DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH

OVERVIEW

HIGH ENERGY PHYSICS

Research in high energy physics is directed at understanding the nature of matter and energy at the most fundamental level, as well as the basic forces which govern all processes in nature. The primary goal of the program is to acquire new knowledge and understanding. To carry out this forefront research, the program requires and develops advanced technologies for application to accelerators and detectors. These new technologies often find near term as well as long term applications in other fields.

Since the program supports basic research into the nature of matter and energy at the most fundamental level, it is directly relevant in the long term to the national goal of energy security and high energy physics. Research in high energy physics is a stated part of the DOE mission and the DOE serves as the Executive Agent for the U.S. high energy physics program. High energy physics has proven to be an extremely challenging and appealing intellectual activity. It attracts some of the best minds in the nation, and provides substantial input to the intellectual ferment which fuels the nation's science and engineering enterprise. High energy physics is an excellent discipline for the training of physicists, and many high energy physics Ph.D. recipients go on to highly productive careers in other scientific disciplines.

High energy physics contributes to the nation's economic competitiveness. The accelerators and detectors needed for the pursuit of high energy physics research require state-of-the-art technology in many areas such as fast electronics, high speed computing, superconducting magnets, and high power radio-frequency devices. In these areas high energy physics often pushes the technology, and in some areas provides a major component of the civilian marketplace. Further, high energy physics continues to make major contributions to accelerator technology and provides a major portion of the expertise needed to support the substantial recent expansion of applications of accelerators to other scientific disciplines and to industrial processes (synchrotron light sources, medical diagnostics and treatment, etc).

The Fermi National Accelerator Laboratory (Fermilab) is one of the outstanding scientific institutions in the world and the research facilities under construction at the Superconducting Super Collider Laboratory (SSCL) will have unparalleled capabilities. Thus, high energy physics research activities contribute in a major way to the world preeminence of the nation's scientific and technical enterprise both now and in the future.

The budget presented herein is divided into major categories. The Physics Research section of the budget provides support for the scientists who plan and perform the research. The Facility Operations section of the budget provides support for the large accelerator and detector facilities essential to perform the research. The High Energy Physics Technology section of the budget provides for the R&D necessary to maintain the accelerator and detector facilities at the required forefront of the science. The Capital Equipment and Construction sections of the budget provide for the hardware and facilities required for ongoing progress of the research programs. Taken together, these activities provide for a balanced program of excellent research in high energy physics.

There are three DOE supported high energy physics accelerator centers: Fermilab, the Stanford Linear Accelerator Center (SLAC), and the Alternating Gradient Synchrotron (AGS) complex at Brookhaven National Laboratory (BNL). Each of these centers provides unique research capabilities and is operated as a national facility which is made available to qualified experimenters on the basis of the scientific merit of their research proposals. To these is being added the Superconducting Super Collider Laboratory. Funding for construction of the Superconducting Super Collider (SSC) is presented in a separate FY 1994 budget request.

Experiments by U.S. scientists are also carried out at the Cornell Electron Storage Ring (CESR) facility, which is largely supported by the National Science Foundation, and at foreign accelerators which have unique capabilities not available in the U.S. Finally, some important experiments do not require accelerators, but instead take advantage of processes that occur in the natural environment, sometimes deep

underground, deep underwater, or on mountain tops. The experimental research, as well as theoretical research, is carried out largely by university-based scientists.

More than 75 percent of the physics research done at U.S. high energy physics accelerator facilities is carried out by university-based scientists, and their participation is critical to the strength and vitality of the U.S. program. It is essential that the capability of university scientists to participate effectively in world forefront experiments be maintained. With the planned utilization of the existing facilities, strong continuing support for university-based scientists will be needed to allow effective participation by these scientists and to maintain the technical capabilities of the major university laboratories. Support for scientists participating in planning and in R&D activities related to the use of the SSC is an increasing component of the national high energy physics research activity.

The ability to carry out forefront exploratory research on the physics frontier is critically dependent on the experimental capabilities of the accelerator, colliding beam, and detector facilities, the effective utilization of those facilities, and the provision of upgraded and new facilities on a timely basis. This dependence of the program on facilities strongly influences program planning and strategy.

The Tevatron at Fermilab is the world's highest energy particle accelerator, and the first one to be constructed using superconducting magnets. It will keep the U.S. program highly competitive and at the cutting edge for the next several years. Major detector facilities are in place and available for research. Strong and effective utilization of these facilities over the next few years is critical to the U.S. program. The Fermilab Main Injector, presently under construction, will greatly increase the research capability of the Tevatron complex.

The SSC is being constructed to provide a new and much more powerful particle accelerator capable of exploring the tera electron volt (TeV) mass region. The SSC is essential to advance our understanding of the fundamental nature of matter and energy and to enable the U.S. High Energy Physics program to remain at the research frontier beyond the 1990's. The SSC will be a proton-proton collider having an energy of 20 TeV per beam. It will permit exploration of this new domain of physics research which cannot be reached by any existing facility. Construction of the SSC and of its initial complement of detectors is presented in a separate SSC budget submission. The SSC is an integral part of the national High Energy Physics program; therefore, the research support for the physicists planning and preparing experiments to be conducted at the SSC will continue to be an integral part of the High Energy Physics program presented in this budget submission.

The strategy for the overall High Energy Physics program for FY 1994 revolves around the following key factors:

o Careful planning to optimize the physics output of the program. The report of the 1992 HEPAP subpanel is available and has provided great help in structuring the program for best results in the near and mid term.

o Operations of the forefront research capabilities of the Tevatron accelerator/collider will be conducted at a reasonable level. The Tevatron collider operations in FY 1994 will allow research utilization both of the mature Collider Detector at Fermilab (CDF) and of the complementary new D-Zero detector facility. The SLAC linac will be operated for fixed target experiments in End Station A, for high energy linear collider R&D, and for physics research with the SLC. With its new booster, BNL's Alternating Gradient Synchrotron (AGS) will provide progress toward improved direct tests of the Standard Model via detailed study of rare decay modes of kaons.

o Construction of the Main Injector at Fermilab will be continued. This project will greatly enhance the physics capabilities of the existing Tevatron accelerator and its detector facilities by the end of the decade. It will provide early experience with collider detectors at luminosities approaching that of the SSC, and could yield new physics results which would significantly influence the SSC physics goals and detector designs. It will also make calibration and test beams for SSC detector subsystems continuously available for use without interference with the Tevatron research programs.

o Preparations for the initial complement of SSC detectors are an important component of the current High Energy Physics (HEP) program, and given the long lead time required, work on these detectors has begun. The design of two major detectors proposed by the Gammas, Electrons, and Muons (GEM) collaboration and the Solenoidal Detector Collaboration (SDC) are in the final stages of evaluation by the SSC Laboratory. The large scale of the detector facilities and their components dictate that detailed planning be done now and detector fabrication begin soon so that the detectors will be ready in time for initial SSC operations. Support and oversight of the research component of this planning and R&D activity

will be an important component of the HEP program in FY 1994 and beyond. Detector fabrication and related detector R&D funding is included as part of the SSC project.

o Construction of a B-Factory will be initiated after review of the proposals from SLAC and Cornell. This will be an asymmetric, very high intensity electron-positron colliding beam facility optimized for the study of CP violation in the B meson system. This project is part of the President's Economic Investment package.

o Continued effective participation of university scientists is critical to the ongoing vitality of this program. Universities have a leading role in providing intellectual leadership for the field of high energy physics and in the training of graduate and post-doctoral scientists and engineers for this and many other fields.

o Pursuit of long range accelerator and detector R&D studies to develop new and advanced concepts and technologies is critical to the long range viability and continued advancement of the program. Innovative new technologies are essential to the continued enhancement and extension of accelerator and detector capabilities of high energy physics research. Priority will be given to continuing the most promising concepts.

DEPARTMENT OF ENERGY
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OFFICE OF ENERGY RESEARCH
(Tabular dollars in thousands narrative in whole dollars)

LEAD TABLE

High Energy Physics

Activity	FY 1992 Adjusted	FY 1993 Appropriation	FY 1993 Adjustment	FY 1994 Request
Operating Expenses				
Physics Research	$145,290	$145,900	$0	$148,560
Facility Operations	270,046	281,909	-8,910	268,455
High Energy Technology	68,331	69,425	-4,010	59,415
Capital Equipment	87,740	73,220	-5,580	65,085
Construction	47,019	42,930	0	86,254
Total High Energy Physics	$618,426	$613,384	-$18,500 e/	$627,769
Summary				
Operating Expenses	$483,667 a/b/	$497,234	-$12,920	$476,430
Capital Equipment	87,740	73,220	-5,580	65,085
Construction	47,019	42,930	0	86,254
Total Program	$618,426 c/d/	$613,384	-$18,500 e/	$627,769
Staffing (FTEs)	(Reference General Science Program Direction)			

Authorizations:
P.L. 95-91, "Department of Energy Organization Act" (1977)

a/ Total has been reduced by $6,114,000 reprogrammed to Energy Supply for SBIR.
b/ Reflects reprogramming of $109,000 operating to Environmental Restoration and Waste Management 92-R-13.
c/ Reflects transfer of $396,000 to A&O for ES&H activities.
d/ Reflects Congressional Rescission of $3,350,000 from Fermilab Main Injector project.
e/ Reflects general reduction for use of prior year balances.

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(dollars in thousands)

SUMMARY OF CHANGES

High Energy Physics

FY 1993 Appropriation	$ 613,384
- Adjustment - Reflects general reduction for use of prior year balances	- 18,500
FY 1993 Adjusted	594,884
- Funding required to maintain a constant overall level of program activity	+ 18,556
Operating	
- Reduction in funding reflecting decreases in many parts of the program	- 25,382
Capital Equipment	
- Reduction in funding for Capital Equipment requiring reductions in the planned level of activity for fabrication of experimental and accelerator apparatus	- 5,219
SSC Laboratory	
- Increase in funding for High Energy Physics research activities at the SSC Laboratory that are not related to construction of the SSC	+ 2,500
Construction	
- Continuation of Fermilab Main Injector construction project	+ 10,000
- Initiation of B-Factory construction project	+ 36,000
- Reduction in funding for AIP and GPP	- 3,570
FY 1994 Congressional Budget Request	$ 627,769

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GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

HIGH ENERGY PHYSICS

I. Preface: Physics Research

This activity provides support for university and laboratory based research groups conducting experimental and theoretical research in high energy physics. This research probes the nature of matter and energy at the most fundamental level, and the characteristics of the basic forces in nature. Experimental research activities include: planning, design, fabrication and installation of experiments; conduct of experiments; analysis and interpretation of data; and dissemination of results. Theoretical physics research provides the framework for interpreting and understanding observed phenomena and, through predictions and extrapolations based on existing theories, identifies key questions for future experimental explorations. This subprogram supports research groups at more than 100 universities as well as at the 10 DOE laboratories which participate in high energy physics research.

Experiments in high energy physics require the use of large particle accelerators, together with complex detection apparatus, to study the results of the collisions of particles at high energies. The DOE-supported operating high energy physics accelerators are located at three existing central laboratories, Fermilab, SLAC, and BNL. These three, together with the SSC, which is under construction at the SSC Laboratory, are made available to qualified scientists on the basis of the scientific merit and promise of their research proposals. Detectors and experimental facilities are located at the DOE accelerator laboratories, at other accelerators around the world, and at a number of sites not associated with accelerators. More than 75 percent of the research done with these facilities is performed by university-based physicists. The balance of the research is done by scientists at the accelerator laboratories and certain other DOE laboratories. Because of the size and complexity of a typical high energy physics experiment, users from a number of institutions frequently collaborate on a given experiment. These research teams typically include a mix of physicists, engineers, technicians, and graduate students. After a research proposal to the laboratory is approved, the research teams participate in the design and fabrication of the experimental apparatus and provide manpower for the experiment during the data-taking phase at the laboratory. There is significant interaction and participation from laboratory staff and use of laboratory support facilities for each experiment. The entire process, from conception of the experiment to publication of results, typically takes up to five years if no major new detector is involved; if major detector design and fabrication is involved, the total duration can be several years longer. U.S. user groups also participate in experiments which take advantage of unique accelerator capabilities and opportunities at other laboratories; for example, the Cornell Electron Storage Ring (CESR), supported by the U.S. National Science Foundation, and at foreign laboratories such as DESY (Germany), CERN (Western Europe), KEK (Japan), and IHEP (Protvino, Russia). There is also a program of experiments not requiring beams from accelerators, of which experiments to search for proton decay and magnetic monopoles are presently the major component.

FY 1994 will be a year of strong research output as the researchers proceed with the analysis of data collected in FY 1993 and previous years from the SLC collider at SLAC with the SLD detector and from the world unique Tevatron collider at Fermilab with its CDF and D-Zero collider detector facilities and fixed target facilities at SLAC, FNAL, and BNL. Experimental groups will be supported at a reduced level. Priority will be given to analysis of existing data and data collection at the operating facilities. The ongoing enhancement of the technical capabilities of the major university laboratories will proceed at a very modest level. In addition, FY 1994 will include major effort on planning for experiments for the SSC.

This budget includes $2,000,000 in FY 1993 and FY 1994 for the FCCSET education initiative.

II. A. Summary Table: Physics Research

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Fermi National Accelerator Laboratory	$ 10,476	$ 10,716	$ 10,516	- 2
Stanford Linear Accelerator Center	12,790	12,135	10,485	- 14
Superconducting Super Collider Laboratory	2,850	2,000	4,000	+100
Brookhaven National Laboratory	8,685	8,165	8,005	- 2
Argonne National Laboratory (East)	5,855	5,863	5,753	- 2
Lawrence Berkeley Laboratory	11,263	10,820	10,780	0
Universities and Other Labs	93,371	96,201	99,021	+ 3
Total, Physics Research	$ 145,290	$ 145,900	$ 148,560	+ 2

II. B. Major Laboratory and Facility Funding

ARGONNE NATIONAL LABORATORY (EAST)	$ 5,855	$ 5,863	$ 5,753	- 2
BROOKHAVEN NATIONAL LABORATORY	$ 8,685	$ 8,165	$ 8,005	- 2
FERMI NATIONAL ACCELERATOR LABORATORY	$ 10,476	$ 10,716	$ 10,516	- 2
LAWRENCE BERKELEY LABORATORY	$ 11,263	$ 10,820	$ 10,780	0
STANFORD LINEAR ACCELERATOR CENTER	$ 12,790	$ 12,135	$ 10,485	- 14
SUPERCONDUCTING SUPER COLLIDER LABORATORY	$ 2,850	$ 2,000	$ 4,000	+100

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Physics Research			
Fermi National Accelerator Laboratory	The fixed target research groups completed data taking and achieved completion of almost all of the approved experiments. Work continued on analysis of the data collected and on the design of modifications and reconfigurations of their detector facilities for future use in FY 1994. The colliding beam research groups entered into an intense period of commissioning of their detector facilities again with beam, and then a long physics run during the last half of the year. Theoretical physics, particle astrophysics and SDC design work continued.	After three months interruption for installation and commissioning of the Linac Upgrade project, the Tevatron collider run begun in FY 1992, will resume and continue through most of the rest of FY 1993. The collider research groups will continue data collection, while the fixed target research groups will continue their physics analysis activities of last year, and preparations for a data collection period starting in FY 1994. The SDC participants expect to begin fabrication work on components and subsystems of that future SSC detector facility, and preparations for putting them into test beams. Particle astrophysics and theoretical physics will continue.	The CDF and D-Zero colliding beam detector facilities will continue to collect data for most of FY 1994, and continue to work on data analysis and the next round of detector apparatus upgrade projects. The Fermilab research physicists collaborating on the fabrication of the SDC detector facility for the SSC will continue that work, and will also bring into use several test beams parasitically with the Tevatron fixed target research programs. Theoretical physics, particle astrophysics and other physics research efforts will be ongoing.
	$ 10,476	$ 10,716	$ 10,516
Stanford Linear Accelerator Center	Research in High Energy Physics at SLAC involves experiments carried out with the SLAC Linear Collider (SLC) and the SLAC 2-mile Linac. The linac serves a unique fixed target facility at End Station A (ESA) and accelerates both electrons and positrons to 50 GeV for SLC. A recently commissioned and superior detector (SLD) was used to continue SLAC's investigations of Z bosons. Polarized electrons, producing polarized Z's, became available in mid-1992. Analysis of the resulting unique data samples was begun. Analysis of data from earlier runs continued. Fixed target experiments in ESA using polarized targets were initiated. The theoretical physics group continued its role of providing interpretation and insights on new experimental results.	SLAC's highest priority is to run the SLD at the SLC at the highest achievable luminosity and polarization. It is expected that by the end of FY 1993 there will be an accumulation of good measurements on 50,000 to 100,000 polarized Z's. Effort will be concentrated on analyzing the complete run. Data taking and analysis of fixed target experiments in End Station A using the 2-mile Linac polarized electron beam will continue. Detailed study of charm and tau physics in collaboration with the Institute of High Energy Physics in Beijing, China will continue. Theoretical physics efforts will continue.	The highest priority will be to operate the SLC with the SLD with the highest possible beam luminosity and polarization. It is anticipated that about 100,000 polarized Z's will be recorded. Effort will be concentrated on completely analyzing all of the data. Data taking and analysis of polarized target experiments in End Station A using the 2-mile Linac polarized electron beam will continue. Detailed study of charm and tau physics in collaboration with the Institute of High Energy Physics in Beijing, China will continue. Theoretical physics efforts will continue.

III. Physics Research (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Stanford Linear Accelerator Center (Cont'd)	$ 12,790	$ 12,135	$ 10,485
Superconducting Super Collider Laboratory	Physicists on the staff of the SSC Laboratory conducted research in high energy physics not specifically related to the construction of the SSC. The research consisted of preparation of and participation in collaborative experiments initially using the CDF facility at Fermilab and other facilities in the future. There was, in addition, a theory effort focussed on physics questions relevant to the planned SSC experimental program. The SSC laboratory also participated in planning and developing the experiments which will be conducted at the SSC.	Program continues at about the same level of effort. Activities focus on work with the CDF facility. Theory activities continue.	SSCL physicists will continue to conduct research not specifically related to the construction of the SSC. The increase in the funding request results from the continuation of the planned buildup of the lab research staff toward that required for full operation. This buildup in research staff strengthens the effort in existing areas as well as expands it to include new efforts needed to support the evolving scientific program. The off-site work will consist of participation in the CDF and D-Zero experiments at Fermilab. Work will also be under way on the planning for possible future experiments at the SSC. The theory group will continue studies related to physics questions and the analysis of the anticipated data from the planned SSC experiments.
	$ 2,850	$ 2,000	$ 4,000
Brookhaven National Laboratory	One of the rare kaon-decay experiments commissioned its new radiation-hardened beamline and upgraded high-rate detector. Operational beam time was used largely for engineering shakedown runs of the beamlines and detectors. Fabrication of the g-2 detector continued. The BNL D-Zero group ran most of FY 1992 with the Tevatron collider at Fermilab.	The radiation-hardened high intensity kaon beamline and the upgraded high rate kaon-decay experiment should accumulate data challenging specific Standard Model predictions for the rates of certain rare kaon decays. Fabrication of the g-2 detector will continue. Analysis of data from the D-Zero experiment may be showing exciting new physics at high particle masses.	Priority will be given to exploitation of the radiation-hardened high intensity beam lines and the upgraded Kaon-decay detectors. These experiments should accumulate data challenging specific Standard Model predictions and testing laws of conservation of lepton flavors. Major components of the muon anomalous magnetic moment (g-2) detector and beamlines will be ready for testing. Analysis of data from the D-Zero experiment at Fermilab will continue as D-Zero continues to run through most of FY 1994. BNL researchers will be participating in the development of the GEM detector for SSC.

III. Physics Research (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Brookhaven National Laboratory (Cont'd)	$ 8,685	$ 8,165	$ 8,005
Argonne National Laboratory (East)	The ANL program included the ZEUS electron-proton detector at DESY in Hamburg and the CDF at Fermilab. The SOUDAN-2 detector, with leadership from ANL, was largely completed. A large fraction of the effort given to detector development was focussed on the barrel calorimeter for SDC which has been selected to be one of the first experiments at the SSC lab. This work builds smoothly on the successful ZEUS calorimetry work. ANL has a strong theory group with an outstanding phenomenology component. Much of the research was focused on the physics of CDF and SDC.	Experimental groups will continue to concentrate on taking data from detectors at colliding beam facilities with beams of energies and intensities previously unattainable. The ANL program will include the ZEUS electron-proton detector at DESY in Hamburg and CDF at Fermilab. The SOUDAN-2 detector, with leadership from ANL, will be completed and ready to take data. An increasing fraction of the effort will be given to detector development focussed on the large SDC which has been selected to be one of the two first experiments at the SSC lab.	The ANL program will continue its strong participation in the operation of the CDF detector at Fermilab and in the operation of the ZEUS detector at DESY. The Soudan-2 detector will be in its second year of steady-state running. Work on the calorimeter for the SDC detector at the SSC will be underway. The theoretical research effort will continue at about the same level of effort.
	$ 5,855	$ 5,863	$ 5,753
Lawrence Berkeley Laboratory	Experimental groups at LBL concentrated on taking data from CDF and D-Zero detectors at Fermilab. A large fraction of the effort at LBL was given to detector development focussed on the SDC detector which has been selected to be one of the first of two large detectors at the SSC lab. Strong theory and astrophysics programs exist at LBL. The Particle Data Group which serves as the archivist of particle data properties is part of the LBL program.	Experimental groups will continue to concentrate on taking data from the CDF and D-Zero detectors at Fermilab. A large fraction of the effort will be given to detector development focussed on the large SDC detector which has been selected to be one of the first experiments at the SSC lab. Strong theory and astrophysics programs will continue. The Particle Data Group will continue to serve as the archivist of particle data properties.	The lab will continue with the activities described for FY 1993. Experimental groups will complete the present data taking phase at Fermilab with the D-Zero and CDF detectors and concentrate on analysis of this data. Activities as members of the SDC collaboration at the SSC will continue to get high priority. The theory and astrophysics group will remain strong and active and the Particle Data Group will continue its essential activities as the archivists on particle properties.
	$ 11,263	$ 10,820	$ 10,780

III. Physics Research (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Universities and Other Labs	Groups at universities and other DOE laboratories participated in major experiments at U.S. and foreign laboratories. Also, many of the groups engaged in planning and R&D activities in preparation for experiments at the SSC. Important new experiments had initial running, including: the SLD experiment at the SLC (SLAC); the D-Zero and upgrade of CDF experiments at the Tevatron (Fermilab); and, the ZEUS experiment at HERA (DESY). Also, the precision measurement of the muon's anomalous magnetic moment was in preparation at BNL, as was the MACRO experiment (Italy), the SOUDAN II experiment (Minnesota), and the DUMAND experiment (Hawaii). The manpower, technical, and computational capabilities of leading universities was increased somewhat to better analyze the voluminous data produced by cutting edge experiments. Includes funds for a computer lease at the Laboratory for Nuclear Science (LNS) Facility Upgrade, MIT. ($120)	Groups at universities and other DOE laboratories will participate in major experiments at U.S. and foreign laboratories. Also, many of the groups will engage in planning and R&D activities in preparation for experiments at the SSC. Important new experiments will continue running, including: the SLD experiment at the SLC (SLAC); the D-Zero and CDF experiments at the Tevatron (Fermilab); the ZEUS experiment at HERA (DESY); the MACRO Experiment (Italy); and the SOUDAN II experiment (Minnesota). Also, the precision measurement of the muon's anomalous magnetic moment will be in preparation at BNL, as will some upgraded experiments at BNL for rare K-decays, and preparations for fixed target experiments at Fermilab, and the DUMAND experiment (Hawaii). Only the most scientifically compelling new non-accelerator and foreign accelerator experiments will be undertaken. Includes funds for a computer lease at the Laboratory for Nuclear Science (LNS) Facility Upgrade, MIT. ($120)	Groups at universities and other DOE laboratories will participate in major experiments at U.S. and foreign laboratories. Also, many of the groups will engage in planning and R&D activities in preparation for experiments at the SSC. Important new experiments will continue running, including: the D-Zero and CDF experiments at the Tevatron (Fermilab); the L3, ALEPH, OPAL and DELPHI experiments at LEP (CERN); the ZEUS experiment at HERA (DESY); the MACRO experiment (Italy); the SOUDAN II experiment (Minnesota); the GRANITE experiment (Arizona); and the DUMAND experiment (Hawaii). Also, some upgraded experiments at BNL for rare K-decays will be in the final stages of preparation, as will the precision measurement of the muons anomalous magnetic moment, and the search for highly strange nuclei. Preparations for fixed target experiments at Fermilab will continue. To optimize support for the highest priority activities, a small number of university groups will be dropped or substantially reduced. Includes funds for a computer lease at the Laboratory for Nuclear Science (LNS) Facility Upgrade, MIT. ($120)
	No activity.	Funding in the amount of $1,485,000 has been budgeted for the SBIR program.	Funding in the amount of $1,400,000 has been budgeted for the SBIR program.
	$ 93,371	$ 96,201	$ 99,021
Physics Research	$ 145,290	$ 145,900	$ 148,560

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

HIGH ENERGY PHYSICS

I. Preface: Facility Operations

This activity includes funding for the operation and maintenance of the national laboratory research facilities including accelerators, colliders, secondary beam lines, detectors for experiments, experimental areas, computing and computer networking facilities. It includes the costs of manpower, electric power, expendable supplies, replacement parts and subsystems, and inventories. The major DOE supported facilities to be operated in FY 1994 are the Fermilab Tevatron (800 GeV proton fixed target and 900 GeV antiproton-proton colliding beams); SLAC (50 GeV linear accelerator) and the SLC (50 GeV, GeV electron-positron collider); and the BNL AGS (25 GeV proton fixed target program) with the recently commissioned AGS booster. The BNL AGS, the SLC at SLAC, and the Fermilab Tevatron will be operated for physics for most of FY 1994.

II. A. Summary Table: Facility Operations

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Fermi National Accelerator Laboratory.....	$ 136,430	$ 137,932	$ 140,680	+ 2
Stanford Linear Accelerator Center Operations...	90,215	88,730	80,000	- 10
Brookhaven National Laboratory-AGS Operations...	43,371	43,860	42,920	- 2
Other Operations.....	30	2,477	4,855	+ 96
Total, Facility Operations	$ 270,046	$ 272,999	$ 268,455	- 2

II. B. Major Laboratory and Facility Funding

BROOKHAVEN NATIONAL LABORATORY	$ 43,371	$ 43,860	$ 42,920	- 2
FERMI NATIONAL ACCELERATOR LABORATORY	$ 136,430	$ 137,932	$ 140,680	+ 2
STANFORD LINEAR ACCELERATOR CENTER	$ 90,215	$ 88,730	$ 80,000	- 10

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Facility Operations			
Fermi National Accelerator Laboratory	The Tevatron operated for research for 38 weeks in FY 1992. The first 14 weeks of the fiscal year concluded the fixed target research programs begun last year, including the full completion of 10 major experimental efforts. This was followed by a several month shutdown required in order to change the Tevatron accelerator complex over to the colliding beam mode of operations, and in order to move into place the two massive collider detector facilities. These are the upgraded CDF detector facility, and the newly completed, complementary, D-Zero detector facility. There was then a 24 week period of colliding beam data collection; the first with both detectors in operation.	The Tevatron will operate for physics research for about 30 weeks in FY 1993 in the collider mode. Final installation of the Linac Upgrade construction project, and of upgrades to the Tevatron refrigeration system, will be accomplished during a 4 1/2 month shutdown in mid-year. Maintenance on the accelerator facilities, as well as the installation of upgraded CDF and D-Zero detector components, will also be done while the Tevatron is off.	After a brief Tevatron and Linac commissioning period, the D-Zero and CDF detectors will resume data taking with the significantly higher Tevatron luminosity which the upgraded Linac capabilities will make available. The Tevatron colliding beam operating period begun in mid-FY 1992 will continue through the rest of FY 1994. The Tevatron is anticipated to be in operation for physics research for as many as 35 weeks during FY 1994.
	$ 136,430	$ 137,932	$ 140,680
Stanford Linear Accelerator Center Operations	SLAC operated SLC and SLD for about 30 weeks at 120 pps for commissioning of the polarized beam for physics research. Polarized beam in SLC was regularly available during most of the 1992 running. With significantly improved luminosity, polarized beam in the SLD should yield important new physics results. About 2 weeks of linac running at 120 pps was dedicated to experiments in End Station A near the end of FY 1992.	SLAC is expected to operate SLC and SLD for about 26 weeks with polarized beam. With significantly improved luminosity, and the polarized beam of very small size, the modern SLD detector is expected to provide important new physics results. The first two months of FY 1993 were dedicated to running 6-sectors of the linac at 120 pps for experiments in End Station A. Over a three month period, short runs with the linac will be devoted to commissioning SLAC's Final Focus Test Beam (FFTB) which is important for understanding the extension of linear colliders to much higher energies.	The SLC will operate for about 22 weeks and with greater than 50% beam polarization. With the unique capabilities of the SLC beams, the state-of-the-art SLD is expected to provide additional important new physics results. About 2 weeks of SLC running will be used for high energy linear collider R&D studies. It is expected that the polarized target experiments in End Station A using polarized electron beams from the SLAC linac will run about 5 weeks.
	$ 90,215	$ 88,730	$ 80,000

III. Facility Operations (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Brookhaven National Laboratory-AGS Operations	Commissioning of the new Booster required a series of short runs spread out over the year. The beam injection link from the Booster to the AGS was also commissioned. Tests of the upgrades necessary for the AGS to handle safely the new high intensities also required sporadic running time. The AGS operated for about 8 weeks of high energy physics data-taking and also about 8 weeks of nuclear physics. One of the kaon-decay experiments had a shakedown run with its new radiation-hardened beamline and upgraded high-rate detector. The system for extraction of beam from the AGS to the g-2 experiment was tested.	The AGS is expected to operate for about 12 weeks of slow extracted beam for high energy physics, and in addition up to 4 weeks for nuclear physics. An upgrade of the AGS extraction system for high intensity will be installed and tested. The installation and testing of the new RF cavities in the AGS will complete the upgrades required for the AGS to accommodate effectively the Booster intensity. The AGS experimental program, including beamlines and detectors for six high energy experiments on the AGS floor, will be readied for high intensity data-taking in FY 1994.	The AGS is expected to operate for about 16 weeks with a slow extracted beam so as to optimize the exploitation of the more intense beams and the upgraded detectors used to study the rare K-decays. In total five or six experiments will be operated simultaneously greatly enhancing the experimental program. The AGS is also expected to run for up to 8 weeks for nuclear physics.
	$ 43,371	$ 43,860	$ 42,920
Other Operations	Included program specific computer networking activities.	Continuation of FY 1992 program at about the same level of effort. Includes program specific computer networking activities.	Continuation of FY 1993 program at about the same level of effort for specific computer networking activities.
	Funding in the amount of $644,000 has been transferred to the SBIR program.	Funding in the amount of $2,110,000 has been budgeted for the SBIR program.	Funding in the amount of $3,360,000 has been budgeted for the SBIR program.
	$ 30	$ 2,477	$ 4,855
Facility Operations	$ 270,046	$ 272,999	$ 268,455

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

HIGH ENERGY PHYSICS

I. Preface: High Energy Technology

This activity provides funding to maintain and develop the technological base that supports the scientific effectiveness, reliability, and efficiency of existing High Energy Physics research facilities and that is essential for extending the capabilities of accelerators, colliders, and detectors by developing and proving new concepts and technologies. It includes R&D with a near term focus in support of current, ongoing construction projects, fabrication of major detectors, and improving existing research capabilities. There is also a strong longer-term focus on development of advanced concepts leading to greater performance capability and more cost effective operation of accelerator and detector facilities. Includes theoretical studies of accelerator physics; exploration of new concepts for particle acceleration, storage, and transport; and fabrication and testing of apparatus based on these studies. This activity also includes studies of new types of detectors and improved detector performance, for example: improved particle identification, improved precision in delineating tracks and locating vertices, decrease in susceptibility to degradation of performance caused by nuclear radiation, etc. The High Energy Physics Technology program is carried out primarily in the DOE laboratories, but with a significant program of advanced concept development in universities and industry. Since the limits of present accelerator technology are being reached by present generations of existing and planned machines (SSC, LEP at CERN), a strong effort has focused on a search for new accelerator technologies applicable to the long-term needs for physics research.

II. A. Summary Table: High Energy Technology

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Fermi National Accelerator Laboratory	$ 17,555	$ 17,625	$ 14,000	- 21
Stanford Linear Accelerator Center	16,835	15,575	13,215	- 15
Brookhaven National Laboratory	9,800	6,345	6,085	- 4
Lawrence Berkeley Laboratory	9,335	8,870	8,740	- 1
Universities, Other Laboratories, and Other Contractors	14,806	17,000	17,375	+ 2
Total, High Energy Technology	$ 68,331	$ 65,415	$ 59,415	- 9

II. B. Major Laboratory and Facility Funding

BROOKHAVEN NATIONAL LABORATORY	$ 9,800	$ 6,345	$ 6,085	- 4
FERMI NATIONAL ACCELERATOR LABORATORY	$ 17,555	$ 17,625	$ 14,000	- 21
LAWRENCE BERKELEY LABORATORY	$ 9,335	$ 8,870	$ 8,740	- 1
STANFORD LINEAR ACCELERATOR CENTER	$ 16,835	$ 15,575	$ 13,215	- 15

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
High Energy Technology			
Fermi National Accelerator Laboratory	The R&D programs to improve the performance of the accelerator and storage ring subsystems were continued. There was a major R&D effort related to the Main Injector construction project, including an increased effort on the design and fabrication of the full scale prototype and pre-production dipole magnets. Design, development and prototyping of power supplies, rf power amplifiers, and instrumentation and controls systems was undertaken. R&D work continued on Tevatron low-beta insertions and the system that will allow operation with more than six bunches in the Tevatron, as well as work on the antiproton source cooling systems, controls and diagnostics. The last year of R&D associated with the Linac Upgrade continued with a view to completing the project and beginning commissioning. R&D was also performed on improvements to beam transport, targeting systems designs, and new particle detection techniques. Studies for future improvements to the Collider Detector at Fermilab (CDF) and to the D-Zero detector, in support of the expected increased Tevatron luminosity also continued.	Priority is being given to support of the Main Injector construction project. R&D will continue to be directed toward final engineering design of the accelerator components. R&D efforts directed at dipole magnets will be completed while the design and prototyping work on power supplies, rf amplifiers and instrumentation and controls systems will be continued. Priority is also being given to support of collider operations and the continuing luminosity upgrades. R&D directed at increasing the beam intensity for the fixed target and a proton beam sweeping magnet for the antiproton production system will be undertaken. Development of transverse dampers needed at injection into the Main Ring and the Tevatron to restrict emittance growth, will continue. Studies for future improvements to the CDF and D-Zero detectors will also continue.	R&D in support of the Main Injector construction project will continue. In preparation for the future Main Injector commissioning, R&D effort on the design for upgrades of beam diagnostic equipment will be started. R&D work for the Main Injector also includes work on extraction and debunching the beam. Other R&D includes a beamline to link the 120 GeV extracted beam to the existing switchyard for test beams during Collider runs, a new dedicated high intensity beamline for a new generation of high flux experiments, development of a power amplifier, and continued development and testing of higher order mode damper for the existing Main Ring cavity. Studies for future improvements to the CDF and D-Zero detectors will also continue.
	$ 17,555	$ 17,625	$ 14,000

III. High Energy Technology (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Stanford Linear Accelerator Center	The strong R&D program to support improved operation of the SLC for physics research using polarized electrons continued. Consistent with HEPAP recommendations, R&D on advanced accelerator concepts needed for development of linear colliders in the TeV range continued using machine studies carried out with SLC, and advanced theoretical studies. R&D continued on cost effective, high-power, highly efficient microwave sources operating at or above 11 GHz and on new, high-gradient accelerating structures with a view to developing integrated systems. Studies on very high current beam effects and collective phenomena continued. Generic R&D to develop detector technology needed to do physics research in a very high-luminosity, high-radiation environment continued.	Priority is being given to R&D to support the operation of the SLC for physics research with particular emphasis on improved performance with polarized electrons. Work on very high intensity electron-positron colliders is focussed on magnetic optics designs, interaction region background reduction, and space charge driven beam instabilities. Long range R&D in support of TeV linear colliders will continue. Experiments to study nonlinear beam optics and methods for achieving small focal spots will begin on the newly completed Final Focus Test Beam line. The design of a prototype 1-GeV accelerator module planned to study new linear collider accelerator structures and radiofrequency power sources will continue. R&D to develop the detector technology required to do physics at high luminosity electron-positron colliders and at the SSC will continue.	R&D will include work on broad band, multibunch feedback systems; very low impedance radiofrequency cavities; high power microwave tube windows; and vacuum chambers capable of handling the high heat load resulting from the very high power levels of synchrotron radiation. R&D in support of SLC will be reduced in light of the planned phase down of SLC after FY 1994. This planned phase down results from the completion of the SLC physics mission. Long range R&D in support of high energy linear colliders will continue at a reduced level. Experiments using the Final Focus Test Beam will be in their second year. The development of a 1 GeV accelerator module to study new linear accelerator structures and test new radiofrequency power sources will continue. R&D to develop detector technology required to do physics at high luminosity electron- positron colliders and the SSC will continue.
	$ 16,835	$ 15,575	$ 13,215
Brookhaven National Laboratory	This activity supports R&D programs to improve flexibility, reliability and economy of AGS operation and to reduce radiation levels and maintenance requirements; R&D addressing simplified polarized proton acceleration, particularly with Siberian Snakes; and improvement of particle detectors, beam lines and targets for AGS experiments. With completion of the AGS Booster, R&D shifted to the injection of full intensity Booster beams into the AGS and the acceleration of these higher beam intensities in the AGS. There was an expanded program of experiments on new acceleration concepts at the Accelerator Test Facility (ATF) and on ultra bright radiation sources,	Support for superconducting magnet R&D and accelerator theory in the Accelerator Development Department is substantially reduced. R&D will continue at a reduced level in support of improving reliability and economy of AGS operation and reducing radiation levels and maintenance requirements. Improvement of particle detectors, beam lines and targets for AGS experiments will continue at a reduced level, preserving work on important new experiments and in particular on a new fast extraction system for use with the muon g-2 experiment. Support will continue for R&D in novel accelerator concepts and high brightness particle sources at the ATF at a reduced but	Priority will be given to R&D in support of AGS operations. Particle detectors, beam lines and targets will be improved only as necessary to maintain the existing capability for AGS experiments. The new, fast AGS extraction system to extract beam for the muon g-2 experiment will be installed. Promising novel accelerator concepts will be tested experimentally at the ATF. Support will also continue for R&D related to the planned GEM detector at the SSC lab.

III. High Energy Technology (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Brookhaven National Laboratory (Cont'd)	including initial studies on switched power technology for improved high brightness electron sources and very high gradient acceleration. R&D on detectors included an increased effort related to BNL participation in the GEM collaboration for designing one of the new experiments for the SSC.	viable level. Support will also continue for R&D related to the planned GEM detector at the SSC lab.	
	$ 9,800	$ 6,345	$ 6,085
Lawrence Berkeley Laboratory	This activity includes R&D on high-field superconducting material and magnet technology; beam instrumentation and cooling; advanced research into the generation of very high energy particle beams, including advanced high-power microwave sources and the two-beam acceleration concept. It also includes studies of accelerator and charged-particle beam physics and technology issues central to achieving very high luminosities in colliding beam machines. These include the production of low-emittance, high-brightness beams, and measurement control of the phenomena associated with such beams. R&D on advanced detector systems is also carried out. R&D activities on high current effects in accelerator systems focus on beam loading, active dampers, beam-beam interaction, beam-plasma effects, and improved magnetic optical design. Experimental tests on accelerator physics innovations, using beam from the ALS linac, were carried out. R&D on new particle detectors included increased emphasis on design and development of the SDC for physics research at the SSC.	Priority is being given to activities in support of very advanced superconducting magnet technology needed for the future national program. Activities in very advanced, exploratory accelerator and detector R&D will be curtailed, including R&D in support of the SSC related SDC. Advanced accelerator R&D work will focus on rf power systems, ultra-high vacuum systems, beam dynamics, magnet design, and new concepts.	Priority will be given to detector R&D in support of the SDC detector for the SSC. Support of very advanced superconducting material and magnet technology needed for the future national program will continue. Activities in very advanced, exploratory accelerator R&D will continue and will focus on radio-frequency (rf) power systems, methods of vacuum improvement, beam dynamics, magnet design, and studies of new accelerator and beam concepts, including tests using the beam from the Advanced Light Source (ALS) linac.
	$ 9,335	$ 8,870	$ 8,740

III. High Energy Technology (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Universities, Other Laboratories, and Other Contractors	This subprogram supports a broad range of topics in very advanced accelerator and detector technologies needed to ensure a strong future experimental research capability in high energy physics. Research carried out in universities, industry, research institutes, and government research centers (e.g. NIST, NRL, etc.) addressed topics ranging from development of improved superconductors through new and advanced accelerator concepts, such as the use of lasers and collective effect phenomenon to accelerate charged particles, to new theoretical concepts in non-linear charged particle beam dynamics. The focus of this work is on technologies applicable beyond the year 2000. Some exploratory work on the development and potential application of very high critical field superconducting magnets was begun. A concerted effort was made to search for promising new charged particle beam acceleration concepts. First major tests of advanced accelerator concepts identified as feasible in prior year R&D were undertaken at the advanced accelerator test-bed (ATF) established as a user center at BNL. It should be noted that the principal funding for graduate student training in accelerator physics is in this subprogram.	The program will continue the focus on utilization of the special resources of universities, industry, not for profit research institutes, and government laboratories to address a broad spectrum of technology development important to the very long term future productivity of the physics research. Major tests of new charged particle acceleration schemes will be in progress at the advanced test bed at BNL and on a new wakefield test set-up at ANL. Work on very high field superconducting magnets will be in progress. R&D will continue on advanced, generic technology essential for future detectors.	Program activities will include wakefield accelerator experiments at ANL, high-power microwave testing at LLNL, a variety of new accelerator concept tests at the accelerator test-bed at BNL, and full operation of the high brightness source at UCLA. Work will continue on superconducting materials for very high field superconducting magnets and on new and innovative approaches to designing and building such magnets. R&D will also continue on generic technology for future particle physics detectors.
	Funding in the amount of $5,470,000 has been transferred to the SBIR program.	Funding in the amount of $3,670,000 has been budgeted for the SBIR program.	Funding in the amount of $2,465,000 has been budgeted for the SBIR program.
	$ 14,806	$ 17,000	$ 17,375
High Energy Technology	$ 68,331	$ 65,415	$ 59,415

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

HIGH ENERGY PHYSICS

I. Preface: Capital Equipment

Capital Equipment funding is required in order to provide the secondary beam line components, particle detection apparatus, the portable shielding, and data analysis systems essential to do high quality, forefront high energy physics experiments. It is also required for replacement of accelerator and detector facility components that have worn out or become obsolete. A proper complement of detectors and secondary beams is essential for effective utilization and operation of the high energy physics accelerator and colliding beam facilities.

Timely introduction of new beam and detector capabilities, and the regular upgrading and modification of existing capabilities, is essential. The large scale of the equipment required for high energy physics research systems is illustrated by a few examples: a typical secondary beam line can range from several hundred feet to a mile or more in length, and requires many beam transport, beam shaping and control elements; the portable shielding required around detectors and targets can involve arrays of hundreds of shielding blocks weighing as much as 10 tons each; the analysis magnets incorporated in detection systems weigh many tons; large calorimeters of 300 tons or more are not uncommon; and electronics systems with hundreds of thousands of data channels are typically required for major detectors. A time span of as much as five years is often involved from design, through fabrication, to installation, checkout, and operation of these large systems. Examples of specific items of equipment needed include: beam transport magnets; large spectrometer magnets for detector systems; precision regulated power supplies; particle beam diagnostic and control systems; electronic and optical detectors with precision spatial and time resolution; high precision calorimeters and tracking chambers for colliding beam detectors; high speed and large volume data processing systems; special cryogenic components for liquid hydrogen targets and superconducting devices; and a host of specialized electronics and other items of laboratory support equipment.

II. A. Summary Table: Capital Equipment

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Fermi National Accelerator Laboratory.....	$ 30,860	$ 31,310	$ 28,300	- 10
Stanford Linear Accelerator Center.....	18,809	14,320	12,000	- 16
Brookhaven National Laboratory.....	13,710	5,800	8,400	+ 45
Superconducting Super Collider Laboratory.....	500	500	1,000	+100
Universities and Other Laboratories.....	19,371	11,730	11,405	- 3
Brookhaven National Laboratory- General Purpose Equipment.....	4,490	3,980	3,980	0
Total, Capital Equipment	$ 87,740	$ 67,640	$ 65,085	- 4

II. B. Major Laboratory and Facility Funding

	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
BROOKHAVEN NATIONAL LABORATORY	$ 13,710	$ 5,800	$ 8,400	+ 45
FERMI NATIONAL ACCELERATOR LABORATORY	$ 30,860	$ 31,310	$ 28,300	- 10
STANFORD LINEAR ACCELERATOR CENTER	$ 18,809	$ 14,320	$ 12,000	- 16
SUPERCONDUCTING SUPER COLLIDER LABORATORY	$ 500	$ 500	$ 1,000	+100

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Capital Equipment			
Fermi National Accelerator Laboratory	In preparation for the significantly increased luminosity to be provided in the 1993 Tevatron collider run due to completion of the Linac Upgrade project, both of the collider detector facilities upgraded their particle tracking systems and data acquisition electronics. In addition, the CDF detector facility was upgraded to improve its calorimeters and muon detection systems ($6,900 total); and the D-Zero detector facility was upgraded with more extended scintillator veto arrays and a new silicon-based vertex detector system ($7,600 total). The fixed target experimental program and test beams were provided with beam line and detector modifications ($8,000); equipment additions continued for the Fermilab computing systems both in the experimental areas and in the central computing facility, and for data acquisition electronics ($4,430); equipment for the support of the entire accelerator complex, for R&D efforts, for the extended cryogenic and controls systems, and for general site-related needs ($3,930).	Design and fabrication of new electronics and other subsystems are needed in order to accommodate the greatly increased proton and anti-proton bunch crossing frequency planned to be instituted during FY 1994. Both facilities will require faster triggering capabilities as well as increased on-line computing and data collection electronics capacities. CDF needs a much improved Silicon vertex detector system as well, and D-Zero will have to replace its central tracking and electron identification systems. The equipment funding allocated for these major Fermilab collider detector facilities in FY 1993 will total $7,800 for D-Zero and $7,900 for CDF. During the Tevatron shutdown planned for the installation of the final Linac Upgrade Project components in late FY 1993, new and upgraded components for both the CDF and the D-Zero detector facilities will be installed. The fixed target research program and the test beams will require modifications to beam lines and detectors in preparation for the next fixed target run in FY 1995 ($7,100). Continuing extensions to the computing facilities in order to be able to match the steadily increasing data collection	Steadily increasing colliding beam luminosity and shorter beam crossing time make it essential to replace the original CDF calorimeter readouts based on a gaseous ionization collection medium with a system using fast scintillating materials. This also makes possible removal of the forward calorimeters, such that the forward and backward muon toroids can be moved closer to the central detector. The solid angle for muon detection would thereby be significantly increased. The same effects will render the D-Zero central tracking systems marginal, and they are to be replaced with fast and radiation hard scintillating fibers inside a new central magnetic solenoid. The equipment funding required for improvements to these two Fermilab collider detector facilities in FY 1994 totals $7,800 for CDF and $7,400 for D-Zero. Final preparation of the new major fixed target experiments scheduled to begin research operation early in FY 1995 will be supported at $6,300. A major fraction of that sum will be needed to complete the new detector for the precision study of neutral K meson decay modes. Data acquisition electronics and additional computing capabilities in the

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Fermi National Accelerator Laboratory (Cont'd)		rates of the major experimental facilities will be made ($4,250); equipment will be provided for the sequence of accelerators and their control systems, instrumentation, and general site-related equipment ($4,260).	experimental areas, as well as extensions to the central computing facility ($3,800) is required. Equipment is required in support of R&D programs, the accelerator complex, and for general site requirements ($3,000).
	$ 30,860	$ 31,310	$ 28,300
Stanford Linear Accelerator Center	Major emphasis was on equipment needs in commissioning the high luminosity polarized beam capability and the SLD detector for full physics operations ($5,059); second polarized source ($1,350); support for advanced accelerator R&D ($7,300); new experiments ($1,000); other computing hardware ($1,845); and general laboratory equipment including new machine tools and upgrade of heating, ventilation and air conditioning upgrades distribution system ($2,255).	Funds will be provided for support of the high priority research with SLD ($2,000), and the SLC ($2,000) and its polarized beam ($2,600). Funds are provided in support of physics research including computer equipment ($1,350) and to meet needs in advanced accelerator R&D including the Final Focus Test Beam ($3,190). Support will also be provided for general laboratory equipment including new machine tools, Computer Aided Design/Computer Aided Manufacturing, and heating, ventilation and air conditioning upgrades ($3,180). The reduced funding will impact all parts of the program but primarily the fabrication of large scale test setups in the linear collider R&D effort.	Funds will be provided for the highest priority needs of the SLC/SLD research program ($1,800). Funds will be provided in support of other physics research including computer equipment ($4,800) and to meet needs in advanced accelerator R&D including the Final Focus Test Beam ($4,000). Support will also be provided for general laboratory equipment including new machine tools, Computer Aided Design/Computer Aided Manufacturing, and heating, ventilation and air conditioning upgrades ($1,400).
	$ 18,809	$ 14,320	$ 12,000
Brookhaven National Laboratory	Continuation of muon anomalous magnetic moment (g-2) experiment ($4,540); support for rare kaon decay and other experiments ($5,770); beam line components ($1,800); accelerator R&D ($400); and general AGS support ($1,200).	Continued fabrication of the muon anomalous magnetic moment (g-2) experiment ($1,920); support for upgrades to the experiments to handle the new higher Booster intensities ($2,100); beamline components, including radiation-hardened magnets and new shielding ($1,000); accelerator R&D ($620); general AGS support ($160). The reduced funding will impact all points of the program, but primarily the upgrades of existing experiments and the preparation of new experiments.	The level of funding for this effort is increased to continue support for the muon anomalous magnetic moment (g-2) experiment ($2,000); support for upgrades to the experiments to handle the new higher AGS intensities ($2,700); beamline components, including radiation-hardened magnets and new shielding ($2,730); accelerator R&D ($710); and general AGS support ($260).

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Brookhaven National Laboratory (Cont'd)	$ 13,710	$ 5,800	$ 8,400
Superconducting Super Collider Laboratory	Capital equipment funding was provided in support of the physics research -- activities of the SSC laboratory staff not directly related to the construction of the SSC. The funds provide for general purpose lab equipment, computer work station, and electronics and other hardware related to the CDF program.	Program continues at about the same level of effort.	Increased support commensurate with the increased level of activity discussed under the Physics Research subprogram.
	$ 500	$ 500	$ 1,000
Universities and Other Laboratories	The ZEUS detector at the new HERA accelerator in Hamburg, Germany, the MACRO detector (Italy) and the Soudan detector (Minnesota) were completed and began data taking. The DUMAND detector (Hawaii) was partially completed. The L3/ALEPH computer upgrades and other modest detector upgrades at LEP (CERN) received additional funding and there were new experiments in preparation such as new fixed target experiments at the Tevatron, SLAC and AGS. Funding was provided to meet, in part, ongoing need for upgrade of computer and other data analysis equipment, as well as advanced equipment for design and fabrication of experimental equipment, in order that university-based physicists fully and actively contribute to high energy physics research on campus. Hardware for advanced accelerator concept experiments at BNL's accelerator test bed and ANL's wakefield test set-up is included. Capital equipment funds were provided to LBL for equipment to support ongoing experiments at Fermilab and SLAC, equipment for advanced detector prototypes, for equipment in support of the superconducting R&D	The U.S. ZEUS Collaboration continues its initial program of research at HERA (Hamburg), as will other U.S. groups at MACRO (Italy) and Soudan (Minnesota). DUMAND (Hawaii) is in the final steps of preparation. It is anticipated that there will be very few new experiments. Some funding has been provided to meet, in part, ongoing needs for upgrade of computer and other data analysis equipment, as well as advanced equipment for design and fabrication of experimental equipment, in order that university-based physicists can contribute to high energy physics research on campus. Hardware for advanced accelerator concept experiments at the BNL-ATF and the ANL wakefield test facility is included. Includes funding for the MIT-LEPICS computer upgrade ($900). Preparations for data taking in FY 1994 of some upgraded rare K-decay experiments at BNL and fixed target experiments at Fermilab and SLAC will be in progress. Capital equipment funds are needed at LBL for equipment to support ongoing experiments at Fermilab and SLAC, equipment for advanced detector prototypes, for equipment in support of	It is anticipated that there will be a few new experiments beginning their fabrication effort. Some funding will be provided to meet, in part, ongoing needs for upgrade of computer and other data analysis equipment, as well as for design and fabrication of experimental equipment, in order that university-based physicists can fully and actively contribute to high energy physics research on campus. Hardware for advanced accelerator concept experiments at the BNL-ATF and the ANL wakefield test facility is included. Ongoing university program fabrication efforts include upgraded rare K-decay experiments and search for highly strange nuclei at BNL, L3, and OPAL, upgrades at CERN, DUMAND (Hawaii), GRANITE (Arizona), NEPTUN-A (Russia), ZEUS (HERA), and MACRO (Italy). Capital equipment funds are needed at LBL for equipment to support ongoing experiments at Fermilab and SLAC, equipment for advanced detector prototypes, for equipment in support of the superconducting R&D magnet work, advanced accelerator research and development studies and related test and support equipment.

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Universities and Other Laboratories (Cont'd)	magnet work, advanced accelerator research and development studies and related test and support equipment. Included funding for the MIT-LEPICS computer upgrade. ($900)	the superconducting R&D magnet work, advanced accelerator research and development studies and related test and support equipment. New non-accelerator experiments and upgrades to experiments at foreign accelerators will be undertaken only in cases with exceptional importance. The funding reductions will impact proposed new experiments and significant enhancements of existing detectors.	
	$ 19,371	$ 11,730	$ 11,405
Brookhaven National Laboratory- General Purpose Equipment	Provides general purpose equipment for the entire laboratory.	Provides general purpose equipment for the entire laboratory.	Provides general purpose equipment for the entire laboratory.
	$ 4,490	$ 3,980	$ 3,980
Capital Equipment	$ 87,740	$ 67,640	$ 65,085

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

HIGH ENERGY PHYSICS

I. Preface: Construction

II. A. Summary Table: Construction

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Accelerator Improvements and Modifications	$ 15,805	$ 15,095	$ 13,105	- 13
Fermilab Linac Upgrade	6,166	0	0	0
General Plant Projects	13,398	12,835	12,149	- 5
Fermilab Main Injector	11,650	15,000	25,000	+ 67
B-Factory	0	0	36,000	>999
Total, Construction	$ 47,019	$ 42,930	$ 86,254	+101

II. B. Major Laboratory and Facility Funding

BROOKHAVEN NATIONAL LABORATORY	$ 9,438	$ 8,545	$ 8,425	- 1
FERMI NATIONAL ACCELERATOR LABORATORY	$ 29,481	$ 26,955	$ 34,935	+ 30
STANFORD LINEAR ACCELERATOR CENTER	$ 8,100	$ 7,430	$ 6,894	- 7

III. Activity Descriptions: (New BA in thousands of dollars)

Program Activity	FY 1992	FY 1993	FY 1994
Construction			
Accelerator Improvements and Modifications	This funding was used to support continuing large need for modifications to maintain and improve the technical capability and operational efficiency of the accelerator complexes.	Level of effort reduced about 9% relative to FY 1992 reflecting overall funding constraints.	Level of effort reduced relative to FY 1993. FNAL and SLAC will delay improvements for efficiency and sacrifice performance enhancement of aging facilities. Approximately constant level maintained at BNL to improve AGS for completion of HEP experiments at high luminosity enabled by Booster.
	$ 15,805	$ 15,095	$ 13,105
Fermilab Linac Upgrade	All of the klystron power sources were installed and prepared for use. The final sets of copper accelerating cavities were completed and moved into the Linac enclosure. All of the civil construction and technical component fabrication was completed by the end of FY 1992. Only the final installation of assembled components in the linac gallery will remain to be completed.	Project funding was completed in FY 1992. The new components will be connected, aligned and brought into operation. Full operational status and project completion will be accomplished by mid-FY 1993.	Project completed. No project activity.
	$ 6,166	$ 0	$ 0
General Plant Projects	Funding was used for small general purpose construction projects, e.g. roads, utilities, and environmental, safety, health and security needs.	Level of effort reduced about 9% relative to FY 1992 reflecting overall funding constraints.	This activity continues at a level of effort reduced by about 10% relative to FY 1993.
	$ 13,398	$ 12,835	$ 12,149

III. Construction (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Fermilab Main Injector	Preliminary and then engineering design work will start on both the civil construction and technical components. The first physical construction will begin with environmental mitigation and site preparation work. Long lead time procurements will be prepared on pre-cast concrete elements for the ring enclosure and on sheet steel for the dipole magnet cores.	Engineering design work will continue on all aspects of the project. The first major civil construction work will begin on the largest service building and on the ring enclosure. Fabrication of major components and subassemblies for technical components will start. Emphasis will be on procurements for the dipole magnets and for the high current power supplies.	Engineering design work on all aspects of the project will be completed by mid-year. About one quarter of the ring enclosure construction will be completed, and beneficial occupancy of the largest service building will be gained. About five percent of the dipole magnets will be completely assembled and tested, and one of the nine 9000 ampere power supplies will be in assembly. Fabrication of most of the other major technical components will have begun by the end of the fiscal year.
	$ 11,650	$ 15,000	$ 25,000
B-Factory	No activity.	No activity.	Construction of a B-Factory will be initiated after review of the proposals from Cornell and SLAC. The project will provide an asymmetric, very high luminosity electron-positron collider whose design is optimized for the study of CP violations in the B meson system. This project is part of the President's Economic Investment package.
	$ 0	$ 0	$ 36,000
Construction	$ 47,019	$ 42,930	$ 86,254

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
(Changes from FY 1993 Congressional Budget Request are denoted with a vertical line in left margin.)

OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
High Energy Physics
(Tabular dollars in thousands. Narrative material in whole dollars.)

IV. A. Construction Funded Project Summary

Project No.	Project Title	Previous Obligations	FY 1993 Appropriated	FY 1994 Request	Unappropriated Balance	TEC
GPE-103	General Plant Projects, Various Locations	$ ---	$ ---	$ 12,149	$ 0	$ 12,149
94-G-301	Accelerator Improvements and Modifications, Various Locations	---	---	13,105	0	13,105
94-G-304	B-Factory, Site Undesignated	---	---	36,000	TBD	TBD
92-G-302	Fermilab Main Injector, Fermilab	11,650	15,000	25,000	177,950	229,600
Total, High Energy Physics		$ 11,650	$ 15,000	$ 86,254	N/A	N/A

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project GPE-103 General Plant Projects, Various locations — TEC: $12,149, TPC: $12,149

Start Date: 3rd. Qtr. FY 1994 Completion Date: 2nd Qtr. FY 1996

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Obligations	Costs
1994	$12,149	$12,149	$3,800
1995	0	0	5,900
1996	0	0	2,449

3. Narrative: General Plant Projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required for general purpose, non-programmatic facilities at the Brookhaven National Laboratory, Fermi National Accelerator Laboratory and the Stanford Linear Accelerator Center facilities. High Energy Physics has the responsibility to provide funding for all GPP needs at BNL, Fermilab, and SLAC.

These projects are required for the general maintenance, modifications and improvement of the overall laboratory plant remediation of environmental problems and include minor new construction, capital alterations and additions, and improvements to buildings and utility systems. These are short-term projects whose timely accomplishment is essential for timely response to environmental and safety needs, maintaining the productivity, increasing the operational cost effectiveness, and ensuring that necessary support services are available to the research program.

A description and listing of examples of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheet. Some of these may be located on non-government owned property. Following is a listing of the funding proposed for the various locations:

Brookhaven National Laboratory	$ 5,695
Fermi National Accelerator Laboratory	3,660
Stanford Linear Accelerator Center	2,794
Total Estimated Cost.....	$12,149

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994 Request
Construction.....	XXXX	$13,398	$12,835	$12,149

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project 94-G-301 Accelerator Improvements and Modifications, Various Locations — TEC: $13,105 TPC: $13,105

Start Date: 3rd. Qtr. FY 1994 Completion Date: 2nd Qtr. FY 1996

2. Financial Schedule (Federal Funds:

Fiscal Year	Appropriation	Obligations	Costs
1994	$ 13,105	$ 13,105	$ 3,300
1995	0	0	5,400
1996	0	0	4,405

3. Narrative: Accelerator Improvement projects provide for a variety of minor modifications, improvements and additions to the major high energy particle accelerators, colliding beam devices and experimental facilities. Funds of this type are necessary on an annual basis to maintain and improve the scientific effectiveness of these facilities as well as their operating reliability and cost effectiveness. The funds requested, which represent less than 1 percent of the present value of the government's investment in these facilities, produce a substantial return in terms of more cost effective operation and greater research productivity.

These projects are essential on an annual basis to maintain the short term operating efficiency and reliability, and the research flexibility of the high energy accelerators, colliding beam systems and related experimental facilities, thereby maintaining or enhancing their level of scientific effectiveness and productivity.

A description and listing of examples of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheet. Some of these may be located on non-government owned property. Following is a listing of the funding proposed for the various locations:

Brookhaven National Laboratory	$ 2,730
Fermi National Accelerator Laboratory	6,275
Stanford Linear Accelerator Center	4,100
Total Estimated Cost.....	$13,105

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994
Construction.....	XXXX	$15,805	$15,095	$13,105

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project 94-G-304, B-Factory
Site Undesignated

TEC: TBD
TPC: TBD

Start Date: 2nd. Qtr. FY 1994 Completion Date: TBD

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Obligations	Costs
1994	$ 36,000	$ 36,000	$ 27,000
1995			9,000

3. Narrative: This project will provide two rings of magnets for storage of electrons at about 9 GeV and of positrons at about 3 GeV. The counter rotating beams of electrons and positrons will be brought into collision in an intersection area. A key element of the project will be the incorporation of design elements which will allow the very high collision luminosity required for effective studies of the B-meson system.

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994 Request	To Complete
Construction.....	$ ---	$ ---	$ ---	$36,000	TBD
Capital Equipment.....	---	---	---	TBD	TBD
Operating Expenses.....	---	---	---	TBD	TBD

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project 92-G-302 Fermilab Main Injector, Batavia, Illinois — TEC: $ 229,600, TPC: $ 259,300

Start Date: 3rd. Qtr. FY 1992 — Completion Date: 3rd. Qtr. FY 1999

2. Financial Schedule (Federal Funds): a/

Fiscal Year	Appropriation	Adjustments	Obligations	Costs
1992	$ 15,000	- 3,350 b/	$ 11,650	$ 990
1993	15,000 c/		15,000	19,000
1994	25,000		25,000	21,660
1995	43,000		43,000	35,800
1996	52,000		52,000	48,400
1997	52,000		52,000	52,000
1998	30,950		30,950	36,300
1999	0		0	15,450

3. Narrative: Due primarily to a combination of enhanced ES&H criteria and re-estimates due to design advances, this project has been stretched out from the 4th Quarter of FY 1997 to the 3rd Quarter of FY 1999 resulting in an attendant increase in TEC and TPC. The TEC has been increased from $185,000,000 to $229,600,000. The TPC has been increased from $215,200,000 to $259,300,000.

This project provides for the construction of a new replacement accelerator to provide particles for injection into the existing Fermilab superconducting Tevatron accelerator, and also for direct delivery to the existing fixed target experimental and test beam areas.

The primary programmatic goal of this project is to greatly increase the luminosity delivered to the two existing collider detector facilities at Fermilab. It will also make it possible to provide particle beams for the testing and calibration of SSC detector components and subsystems, and create an expanded capability for 120 GeV beams for physics research, without interference with operation of the ongoing Fermilab Tevatron collider or fixed target research programs.

Purpose of this project is to greatly increase the data rate for the two existing Tevatron collider detector facilities, thereby enhancing significantly their efficiencies and physics research capabilities. This will in particular maximize the likelihood of the discovery at Fermilab of the top quark; the last unobserved fundamental particle forming the basis of our current understanding of the structure of matter.

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994 Request	To Complete
Construction.....	$ 0	$11,650	$15,000	$25,000	$177,950
Capital Equipment.....	0	200	200	200	400
Operating Expenses.....	5,400	3,700	4,100	3,200	12,300

a/ For consistency with Departmental accounting system, the Appropriations, Obligations, and Costs for fiscal years prior to 1993 have been changed from amounts on the last data sheet.
b/ Reflects congressional Rescission of $3,350,000 in FY 1992.
c/ Congressional request for $30,000,000 changed to $15,000,000 by Congressional action on FY 1993 request.

DEPARTMENT OF ENERGY
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GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

HIGH ENERGY PHYSICS

1. Title and Location of Project: General plant projects
Various locations

2a. Project No.: GPE-103
2b. Construction Funded

3a. Date A-E Work Initiated: 2nd Qtr. FY 1994

3b. A-E Work Duration: Various

5. Previous Cost Estimate:
Total Estimated Cost (TEC) -- None
Total Project Cost (TPC) -- None

4a. Date Physical Construction Starts: 3rd Qtr. FY 1994

4. Date Construction Ends: 2nd Qtr. FY 1996

6. Current cost estimate:
TEC -- $12,149
TPC -- $12,149

7. Financial Schedule (Federal Funds):

Fiscal Year	Appropriations	Obligations	Costs
1994	$ 12,149	$ 12,149	$ 3,800
1995	0	0	5,900
1996	0	0	2,449

8. Brief Physical Description of Project

These projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required at the Fermi National Accelerator Laboratory and the Stanford Linear Accelerator Center facilities.

1. Title and Location of Project:	General plant projects Various locations	2a. Project No.: GPE-103 2b. Construction Funded

8. Brief Physical Description of Project (Continued)

The following are examples of the major items of work to be performed at the various locations:

Brookhaven National Laboratory		$ 5,695
Security Fence - Accelerator Development Department	$ 275	
Compressor Facility Improvements - Accelerator Development Department	200	
Building Addition - Accelerator Development Department	750	
Helium Storage Facility Expansion - Accelerator Development Department	330	
Storage Building Construction - Alternating Gradient Synchrotron Department	400	
Ring Air Conditioning Improvements - Alternating Gradient Synchrotron Department	260	
Building Construction - Alternating Gradient Synchrotron Department	250	
Laboratory Upgrade - Biology Department	200	
Mezzanine Extension - Department of Applied Science	350	
Building Renovations - Medical Department	250	
Equipment Room - National Synchrotron Light Source Department	200	
Air Conditioning Improvements - Computing and Communications Division	300	
Ductbank Installation - Computing and Communications Division	500	
Emergency Operations Center - Computing and Communications Division	200	
Records Storage Facility - Occupational Medical Clinic	250	
Spray Shop Reconstruction - Building Maintenance	400	
Water System Improvements - Site Distribution System	450	
Security Fencing - Site Areas	130	

1. Title and Location of Project:	General plant projects Various locations	2a. Project No.: GPE-103 2b. Construction Funded

8. Brief Physical Description of Project (Continued)

Fermi National Accelerator Laboratory		$ 3,660
Feynman Addition	$1,100	
Entrance Reception Centers	300	
Facilities Management West Addition	950	
Industrial Building #3 Addition	1,140	
Cafeteria Modifications	170	
Stanford Linear Accelerator Center		$ 2,794
Roofing - Central Lab Addition and Interaction Region 8	$ 500	
Paving Ring Road	190	
Replace Pumps, Piping and Controls for the Central Chiller Plant	190	
Site Compressed Air Valves and Piping	240	
Klystron Gallery Alcoves for 24-Volt Batteries	440	
Isolation and Grounding of Electrical Equipment Along the Klystron Gallery	410	
PCB Decommissioning and Disposal of Substations 512 and SLC II at CEH	240	
PCB Transformer Removal and Replacement - Arcs Supply in Building #136, SLD #1&2 at CEH.	584	

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

General plant 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 are short-term projects whose timely accomplishment is 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. Since it is difficult to detail the most urgently needed items in advance, a continuing evaluation of requirements and priorities may result in additions, deletions, and changes to the currently planned subprojects. No significant R&D program is anticipated as a prerequisite for design and construction of the subprojects under consideration.

1. Title and Location of Project:	General plant projects Various locations	2a. Project No.: GPE-103 2b. Construction Funded

9. Purpose, Justification of Need For, and Scope of Project (Continued)

The funds requested for FY 1994 are estimated as follows:

Brookhaven National Laboratory	$ 5,695
Fermi National Accelerator Laboratory	3,660
Stanford Linear Accelerator Center	2,794
Total Estimated Construction Cost	$12,149

Since needs and priorities may change, other subprojects may be substituted for those listed and some of these may 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
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GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

HIGH ENERGY PHYSICS

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a. Project No.: 94-G-301 2b. Construction Funded
3a. Date A-E Work Initiated: 2nd Qtr. FY 1994 3b. A-E Work Duration: Various	5. Previous Cost Estimate: Total Estimated Cost (TEC): None Total Project Cost (TPC): None
4a. Date Physical Construction Starts: 3rd Qtr. FY 1994 4b. Date Construction Ends: 2nd Qtr. FY 1996	6. Current Cost Estimate: TEC -- $13,105 TPC -- $13,105

7. Financial Schedule (Federal Funds):

Fiscal Year	Appropriations	Obligations	Costs
1994	$13,105	$13,105	$ 3,300
1995	0	0	5,400
1996	0	0	4,405

8. Brief Physical Description of Project

This project provides for a variety of minor modifications, improvements and additions to the major high energy particle accelerators, colliding beam devices and experimental facilities. Funds of this type are necessary on an annual basis to maintain and improve the effectiveness of these facilities. In addition to the replacement of components for improved reliability and cost effectiveness of operation, it is often necessary to modify the facility to accommodate changes required by the research program. The funds requested, which represent less than 1 percent of the present value of the government's investment in these facilities, produce a large return in terms of more cost effective operation and greater research productivity.

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a. Project No.: 94-G-301 2b. Construction Funded

8. Brief Physical Description of Project (Continued)

The following are examples of the major items of work to be performed at the various locations:

Brookhaven National Laboratory..... $2,730

Funds are requested for modifications, improvements, and additions to the Alternating Gradient Synchrotron (AGS) and its related experimental facilities. Items planned include: AGS Main Magnet Power Supply Cycloconverter; Linac RF Transmission Line (Phase I); AGS Ring Equipment Upgrade; AGS BPM System Electronics; AGS Longitudinal Damper (Phase I); Polarized Proton Slow Quadrupole Power Supplies; and Booster LTB BPM Upgrade.

Fermi National Accelerator Laboratory..... $6,275

Funds requested are for modifications, improvements and additions to the Fermilab accelerator facilities (which include the linear accelerator, booster synchrotron, antiproton accumulator, debuncher rings, main ring, and superconducting Tevatron ring) and to the switchyard, beamlines, target facilities and experimental areas.

Modifications to the accelerator facilities are expected to include: antiproton stack-tail bandwidth upgrades; switchyard modifications for 900 GeV operations; antiproton accumulator lattice modifications; and antiproton accumulator aperture upgrade.

Modifications to the experimental facilities are expected to include: neutrino beam modifications, and beamline controls and instrumentation.

Stanford Linear Accelerator Center (SLAC)..... $4,100

Funds are requested for modifications, improvements and additions to the SLAC linear accelerator, the SLC colliding beam facilities, and to the associated experimental facilities. Items now planned for FY 1994 include: North Damping Ring and Linac Modifications for Flat Beam Operations; Linac Wakefield Measurement Facility; and Linac Instrumentation and Controls.

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations

2a. Project No.: 94-G-301
2b. Construction Funded

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

Accelerator improvements are essential on an annual basis to maintain short term operating efficiency and reliability, and the research flexibility of the high energy accelerators, colliding beam systems and related experimental facilities, thereby maintaining or enhancing their level of scientific effectiveness and productivity. Research advances and facility requirements in high energy physics occur at a rapid pace; further, each research facility is a unique assemblage of very specialized, high technology components. Consequently, there is a continuing need to modify facilities, frequently on a short time scale, in response to research needs and to respond to problems that can affect the reliability, efficiency and economy of operation on a time scale shorter than the normal two-year budget cycle. The requested accelerator improvements and modifications will provide greater flexibility for experimental setups, increased performance levels, and increased serviceability, thereby decreasing facility downtime, improving the productivity, scientific effectiveness and cost effectiveness of the U.S. program in High Energy Physics.

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

a. Engineering, design and inspection and component assembly and installation.....	$13,105
Total estimated construction cost.....	$13,105

The estimated costs of the program at each laboratory are preliminary and, in general, indicate the magnitude of each program.

11. Method of Performance

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

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GENERAL SCIENCE AND RESEARCH
(Tabular dollars in thousands. Narrative material in whole dollars.)

HIGH ENERGY PHYSICS

1. Title and Location of Project: B-Factory, Site Undesignated

2a. Project No.: 94-G-304
2b. Construction Funded

3a. Date A-E Work Initiated: 1st Qtr. FY 1994

3b. A-E Work (Titles I & II) Duration: TBD a/

5. Previous cost estimate:
Total Estimated Cost (TEC) -- None
Total Project Cost(TPC) -- None

4a. Date Physical Construction Starts: 1st Qtr. FY 1994

4b. Date Construction Ends: TBD a/

6. Current cost estimate:
TEC -- TBD a/
TPC -- TBD a/

7. Financial Schedule a/

Fiscal Year	Appropriations b/	Obligations	Costs
1994	$ 36,000	$ 36,000	$ 27,000
1995			9,000

8. Brief Physical Description of Project

The project will provide two rings of magnets for storage of electrons at about 9 GeV and of positrons at about 3 GeV. The counter rotating beams of electrons and positrons will be brought into collision in an intersection area. A key element of the project will be the incorporation of design elements which will allow the very high collision luminosity required for effective studies of the B-meson system.

a/ The specific site, schedule and cost will be determined after review of proposals from the Stanford Linear Accelerator Center and from Cornell University.
b/ For planning purposes only, we are assuming a funding profile of $44.0 million in FY 1995, $52.0 million in FY 1996, and $45.0 million in FY 1997.

1. Title and Location of Project:	B-Factory Site Undesignated	2a. Project No.: 94-G-304 2b. Construction Funded

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

The primary purpose of this project is to provide a facility for observing colliding beams of electrons and positrons at a center-of-mass collision energy of 10 GeV to 11 GeV with sufficient luminosity, and with electrons and positrons having sufficiently different energies, to measure the extent to which charge/parity conservation is violated in the B-meson system and thereby test the predictions of the Standard Model of particle physics in this important area. A second important purpose is to provide a facility for pursuing a broad program of experimental studies of bottom quark, charm quark, tau lepton, and two-photon physics with large numbers of events and thus high precision. This broad-based program of experiments will directly confront a number of crucial questions about the Standard Model and, consequently, will provide possibly the best window to new physics understanding of any currently proposed facility.

Violation of charge/parity conservation, or CP violation, is a fundamental, symmetry-breaking process that is believed to be responsible for our very existence - without it the equal amounts of matter and antimatter that it is thought were formed at the origin of the universe might by now have come together and been annihilated. The Standard Model, which is the embodiment of our most basic understanding of particle physics, predicts that CP violation is manifested in significantly different decay rates for neutral B mesons and antimesons that are produced in pairs. Yet, because no existing accelerator can produce enough pairs of B mesons and antimesons to observe the effect, this important prediction has never been confronted with experimental data.

In the B-Factory, the collision energy and luminosity are optimized for copious production of B-meson pairs, and the energy asymmetry of the electron and positron beams is chosen to optimize the detection of different decay rates for B mesons and antimesons. Execution of this project will permit the very important first experimental test of the Standard Model's explanation of CP violation.

While the primary goal of this project is to study CP violation experimentally as a means of testing the validity of the Standard Model, the B-Factory will also provide an opportunity to pursue a rich program of experiments in a large number of other areas of intense interest in high energy physics. For example, studies of rare decay modes of B mesons will be possible with unprecedented sensitivity, as will measurements of transitions in the bound $b\bar{b}$ (quark-antiquark) system. Charmed mesons and baryons will be produced in abundance, and their decays can be studied in great detail. Copious production of tau/anti-tau pairs will permit a wealth of new and precise measurements of the tau system, including the tau lifetime and a substantial

1. Title and Location of Project:	B-Factory Site Undesignated	2a. Project No.: 94-G-304 2b. Construction Funded

9. Purpose, Justification of Need For, and Scope of Project (Continued)

reduction in the upper limit on the tau-neutrino mass. Its high luminosity will also make the B-Factory an ideal place to study final states that can only be reached by two-photon exchange; for example, exotic meson states containing more than two quarks might be discovered. The impact of this broad experimental program will be an exceptionally broad and fundamental test of the validity of the Standard Model.

That a B-Factory is an ideal facility for an exhaustive study of CP violation was endorsed in 1990 by the High Energy Physics Advisory Panel's subpanel on the U.S. High Energy Physics Research Program for the 1990s, the Sciulli Panel. The thrust of the panel's recommendations is that the physics program of a B-Factory is compelling and that, given a technically sound proposal for construction of a machine, funds should be sought with high priority.

10. Detail of Cost Estimate

	Item Cost a/	Total Cost a/
a. Design and Management Costs		TBD
1. Engineering design and inspection at 29 percent of construction costs, Item c	TBD	
2. Project Management at 3 percent of Construction Costs, Item c	TBD	
b. Land and land rights	TBD	
c. Construction Costs		TBD
1. Accelerator Facilities	TBD	
2. Utilities	TBD	
3. Safety and Protection Systems	TBD	
d. Contingencies at approximately 24 percent of above costs		TBD
e. Total line item cost (Section 12.a. 1. (a))		TBD
f. Non-Federal Contribution		TBD
Net Federal total estimated cost (TEC)		TBD

a/ The specific cost will be determined after review of proposals from the Stanford Linear Accelerator Center and from Cornell University.

1. Title and Location of Project: B-Factory
Site Undesignated

2a. Project No.: 94-G-304
2b. Construction Funded

11. Method of Performance

TBD

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

	Prior Years	FY 1994	FY 1995	FY 1996	FY 1997	FY 1998	TOTAL
a. Total project costs							
1. Total facility costs							
(a) Line Item.....		$27,000	$ 9,000	TBD	TBD	TBD	TBD
2. Other project costs							
(a) R&D.....			TBD	TBD	TBD	TBD	TBD
(b) Pre-operations.....			TBD	TBD	TBD	TBD	TBD
(c) Capital Equipment.....			TBD	TBD	TBD	TBD	TBD
(d) Spares.....			TBD	TBD	TBD	TBD	TBD
Total other project costs..			TBD	TBD	TBD	TBD	TBD
Total project cost.....			TBD	TBD	TBD	TBD	TBD
(e) Non-Federal contribution...			TBD	TBD	TBD	TBD	TBD
(f) Net Federal total project cost.....	TBD	TBD	TBD	TBD	TBD	TBD	TBD

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

a. Total project funding
1. Total facility costs
(a) Construction Line Item - To be determined.
2. Other project costs
(a) R&D Necessary to Complete: To be determined.
(b) Pre-operations: To be determined.
(c) Capital Equipment: To be determined.

b. Related annual funding

TBD

a/ The specific cost will be determined after review of proposals from the Stanford Linear Accelerator Center and from Cornell University.

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GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

HIGH ENERGY PHYSICS

1. Title and Location of Project:	Fermilab Main Injector Fermi National Accelerator Laboratory	2a. Project No.: 92-G-302 2b. Construction Funded

SIGNIFICANT CHANGES

- TEC increased from $185,000,000 to $229,600,000 due primarily to a combination of the decrease in proposed FY 1994 funding, the revised outyear funding profile, enhanced ES&H criteria, and re-estimates due to design advances.

- TPC increased from $215,200,000 to $259,300,000 due primarily to a combination of the decrease in proposed FY 1994 funding, the revised outyear funding profile, enhanced ES&H criteria, and re-estimates due to design advances.

- Completion date of 4th quarter FY 1997 changed to 3rd quarter FY 1999 due primarily to a combination of the decrease in proposed FY 1994 funding, the revised outyear funding profile, enhanced E&SH criteria, and re-estimates due to design advances.

DEPARTMENT OF ENERGY
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GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

HIGH ENERGY PHYSICS

1. Title and Location of Project: Fermilab Main Injector
Fermi National Accelerator Laboratory

2a. Project No.: 92-G-302
2b. Construction Funded

3a. Date A-E Work Initiated: 3rd Qtr. FY 1992

3b. A-E Work (Title I & Title II) Duration: 18 months

5. Previous Construction Estimate:
Total Estimated Cost (TEC) -- $185,000
Total Project Cost (TPC) -- $215,200

4a. Date Physical Construction Starts: 4th Qtr. FY 1992

4b. Date Construction Ends: 3rd Qtr. FY 1999

6. Current Cost Estimate:
TEC -- $229,600
TPC -- $259,300

7. Financial Schedule (Federal Funds): a/

Fiscal Year	Appropriations	Adjustments	Obligations	Costs
1992	$ 15,000	- 3,350 b/	$ 11,650	$ 990
1993	15,000 c/		15,000	19,000
1994	25,000		25,000	21,660
1995	43,000		43,000	35,800
1996	52,000		52,000	48,400
1997	52,000		52,000	52,000
1998	30,950		30,950	36,300
1999	0		0	15,450

a/ For consistency with Departmental accounting system, the Appropriations, Obligations, and Costs for fiscal years prior to 1993 have been changed from amounts on the last data sheet.
b/ Reflects Congressional Rescission of $3,350,000 in FY 1992.
c/ Congressional request for $30,000,000 reduced to $15,000,000 by Congressional action on FY 1993 request.

1. Title and Location of Project:	Fermilab Main Injector Fermi National Accelerator Laboratory	2a. Project No.: 92-G-302 2b. Construction Funded

8. Brief Physical Description of Project

Due primarily to a combination of enhanced ES&H criteria and re-estimates due to design advances, this project has been stretched out from the 4th Quarter of FY 1997 to the 3rd Quarter of FY 1999 resulting in an attendant increase in TEC and TPC. The TEC has been increased from $185,000,000 to $229,600,000. The TPC has been increased from $215,200,000 to $259,300,000.

This project provides for the construction of a new accelerator, called the Fermilab Main Injector, which will replace the aging Fermilab Main Ring in all of its functions. It will provide particles for injection into the existing superconducting Tevatron accelerator, as well as for direct delivery to the existing fixed target experimental and test beam areas. The accelerator is 3.3 km in circumference and it is capable of accelerating either protons or antiprotons to 150 GeV. It employs conventional iron core magnets. Also provided are five new beamlines which connect the Main Injector into the existing Fermilab accelerator complex, transport 120 GeV proton beam to the fixed target experimental areas, and provide particle beams for the testing and calibration of SSC detector components and subsystems.

Many technical components will be recycled from the existing Main Ring, including quadrupole magnets, some power supplies and correction magnets, radio frequency accelerating systems, controls system components, and diagnostic devices.

The Main Injector will be located in the southwest corner of the Fermilab site, and will be connected to the existing Tevatron ring enclosure at its F-Zero straight section.

Specifically provided for in the scope of the project are:

a. Construction of a 3.3 km ring enclosure with ancillary service buildings, and utilities; and the fabrication of new technical components including dipole magnets, high current power supplies, and vacuum systems.

b. Construction of beamline enclosures, service buildings, utilities, and technical components which are required to implement an 8 GeV Booster-to-Main Injector beamline, the 150 GeV proton and antiproton Main Injector-to-Tevatron transfer lines, and a 120 GeV Main Injector-to-Antiproton Production Target beamline.

1. Title and Location of Project:	Fermilab Main Injector Fermi National Accelerator Laboratory	2a. Project No.: 92-G-302 2b. Construction Funded

8. Brief Physical Description of Project (Continued)

c. Construction of the technical components required to implement the delivery of 120 GeV beam from the Main Injector to the existing external fixed target and test beam experimental areas, and the construction of a new sub-station and 345KV power lines for distribution of electrical power to the Main Injector location.

d. Modifications to the Tevatron ring enclosure at the F-Zero straight section, for installation of the 150 GeV proton and antiproton transfer lines.

e. Refurbishment and reinstallation in the Main Injector ring enclosure of those technical components which will be reused from the old Main Ring accelerator.

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

The primary purpose of this project is to greatly increase the Tevatron collider luminosity which can be delivered to the two existing collider detector experimental facilities at Fermilab. Fermilab is the only operational high energy physics facility in the world with sufficiently high energy to produce the top quark, which is the last unobserved fundamental particle building block according to our current understanding of the basic structure of matter. Increasing the luminosity of the Fermilab proton-antiproton collider to as much as $5 \times 10^{31} cm^{-2} sec^{-1}$ will almost guarantee first observation of the top quark at Fermilab, so long as its mass lies within the range defined by all known data. The project will also significantly increase the number of protons which can be injected into the Tevatron for subsequent acceleration to 800 GeV and then extraction into the existing fixed target and test beam experimental areas. Other important purposes are to provide an expanded capability of 120 GeV proton beams which can be used for fixed target physics research, and to provide year-round 120 GeV proton beams for the testing and calibration of SSC detector components and subsystems without interrupting Tevatron collider operations for physics research.

Increasing the collider luminosity requires increasing both the numbers of protons and of antiprotons injected into the Tevatron. The substantial increases in injection intensities result from the large effective aperture of the Main Injector accelerator and from its high repetition rate capability. These are achieved through tight beam focussing, high magnetic field quality, and elimination of the two vertical overpasses which had to be installed in the Main Ring during the 1980's in order to provide the collider interaction regions. The Main Injector will be capable of accelerating an intense beam of protons to 120 GeV every 1.5 seconds for the purpose of antiproton production, as compared to a 2.4 second cycle for the present Main Ring. The beam intensity which can be injected

1. Title and Location of Project:	Fermilab Main Injector Fermi National Accelerator Laboratory	2a. Project No.: 92-G-302 2b. Construction Funded

9. Purpose, Justification of Need For, and Scope of Project (Continued)

into the Tevatron by the Main Injector will approach 6 x 10^{13} protons each 60 second cycle, which is about two times greater than could be achieved with the old Main Ring. The Tevatron antiproton-proton colliding beam luminosity will be increased to about 5 x 10^{31} $cm^{-2}sec^{-1}$, which is five times greater than can be achieved using the Main Ring as injector. These performance goals are expected to be achieved after months of operational experience with the new accelerator.

10. Details of Cost Estimate*

	Item Cost	Total Cost
a. Engineering Design Inspection and assembly at 16 percent of construction costs		$ 26,300
b. Main Injector construction costs		165,000
1. Conventional construction	$ 79,200	
2. Special facilities	85,800	
c. Contingencies at 20 percent of above costs		38,300
Total line item cost		$229,600

* The annual escalation rates assumed for FY 1994 through FY 1998 are 3.3, 3.6, 3.7, 3.7, and 3.6 percent respectively.

11. Method of Performance

Design of facilities will be by the operating contractor and subcontractors as appropriate. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.

1. Title and Location of Project: Fermilab Main Injector
Fermi National Accelerator Laboratory

2a. Project No.: 92-G-302
2b. Construction Funded

12. Schedule of Project Funding and Other Related Funding Requirements

a. Total project funding	Prior Year	FY 1992	FY 1993	FY 1994	FY 1995
1. Total facility costs					
(a) Line item.....	$ 0	$ 990	$19,000	$21,660	$35,800
	$ 0	$ 990	$19,000	$21,660	$35,800
2. Other project costs					
(a) R&D costs necessary to complete construction.....	$ 5,400	$ 3,700	$ 4,100	$ 3,200	$ 500
(b) Pre-operating costs.....	0	0	0	0	0
(c) Capital equipment.....	0	200	200	200	200
(d) Inventories and Spares.....	0	0	0	0	0
Total other project costs	5,400	3,900	4,300	3,400	700
Total project costs	$ 5,400	$ 4,890	$23,300	$25,060	$36,500

a. Total project funding	FY 1996	FY 1997	FY 1998	FY 1999	Total
1. Total facility costs					
(a) Line item.....	$48,400	$52,000	$36,300	$15,450	$229,600
	$48,400	$52,000	$36,300	$15,450	$229,600
2. Other project costs					
(a) R&D costs necessary to complete construction.....	$ 0	$ 0	$ 0	$ 0	$ 16,900
(b) Pre-operating costs.....	0	0	1,700	1,900	3,600
(c) Capital equipment.....	100	100	0	0	1,000
(d) Inventories and Spares.....	4,500	3,700	0	0	8,200
Total other project costs	4,600	3,800	1,700	1,900	29,700
Total project costs	$53,000	$55,800	$38,000	$17,350	$259,300

b. Related annual funding (estimated life of project: 20 years)

1. Power costs for Main Injector test beam operations	$5,800
2. Experimental areas operating costs for test beams	1,300
Total incremental annual funding (in FY 1997 dollars)	$7,100

1. Title and Location of Project: Fermilab Main Injector
Fermi National Accelerator Laboratory

2a. Project No.: 92-G-302
2b. Construction Funded

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

a. Total project funding
1. Total facility cost
(a) Line item - explained in items 8,9,10

2. Other project costs
(a) Direct R&D operating costs - This will provide for the design and development of new components and for the fabrication and testing of prototypes. R&D on all elements of the project, in order to optimize performance and minimize costs, is concentrated in the early years. Specifically included are the development of the high current dipole magnets and associated power supplies. A small number of Main Injector dipole magnets and power supplies will be fabricated and tested using R&D operating funds.
(b) Pre-operating costs - Includes personnel and power costs for a 6 month commissioning period.
(c) Spares and inventories - Provides for special process spares for the major technical components, primarily magnets and power supplies, and for an increase in common use inventories for Main Injector related items.
(d) Capital equipment - Includes test instruments, electronics, and other general equipment to support 12.a.1 and 12.a.2.a.

b. Total incremental funding requirements - We assume that the Fermilab Tevatron complex will continue both its fixed target and its colliding beam research programs, with each running about 40% of the time on the average. The Main Injector replaces the present Main Ring in all of its functional roles, and it is designed to require about the same amount of power to operate for those purposes. The new Main Injector capability for test beam operations simultaneously with Tevatron operations for physics research will require an average increase in power plus other operating costs by about $7.1M annually. The operating costs in 12.b reflect the incremental demands of delivering 120 GeV protons to the test beam areas during Tevatron colliding beam and fixed target operating periods for physics research.