DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY 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 and the basic forces which govern all processes in nature. The primary goal of the program is 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.

Research in high energy physics is a stated part of the DOE mission and the DOE serves as the Executive Agent for the national program in high energy physics. Further, since the program supports basic research into the nature of matter and energy at the most fundamental level, the High Energy Physics program is directly relevant in the long term to the national goal of energy security.

The Physics Research section of the budget provides support for the scientists who perform the required 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 the ongoing progress of the planned research program. Taken together, these activities provide for a balanced program of world class research in high energy physics.

In addition to the main objective of improved knowledge of matter and energy as described above, the High Energy Physics program provides, in the short term, strong stimulation for certain high technology areas of the U.S. economy (e.g., large scale computing, high speed electronics, low temperature superconductivity). Further, the High Energy Physics program has contributed and continues to contribute substantially to the field of accelerator design and construction. Thus, the present widespread application of accelerators in other areas of science and technology (e.g., medicine, materials science, microchip manufacture, and Strategic Defense Initiative (SDI)) is based on accelerator technology developed by the High Energy Physics (and Nuclear Physics) programs for their own purposes.

Experimental research in high energy physics most often requires the use of large particle accelerators, colliding beam devices, and large particle detectors. There are three DOE supported high energy physics accelerator centers: Fermi National Accelerator Laboratory (Fermilab), Stanford Linear Accelerator Center (SLAC), and Brookhaven National Laboratory (BNL). Each of these laboratories provides world unique research capabilities, and are operated as national facilities available to qualified experimenters on the basis of the scientific merit of their proposals. To these is being added the Superconducting Super Collider (SSC) which is included in a separate FY 1991 budget. Funding for researchers to work at all four of these facilities is included in this budget. Experiments by U.S. scientists are also carried out at the Cornell Electron Storage Ring and at foreign accelerators with unique capabilities not available in the U.S. Some important experiments do not require beams from accelerators but use detectors elsewhere, sometimes in deep underground or mountaintop laboratories. The experimental research, as well as theoretical research, is carried out largely by university based scientists.

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. The dependence of the program on facilities strongly influences program planning and strategy.

Two recently completed major upgrades of U.S. high energy physics facilities, the Stanford Linear Collider (SLC) and the Fermilab Tevatron Collider, are now in operation for research. These facilities will keep the U.S. program highly competitive and at the cutting edge for the next several years. Effective utilization of these facilities in the next few years is critical to the U.S. program.

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 the participation of university-based scientists 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, particularly the Tevatron and SLC, 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. Also, support for scientists participating in planning and in R&D activities related to the SSC is an increasing component of the high energy physics research activity.

After careful study it has been determined that a new, more powerful particle accelerator capable of exploring the Tev mass region is essential to advance 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 in the mid 1990's and beyond. The SSC will be a proton-proton collider having an energy of 20 Tev per beam. The SSC will permit exploration of this new domain of physics research which cannot be reached by any existing facility. Construction of the SSC and of the initial complement of detectors is requested in a separate SSC budget submission. The SSC is an integral part of the national high energy physics program; therefore, the basic research support for the physicists planning for and preparing experiments to be conducted at the SSC is now and 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 1991 revolves around the following key factors:

- Operation of the new world forefront research capabilities of the SLC collider and the Tevatron accelerator/collider at the maximum reasonable level. The Tevatron collider operations in FY 1991 will allow research utilization both of the fully mature Collider Detector at Fermilab (CDF) and of the just completed complementary new D-Zero detector facility. In addition, the Tevatron will have a major fixed target run. The SLC will be operated for physics research for as many months as fiscally possible, with a new polarized electron beam capability to be commissioned during the year. The Positron Electron Project (PEP) electron-positron collider with the improved Time Projection Chamber (TPC) detector will also be operated at SLAC.

- Continued effective participation of university scientists is critical to the ongoing vitality of this program. University scientists directly carry out over three-fourths of the experimental and theoretical research in the field. Universities have a leading role in providing intellectual leadership for the field of high energy physics and in the training of highly skilled scientists and engineers for this and many other fields.

- 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 for high energy physics research.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
OFFICE OF ENERGY RESEARCH
(dollars in thousands)
LEAD TABLE
High Energy Physics

Activity	FY 1989	FY 1990	FY 1991 Base	FY 1991 Request	Program Change Request vs Base	
					Dollar	Percent
Operating Expenses						
Physics Research.....	$121,586	$131,068	$131,068	$140,250	$+ 9,182	+ 7%
Facility Operations.....	246,447	260,216	260,216	278,715	+ 18,499	+ 7%
High Energy Technology.....	62,878	71,612	71,612	75,190	+ 3,578	+ 5%
Capital Equipment.....	79,747	84,065	84,065	88,180	+ 4,115	+ 5%
Construction.....	39,125	35,116	35,116	38,852	+ 3,736	+ 11%
Total.....	549,783	582,077	582,077	621,187	+ 39,110	+ 7%
Operating Expenses.....	(430,911)a/	(462,896)	(462,896)	(494,155)	+(31,259)	+ 7%
Capital Equipment.....	(79,747)	(84,065)	(84,065)	(88,180)	+ (4,115)	+ 5%
Construction.....	(39,125)	(35,116)	(35,116)	(38,852)	+ (3,736)	+ 11%
Total Program.....	($549,783)b/c/	($582,077)c/d/e/	($582,077)	($621,187)c/	$+(39,110)	+ 7%
Staffing (FTEs).....	(Reference General Science Program Direction)					

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

a/ Total has been reduced by $5,469,000 ($3,536,000 Facility Operations, $1,933,000 High Energy Physics Technology) reprogrammed to Energy Supply for SBIR.
b/ Excludes $7,372,000 which represents applicable portion of $12,000,000 General Reduction contained in FY 1989 Appropriation.
c/ Reflects comparability adjustment for new Environmental Restoration and Waste Management program as follows: FY 1989 - $4,182,000; FY 1990 - $4,574,000; FY 1991 - $3,618,000.
d/ Excludes $11,251,000 which represents applicable portion of $21,000,000 General Reduction contained in FY 1990 Appropriation.
e/ FY 1990 reflects final Gramm-Rudman-Hollings sequester adjustments.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

SUMMARY OF CHANGES

High Energy Physics

FY 1990 Appropriation		$ 582,077
Adjustments - Increased personnel costs		0
FY 1991 Base		582,077
- Funding required to maintain a constant overall level of program activity	+	24,047
Physics Research		
- Physics research at a level consistent with the operating level of facilities	+	3,677
Facility Operations		
- Increase in facility operations funding to provide for an improved level of operations for physics experiments at SLAC and Fermilab	+	7,570
High Energy Technology		
- Maintain constant level of effort for advanced high energy physics technology R&D	+	570
Capital Equipment		
- Maintain constant level of effort for capital equipment funding	+	584

Construction

- Reduction due to completion of AGS Accumulator/Booster in FY 1990.....	-	4,915
- Maintain constant level of effort for AIP and GPP required to support the accelerator facilities.....	+	211
- Increase for ongoing Fermilab Linac Upgrade project.....	+	7,366
FY 1991 Congressional Budget Request.....	$	621,187

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

HIGH ENERGY PHYSICS

I. Preface: Physics Research

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, suggests key questions for future experimental explorations. This subprogram supports research groups at more than 100 universities as well as at the 11 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 high energy particles. 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. 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 foreign laboratories such as DESY (West Germany), CERN (Western Europe), KEK (Japan), and SERPUKHOV (USSR). 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 1990 will be a year of strong research output from the world forefront SLC collider and Tevatron fixed target facilities. A very productive level of research activity is planned for FY 1991 as the data collected in FY 1989 and FY 1990 is analyzed and these facilities continue to operate in an intensive data taking mode. Experimental groups are planned to be supported at a continuing level consistent with the operating level of these facilities and with maintenance of the technical capabilities of the major university laboratories. In addition, FY 1991 is expected to include significant effort on planning for experiments for the SSC.

II. A. Summary Table: Physics Research

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Fermilab	$ 9,385	$ 8,735	$ 9,170	+ 5
SLAC	11,767	11,960	12,560	+ 5
BNL	7,851	7,710	8,095	+ 5
ANL and LBL	15,256	15,700	16,485	+ 5
Universities and Other Labs	77,327	86,963	93,940	+ 8
Total, Physics Research	$ 121,586	$ 131,068	$ 140,250	+ 7

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory	$ 5,676	$ 5,560	$ 5,840	+ 5
Brookhaven National Laboratory	$ 7,851	$ 7,710	$ 8,095	+ 5
Fermi National Accelerator Laboratory	$ 9,385	$ 8,735	$ 9,170	+ 5
Lawrence Berkeley National Laboratory	$ 9,580	$ 10,140	$ 10,645	+ 5
Stanford Linear Accelerator Laboratory	$ 11,767	$ 11,960	$ 12,560	+ 5

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

Program Activity	FY 1989	FY 1990	FY 1991
Physics Research			
Fermilab	Fermilab staff perform experiments using the Fermilab facilities, while also providing a crucial support and liaison function for the many university users involved in experimental programs at Fermilab. Analysis of the data collected from the intensive FY 1988 operations for research of the upgraded fixed target facilities required a major effort, as did the preparation of the publications and theoretical interpretations of this new information. Fermilab researchers also participated strongly in extensive data taking in the Tevatron collider programs. In addition, there is an ongoing theoretical research activity as well as a small program of high energy astrophysics research.	At about a constant level of effort from prior years, the Fermilab research physicists will be involved in the physics analysis of the data processed from earlier runs and in the collection of new data in a lengthy and extensive operation of the fixed target research program. Theoretical and high energy astrophysics research efforts will continue at a steady level of effort. Preparations for the full completion of the D-Zero detector and the FY 1991 colliding beams research programs will also be undertaken.	The Fermilab research groups will shift their overall emphasis somewhat in order to participate in the first operations for colliding beam physics research of the newly completed D-Zero major detector facility which will occur in FY 1991. Analysis of the fixed target program data taken in FY 1990 and early in FY 1991 will be a major activity, as will the preparation for the next scheduled fixed target experiments. The theory groups will continue to pursue the most topical new experimental results.
	$ 9,385	$ 8,735	$ 9,170
SLAC	The SLAC research groups focused their efforts on collaborative experiments with university groups related to SLC operation with first data taking on the Mark II detector at SLC and the first operation for research of the upgraded PEP facility with the upgraded TPC detector. In addition, there was operation of SPEAR for high energy physics. The SLAC research groups were heavily involved in conducting experiments and data taking. There was also a strong theoretical research activity.	The continued luminosity improvements of the SLC will require increased efforts in data taking and data analysis. The research groups will continue to study Z zero particles with the Mark II detector. The new SLD detector will undergo tests and commissioning with the possibility of a first physics run late in the year. Data taking at PEP will continue.	With the scheduled completion of SLD (late in 1990) and the SLC polarized beam as well as substantially increased luminosity, it is expected that realization of the full physics potential for SLC will be approached in FY 1991. Analysis of data from Mark II's previous running at SLC will continue, and research groups will make use of SLC's unique characteristics to study Z zero and other physics in this energy region. FY 1991 is expected to be a very productive year. Data taking at PEP will continue.
	$ 11,767	$ 11,960	$ 12,560

III. Physics Research (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
BNL	The AGS program includes a wide variety of fixed target experiments. For FY 1989, the BNL research groups focused on experiments at the AGS with significant emphasis on operation of the new generation of rare kaon decay experiments. Other BNL activities include participation in preparation for the D-Zero experiment at Fermilab, and in experiments at CERN.	The program will continue FY 1989 activities with significant emphasis on rare kaon decay experiments. Fabrication of detectors for a new neutrino oscillation search is expected to begin. Preparation for the D-Zero experiment at Fermilab will continue. Study of proton-proton elastic scattering with the AGS polarized beam will continue.	With the scheduled completion of the AGS booster providing about a four-fold increase in proton beam intensity, and about a 25 fold increase in the polarized proton beam intensity, more precise studies in the rare kaon decay experiments and in proton-proton elastic scattering with the polarized beam will be undertaken. Early beam tests of the muon anomalous magnetic moment (g-2) experiment are planned. An important part of BNL research will be devoted to data taking and data analysis related to the scheduled first operation of the D-Zero experiment at Fermilab's Tevatron.
	$ 7,851	$ 7,710	$ 8,095
ANL and LBL	These groups concentrate their efforts as users at the U.S. accelerator centers and at foreign facilities with unique capabilities. The LBL program includes important participation with the Mark II experiment at SLC, the leading role in the research with TPC at PEP and in the CDF experiment at Fermilab as well as a large theoretical effort and the Particle Data Center. The ANL program is highlighted by important participation in the ZEUS experiment and in the SOUDAN II proton decay experiment.	These programs remain at about a constant level of activity with continued emphasis on ANL leadership of the U.S. participation in the ZEUS electron-proton project at DESY and on LBL's data taking schedules at the new Fermilab and SLAC facilities and analysis of data for physics results. Both are involved in the conceptual design of potential SSC experiments.	With the increased opportunities for physics research with world-wide facilities reaching energies and intensities previously unavailable, these groups of researchers will concentrate on data taking and data analysis with detectors at SLAC and Fermilab. The LBL efforts will be concentrated on CDF and the newly commissioned D-Zero detector at Fermilab. The ANL program will be concentrated on SOUDAN II and on the newly commissioned ZEUS detector at DESY in Hamburg.
	$ 15,256	$ 15,700	$ 16,485

III. Physics Research (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Universities and Other Labs	This program supports experimental and theoretical research groups at about a hundred universities throughout the nation. The university groups participate in experiments at the major U.S. accelerator facilities and at foreign accelerator facilities with unique capabilities, as well as in non-accelerator experiments and theoretical research. The level of effort is appropriately scoped relative to the level of facility operation.	The funding for the university program will be significantly increased to enhance the capability of university groups to participate effectively in world forefront research and to meet the extraordinary costs of U.S. experiments at remote and foreign facilities. Further, funding will be provided to begin to restore the technical capabilities of major university laboratories. Also, U.S. researchers will be participating in the experiments L3, ALEPH, DELPHI, and OPAL at CERN's LEP electron-positron collider. Also includes continued funding for computer acquisitions at MIT.	University groups will participate in major experiments at U.S. and foreign laboratories and scientists will engage in planning and R&D activities in preparation for experiments at the SSC. Important new experiments include the SLD experiment at the SLC (SLAC) for precision studies of electron-positron beam collisions producing Z particles; the D-Zero experiment at the Tevatron (Fermilab) to study proton-antiproton beam collisions, complementing the CDF experiment; and, the ZEUS experiment at HERA (DESY) to study electron-proton beam collisions at high energies. The manpower, technical, and computational capabilities of leading universities will be increased somewhat to better analyze the voluminous data produced by cutting edge experiments.
	$ 77,327	$ 86,963	$ 93,940
Physics Research	$ 121,586	$ 131,068	$ 140,250

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

HIGH ENERGY PHYSICS

I. Preface: Facility Operations

Provides funding for the operation of accelerators, colliders, secondary beam lines, detectors for experiments, experimental areas, central computing and computer networking facilities. Includes the costs of manpower, electric power, expendable supplies, and inventories. The major DOE supported facilities to be operated in FY 1991 are the Fermilab Tevatron (800 GeV proton fixed target and 900 GeV on 900 GeV antiproton-proton colliding beams); SLAC (50 GeV linear accelerator serving as injector for the PEP 15 GeV on 15 GeV electron-positron collider, and the SLC 50 GeV on 50 GeV electron-positron collider); and the BNL AGS (30 GeV proton and polarized proton fixed target program). The world forefront SLAC SLC and Fermilab Tevatron accelerators will both be available for a significant amount of physics operation in FY 1991.

II. A. Summary Table: Facility Operations

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Fermilab Operations	$ 122,744	$ 129,780	$ 139,365	+ 7
SLAC Operations	80,200	85,250	91,410	+ 7
BNL-AGS Operations	41,928	36,825	39,165	+ 6
Other Operations	1,575	8,361	8,775	+ 5
Total, Facility Operations	$ 246,447	$ 260,216	$ 278,715	+ 7

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory	$ 41,928	$ 36,825	$ 39,165	+ 6
Fermi National Accelerator Laboratory	$ 122,744	$ 129,780	$ 139,365	+ 7
Stanford Linear Accelerator Laboratory	$ 80,200	$ 85,250	$ 91,410	+ 7

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

Program Activity	FY 1989	FY 1990	FY 1991
Facility Operations			
Fermilab Operations	During FY 1989 the superconducting Tevatron was in full operation for research in the antiproton-proton collider mode for 35 weeks with another 3 weeks of accelerator studies. The original design luminosity of the facility was more than exceeded and the total amount of data provided to the experiments was ten times greater than had been earlier anticipated. The major general purpose Collider Detector at Fermilab (CDF) facility recorded some 6,000 high density magnetic tapes full of raw data. Two smaller collider experiments, on elastic scattering and a search for the quark-gluon plasma, were fully completed during this period. This was the most successful collider run on record. Preliminary results from the physics analysis are beginning to emerge, and already a new lower limit of 60 GeV for the mass of the hypothesized top quark has been set.	It is planned to operate the superconducting Tevatron for research for 30 weeks during FY 1990. The first three months of the year will be a cooldown and restart period for the Tevatron. This will be followed by operations for the fixed target research programs. This period includes the first research utilization of a new gas jet fixed target facility in the antiproton accumulator ring. Sixteen major physics experiments will be in operation during this year. Four are continuations from the FY 1988 fixed target run and the other twelve are new efforts. In addition, three test beams will be operated for detector development and calibration.	The Tevatron is planned to be in operation for physics research in FY 1991 for about 36 weeks. The fixed target research program and test beam activities will resume early in the fiscal year and be operated for about 20 weeks. Then, after a few months shutdown to move in the detectors and do routine maintenance on the Tevatron, the antiproton-proton colliding beam research program will start up again. This will involve two major detector facilities: the seasoned and upgraded CDF detector and the recently completed and complementary new D-Zero detector. Thus, the effective physics utilization of the Tevatron collider will be effectively doubled from its previous run in 1989.
	$ 122,744	$ 129,780	$ 139,365
SLAC Operations	SLAC operated for about 22 weeks for physics research with the SLC, mostly at 60 pulses per second (pps). Operation at PEP and SPEAR for high energy physics also took place for 8 weeks at the beginning of the year. Upgrade of the central computing facility continued.	SLAC has scheduled about 30 weeks of SLC operation at 60 to 120 pps for physics research. It is planned that PEP operation with TPC will take place concurrently with SLC for much of the running period.	SLAC has scheduled about 36 weeks of SLC operations at 60 to 120 pps for physics research. It is planned to operate PEP concurrently with SLC for much of the running period. Polarized beams in SLC are expected to be regularly available in the latter half of FY 1991.
	$ 80,200	$ 85,250	$ 91,410

III. Facility Operations (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
BNL-AGS Operations	The AGS operated for about 20 weeks for high energy physics, primarily with slow beam extraction. Studies of rare kaon decays were emphasized. Additional operation of about seven weeks took place for heavy ion physics funded by Nuclear Physics.	The AGS is scheduled to operate for about 13 weeks for high energy physics to be split among the various modes. Emphasis will be on rare kaon decay experiments. Additional operation of 7 weeks is planned for heavy ion physics funded by Nuclear Physics. Total AGS operation in FY 1990 would be about 20 weeks.	The AGS will operate for about 14 to 18 weeks for high energy physics. The new AGS accumulator/booster will be commissioned. Rare kaon decay experiments will continue. About 10 weeks of heavy ion physics funded by Nuclear Physics is also planned.
	$ 41,928	$ 36,825	$ 39,165
Other Operations	Funding is provided to LBL for its participation in the operation, maintenance and upgrading of the Time Projection Chamber (TPC) detector at PEP. It also provides for increases in special stores, and other specialized activities to meet requirements for effective operation of the accelerator laboratories. Funding for the SBIR assessment has been transferred to the SBIR program.	Continuation of FY 1989 program at about same level of effort. Includes computer networking activities. Also includes funding for the SBIR assessment on the HEP program. Implementation plans for the Energy Sciences Network project, identified in the Applied Mathematical Sciences subprogram of the Basic Energy Sciences program, will proceed. The HEP program's share for the implementation of ESNET is $1,085.	Continuation of FY 1990 program at a decreased level of effort. Includes computer networking activities. Also includes funding for the SBIR assessment on the HEP program. Upgrade of ESNET to conform to the National Research and Education Network standards will continue to be pursued. The HEP program share will be about the same level as in FY 1990.
	$ 1,575	$ 8,361	$ 8,775
Facility Operations	$ 246,447	$ 260,216	$ 278,715

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

HIGH ENERGY PHYSICS

I. Preface: High Energy Technology

Provides the technological base for maintaining and improving the scientific effectiveness, reliability, and efficiency of existing facilities and for extending the capabilities of accelerators, colliders, and detectors by developing and proving new concepts and technologies. Includes R&D with a near term focus in support of current, ongoing construction projects, fabrication of major detectors, and improving existing 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. Also includes studies of new types of detectors and improved detector performance. 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 focuses on a search for new accelerator technologies applicable to the long term future (beyond the year 2000) of particle beam physics.

II. A. Summary Table: High Energy Technology

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Fermilab	$ 15,400	$ 15,905	$ 16,700	+ 5
SLAC	15,450	14,960	15,705	+ 5
BNL	12,764	13,575	14,255	+ 5
LBL	7,680	8,025	8,425	+ 5
Universities and Other Contractors	11,584	19,147	20,105	+ 5
Total, High Energy Technology	$ 62,878	$ 71,612	$ 75,190	+ 5

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory	$ 12,764	$ 13,575	$ 14,255	+ 5
Fermi National Accelerator Laboratory	$ 15,400	$ 15,905	$ 16,700	+ 5
Lawrence Berkeley National Laboratory	$ 7,680	$ 8,025	$ 8,425	+ 5
Stanford Linear Accelerator Laboratory	$ 15,450	$ 14,960	$ 15,705	+ 5

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

Program Activity	FY 1989	FY 1990	FY 1991
High Energy Technology			
Fermilab	R&D is directed at improving Tevatron luminosity by reducing emittance, increasing beam intensity and reducing interaction point beam spot sizes. Tests of reduced operating temperature of the Tevatron superconducting magnets will begin. Tests of a new accelerator structure and development of higher power klystrons for the Linac Upgrade project will begin. Studies of the antiproton source will be carried out to improve the yield, cooling rate, and emittance of the antiproton beam. Facility R&D continues general support activities for fixed target and colliding beam technology. Design of high gradient 1.8K quadrupole magnets for the D-Zero interaction region will focus on fabrication of prototypes. While work continues on the CDF detector, a high emphasis is placed on support of D-Zero detector and of data analysis tools.	R&D to increase the energy, intensity and luminosity of the Tevatron will be expanded. This will include increased R&D in support of the Linac Upgrade project and work on a new radio frequency quadrupole preinjector, evaluation of improved accelerating structures, test of new radio frequency drivers, and design of a new 400 MeV linac-to-booster transport line. An enhanced program of reducing beam losses in the booster, main ring, and Tevatron machines will be undertaken as will a program to improve performance of the antiproton source. A major new emphasis during this period will be R&D addressing the optimum scheme for improving the performance of the intermediate energy acceleration system which operates between the 8 GeV booster and the Tevatron. The present intermediate acceleration system is the original warm iron magnet Main Ring. A second emphasis will be R&D for future luminosity improvements for the superconducting Tevatron storage ring. R&D in support of detector facilities will include improved beamlines and beamline controls and special work on improved CDF detector performance.	The program to improve the performance of the accelerator and storage ring subsystems set in motion over the previous several fiscal years will continue. These include work on the linac low energy injection systems and on the booster instrumentation, radio frequency systems, beam damper systems and beam dynamics studies. Main ring beam transmission will continue to be improved through improved diagnostics and machine studies. The antiproton source particle production will be raised through improving beam cooling hardware, production target performance by sweeping the proton beam, increasing target beamline particle acceptance, and improving controls. Studies to lower Tevatron temperature by .5 K and reach 1000 GeV will continue. Work will be done to shorten significantly the change over time from Tevatron collider mode to fixed target mode of operation. There will be a strong effort in support of the Linac Upgrade construction project. The effort begun in FY 1990 on luminosity improvements, much of which involves studies for the new Main Injector, will continue. The generic detector R&D program, which concentrates studies on experimental area beams and devices, colliding beam experimental facilities (CDF and D-Zero), charged particle detector R&D, developing improved data handling methods, and advanced computing methods R&D, will continue.
	$ 15,400	$ 15,905	$ 16,700

III. High Energy Technology (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
SLAC	As SLC technology becomes understood, and operation for physics research gets underway, R&D was redirected toward improving luminosity and performance, and to make further progress on linear collider technology. Installation and testing of major systems of the SLD will be carried out. Studies of advanced concepts, particularly new, high power, high efficiency radiofrequency sources will also be pursued.	An expanded program of R&D on the collider is directed toward the luminosity improvements necessary to support full physics utilization of the SLD. Studies of advanced collider concepts increase as prototype accelerator and final focus components are tested and evaluated. Development continues on high power sources and high gradient accelerating structures. R&D will be done in support of a final focus test facility using existing SLAC beam lines to study nanometer radii beams. Studies of the ultra high current operation of the PEP storage ring for BB-bar production will begin.	Successful operation of the SLC has revealed new R&D information on the performance and operation of linear colliders. Studies based on these results will be undertaken for the dual purpose of improving operating performance and efficiency of the SLC and of guiding and aiding studies of linear colliders that can operate in the TeV range. Improvements in luminosity and reduction of background will particularly focus on enhancing the performance of the SLD detector during its first physics run. Advanced accelerator R&D will continue with development of several new high power radio frequency sources operating at 11 GHz or higher and 100 MW or higher. They will be tested and evaluated in terms of technical suitability and cost effectiveness. Some of these will be tested with radically new high gradient accelerating structures. Work will continue on a new final focus test facility begun in FY 1990 to study electron and positron beams of nanometer radii. The generic activities in support of detector technology development will continue.
	$ 15,450	$ 14,960	$ 15,705
BNL	Program includes continued R&D support for the AGS Accumulator/Booster construction project, and improved polarized proton operation of the AGS, a continuation of the superconducting magnet R&D program, and studies of advanced accelerator concepts, including assembly and tests of an advanced test facility for laser accelerator studies.	Continuation of R&D programs for improved AGS intensity, duty cycle, flexibility of operation and reliability, and for reduced beam loss and maintenance; for Booster project support, such as magnet measurements, beam electrode characterization, machine modelling studies and applications software for beam control and diagnostics; for improvement of particle detectors, beam lines and targets for AGS experiments including preparation for measurement of the muon	Continued R&D programs to improve AGS operation, commission the Booster and integrate it into the Physics Program; improvement of particle detectors, beam lines and targets for AGS experiments; continuation of a program of experiments with the Advanced Test Facility for laser acceleration studies.

III. High Energy Technology (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
BNL (Cont'd)		g-2 value; and for first operation and startup of the program of experiments with the Advanced Test Facility for laser accelerator studies.	
	$ 12,764	$ 13,575	$ 14,255
LBL	Program continues at nearly a constant level of effort. Focus continues on superconducting magnet, beam cooling and detector equipment R&D. Preparations for a two beam accelerator test using the rebuilt Experimental Test Accelerator at LLNL and experimental studies of the relativistic kylstron radiofrequency power source will continue.	R&D programs continue on superconducting magnet technology; beam instrumentation and cooling; accelerator theory; the physics of the relativistic klystron, the two-beam accelerator concept; and on advanced detector components, systems and instrumentation. Studies begin on operation of very high current storage ring technology to yield very high luminosities.	R&D continues on high-field superconducting magnet technology; beam instrumentation and cooling; advanced accelerator theory and experiment; advanced relativistic klystron theory and testing on the Experimental Test Accelerator at LLNL; very high current operation of storage rings; and R&D on advanced detector systems.
	$ 7,680	$ 8,025	$ 8,425
Universities and Other Contractors	This subprogram supports a broad range of advanced topics in advanced accelerator and detector technologies needed to maintain a strong experimental research capability in high energy physics. Research carried out in universities, industry, research institutes, and other government research centers (e.g. NBS, NRL, etc.) addresses topics ranging from development of industrial consensus standards for superconductors, through new and advanced accelerator concepts, such as the use of lasers and collective effect phenomenon to accelerate charged particles, and 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 superconductors	Continuation and expansion of the base program to utilize the special resources of universities, industry, research institutes, and government laboratories to address a broad spectrum of long range advanced technology development. A concerted effort will be made to expand the search for promising new charged particle beam acceleration concepts. First major tests of advanced accelerator concepts identified as feasible in prior year R&D will be undertaken at the advanced accelerator test facilities established as user centers at BNL and ANL. R&D on advanced, generic technology essential for large detectors operating at high event rates will be expanded to its planned level. Also includes funding for the SBIR assessment.	Continuation of the FY 1990 program. Focus continues to be utilization of the special resources of universities, industry, not for profit research institutes, and governmental laboratories to address a broad spectrum of technology development important to the very long term future productivity of the physics research. Several major tests of new charged particle acceleration schemes should be in progress at advanced test facilities established at BNL, ANL and elsewhere. Work on very high field superconducting magnets will be in progress. R&D will continue on advanced, generic technology essential for future detectors. Also includes funding for the SBIR assessment.

III. High Energy Technology (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Universities and Other Contractors (Cont'd)	(including chevrel phase compounds and the new high critical temperature materials) to accelerator magnets will be started.		
	$ 11,584	$ 19,147	$ 20,105
High Energy Technology	$ 62,878	$ 71,612	$ 75,190

DEPARTMENT OF ENERGY
FY 1991 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 to provide the secondary beam line components, particle detection apparatus, 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 major 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 or more 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 analysis 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. Priority is given in FY 1991 to final completion of two major new collider detectors, one for SLC and one for the Tevatron, and to an upgrade of the Fermilab Central Computing Facility.

II. A. Summary Table: Capital Equipment

Program Activity	FY 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Fermilab	$ 27,557	$ 29,860	$ 31,300	+ 5
SLAC	19,865	21,850	22,900	+ 5
BNL	5,457	5,440	5,710	+ 5
Universities and Other Laboratories	22,818	22,675	23,820	+ 5
BNL- General Purpose Equipment	4,050	4,240	4,450	+ 5
Total, Capital Equipment	$ 79,747	$ 84,065	$ 88,180	+ 5

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory	$ 5,457	$ 5,440	$ 5,710	+ 5
Fermi National Accelerator Laboratory	$ 27,557	$ 29,860	$ 31,300	+ 5
Stanford Linear Accelerator Laboratory	$ 19,865	$ 21,850	$ 22,900	+ 5

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

Program Activity	FY 1989	FY 1990	FY 1991
Capital Equipment			
Fermilab	Major progress towards completing the D-Zero detector in 1991 ($13,107); upgrades and improvements to fixed target detectors and secondary beam lines ($7,500); upgrades to the capabilities of the CDF detector ($2,200); site-wide additions to computing and networking capabilities ($2,150); accelerator R&D, and general site equipment ($2,600).	Full completion of the new D-Zero detector facility is expected in FY 1991. Commissioning of the partially completed detector with cosmic rays, and extensive component calibration in test beams, will take place in FY 1990, and most of the subsystems will become fully operational. ($9,900); major improvements to the CDF detector system, including components of the muon detection system upgrade and enhanced particle tracking capabilities in the small angle regions ($5,100); upgrades, improvements and new capabilities for the Fermilab fixed target detectors and beam lines, ($7,500); ongoing additions and improvements to computing and networking capabilities for the experimental areas and the central computing facility ($3,200); equipment needed in support of the accelerator complex, the accelerator R&D programs and for general purpose site support, with special efforts towards replacement of obsolete accelerator controls systems electronics and control computer equipment ($4,160).	The D-Zero detector facility will be fully completed during FY 1991 with the purchase and installation of the final electronics components. Minor upgrades to accommodate the increased luminosity expected in the near future will also be made ($4,000); significant upgrades to the CDF calorimetry and electronics, and an extension to larger acceptance of the massive muon detection systems, will be carried out ($7,300); modifications, improvements and new detector and secondary beam components in support of the fixed target research programs ($7,000); a significant addition to the Fermilab general computing capabilities and facilities in order to handle the huge amounts of raw data generated by both the collider and the fixed target research programs ($6,700); equipment needed for accelerator R&D, in support of the entire accelerator complex, including systems instrumentation needs, controls, local computing and cryogenic components, and for general site needs. ($6,300).
	$ 27,557	$ 29,860	$ 31,300

III. Capital Equipment (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
SLAC	Major progress on the SLD detector, on schedule for completion late in 1990 and first limited physics late in 1989 ($13,500); complete polarization of SLC beams and superconducting quadrupoles for SLC luminosity upgrades ($2,800); improvements to PEP and SPEAR detectors ($1,000); general computer equipment ($1,600); general laboratory support equipment ($965).	Major emphasis on completing the SLD detector with strong expectation of first full physics run late in FY 1990 ($6,500); upgrade polarization capability of SLC beam and complete the superconducting final focus for use with SLD ($1,000); general support for PEP detector ($2,000); upgrade of the central computing facility ($6,500); general computer equipment ($2,100); general laboratory support equipment ($3,750).	Major emphasis on completely commissioning the SLD detector and providing needed support for SLC ($3,400); support for Advanced Accelerator R&D ($3,400); new vertex detector for TPC at PEP ($1,000); other new experiments ($2,090); computing hardware ($3,300); and general laboratory equipment including new machine tools, HVAC upgrades, and a new 12.4 kv substation ($9,710).
	$ 19,865	$ 21,850	$ 22,900
BNL	Major emphasis on new experimental initiatives ($1,600); beam line components ($1,000); support for ongoing experiments ($1,300); support for accelerator R&D ($900); and general AGS support equipment ($657).	Continued emphasis on new experimental initiatives ($1,900); beam line components ($1,000); support for ongoing experiments ($1,300); support for accelerator R&D ($700); and general AGS support equipment ($540).	Significant funding for g-2 experiment ($1,600); support for other experiments ($1,310); beam line components ($1,100); accelerator R&D ($760); and general AGS support ($940).
	$ 5,457	$ 5,440	$ 5,710
Universities and Other Laboratories	This supports the major capital equipment needs of the experimental research groups at the universities, as well as at the non-accelerator laboratories (LBL, ANL, AMES). Provides funding for detectors and detector components to be used to do experiments at U.S. and foreign accelerators, for non-accelerator experiments, and for computational capabilities. The major effort is for Tevatron and AGS experiments, and the substantial participation in the LEP-L3 detector which is under MIT leadership. Another major effort includes U.S. participation in the ZEUS detector at HERA.	Equipment needs will continue for experiments at U.S. accelerators and for non-accelerator experiments. Additionally, equipment funding will be needed for the HERA experiments and for completion of the LEP experiments. Special consideration will be given to enhancing the technical capabilities of university laboratories and to the upgrade of local computational capabilities.	The U.S. ZEUS Collaboration will complete the central calorimeter of the ZEUS detector and thus permit initiation of a full program of electron-proton collider research at the new HERA accelerator in Hamburg, W. Germany. At Fermilab, university-based scientists will prepare and install instrumentation for fixed target experiments which will provide new knowledge into the mechanisms by which charm and beauty quarks are created and decay. Several new experiments are anticipated involving precision measurements of particle properties and/or non-accelerator experiments on high energy particle astrophysics. Throughout the university program, there is an ongoing need for upgrade of computer and other data analysis equipment, as well as infrastructure

III. Capital Equipment (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Universities and Other Laboratories (Cont'd)			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.
	$ 22,818	$ 22,675	$ 23,820
BNL- General Purpose Equipment	Provide general purpose equipment at the Brookhaven National Laboratory, for which the High Energy Physics program has landlord responsibility. Includes equipment used in administrative functions, acquisition of additional memory, storage and channels for existing IBM 3090/180 computer, and vehicles and general purpose equipment for other programmatic activities.	Provides general purpose equipment. Includes upgrade to central computing facility.	Provides general purpose equipment. Includes upgrade to central computing facility.
	$ 4,050	$ 4,240	$ 4,450
Capital Equipment	$ 79,747	$ 84,065	$ 88,180

DEPARTMENT OF ENERGY
FY 1991 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 1989 Actual	FY 1990 Estimate	FY 1991 Request	% Change
Accelerator Improvements and Modifications.....	$ 11,700	$ 13,838	$ 14,535	+ 5
Fermilab Linac Upgrade.....	0	4,634	12,000	+159
General Plant Projects.....	9,793	11,729	12,317	+ 5
AGS Accumulator/Booster.....	14,000	4,915	0	-100
Fermilab Central Computing Upgrade.....	3,632	0	0	0
Total, Construction	$ 39,125	$ 35,116	$ 38,852	+ 11

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

Program Activity	FY 1989	FY 1990	FY 1991
Construction			
Accelerator Improvements and Modifications	Essential modifications and upgrades on an annual basis to maintain the scientific effectiveness and operating reliability and cost effectiveness of accelerators, and experimental facilities. Annual AIP expenditure less than 1% of total Federal investment in these facilities.	Level of effort increased compared to FY 1989 to allow for the modifications needed to increase the intensity and reliability of the Tevatron and especially the SLC.	Constant level of effort compared to FY 1990.
	$ 11,700	$ 13,838	$ 14,535
Fermilab Linac Upgrade	No activity.	Initiate project to upgrade the Fermilab linac injector which will increase the intensity of the extracted beam for fixed target physics and the luminosity for collider physics by 50 to 75 percent. The project includes replacing a portion of the accelerator hardware in the linac resulting in an increase in the output energy from 200 to 400 Mev. This higher energy produces a smaller beam, better injection and smaller subsequent beam losses in the booster, main ring, and Tevatron. TEC - $22,800.	Production of the copper accelerating cavities begun in FY 1990 will continue through FY 1991 and several modules of them will be moved into the Linac gallery preparatory to the final installation work in FY 1992. Most of the klystron power sources will be delivered, installed, and tested. The building and utility additions to the Linac gallery will be largely completed by the end of the fiscal year.
	$ 0	$ 4,634	$ 12,000
General Plant Projects	Essential on annual basis to maintain safety and effectiveness of general laboratory plant and support facilities.	Improved level of effort compared to FY 1989 to take into account needs of new facilities and for prompt and careful attention to a number of environmental concerns.	Constant level of effort compared to FY 1990.
	$ 9,793	$ 11,729	$ 12,317
AGS Accumulator/Booster	Complete conventional construction and major procurement and fabrication of technical systems.	Complete all construction activities.	No activity.
	$ 14,000	$ 4,915	$ 0

III. Construction (Cont'd):

Program Activity	FY 1989	FY 1990	FY 1991
Fermilab Central Computing Upgrade	Acquisition of large data storage system; final completion of all parts of the project.	No activity.	No activity.
	$ 3,632	$ 0	$ 0
Construction	$ 39,125	$ 35,116	$ 38,852

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

High Energy Physics

IV. A. Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1990 Request	FY 1991 Request	Unappropriated Balance	TEC
GPE-103	General Plant Projects	$ ---	$ ---	$ 12,317	$ ---	$ 12,317
91-G-304	Accelerator Improvements and Modifications	---	---	14,535	---	14,535
90-R-104	Fermilab Linac Upgrade	---	4,634	12,000	6,166	22,800
Total, High Energy Physics Construction		$ ---	$ 4,634	$ 38,852	$ 6,166	XXX

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

High Energy Physics

IV. B. Plant Funded Construction Project

1. Project title and location: GPE-103 General Plant Projects
Various locations

Project TEC: $12,317
Start Date: 3rd Qtr. FY 1991
Completion Date: 2nd Qtr. FY 1993

2. Financial Schedule:

Fiscal Year	Appropriated	Obligations	Costs
1991	$12,317	$12,317	$ 4,300
1992	---	---	6,500
1993	---	---	1,517

3. Narrative:

(a) General Plant Projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required for general purpose, non-technical 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.

(b) 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 maintaining the productivity, increasing the operational cost effectiveness, and ensuring that necessary support services are available to the research program at the DOE-owned facilities.

(c) A description and listing of the major items of work to be performed at the various locations is contained in the Construction Project Data 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	$ 5,742
Fermi National Accelerator Laboratory	3,845
Stanford Linear Accelerator Center	2,730
Total Estimated Cost.....	$12,317

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

High Energy Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 91-G-304 Accelerator Improvements and Modifications
Various locations

Project TEC: $14,535
Start Date: 3rd Qtr. FY 1991
Completion Date: 2nd Qtr. FY 1993

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1991	$ 14,535	$ 14,535	$ 3,700
1992	---	---	5,800
1993	---	---	5,035

3. Narrative:

(a) 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.

(b) 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.

(c) A description and listing of the 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	$ 2,875
Fermi National Accelerator Laboratory	7,300
Stanford Linear Accelerator Center	4,360
Total Estimated Cost.....	$14,535

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

High Energy Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 90-R-104 Fermilab Linac Upgrade
Batavia, Illinois

Project TEC: $22,800
Start Date: 1st Qtr. FY 1990
Completion Date: 2nd Qtr. 1993

2. Financial schedule:

Fiscal Year	Appropriations	Obligations	Costs
1990	$ 4,634	$ 4,634	$ 2,500
1991	12,000	12,000	8,000
1992	6,166	6,166	7,400
1993	-	-	4,900

3. Narrative:

(a) Purpose of this project is to increase intensity of extracted beam for the fixed target physics program and luminosity for the collider physics program by approximately 50 percent.

(b) This is achieved by doubling the injection energy from the Linac into the booster to 400 MeV in order to reduce the size of the beam bunch. This in turn reduces subsequent beam losses in the booster, main ring, and Tevatron.

(c) This project replaces the downstream half of the Linac drift tube accelerating cavities and their obsolete power tubes with new cavities and modern klystron power supplies.

4. Total Project Funding (BA):

	Prior Years	FY 1990	FY 1991 Request	To Complete
Construction.....	$ 0	$ 4,634	$12,000	$ 6,166
Capital Equipment.....	150	100	100	50
Operating Expenses.....	2,470	2,100	800	1,410

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
HIGH ENERGY PHYSICS

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

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

2. Project No.: GPE-103

3. Date A-E work initiated: 2nd Qtr. FY 1991

3a. Date physical construction starts: 3rd Qtr. FY 1991

4. Date construction ends: 2nd Qtr. FY 1993

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

6. Current cost estimate: $12,317
Less amount for PE&D: 0
Net cost estimate: $12,317
Date: May 1989

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1991	$ 12,317	$ 12,317	$ 12,317	$ 4,300
1992	0	0	0	6,500
1993	0	0	0	1,517

8. Brief Physical Description of Project

These projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required at the Brookhaven National Laboratory, Fermi National Accelerator Laboratory and the Stanford Linear Accelerator Center facilities. GPP projects focus on the general laboratory facilities whereas AIP projects focus on the technical facilities.

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

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

2. Project No.: GPE-103

8. Brief Physical Description of Project (continued)

Brookhaven National Laboratory		$5,742
Site Improvements - Accelerator Development Dept.	$ 200	
Complete CBA Ring Road - Accelerator Development Dept.	200	
Office Building Addition - Accelerator Development Dept.	480	
Northwest Experimental Area Power Upgrade - AGS Dept.	250	
Building Modifications - AGS Dept.	300	
Additional Office Space - Applied Sciences Dept.	420	
Biochemical Laboratory Rehabilitation - Biology Dept.	150	
Patient Facility at the BMRR - Medical Dept.	220	
Laboratory Renovations - Medical Dept.	160	
Upgrade Basement Area - Nuclear Energy Dept.	230	
Warehouse Facility - NSLS Dept.	300	
Environmental Facilities Upgrades	1,000	
Fire Protection Upgrades	850	
Electrical Distribution Systems Improvements	800	
Life Safety Upgrades	182	
Fermi National Accelerator Laboratory		$3,845
General Utility Improvements	$ 300	
Accelerator Technical Space	1,200	
Accelerator Repair & Test Facility Addition	1,200	
Giese Road Power Station Upgrade	1,145	

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

2. Project No.: GPE-103

8. Brief Physical Description of Project (continued)

Stanford Linear Accelerator Center		$2,730*
HVAC Replacement	$ 758	
Roofing	162	
Transportation Group Facility	405	
Paving Campus Loop Roads and PEP Ring Road	352	
Replace Hydrogen Recombiner Controls	86	
Replace Cooling Tower	967	

*These projects will be constructed at the Stanford Linear Accelerator Center on non-Government owned property.

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

2. Project No.: GPE-103

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

The funds requested for FY 1991 are estimated as follows:

Brookhaven National Laboratory	$ 5,742
Fermi National Accelerator Laboratory	3,845
Stanford Linear Accelerator Center	2,730
Total Estimated Cost	$12,317

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
FY 1991 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
HIGH ENERGY PHYSICS

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

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

2. Project No.: 91-G-304

3. Date A-E work initiated: 2nd Qtr. FY 1991

3a. Date physical construction starts: 3rd Qtr. FY 1991

4. Date construction ends: 2nd Qtr. FY 1993

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

6. Current cost estimate: $14,535
Less amount for PE&D: 0
Net cost estimate: $14,535
Date: May 1989

7. Financial Schedule:

Fiscal year	Authorization	Appropriations	Obligations	Costs
1991	$14,535	$14,535	$14,535	$ 3,700
1992	0	0	0	5,800
1993	0	0	0	5,035

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

2. Project No.: 91-G-304

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..... $2,875,000

Funds are requested for modifications, improvements, and additions to the Alternating Gradient Synchrotron (AGS) and its related experimental facilities. Items planned include: improved components of the Slow Extracted Beam switchyard and extraction systems, replacement of critical components of the linac RF acceleration system and its controls; and replacement of the AGS RF power amplifiers.

Fermi National Accelerator Laboratory..... $7,300,000

Funds requested are for modifications, improvements and additions to the Fermilab accelerator facilities (which includes 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 sweeping system improvements; accelerator central control improvements; Tevatron kicker improvements; accumulator stacktail cooling system improvements; linear accelerator accelerating tank improvements; central control system improvements; Tevatron beam separator upgrade; superconducting and conventional magnet improvements; and accelerator floating point system upgrade.

Modifications to the experimental facilities are expected to include: beamline control and diagnostic upgrade; primary beam transport magnet and power supply improvements; neutrino oscillation facility; beamline for a new kaon and tagged neutrino facility; and beamline for a new kaon facility.

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

2. Project No.: 91-G-304

8. Brief Physical Description of Project (continued)

Stanford Linear Accelerator Center (SLAC)..... $4,360,000

Funds are requested for modifications, improvements and additions to the SLAC linear accelerator, the PEP and SLC colliding beam facilities, and to the associated experimental facilities. Items now planned for FY 1991 include: Linac improvements; power supply upgrades; modifications to the beam switchyard; upgrade of arcs and final focus; upgrade of the SLC kicker system; SLC control system upgrade; and replacement of PEP control computer.

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.

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No.: 91-G-304

10. Details of Cost Estimate

a. Engineering, design and inspection and component assembly and installation.....	$14,535
Total estimated cost.....	$14,535

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.

DEPARTMENT OF ENERGY
FY 1991 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
HIGH ENERGY PHYSICS

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

1. Title and location of project: Fermilab Linac Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 90-R-104

3. Date A-E work initiated: 1st Qtr. FY 1990

3a. Date physical construction starts: 1st Qtr. FY 1990

4. Date construction ends: 2nd Qtr. FY 1993

5. Previous cost estimate: $
Date:

6. Current cost estimate: $ 22,800
Date: May 1988

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1990	$ 4,634	$ 4,634	$ 4,634	$ 2,500
1991	12,000	12,000	12,000	8,000
1992	6,166	6,166	6,166	7,400
1993	-	-	-	4,900

8. Brief Physical Description of Project

This project provides for the replacement of the downstream accelerating cavities and ancillary systems of the Linear Accelerator to increase the kinetic energy from 200 MeV to about 400 MeV. It also provides for the replacement of some of the elements in the beam analysis and transport system at the end of the Linac, and injection system into the 8-GeV Booster Accelerator in order to accommodate the higher energy. Cavities in the downstream end of the Linear Accelerator will be replaced with more efficient, higher accelerating gradient cavities and a matching section will be inserted between the existing Linac cavities and the higher accelerating gradient cavities. The downstream drift tube tanks will be replaced with new structures operating at a frequency of 800 MHz, four times the operating frequency of the present Linac. The higher frequency cavities will be operated at an accelerating gradient of 7 MV/m or more compared to the 2.5 MV/m in the present drift tube system. .They will be installed in the space made available by removing the old drift-tube tanks, and will be driven by 12 MW, 800 MHz klystron type

1. Title and location of project: Fermilab Linac Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 90-R-104

8. Brief Physical Description of Project (continued)

radiofrequency power amplifiers. This new high frequency configuration will be capable of accelerating the beam from 116 MeV to about 400MeV.

In addition to the cavity structures and rf power sources, other components will be required. These include: focusing and steering elements in the Linac and along the transport line from the Linac to the Booster accelerator, an rf debunching cavity, Booster injection girder elements, and beam position, size, and bunch length monitors.

The scope of this project specifically provides for:

a) 800 MHz rf Linac cavities to accelerate the beam.
b) RF power sources and associated equipment.
c) A 200 MHz to 800 MHz matching section and power source.
d) Focusing and steering elements along the new Linac sections.
e) Diagnostic and vacuum equipment, and other associated power supplies and equipment along the new Linac sections.
f) Modifications to the beam analysis area, beam transport line to the Booster and Booster injection, consisting of changes to or replacement of magnetic or electrostatic components, rf debunching cavity, diagnostic devices and vacuum components, and other associated electronics equipment and power supplies.
g) Control system interface to integrate the new components into the Fermilab accelerator controls system.
h) Building and utility additions to the Linac gallery (about 14,000 sq ft).
i) Standby station.

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

The overall purpose of this project is to increase the collision rate in the antiproton-proton collider. The beam emittances, longitudinal and transverse, are among the critical parameters which determine beam size and consequently transmission efficiency throughout the chain of accelerators and, therefore, the final luminosity and intensity of the collisions.

1. Title and location of project: Fermilab Linac Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 90-R-104

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

When either the beam emittance grows or intensity is lost at any stage in the acceleration chain, the growth cannot be reversed and the loss cannot be restored in subsequent steps in the chain. These limitations in early stages of the chain adversely affect performance of later stages. One such limitation occurs during the first few milliseconds after injection from the Linac to the Booster where the beam transverse emittance grows significantly. This emittance growth is due to the beam tune spread resulting from electromagnetic space charge forces of the beam acting on its own individual particles. This emittance growth can be reduced by increasing the injection energy of the beam going into the Booster. Specifically, by increasing the booster injection kinetic energy from 200 MeV to about 400 MeV, the betatron tune spread at injection due to space charge will be reduced by a factor of about 1.75 at the present intensities. The transverse emittance growth will be reduced as a consequence. If this gain at Booster injection is preserved in subsequent steps of acceleration in the Booster, Main Ring and Tevatron, as expected, there will be a gain in peak luminosity in the Collider, mode as well as in the extracted beam intensity in the Fixed Target mode, by 50 to 75 percent.

In addition to beam performance improvements, this project will replace the downstream end of the present Linac, which is outdated, with a new system based on modern technology. Design and fabrication of standing-wave Alvarez linear accelerators has advanced remarkably in the last 20 years since the Fermilab 200-MeV Linac was built. The present Linac relies upon a final radiofrequency power amplifier tube, which is no longer commercially available, for each of its nine stations. Though the repair and rebuilding of each failed tube can and has been done a number of times, it cannot go on indefinitely, and represents the single largest materials and services Linac operating expense. By replacing half of the existing stations with modern 800 MHz, 12 MW klystron power sources, half of the 200 MHz output tubes can be taken out of service, reducing the operating problem and creating 4 spares for the first part of the linac. Several vendors can now make 800MHz klystrons with this peak power rating.

10. Details of Cost Estimate

	Item Cost	Total Cost
a. Engineering, design and inspection at 16% of construction costs		$ 2,600
b. Construction costs		16,450
1. Conventional construction	$ 1,850	
2. Special facilities	14,600	
c. Contingency at about 19% of above costs		3,750
Total		$22,800

1. Title and location of project: Fermilab Linac Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 90-R-104

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.

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

	Prior Years	FY 1990	FY 1991	FY 1992	FY 1993	Total
a. Total project costs						
1. Total facility costs						
(a) Construction line item	$ 0	$ 2,500	$ 8,000	$ 7,400	$ 4,900	$22,800
Total facility costs	$ 0	$ 2,500	$ 8,000	$ 7,400	$ 4,900	$22,800
2. Other project costs						
(a) R&D operating costs necessary to complete construction	2,470	2,100	800	300	0	5,670
(b) Pre-operating costs	0	0	0	420	690	1,110
(c) Capital Equipment	150	100	100	50	0	400
Total other project costs	2,620	2,200	900	770	690	7,180
Total project costs	$ 2,620	$ 4,700	$ 8,900	$ 8,170	$ 5,590	$29,980

b. Total related incremental annual funding requirements (estimated life of project: 15 years)
1. Facility operating cost-power..... $150
Total related incremental annual funding requirements..... $150

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Fermilab Linac Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 90-R-104

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

a. Total project funding

1. Total facility costs (a) Construction line item - explained in items 8, 9, and 10.

2. Other project funding
(a) Direct R&D operating costs - This will provide for the design and development of components, and for the fabrication and testing of prototypes for the special facilities.

(b) Pre-operating costs - This will provide for funds to cover the initial run-in period of the new Linac structures and the beam commissioning period. The plan is to assemble the new rf structure beside the present Linac tanks during down days and short down periods. Then only when it is ready will there be a shutdown of 2-3 months to remove the old tanks and replace them with the new sections.

b. Total related incremental annual funding requirements (estimated life of the project 15 years)

There will be an increase in cost for power, utilities, and building maintenance required for the higher energy Linac of about $150K/year. The Linac will not require any additional people to maintain or operate the new equipment.