	---	1,700
88-R-201	Accelerator Improvements and Modifications	---	2,100	---	---	2,100
87-R-203	Continuous Electron Beam Accelerator Facility	16,200	33,500	44,500	170,800	265,000
GP-E-300	General Plant Projects	---	700	---	---	700
GP-E-500	General Plant Projects	---	---	500	---	500
Total, BRUF-NP Construction		$ 16,200	$ 36,300	$ 46,700	$ 170,800	XXX

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
BASIC RESEARCH USER FACILITIES
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Basic Research User Facilities - Nuclear Physics (BRUF-NP)

IV. B. Plant Funded Construction Project

1. Project title and location: 89-R-501 Accelerator Improvements and Modifications
Various locations

Project TEC: $ 1,700
Start Date: 2nd Qtr. FY 1989
Completion Date: 2nd Qtr. FY 1991

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1989	$ 1,700	$ 1,700	$ 1,000
1990	0	0	600
1991	0	0	100

3. Narrative:

(a) Accelerator Improvement Projects provide for additions, modifications, and improvements to major research accelerators. The requested projects are necessary to maintain and improve reliability and efficiency of operations. Funds for these projects are needed annually to provide increased performance levels and increased serviceability, thereby decreasing facility downtime, improving the productivity and cost effectiveness of the program.

(b) A description and listing of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheets. Some of these may be located on non-Government owned property. The following is a list of the proposed FY 1989 funding for the various locations:

Brookhaven National Laboratory (AGS/Tandem)	$ 900
Lawrence Berkeley Laboratory	400
Los Alamos National Laboratory (Clinton P. Anderson Meson Physics Facility)	400
Total Estimated Costs..................	$ 1,700

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
BASIC RESEARCH USER FACILITIES
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Basic Research User Facilities - Nuclear Physics (BRUF-NP)

IV. B. Plant Funded Construction Project

1. Project title and location: 87-R-203 Continuous Electron Beam Accelerator Facility
Newport News, Virginia

Project TEC: $265,000
Start Date: 2nd Qtr. FY 1987
Completion Date: 4th Qtr. FY 1993

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1987	$ 16,200	$ 16,200	$ 7,842
1988	33,500	33,500	24,000
1989	44,500	44,500	42,000
1990	65,000	65,000	58,000
1991	65,000	65,000	62,000
1992	35,800	35,800	52,000
1993	5,000	5,000	19,158

3. Narrative:

(a) The Continuous Electron Beam Accelerator Facility (CEBAF) is a single purpose, basic nuclear physics research facility based on a four billion electron volt (GeV) electron linear accelerator that is capable of providing high intensity, continuous (i.e., not pulsed) electron beams. The facility will include the experimental areas needed to conduct basic nuclear research, and buildings to house the accelerator complex and its operation and maintenance activities. The facility will possess a complement of equipment for initial experiments and supporting facilities to exploit the capabilities of the accelerator.

(b) CEBAF will be the only facility in the world capable of producing electron beams that simultaneously meet the criteria of high energy, high intensity, and continuous nature necessary to advance the frontiers of nuclear physics. CEBAF's electron accelerator with its capability of providing beams at any energy in the range 0.5 to 4 GeV, is designed to study the largely unexplored transition between the nucleon-meson and the quark-gluon description of nuclear matter.

(c) Construction of CEBAF will continue in an expeditious manner, consistent with available funds. FY 1989 construction funds will be used for major hardware fabrication of RF cavities, cryounits, the central helium liquifier and its transfer lines, and the linac and arc magnets. Also, construction of the beam enclosure tunnel and support structures will continue.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
BASIC RESEARCH USER FACILITIES
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Basic Research User Facilities - Nuclear Physics (BRUF-NP)

IV. B. Plant Funded Construction Project

1. Project title and location: GP-E-500 General Plant Projects
Los Alamos National Laboratory (LANL)

Project TEC: $ 500
Start Date: 2nd Qtr. FY 1989
Completion Date: 2nd Qtr. FY 1991

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1989	$ 500	$ 500	$ 100
1990	0	0	300
1990	0	0	100

3. Narrative:

(a) This General Plant Project provides for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required at (LANL). GPP projects focus on general laboratory facilities whereas the AIP projects focus on the technical facilities.

(b) These projects are required for the general maintenance, modification and improvement of the overall laboratory plant and include minor new construction, capital alterations and additions, and improvements to buildings and utility systems. These projects are essential for maintaining the productivity, increasing the operational cost effectiveness, and ensuring that necessary support services are available to the research program at the DOE-owned facilities.

(c) A description and listing of the major items of work to be performed is contained in the Construction Project Data Sheets. The following is the proposed FY 1989 funding.

Los Alamos National Laboratory	
(Clinton P. Anderson Meson Physics Facility)	$ 500
Total Estimated Cost....................	$ 500

DOE/MA-0274

Congressional Budget Request

Non-Defense Activities
Construction Project Data Sheets

FY 1989

U.S. Department of Energy
Assistant Secretary,
Management and Administration
Office of the Controller
Washington, D.C. 20585

February 1988

DEPARTMENT OF ENERGY

FISCAL YEAR 1989 CONGRESSIONAL BUDGET REQUEST

CONSTRUCTION PROJECT DATA SHEETS

ENERGY SUPPLY RESEARCH AND DEVELOPMENT

BASIC RESEARCH USER FACILITIES

GENERAL SCIENCE AND RESEARCH

URANIUM ENRICHMENT

NAVAL PETROLEUM AND OIL SHALE RESERVES

FOSSIL ENERGY RESEARCH AND DEVELOPMENT

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
NUCLEAR PHYSICS

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No. 89-R-201

3. Date A-E work initiated: 1st Qtr. FY 1989

3a. Date physical construction starts: 2nd Qtr. FY 1989

4. Date construction ends: 2nd Qtr. FY 1991

5. Previous cost estimate: None
Less amount for PE&D: None
Net cost estimate: None
Date: None

6. Current cost estimate: $2,600
Less amount for PE&D: 0
Net cost estimate: $2,600
Date: May 1987

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1989	$ 2,600	$ 2,600	$ 2,600	$ 1,600
1990	0	0	0	700
1991	0	0	0	300

8. Brief Physical Description of Project

This project provides for additions, modifications, and improvements to major research accelerators and ancillary experimental facilities. The requested funds are necessary to maintain and improve reliability and efficiency of operations and to provide new experimental capabilities as required for execution of planned research programs.

Argonne National Laboratory (ATLAS).. $ 1,500

The positive-ion injector of ATLAS will be upgraded by increasing its accelerating voltage from 8 to 12 million volts. This will be accomplished by adding to the existing injector six low-beta resonators in a new cryostat and by making numerous smaller improvements throughout the injector system. ATLAS will then be able to accelerate uranium ions effectively.

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No. 89-R-201

8. Brief Physical Description of Project (continued)

Lawrence Berkeley Laboratory (88-Inch Cyclotron).. $ 600

An advanced ECR ion source with expected performance beyond the state-of-the-art is proposed for constructed at the 88-Inch Cyclotron. The source will be designed to operate at RF frequencies of 14 to 18 Ghz to increase the plasma density and output current. The plasma chamber will be one-third the volume of the existing ECR source at LBL to increase the power density of the plasma. These changes are expected to increase the intensity of intermediate charge states at least four fold, thereby increasing the energy of the cyclotron beam by 30 to 50% for medium mass ions. The project includes an independent charge-state analyzing system and coupling to the existing injection line, to allow development of the source and flexible operation with the cyclotron.

Massachusetts Institute of Technology
(Bates Linear Accelerator Center).. $ 500

Equipment for South Hall Ring Experiment and the recently upgraded Bates linear accelerator will be provided. Included are precision survey equipment and vacuum chambers for magnetic elements. The surveying equipment comprises a precision laser theodolite, a laser interferometer, surveying monuments, mirrors, levels, calibrated tapes, and computer interface. The vacuum chambers are for the ring magnetic elements, and include chambers for both static and dynamic dipoles, quadrupoles, sextupoles, and octupoles.

9. Purpose, Justification of Need for, and Scope of Project

Argonne National Laboratory (ATLAS)

The proposed upgrade will permit the ATLAS system to accelerate the heaviest nuclei, up to energies of 8 MeV/AMU. The high beam intensity, excellent beam quality, and continuous (CW) character of the beam from the improved system will provide unique research capabilities for the heaviest ions. No other accelerator in the U.S. will be able to provide equivalent beams for the mass range greater than 100 AMU. A research problem of particular interest will be the investigation of the positron lines observed at the UNILAC accelerator in Germany, an unexplained phenomenon that has excited world-wide interest.

1. Title and location of project: Accelerator improvements and modifications, various locations	2. Project No. 89-R-201

9. Purpose, Justification of Need for, and Scope of Project (continued)

Lawrence Berkeley Laboratory (88-Inch Cyclotron)

The advanced ECR ion source will extend the range of ion species and increase the energy and intensities of heavy-ion beams from the 88-Inch Cyclotron. Energies of at least 10 MeV/AMU are expected out to mass 130. This will permit a variety of new nuclear physics experiments previously not possible at the cyclotron. Improvements in ECR source technology will benefit the nuclear physics programs at other laboratories in the U.S.

Massachusetts Institute of Technology (Bates Linear Accelerator Center)

The project provides essential survey and vacuum equipment for the recently upgraded Bates linear accelerator and the South Hall Ring Experiment. The precision survey equipment is needed to achieve the very high level of accuracy of location of the various elements of the ring and parts of the beam transport system. Many of these elements must be located to an accuracy of 0.1 mm for proper operation. The vacuum chambers will provide the necessary high vacuum for the beam path through all the magnetic elements of the ring.

10. Details of Cost Estimate

a. Engineering, design, inspection, construction, procurement, component assembly, and installation	$ 2,600
Total Estimated Cost	$ 2,600

The estimated cost of the programs at each laboratory are preliminary and, in general, indicate the magnitude of each program. Some of these will be located on non-Government owned property.

11. Method of Performance

Design will be by contractor staff. To the extent feasible, construction and procurement will be accomplished by fixed-price subcontractor awarded on the basis of competitive bidding.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET SUBMISSION
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
NUCLEAR PHYSICS

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: General plant projects various locations

2. Project No. GP-E-300

3. Date A-E work initiated: 1st Qtr. FY 1989

3a. Date physical construction starts: 2nd Qtr. FY 1989

4. Date construction ends: 2nd Qtr. FY 1991

5. Previous cost estimate: None
Less amount for PE&D: None
Net cost estimate: None
Date: None

6. Current cost estimate: $3,200
Less amount for PE&D: 0
Net cost estimate: $3,200
Date: May 1987

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1989	$ 3,200	$ 3,200	$ 3,200	$ 700
1990	0	0	0	1,800
1991	0	0	0	700

8. Brief Physical Description of Project

This project provides for minor new construction, other capital alterations and additions, and for improvements to land, buildings, and utility systems. Where applicable, the request also includes the cost of installed capital equipment integral to a subproject. No significant R&D program is anticipated as a prerequisite for design and construction.

Lawrence Berkeley Laboratory.. $ 2,600

Requirements include: Building 77 plating shop replacement necessary to mitigate environmental and safety hazards; replacement of Building 6 roof and portions of wood sheathing, wood perimeter wall and gutter; replacement of a 450 KVA transformer filled with PCB-contaminated oil; enhancement of power switching capability at Building 88, road widening and paving; and a variety of electrical and mechanical equipment replacements.

1. Title and location of project: General plant projects various locations

2. Project No. GP-E-300

8. Brief Physical Description of Project (continued)

Massachusetts Institute of Technology (Bates Linear Accelerator Center) .... $ 600

This project will provide a vault for the South Hall Ring Experiment, which will exploit high energy electron beams from the recent accelerator upgrade, and a unique high-luminosity internal target capability. The vault will be poured-in-place concrete with interior dimensions of 10 feet x 10 feet for a distance of about 200 feet where the vault is at grade and concrete radiation shielding required.

9. Purpose, Justification of Need for, and Scope of Project

Projects at the Lawrence Berkeley Laboratory and the Bates Linear Accelerator Center at Massachusetts Institute of Technology are needed to improve efficiency and productivity of these installations and to assure continuation of safe and reliable operations for both personnel and instrumentation.

The distribution of funds requested for FY 1989 is as follows:

Lawrence Berkeley Laboratory	$ 2,600
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	600
Total Estimated Cost	$ 3,200

Since needs and priorities may change, other subprojects may be substituted for those listed. Some of these will be located on non-Government owned property.

10. Details of Cost Estimate

See description, item 8. The estimated costs are preliminary and, in general, indicate the magnitude of each program. These costs include engineering, design, and inspection.

11. Method of Performance

Design will be by contractor staff or on the basis of negotiated architect-engineer contracts. To the extent feasible, construction and procurement will be accomplished by firm fixed-price contracts and subcontracts on the basis of competitive bidding.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET SUBMISSION
CONSTRUCTION PROJECT DATA SHEETS
BASIC RESEARCH USERS FACILITIES - PLANT AND CAPITAL EQUIPMENT
BASIC RESEARCH USERS FACILITIES - NUCLEAR PHYSICS (BRUF-NP)

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No. 89-R-501

3. Date A-E work initiated: 1st Qtr. FY 1989

3a. Date physical construction starts: 2nd Qtr. FY 1989

4. Date construction ends: 2nd Qtr. FY 1991

5. Previous cost estimate: None
Less amount for PE&D: None
Net cost estimate: None
Date: None

6. Current cost estimate: $1,700
Less amount for PE&D: 0
Net cost estimate: $1,700
Date: May 1987

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1989	$ 1,700	$ 1,700	$ 1,700	$ 1,000
1990	0	0	0	600
1991	0	0	0	100

8. Brief Physical Description of Project

This project provides for additions, modifications, and improvements to major research accelerators and ancillary experimental facilities. The requested funds are necessary to maintain and improve reliability and efficiency of operations and to provide new experimental capabilities as required for execution of planned research programs.

1. Title and location of project: Accelerator improvements and modifications, various locations — 2. Project No. 89-R-501

8. Brief Physical Description of Project (continued)

Brookhaven National Laboratory (AGS/Tandem).. $ 900

High temperature bake-out capability will be installed in selected areas of the main ring of the Alternating Gradient Synchrotron (AGS) to increase the outgassing rate and reduce the residual gas load in the ring.

Lawrence Berkeley Laboratory (Bevalac).. $ 400

Additional work to modernize the accelerator control system of the Bevatron and SuperHILAC is proposed. High performance computer work stations, an interconnecting network, and special computer controllers to interface with the present control system will be installed within the project.

Los Alamos National Laboratory (LAMPF).. $ 400

The Remote Interface and Control Equipment (RICE) system provides for computer control of many thousands of LAMPF accelerator components. The present RICE hardware includes a RICE Interface Unit (RIU) for interface to the accelerator control computer. This project will upgrade the 75 RICE packages with modern components, and will employ a MicroVAX computer and a redesigned RIU to make them smarter and faster.

9. Purpose, Justification of Need for, and Scope of Project

Brookhaven National Laboratory (AGS/Tandem)

For heavy ion acceleration, it is essential to reduce the average vacuum pressure in the AGS ring to the 10^{-9} Torr level to avoid ionization and thereby electron pickup, which leads to loss of beam. The project to install bake-out capability is part of a major AGS vacuum improvement program that includes replacement of practically all vacuum hardware, and modernization of the vacuum system controls and diagnostics.

Lawrence Berkeley Laboratory (Bevalac)

The principal goal of the Bevalac control system upgrade is to improve operational efficiency. Tuneup procedures will be simpler since there will be fewer controls to attend to, and the setups will be more reproducible. Furthermore, monitoring the conditions of the accelerator and beam lines will be much easier and can be automated, since many more monitoring endpoints will be available.

1. Title and location of project: Accelerator improvements and modifications, various locations | 2. Project No. 89-R-501

9. Purpose, Justification of Need for, and Scope of Project (continued)

Los Alamos National Laboratory (LAMPF)

The present RICE control system, installed in 1970, is much too slow to perform the increasingly complex tasks required for present and future operating modes. The new system will exhibit a much faster response. The updated system will also alleviate the increasing problem of obtaining parts for an obsolescent system.

10. Details of Cost Estimate

a. Engineering, design, inspection, construction, procurement, component assembly, and installation	$ 1,700
Total Estimated Cost	$ 1,700

The estimated cost of the programs at each laboratory are preliminary and, in general, indicate the magnitude of each program. Some of these will be located on non-Government owned property.

11. Method of Performance

Design will be by contractor staff. To the extent feasible, construction and procurement will be accomplished by fixed-price subcontractor awarded on the basis of competitive bidding.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET SUBMISSION
CONSTRUCTION PROJECT DATA SHEETS
BASIC RESEARCH USER FACILITIES - PLANT AND CAPITAL EQUIPMENT
BASIC RESEARCH USER FACILITIES - NUCLEAR PHYSICS (BRUF-NP)

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: General plant projects various locations

2. Project No. GP-E-500

3. Date A-E work initiated: 1st Qtr. FY 1989

3a. Date physical construction starts: 2nd Qtr. FY 1989

4. Date construction ends: 2nd Qtr. FY 1991

5. Previous cost estimate: None
Less amount for PE&D: None
Net cost estimate: None
Date: None

6. Current cost estimate: $ 500
Less amount for PE&D: 0
Net cost estimate: $ 500
Date: May 1987

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1989	$ 500	$ 500	$ 500	$ 100
1990	0	0	0	300
1991	0	0	0	100

8. Brief Physical Description of Project

This project provides for minor new construction, other capital alterations and additions, and for improvements to land, buildings, and utility systems. Where applicable, the request also includes the cost of installed capital equipment integral to a subproject. No significant R&D program is anticipated as a prerequisite for design and construction.

1. Title and location of project: General plant projects various locations

2. Project No. GP-E-500

8. Brief Physical Description of Project (continued)

Los Alamos National Laboratory (LAMPF).. $ 500

The Equipment Test Laboratory Assembly Building, to be used by the LAMPF Engineering Support Group, will be a standard prefabricated metal structure approximately 4000 sq. ft. in area. Utilities necessary to support light to heavy fabrication, including welding, will be necessary. This building will provide floor space for fabrication, assembly and checkout of LAMPF experimental support equipment. Existing floor space available for this purpose is very limited.

9. Purpose, Justification of Need for, and Scope of Project

Projects at the LAMPF facility at Los Alamos National Laboratory are needed to improve efficiency and productivity of these installations and to assure continuation of safe and reliable operations for both personnel and instrumentation.

Since needs and priorities may change, other subprojects may be substituted for those listed.

10. Details of Cost Estimate

See description, item 8. The estimated costs are preliminary and, in general, indicate the magnitude of each program. These costs include engineering, design, and inspection.

11. Method of Performance

Design will be by contractor staff or on the basis of negotiated architect-engineer contracts. To the extent feasible, construction and procurement will be accomplished by firm fixedvprice contracts and subcontracts on the basis of competitive bidding.

DEPARTMENT OF ENERGY
FY 1989 CONGRESSIONAL BUDGET SUBMISSION
CONSTRUCTION PROJECT DATA SHEETS
BASIC RESEARCH USER FACILITIES - PLANT AND CAPITAL EQUIPMENT
BASIC RESEARCH USER FACILITIES - NUCLEAR PHYSICS (BRUF-NP)

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

3. Date A-E work initiated: 2nd Qtr. FY 1985

3a. Date physical construction starts: 2nd Qtr. FY 1987

4. Date construction ends: 4th Qtr. FY 1993

5. Previous cost estimate: $255,967
Less amount for PE&D: 967
Net cost estimate: $255,000
Date: 8/86

6. Current cost estimate: $265,967
Less amount for PE&D: 967
Net cost estimate: $265,000
Date: 8/87

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Cost
FY 1987	$ 16,200	$ 16,200	$ 16,200	$ 7,842
FY 1988	33,500	33,500	33,500	24,000
FY 1989	44,500	44,500	44,500	42,000
FY 1990	65,000	65,000	65,000	58,000
FY 1991	65,000	65,000	65,000	62,000
FY 1992	35,800	35,800	35,800	52,000
FY 1993	5,000	5,000	5,000	19,158

8. Brief Physical Description of Project

The Continuous Electron Beam Accelerator Facility (CEBAF) is a single purpose, basic nuclear research facility to be located in Newport News, Virginia on a site which includes the land and buildings once occupied by the Space Radiation Effects Laboratory (SREL). Southeastern Universities Research Association (SURA) is expected to remain the operating contractor during design, construction, and later operations phases of this project. The site for this facility is Federally owned.

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

8. Brief Physical Description of Project (continued)

The accelerator facility will include: a 4 billion electron volt (GeV), high intensity, recirculated continuous beam electron linear accelerator (linac); experimental areas and equipment to conduct basic nuclear research; and buildings to house the accelerator complex and its operations and maintenance activities. The facility will possess a complement of equipment for initial experiments and supporting facilities to exploit the capabilities of the accelerator.

a) Improvements to Land and Conventional Construction

Improvements to the site will include such items as drainage, roadways, and the extension of utilities. Support facilities for the accelerator complex will be housed in both new and existing structures. The Virginia Associated Research Center (VARC), an existing single-story structure located on an adjacent site owned by the Commonwealth of Virginia, will provide research and administrative offices. Title to VARC will remain with the Commonwealth of Virginia, which by agreement has made it available to SURA indefinitely for CEBAF use. The Space Radiation Effects Laboratory building, will be renovated to provide shop areas, component test and assembly areas, laboratories, and office space. Support structures include: (1) housing for the linac, recirculator magnets, and beam lines and (2) buildings for the end stations, refrigerator, accelerator service functions, and an office and computer center.

b) Accelerator System

The central research tool of CEBAF will be an electron linear accelerator. It will consist of a 1 GeV superconducting linear accelerator split into two segments. The segments will be connected by a recirculator system to transport the electron beams from one segment of the linac to the other. Four complete passes of acceleration through the linac will provide an energy of 4 GeV. The accelerator complex will also include a beam extraction system to extract three continuous beams from the linac; a beam transport system to take the three beams to three experimental halls; a cryogenic system including helium refrigerator, liquid helium storage vessels, and distribution lines; and instrumentation and control systems for the accelerator complex.

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

8. Brief Physical Description of Project (continued)

c) Research Equipment

The accelerator will service three independent experimental areas. Research equipment will include an initial complement of experimental instrumentation and other support facilities necessary to perform scientific research using CEBAF's high quality electron beams and secondary photon beams.

9. Purpose, Justification of Need for, and Scope of Project

CEBAF will be the only facility in the world capable of producing electron beams which simultaneously meet the criteria of high energy, continuous beams, and high intensity necessary to advance the frontiers of electromagnetic nuclear physics. CEBAF has been identified as the highest priority new accelerator for the U.S. nuclear physics program. The unique combination of beam parameters available at CEBAF will make it a facility of unparalleled capability, and the research at CEBAF will enable the U.S. to maintain its preeminence in this important area of nuclear science. CEBAF's electron linac, with its capability of providing intense continuous beams at any energy in the range of 0.5 to 4.0 GeV, is designed to study the largely unexplored transition between the nucleon-meson and the quark-gluon descriptions of nuclear matter. In particular, it will study the extent to which individual nucleons change their size, shape, and quark structure in the nuclear medium, study how nucleons cluster in the nuclear medium, and study the force which binds quarks into nucleons and nuclei at distances where this force is strong and the quark confinement mechanism is important. CEBAF's continuous beam will make it possible to observe one or more of the reaction products in coincidence with the scattered electron, ensuring that these studies can be carried out accurately. The broad spectrum of physics accessible at CEBAF ensures that it will become and remain one of the important scientific centers in the world.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

10. Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, Design, Inspection, and Administration..........			$ 46,000
1. Conventional Construction at approximately 17% of item b.1		$ 9,000	
2. Technical components at approximately 29% of item b.2 ...		37,000	
b. Construction Costs...			181,000
1. Conventional Construction................................		54,000	
a. Accelerator facilities...............................	$ 18,000		
b. Experimental facilities..............................	24,000		
c. Support facilities...................................	12,000		
2. Technical components.....................................		127,000	
a. Accelerator components...............................	96,000		
b. Research equipment...................................	31,000		
c. Standard Equipment..			2,000
d. Contingency at approximately 16% of above costs.............			36,000
Total Estimated Cost...........			$265,000

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

11. Method of Performance

Design, construction, and inspection of the facility will be done by the Operating Contractor, subcontracting with an A/E contractor for design and a general contractor for construction of the conventional facilities. To the extent feasible, construction, procurement, and installation will be accomplished by fixedvprice contracts and subcontracts awarded on the basis of competitive bidding.

12. Funding Schedule of Project Funding and Other Related Funding Requirements

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	Total
a. Total project cost										
1. Total facility cost										
a. Construction line item.....	$ 0	$ 0	$ 7,842	$24,000	$42,000	$58,000	$62,000	$52,000	$19,158	$265,000
b. PE&D...........	300	667	0	0	0	0	0	0	0	$ 967
Total facility cost.........	$ 300	$ 667	$ 7,842	$24,000	$42,000	$58,000	$62,000	$52,000	$19,158	$265,967
2. Other project costs										
R&D necessary to complete construction...	$ 4,500	$ 4,918	$ 6,250	$ 6,250	$ 6,000	$ 2,900	$ 1,629	$ 0	$ 0	$ 32,447
Spares.............	0	0	0	0	0	1,100	2,400	2,600	0	6,100
Total other project costs..	$ 4,500	$ 4,918	$ 6,250	$ 6,250	$ 6,000	$ 4,000	$ 4,029	$ 2,600	$ 0	$ 38,547
Total project cost...........	$ 4,800	$ 5,585	$14,092	$30,250	$48,000	$62,000	$66,029	$54,600	$19,158	$304,514

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia	2. Project No. 87-R-203

12. Funding Schedule of Project Funding and Other Related Funding Requirements (continued)

b. Other related funding requirements (FY 1987 dollars)

1. Annual facility operating costs including in-house research....................	$ 28,000
2. Annual plant and capital equipment costs not related to construction but related to the programmatic effort in the facility.............................	4,000
Total other related annual funding requirements................................	$ 32,000

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

a. Total project cost
   1. Total facility cost
      Explained in items 8, 9, and 10
   2. Other projects costs
      R&D necessary to complete construction

The CEBAF linac will use superconducting radiofrequency accelerating cavity technology to generate high energy continuous electron beams. The R&D funds will be used to design, evaluate, and construct prototypes of the technical components which are essential for meeting the design goals for the facility.

b. Other related funding requirements

   1. Annual facility operating costs upon completion of construction

This item includes the cost of all personnel employed by the facility for its operation, maintenance, and in-house research, together with electric power and materials and services costs. Approximately 230 man-years of effort annually will be required.

   2. Annual plant and capital equipment costs upon completion of construction

This item includes capital equipment needed to maintain the research capability of the facility to meet evolving research requirements as well as funds for accelerator improvement projects and minor general plant projects required to ensure its continued high performance.