DEPARTMENT OF ENERGY
FY 1990 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.

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 accelerator centers, Fermilab, Brookhaven National Laboratory (BNL), and Stanford Linear Accelerator Center (SLAC), each of which provides world unique capabilities and is operated as a national facility 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 being proposed for construction in a separate FY 1990 budget. Experiments are also carried out 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 mountain top 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 accelerators, colliding beam and detector facilities, 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 recent 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.

The participation of university based scientists is critical to the strength and vitality of the U.S. program. It is essential to maintain the capability of university scientists to participate effectively in world forefront experiments. With the planned strong utilization of the existing facilities, particularly the Tevatron and SLC, corresponding increases for university based scientists will be needed to allow effective participation by these scientists. Further, funds are being requested for the restoration of the technical capabilities of the major university laboratories which have significantly eroded in recent years.

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. (Starting this year, the SSC will be described in a separate budget document.)

The strategy for the overall High Energy Physics program for FY 1990 revolves around the following key factors:

- Highest priority is given to strong facilities operation and research programs at the new world forefront research capabilities of the SLC electron-positron collider and the Tevatron proton-antiproton collider. High priority is also given to operating the Tevatron fixed target program at a high level. Operation at SLAC of the upgraded Positron Electron Project (PEP) electron-positron collider with the improved Time Projection Chamber (TPC) detector and operation at BNL of the Alternating Gradient Synchrotron (AGS) program focusing on rare kaon decay, neutrino and unique polarized proton experiments are also important.

- Significant funding for the SSC project was provided in FY 1989 for R&D and preliminary design activities. First construction funding is being requested in FY 1990.

- Continued effective participation of university scientists is critical to the validity 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 training of highly skilled scientists and engineers for this and many other fields.

- The capabilities of existing U.S. high energy physics facilities must be improved to keep the U.S. program highly competitive. A key element in maintaining the competitive edge of the U.S. program is the initiation, in FY 1990, of the Fermilab Linac Upgrade project.

- 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 and unanticipated new technologies are essential to the continued enhancement and extension of accelerator and detector capabilities.

DEPARTMENT OF ENERGY
FY 1990 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
OFFICE OF ENERGY RESEARCH
(dollars in thousands)

LEAD TABLE
High Energy Physics

Activity	FY 1988 Actual	FY 1989 Estimate	FY 1990 Base	FY 1990 Request	Program Change Request vs Base	
					Dollar	Percent
Operating Expenses						
Physics Research	$114,428	$121,762	$121,762	$133,070	$+ 11,308	+ 9%
Facility Operations	230,100	252,364	252,364	277,670	+ 25,306	+ 10%
High Energy Technology	63,700	65,108	65,108	82,040	+ 16,932	+ 26%
Capital Equipment	76,700	79,800	79,800	85,500	+ 5,700	+ 7%
Construction	41,200	40,400	40,400	37,950	- 2,450	- 6%
Total	526,128	559,434	559,434	616,230	+ 56,796	+ 10%
Operating Expenses	(408,228)a/	(439,234)	(439,234)	(492,780)	+ 53,546	+ 12%
Capital Equipment	(76,700)	(79,800)	(79,800)	(85,500)	+ 5,700	+ 7%
Construction	(41,200)	(40,400)	(40,400)	(37,950)	- 2,450	- 6%
Total Program	($526,128)	($559,434)b/	($559,434)	($616,230)	$+ 56,796	+ 10%
Staffing (FTEs)	(Reference General Science Program Direction)					

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

a/ Total has been reduced by $5,470,000 ($2,270,000 Physics Research; $3,200,000 Facility Operations) 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.

DEPARTMENT OF ENERGY
FY 1990 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

SUMMARY OF CHANGES

High Energy Physics

FY 1989 Appropriation		$ 559,434
Adjustments - Increased personnel costs		0
FY 1990 Base		559,434
- Funding required to maintain a constant overall level of program activity	+	31,990
Physics Research		
- Funding to enhance technical support capabilities at the universities	+	4,002
Facility Operations		
- Strong operation for research of the new world leading collider facilities at Fermilab and SLAC	+	10,164
High Energy Technology		
- R&D needed to maintain current accelerator facilities in a state of full and effective operation, and advanced accelerator and detector R&D, including studies of advanced accelerator concepts which have reached the stage requiring experimental verification	+	13,025

Capital Equipment

- Funding to enhance technical support capabilities at the universities.....	+	912

Construction

- Initiate upgrade of Fermilab Linac.....	+	4,700
- Reduced requirement for final year of AGS Accumulator/Booster construction.....	-	9,015
- Slightly increased level of effort for AIP and GPP required to support the accelerator facilities and to support essential environmental protection efforts.....	+	4,650
- Reduction due to completion of Central Computing Upgrade at Fermilab in FY 1989.....	-	3,632
FY 1990 Congressional Budget Request.....	$	616,230

DEPARTMENT OF ENERGY
FY 1990 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 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 about 100 universities as well as at Fermilab, SLAC, BNL, LBL, ANL, LANL, Ames, ORNL, and PNL.

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 accelerators are located at three central laboratories, and 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 three 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 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), and KEK (Japan). 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 1989 will be a year of strong research output from the new world forefront Tevatron and SLC colliders and new Tevatron fixed target capabilities. A highly productive level of research activity is planned for FY 1990 as the data collected in FY 1988 and FY 1989 is analyzed and these facilities continue to operate in an intensive data taking mode. Experimental groups are planned to be supported at an increased level consistent with the operating level of these facilities. Additional funding will be provided to restore the operational effectiveness and technical capabilities of the university groups.

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Physics Research.....	$114,428	$121,762	$133,070	+ 9
Total, Physics Research.....	$114,428	$121,762	$133,070	+ 9

II. B. Major Laboratory and Facility Funding

Fermi National Accelerator Laboratory.....	$ 8,967	$ 8,400	$ 8,900	+ 6
Stanford Linear Accelerator Center.....	11,178	11,500	12,200	+ 6
Brookhaven National Laboratory.	7,272	7,747	8,000	+ 3
Argonne National Laboratory....	5,072	5,350	5,600	+ 5
Lawrence Berkeley Laboratory...	9,130	9,580	10,000	+ 4
Other Laboratories.....	2,256	1,855	1,920	+ 4
Universities and Other.....	70,553	77,330	86,450	+ 12
Total Physics Research.....	$114,428	$121,762	$133,070	+ 9

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Fermilab	Fermilab staff participate in the preparation, conduct and analysis of data from 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 first year of research (FY 87)	The Fermilab research groups will continue at about the same level of effort as in FY 1988. They will be engaged in a massive analysis effort on the large amounts of data collected during the FY 1987-88 fixed target research operations. They will also be helping to collect data during the extended FY 1988-89 collider operations period, and	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 from both the collider and the fixed target operations scheduled for FY 1990. They will also carry out the first physics checkout run of the massive

III. Physics Research (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Fermilab (Cont'd)	using the Tevatron's new collider and upgraded fixed target facilities required a major effort, as did the preparation of the publications and theoretical interpretations of this new information. Researchers also participated in extensive data taking, in both the fixed target and collider programs. There is also a theoretical research activity underway as well as a small program of high energy astrophysics research. ($8,967)	readying the next round of fixed target experiments which will begin in mid-FY 1989. The theory group will continue to pursue the most topical new results from the experimental work. Theoretical and astrophysics research will continue. ($8,400)	new D-Zero detector facility at Fermilab, since the central systems will have been completed. 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 fixed target research programs will also be undertaken. ($8,900)
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, and the first operation for research of the upgraded PEP facility with the upgraded TPC detector. In addition, there was the first operation of SPEAR for HEP following the FY 1987 shutdown. The SLAC research groups were heavily involved in conducting experiments and data taking. There was also a strong theoretical research activity. ($11,178)	It is expected that SLC will achieve enhanced luminosity. The groups will concentrate efforts on study of Z zero particles produced in the MARK II detector and tests of the new SLD detector. Data taking with the MARK III detector at SPEAR and the TPC at PEP will continue. ($11,500)	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 expectation of a first physics run. Data taking at PEP and SPEAR will continue. ($12,200)
BNL	The AGS program includes a wide variety of fixed target experiments. For FY 1988, the BNL research groups focused on experiments at the AGS	The program will continue at about the same level of effort. A major FY 1989 activity will be the data-taking on the rare kaon decay	The program will continue FY 1989 activities with significant emphasis on rare kaon decay experiments. Preliminary data taking for new

III. Physics Research (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
BNL (Cont'd)	with significant emphasis on operation of the new generation of rare kaon decay experiments. Other BNL activities include participation in the D-Zero experiment at Fermilab and experiments at CERN. ($7,272)	experiments at the AGS and continued preparation for the D-Zero experiment at Fermilab. In addition, a new initiative to measure the anomalous magnetic moment of the muon will begin. ($7,747)	neutrino oscillation search is expected to begin. Participation in the D-Zero experiment at Fermilab will continue. Early beam tests of the muon anomalous magnetic moment (g-2) experiment are anticipated. Study of proton-proton elastic scattering with the AGS polarized beam will continue. ($8,000)
ANL, LBL, and Other Labs	These groups concentrate their efforts as users at the U.S. accelerator centers and at foreign facilities with unique capabilities. The LBL program includes participation with the Mark II experiment at SLC as well as a large theoretical effort and the Particle Data Center. ($16,458)	These programs will remain at about a constant level of activity with emphasis on data taking schedules at the new Fermilab and SLAC facilities and analysis of data for physics results. ($16,785)	These programs will remain at about a constant level of activity with continued emphasis on data taking schedules at the new Fermilab and SLAC facilities and analysis of data for physics results. ($17,520)
University Program	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	The level of effort for research will be slightly increased in FY 1989 to enable university groups to participate more effectively in the data taking in FY 1989 and analysis of the data acquired in FY 1988. Continue Class IV computer upgrade and Class V mainframe acquisition at MIT initiated in FY 1988. Includes funding for the SBIR assessment. ($77,330)	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

III. Physics Research (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
University Program (Cont'd)	effort is appropriately scoped relative to the level of facility operation. ($70,553)		university laboratories. Also includes continued funding for computer acquisitions at MIT. Includes funding for the SBIR assessment. ($86,450)
Total	$114,428	$121,762	$133,070

I. Preface: Facility Operations

Provides funding for the operation of accelerators, colliders, secondary beam lines, detectors for experiments, experimental areas, and central computing facilities. Includes the costs of manpower, electric power, expendable supplies, and inventories. Major DOE supported facilities to be operated in FY 1990 include: 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 SPEAR 4 GeV on 4 GeV electron-positron collider, the PEP 15 GeV on 15 GeV electron-positron collider, and the SLC 50 GeV on 50 GeV electron-positron collider); and, BNL AGS (30 GeV proton and polarized proton fixed target program). The world forefront SLAC SLC and Fermilab Tevatron accelerators will both be available full-time for physics operation in FY 1990, as well as the AGS, PEP and SPEAR. Incremental funds will be required in FY 1990 at SLAC and Fermilab to provide for an improved level of operation for physics experiments. The FY 1990 request gives highest priority to operation of the world leading SLC and Tevatron colliders for physics research at a high level, with some additional operation of the AGS at BNL.

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Facility Operations.....	$230,100	$252,364	$277,670	+ 10
Total, Facility Operations.	$230,100	$252,364	$277,670	+ 10

II. B. Major Laboratory and Facility Funding

Fermi National Accelerator Laboratory	$115,500	$122,800	$134,500	+ 10
Stanford Linear Accelerator Center	73,400	80,200	92,400	+ 15
Brookhaven National Laboratory	39,300	41,600	44,000	+ 6
Other Operations	1,900	7,764	6,770	- 13
Total Facility Operations	$230,100	$252,364	$277,670	+ 10

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Fermilab Operations	During FY 1988 the superconducting Tevatron was in operation for physics research utilization during 8 months. Of these, 4 1/2 months were in the fixed target mode of operation at 800 GeV. During this time all of the upgraded and new secondary beam capabilities built over the last several years as the Tevatron II construction project were fully operational. Fifteen major experiments collected data, two test beams were available, and the last new beam was successfully commissioned. Ten of the experiments were fully completed, and over 35,000 high density magnetic computer tapes were filled with raw data. This concluded the most fruitful and successful fixed target run of the last 10 years, and set new records in	The Tevatron is scheduled to be in operation for research for only 8 months during FY 1989. The first 6 months will be the continuation of the colliding beam operations begun in late FY 1988 with four experiments collecting data: the massive general purpose CDF facility, and three smaller special purpose experiments. The intensity of the antiproton beams, the numbers of colliding bunches, and the corresponding collider luminosity and data rate are expected to reach new world records. Consequently the fully operational and well calibrated CDF experimental facility has enormous discovery potential and there is great optimism that major and significant new advances in our understanding of the fundamental	It is planned to operate the superconducting Tevatron for research for a full 10 months during FY 1990. The year will begin in the fixed target mode of operations begun late in FY 1989, and this run is scheduled to continue for 4 1/2 months. Of the 14 major experiments scheduled to take this data, about half are anticipated to be completed during FY 1990. This period includes the first research utilization of a new gas jet fixed target facility in the antiproton accumulator ring. After a brief scheduled 2 month maintenance changeover and study period, the FY 1990 collider run is scheduled to operate during the last 5 1/2 months of the fiscal year. There are two major new features of this run. It will be the first physics run for the

III. Facility Operations (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Fermilab Operations (Cont'd)	both instantaneous and integrated intensity of accelerated beam for a superconducting synchrotron. The 900 GeV antiproton on 900 GeV proton colliding beam operations will run for the last 3 1/2 months of FY 1988 and continue well into the next fiscal year. Data will be taken during this period by the fully completed Collider Detector at Fermilab (CDF) experimental facility and also by three other smaller experiments; similarly now fully complete. ($115,500)	properties of matter will result. Once the collider run ends there will be a roughly 4 month period of changeover to the fixed target mode of Tevatron operations, of accelerator maintenance and study periods, and the startup of the new fixed target research program. We project about 2 full months of good research data collection at the end of FY 1989, and a long continuation into the first half of FY 1990. Since 14 major experiments are on this fixed target schedule, only four of which are continuations from the FY 1988 run, another diverse and rich new research program will be started in late FY 1989. Test beams will also continue to be operated during this run. ($122,800)	new and largely-completed major second collider experimental research facility; the D-Zero detector facility, which is complementary to the capabilities of the CDF facility and it will add very important new capabilities to the Tevatron collider physics program. Furthermore, CDF will have in operation the first major systems upgrades with, in particular, a greatly increased acceptance for the detection of muons. In addition, continued improvements in the antiproton intensity capability will come into operation and are expected to yield considerable increases in the research productivity of the antiproton-proton collider program. ($134,500)
SLAC Operations	SLAC operated for about 5 months for physics with the SLC, mostly at reduced pulse rate. Operation at PEP and SPEAR for high energy physics also took place for two months at the end of the year. Funding is included for an upgrade to the central computing facility. ($73,400)	SLAC has scheduled about 32 weeks of SLC operation at 60 pulses per second for physics. Operation of PEP and SPEAR for high energy physics will also take place for about two months early in the year. Continuation of upgrade to central computing facility initiated in FY 1988. ($80,200)	SLAC has scheduled about 39 weeks of SLC operation at 120 pulses per second for physics. Operation of PEP and SPEAR will take place concurrently with SLC for about 39 and 24 weeks respectively. ($92,400)

III. Facility Operations (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
BNL-AGS Operations	AGS operated for about 15 weeks for high energy physics to include 12 weeks for slow beam operation and 3 weeks for polarized protons. Additional operation of about 8 weeks took place for heavy ion physics funded by Nuclear Physics. Therefore, total AGS operation in FY 1988 was about 23 weeks. ($39,300)	AGS will operate for about 17 weeks for High Energy Physics to be split among the various operating modes. Emphasis would be on rare kaon experiments and neutrino experiments. Additional operation of 8 weeks is planned for heavy ion physics funded by Nuclear Physics. Total AGS operation in FY 1989 would be about 25 weeks. ($41,600)	The AGS will operate for about 22 weeks for high energy physics to be split among the various modes. Emphasis will be on rare kaon decay experiments and neutrino experiments. The new AGS accumulator/booster will be commissioned. Additional operation of 8.5 weeks is planned for heavy ion physics funded by Nuclear Physics. Total AGS operation in FY 1990 would be about 30.5 weeks. ($44,000)
Other Operations	This provides funding 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 process spares, common use stores, and other specialized activities to meet requirements for effective operation of the accelerator laboratories. (SBIR funding in FY 1988 has already been transferred. ($1,900)	Continuation of FY 1988 programs at about same level of effort. Also includes funding for the SBIR assessment on the High Energy Physics program. ($7,764)	Continuation of FY 1989 programs at about same level of effort. Also includes funding for the SBIR assessment on the High Energy Physics program. ($6,770)
Total	$230,100	$252,364	$277,670

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 ongoing construction, ongoing major detectors (D-Zero and SLD), and improving existing facilities. There is also a strong

I. Preface: High Energy Technology (Cont'd)

longer term focus on development of advanced concepts leading to future accelerators, colliders, and detectors based on new concepts which will have greater performance capability and more cost effective operation. 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 Technology program is carried out primarily in the DOE laboratories, but with a significant program of advanced concept development in universities and industry. The program also includes advanced accelerator R&D studies with a particular emphasis on high energy accelerators employing superconducting magnets.

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
High Energy Technology.....	$ 63,700	$ 65,108	$ 82,040	+ 26
Total, High Energy Technology	$ 63,700	$ 65,108	$ 82,040	+ 26

II. B. Major Laboratory and Facility Funding

Fermi National Accelerator Laboratory.....	$ 15,410	$ 14,580	$ 19,400	+ 33
Stanford Linear Accelerator Center.....	13,430	14,000	17,700	+ 26
Brookhaven National Laboratory.	14,940	12,510	13,950	+ 12
Lawrence Berkeley Laboratory...	7,750	7,630	8,660	+ 13
Universities and Other.....	12,170	16,388	22,330	+ 36
Total, High Energy Technology.	$ 63,700	$ 65,108	$ 82,040	+ 26

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Fermilab	Work will continue to increase 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 future Linac upgrade 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 the fixed target and colliding beam technology. Design of high gradient 1.8K quadrupole magnets for the D-Zero interaction region will be completed and fabrication of prototypes will commence. While work continues on the CDF detector, a high emphasis is placed on support of D-Zero detector and of data analysis tools. ($15,410)	R&D in support of improving Tevatron operation for 1 TeV beam energies in FY 1990 will be carried out. Studies will continue on injector performance improvements, focusing on raising the Linac energy and on improving beam currents through use of Radio Frequency Quadrupole Accelerators with negative hydrogen ions. R&D will be carried out to improve stochastic cooling of anti-protons and collider luminosity, with the goal of raising research productivity. Facility R&D will focus on the need to complete the D-Zero detector, and make it operational in FY 1990 and on the design of a silicon strip microvertex detector for the CDF detector. ($14,580)	R&D to increase the energy, intensity and luminosity of the Tevatron will be expanded. This will include work to lower Tevatron magnet temperature from 4.8K to 4.2K, an expanded R&D effort for 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 upgrades of 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. ($19,400)

III. High Energy Technology (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
SLAC	As SLC technology becomes understood, and operation for physics research starts late in the fiscal year, R&D will be carried out to improve 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. ($13,430)	R&D to increase luminosity and performance of the SLC collider will continue. Installation and testing of most major SLD subsystems will be completed and preparation will begin for moving the detector into the interaction region. The studies of advanced concepts for colliders will continue. Studies of high efficiency radiofrequency sources, high gradient acceleration schemes, and advanced final focusing techniques will be pursued. ($14,000)	A substantially expanded program of R&D on the collider will be directed toward the luminosity improvements necessary for full physics output of the SLD. Studies of advanced collider concepts will be increased as prototype accelerator and final focus components are tested and evaluated. Development will continue on high power sources and high gradient accelerating structures. Realistic designs for a possible next generation linear collider will be explored. ($17,700)
BNL	Program includes continued R&D support for the AGS Accumulator/ Booster 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 an advanced test facility for laser accelerator studies. ($14,940)	Program will include R&D to prepare the AGS for operation at the new injection energy and intensity to be available from the booster, to pursue advanced accelerator concepts including initial experiments with the advanced test facility for laser accelerator studies, and to improve particle detectors, beam lines and targets for AGS experiments. ($12,510)	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 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 g-2 value; and for an expanded program of experiments with the advanced test facility for laser accelerator studies. ($13,950)

III. High Energy Technology (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
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 ETA at LLNL will continue. ($7,750)	Continuation of the FY 1988 programs at roughly the same level of effort. Generic detector R&D will focus on solid silicon sensors with large-area, radiation-hard, pixel arrays for operation in high background rate environments. ($7,630)	R&D programs continue on superconducting magnet technology; beam instrumentation and cooling; accelerator theory; the physics of the relativistic klystron two-beam accelerator concept; and on advanced detector components, systems and instrumentation. ($8,660)
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 new theoretical concepts in non linear charged particle beam dynamics. Some exploratory work on the development and potential application of very high critical field superconductors (including chevrel phase compounds and the new	A continuation of the base program at a somewhat enhanced level of effort. Particular emphasis will be given to development of new high power radiofrequency sources, high critical field superconductors, and development of larger scale testing of advanced accelerator concepts, such as the inverse free electron laser accelerator, which have been theoretically shown to be feasible. R&D on new technologies for large detectors operating in very high luminosity hadron colliders will be expanded. ($16,388)	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 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. ($22,330)

III. High Energy Technology (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Universities and Other Contractors (Cont'd)	high critical temperature materials) to accelerator magnets will be started. ($12,170)		
Total	$ 63,700	$ 65,108	$ 82,040

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 1990 to completion of two major new collider detectors, for SLC and Tevatron, to a major upgrade of the SLAC Central Computing Facility and to sustaining the base program efforts of the laboratories and universities at about the FY 1989 level of effort.

II. A. Summary Table

Program Activity	FY 1988	FY 1989	FY 1990	% Change
Capital Equipment.....	$ 76,700	$ 79,800	$ 85,500	+ 7
Total, Capital Equipment.....	$ 76,700	$ 79,800	$ 85,500	+ 7

II. B. Major Laboratory and Facility Funding

Fermi National Accelerator Laboratory.....	$ 25,253	$ 28,700	$ 30,600	+ 7
Stanford Linear Accelerator Center.....	18,033	21,000	22,250	+ 6
Brookhaven National Laboratory.	6,119	5,250	5,550	+ 6
Universities and Other Laboratories.....	23,395	20,800	22,800	+ 10
Brookhaven National Laboratory-Other Capital Equipment.....	3,900	4,050	4,300	+ 6
Total, Capital Equipment.....	$ 76,700	$ 79,800	$ 85,500	+ 7

III. Activity Descriptions

Program Activity	FY 1988	FY 1989	FY 1990
Fermilab	Major progress towards completing the D-Zero detector late in 1990, with initial physics capability in 1989 ($11,400); upgrades and improvements to fixed target detectors and secondary beam lines ($6,900); upgrades to the capabilities of the CDF detector ($2,800); site-wide additions to computing and networking capabilities ($1,700); accelerator R&D, and general site equipment ($2,453). ($25,253)	D-Zero detector to reach limited physics capability near the end of this year, with completion expected late in 1990 ($14,000); major improvements to the CDF detector including extension of muon detection systems to full solid angle coverage ($3,100); new and upgraded detectors and secondary beams for the fixed target research program ($6,850); computing equipment for the central facility and experimental areas ($1,750); accelerator R&D, and general site equipment ($3,000). ($28,700)	Full completion of the new D-Zero detector facility is expected in mid FY 1991. The first physics run with the partially completed detector will take place in mid-FY 1990, and the final subsystems will become fully operational early in FY 1991 ($11,500); major improvements to the CDF detector system, including completion 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, including the first significant additions since the mid-1980's ($7,000); ongoing additions and improvements to computing and networking capabilities

III. Capital Equipment (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Fermilab (Cont'd)			for the experimental areas and the central computing facility ($2,100); 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 ($4,900). ($30,600)
SLAC	Major emphasis on proceeding with SLD detector on a schedule for completion in 1990 with limited first physics in late in 1989 ($13,400); completion in 1990; Mark II and Mark III improvements ($520); polarization of SLC beams ($1,100); superconducting final focus of SLC beams ($1,750); general laboratory support equipment ($1,263). ($18,033)	Major progress on 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 ($2,100); improvements to PEP and SPEAR detectors ($1,000); general computer equipment ($1,600); general laboratory support equipment ($2,800). ($21,000)	Major emphasis on completing the SLD detector with strong expectation of first full physics run in FY 1990 ($6,500); upgrade polarization capability of SLC beam and complete the superconducting final focus ($1,000); general support for PEP and SPEAR detectors ($2,000); upgrade of the central computing facility ($7,500); general computer equipment ($2,100); general laboratory support equipment ($3,150). ($22,250)
BNL	Major emphasis on new experimental initiatives ($2,000); beam line components ($1,000); support for other experiments ($800); support for accelerator R&D ($1,339); general AGS support equipment ($980). ($6,119)	Continued emphasis on new experimental initiatives ($1,600); beam line components ($1,000); support for ongoing experiments ($1,300); support for accelerator R&D ($600); and general AGS support equipment ($750). ($5,250)	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 ($650). ($5,550)

III. Capital Equipment (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
Universities and Other Laboratories	This supports the major capital equipment needs of the experimental research groups at the universities and 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 detectors, 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. ($23,395)	Equipment needs will continue for preparation of Tevatron fixed target experiments and non-accelerator experiments. Additional needs are expected for U.S. groups participating in LEP and HERA experiments, as LEP experiments begin initial data taking with partially complete detectors. ($20,800)	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 upgrades to the LEP experiments. Special consideration will be given to enhancing the technical capabilities of university laboratories and to the upgrade of local computational capabilities. ($22,800)
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, vehicles and general purpose equipment for other programmatic activities. ($3,900)	Includes acquisition of additional memory, storage and channels for existing IBM 3090/180 computer, and vehicles and general purpose equipment for other programmatic activities. ($4,050)	Provides general purpose equipment. Includes major upgrade to central computing facility. ($4,300)
Total	$ 76,700	$ 79,800	$ 85,500

III. Activity Description

Program Activity	FY 1988	FY 1989	FY 1990
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. ($11,200)	Same level of effort as FY 1988. ($11,700)	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. ($14,855)
Fermilab Linac Upgrade	No activity.	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. ($4,700)
General Plant Projects	Essential on annual basis to maintain safety and effectiveness of general laboratory plant and support facilities. ($10,700)	Slight increase in level of effort compared to FY 1988. ($11,068)	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. ($13,410)

III. Construction (Cont'd)

Program Activity	FY 1988	FY 1989	FY 1990
AGS Accumulator/Booster	Continue construction project. Initiate ring tunnel construction and procurement of technical components. TEC $31,700, remaining funds in FY 1989 and FY 1990. ($8,300)	Complete conventional construction and major procurement and fabrication of technical systems. ($14,000)	Complete all project activities. ($4,985)
Fermilab Central Computing Upgrade	Provides for procurement of large processor. ($11,000)	Final project funding. Includes some ADP hardware and site completion work. ($3,632)	No activity.
Total	$41,200	$40,400	$ 37,950

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KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

High Energy Physics

IV. A. Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1989 Appropriated	FY 1990 Request	Unappropriated Balance	TEC
90-R-101	Accelerator Improvements and Modifications	$ ---	$ ---	$ 14,855	$ ---	$ 14,855
90-R-104	Fermilab Linac Upgrade	---	---	4,700	18,100	22,800
86-R-105	AGS Accumulator/Booster	12,715	14,000	4,985	0	31,700
GP-E-103	General Plant Projects	---	---	13,410	---	13,410
Total, High Energy Physics Construction		$ 12,715	$ 14,000	$ 37,950	$ 18,100	XXX

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

High Energy Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 90-R-101 Accelerator Improvements and Modifications
Various locations

Project TEC: $14,855
Start Date: 3rd Qtr. FY 1990
Completion Date: 2nd Qtr. FY 1992

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1990	$ 14,855	$ 14,855	$ 3,800
1991	---	---	6,000
1992	---	---	5,055

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	$ 2,755
Fermi National Accelerator Laboratory	7,420
Stanford Linear Accelerator Center	4,680
Total Estimated Cost.....	$14,855

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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	$ 4,700	$ 4,700	$ 2,500
1991	12,000	12,000	8,000
1992	6,100	6,100	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 kylstron power supplies.

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KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

High Energy Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 86-R-105 AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, New York

Project TEC: $31,700
Start Date: 3rd Qtr. FY 1986
Completion Date: 2nd Qtr. FY 1991

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1986	$ 1,915	$ 1,915	$ 1,207
1987	2,500	2,500	1,939
1988	8,300	8,300	3,841
1989	14,000	14,000	13,200
1990	4,985	4,985	10,000
1991	---	---	1,513

3. Narrative:

(a) The Accumulator/Booster (A/B ring) is a rapid cycling synchrotron that serves as an intermediate stage between the present linac injector or tandem Van de Graaff and the Alternating Gradient Synchrotron (AGS) for protons, polarized protons, and heavy ions.

(b) The Accumulator/Booster will improve the performance and capabilities of the AGS for (1) normal proton operation, (2) operation with polarized protons and (3) operation with heavy ions. For normal proton operation, beam intensity will be raised by a factor of 4; for polarized proton operation, beam intensity will be raised by a factor of more than 20; and, for heavy ion operation, ion mass capability will be extended from mass 32 to about mass 200. In each of these three modes of operation, the increased capability will have direct and immediate benefits by making accessible areas of science not previously accessible or by significantly increasing the data collection rate for the experimental program already planned and underway at the AGS.

(c) The FY 1990 funding will continue construction of AGS Accumulator/Booster and will permit completion of the project with assembly, installation and test of technical systems, including ring magnets and power supplies, RF systems, vacuum systems, injection and ejection systems, and beam monitor and control instrumentation.

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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: GP-E-103 General Plant Projects
Various locations

Project TEC: $13,410
Start Date: 3rd Qtr. FY 1990
Completion Date: 2nd Qtr. FY 1992

2. Financial Schedule:

Fiscal Year	Appropriated	Obligations	Costs
1990	$13,410	$13,410	$ 4,500
1991	---	---	7,000
1992	---	---	1,910

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	$ 6,300
Fermi National Accelerator Laboratory	3,700
Stanford Linear Accelerator Center	3,410
Total Estimated Cost.....	$13,410