DEPARTMENT OF ENERGY
FY 1992 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH

OVERVIEW

HIGH ENERGY PHYSICS

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

High energy physics is a major contributor to the National Energy Strategy (NES) goal "Fortifying our Foundations". As stated above, high energy physics research 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. In addition, high energy physics has proven to be an extremely challenging and appealing intellectual activity. High energy physics has attracted and continues to attract some of the best minds in the nation and has provided substantial and sustained input to the intellectual excitement and ferment which fuels the nation's science and engineering enterprise. High energy physics is widely known to be an excellent discipline for the training of physicists, and many high energy physics Ph.D. recipients go on to highly productive careers in other scientific disciplines.

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

Fermi National Accelerator Laboratory (Fermilab) is one of the outstanding scientific institutions in the world. The accelerator at the recently formed Superconducting Super Collider Laboratory (SSCL) will have unparalleled capabilities. Thus, high energy physics contributes in a major way to the world preeminence of the nation's scientific and technical enterprise.

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 budget contained herein is divided into major categories. 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 excellent research in high energy physics.

There are three DOE supported high energy physics accelerator centers: Fermilab, Stanford Linear Accelerator Center (SLAC), and Brookhaven National Laboratory (BNL). Each of these laboratories provides 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 Laboratory. Funding for construction of the Superconducting Super Collider (SSC) is included in a separate FY 1992 budget request.

Experiments by U.S. scientists are also carried out at the Cornell Electron Storage Ring (CESR) which is largely supported by the National Science Foundation. In addition, U.S. experimenters carry out research at foreign accelerators with unique capabilities not available in the U.S. Finally, some important experiments do not require accelerators, but instead take advantage of processes that occur in the natural environment, sometimes deep underground, deep underwater, or on mountaintops. 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. This 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. The Tevatron is unique and operating at full intensity. It keeps the U.S. program highly competitive and at the cutting edge for the next several years. SLC should approach the level of 100,000 polarized Z^0's per year by the end of 1991 and will contribute new and unique opportunities. 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 use of 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 beyond the 1990's. 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 1992 revolves around the following key factors:

- o Operations of the forefront research capabilities of the SLC collider and of the Tevatron accelerator/collider will be conducted at the maximum reasonable level. The Tevatron collider operations in FY 1992 will allow research utilization both of the mature Collider Detector at Fermilab (CDF) and of the complementary new D-Zero detector facility. The SLC will be operated for physics research with its new polarized electron beam capability and with the SLC Large Detector (SLD). The Positron Electron Project (PEP) electron-positron collider with the improved Time Projection Chamber (TPC) detector is expected to be operated at SLAC. With its new booster becoming operational, BNL's Alternating Gradient Synchrotron (AGS) will provide improved direct tests of the Standard Model via detailed study of rare decay modes of kaons.

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

- 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.

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

DEPARTMENT OF ENERGY
FY 1992 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)
LEAD TABLE

High Energy Physics

Activity	FY 1990 Actual	FY 1991 Estimate	FY 1992 Base	FY 1992 Request	Program Change Request vs Base Dollar	Program Change Request vs Base Percent
Operating Expenses						
Physics Research.............	$131,068	$137,020	$137,020	$150,370	$+ 13,350	+ 10%
Facility Operations..........	257,327	260,370	260,370	275,690	+ 15,320	+ 6%
High Energy Technology.......	68,722	69,355	69,355	73,830	+ 4,475	+ 6%
Capital Equipment.............	84,065	82,990	82,990	87,740	+ 4,750	+ 6%
Construction..................	35,116	38,852	38,852	78,819	+ 39,967	+ 103%
Total.....................	576,298	588,587	588,587	666,449	+ 77,862	+ 13%
Operating Expenses............	(457,117)a/	(466,745)	(466,745)	(499,890)	(+ 33,145)	+ 7%
Capital Equipment.............	(84,065)	(82,990)	(82,990)	(87,740)	(+ 4,750)	+ 6%
Construction..................	(35,116)	(38,852)	(38,852)	(78,819)	(+ 39,967)	+ 103%
Total Program.............	($576,298)	($588,587)	($588,587)	($666,449)	(+ 77,862)	+ 13%

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

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

a/ Total has been reduced by $5,779,000 ($2,889,000 Facility Operations, $2,890,000 High Energy Technology) reprogrammed to Energy Supply for SBIR.

DEPARTMENT OF ENERGY
FY 1992 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

SUMMARY OF CHANGES

High Energy Physics

FY 1991 Enacted Appropriation..		$ 588,587
Adjustments - Increased personnel costs..		0
FY 1992 Base...		588,587
- Funding required to maintain a constant overall level of program activity............	+	27,158
- Funding provided to partially alleviate temporary measures taken to accomodate the FY 1991 budgetary constraints..	+	5,836
Physics Research		
- Physics research at a level consistent with the operating level of the facilities and in support of the High Energy Physics research program at the SSC....................	+	5,525
Facility Operations		
- Increase in facility operations funding to provide for an improved level of operations for physics experiments at SLAC and Fermilab..	+	415
High Energy Technology		
- Slight increase in level of effort for advanced high energy physics technology R&D....	+	500

Construction

- Initiate Fermilab Main Injector construction project	+	43,450
- Increase level of effort for AIP and GPP required to support the accelerator facilities	+	812
- Reduction for final year of funding for ongoing Fermilab Linac Upgrade project	-	5,834
FY 1992 Congressional Budget Request	$	666,449

DEPARTMENT OF ENERGY
FY 1992 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, identifies 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. The balance of the research is done by scientists at the accelerator laboratories and certain other DOE laboratories. Because of the size and complexity of a typical high energy physics experiment, users from a number of institutions frequently collaborate on a given experiment. These research teams typically include a mix of physicists, engineers, technicians, and graduate students. After a research proposal to the laboratory is approved, the research teams participate in the design and fabrication of the experimental apparatus and provide manpower for the experiment during the data-taking phase at the laboratory. There is significant interaction and participation from laboratory staff and use of laboratory support facilities for each experiment. The entire process, from conception of the experiment to publication of results, typically takes up to five years if no major new detector is involved; if major detector design and fabrication is involved, the total duration can be several years longer. U.S. user groups also participate in experiments which take advantage of unique accelerator capabilities and opportunities at other laboratories; for example, the Cornell Electron Storage Ring (CESR), supported by the U.S. National Science Foundation, and at foreign laboratories such as DESY (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 1992 will be a year of strong research output as the data collected in FY 1992 and previous years is analyzed from the world forefront SLC collider with the recently installed SLD detector and the Tevatron collider with its CDF and D-Zero collider detectors. 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 1992 will include significant effort on planning for experiments for the SSC.

II. A. Summary Table: Physics Research

Program Activity	FY 1990 Enacted	FY 1991 Enacted	FY 1992 Request	% Change
Fermilab	$ 8,735	$ 8,720	$ 9,220	+ 6
SLAC	11,960	11,900	12,580	+ 6
BNL	7,710	7,840	8,290	+ 6
ANL and LBL	15,700	16,255	17,190	+ 6
Universities and Other Labs	86,963	92,305	103,090	+ 12
Total, Physics Research	$ 131,068	$ 137,020	$ 150,370	+ 10

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory	$ 5,560	$ 5,550	$ 5,870	+ 6
Brookhaven National Laboratory	$ 7,710	$ 7,840	$ 8,290	+ 6
Fermi National Accelerator Laboratory	$ 8,735	$ 8,720	$ 9,220	+ 6
Lawrence Berkeley National Laboratory	$ 10,140	$ 10,705	$ 11,320	+ 6
Stanford Linear Accelerator Laboratory	$ 11,960	$ 11,900	$ 12,580	+ 6

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

Program Activity	FY 1990	FY 1991	FY 1992
Physics Research			
Fermilab	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.	During this fiscal year, the extended fixed target physics research operating period begun in mid-FY 1990 will be concluded. Twelve major experiments will complete their data taking phase, and the Fermilab research groups will enter into an intensive effort of data reduction and physics analysis. Other research groups will be preparing for a lengthy period of operations with the two collider detector facilities. The theory and particle astrophysics groups will continue to pursue the most topical new results.	The major efforts of most of the Fermilab research physicists will be devoted to an extended period of Tevatron collider operations in FY 1992. The upgraded CDF detector facility and the newly commissioned D-Zero detector facility will both undertake lengthy data-taking periods through the first 9 months of the fiscal year. The unprecedented Tevatron luminosity which is anticipated will result in an exceptionally high volume of raw data. A great deal of effort will also be dedicated to the physics analysis and preparation of publications based on the FY 1990-1991 fixed target operations period. Preparation of apparatus and software for the upcoming FY 1993 fixed target run will also be undertaken. The theoretical physicists will interpret new results as they become available and refine their models and analyses as needed.
	$ 8,735	$ 8,720	$ 9,220
SLAC	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 early in FY 1991. 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 by the end of calendar year 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 productive year.	By the end of calendar year 1991, it is expected that the SLC will have reached the level of 100,000 Z zero's per year with polarized beam in the SLD. Further increases in luminosity during FY 1992 should occur. The combination is expected to yield new physics and maximal effort will be made to operate as many SLD hours as feasible. Analysis of Mark II data will be winding down. Research groups will continue to use SLC-SLD's unique characteristics to study Z zero properties and other physics in this energy region. Data taking at PEP is planned to resume and

Program Activity	FY 1990	FY 1991	FY 1992
SLAC (Cont'd)			analysis is expected to yield new physics.
	$ 11,960	$ 11,900	$ 12,580
BNL	The program will continue FY 1989 activities with significant emphasis on rare kaon decay experiments. Preparation for the D-Zero experiment at Fermilab will continue. Study of proton-proton elastic scattering with the AGS polarized beam will continue. Fabrication of the new muon anomalous magnetic moment detector 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.	With the exploitation of the four-fold increase in proton beam intensity and the 25-fold increase in the polarized beam intensity, the rare kaon decay experiments and proton-proton elastic scattering are expected to begin to yield interesting new results. The muon anomalous magnetic moment (g-2) experiment will benefit significantly from the increased beam intensity. The D-Zero detector at Fermilab is expected to run most of FY 1992 with the Tevatron collider. Analysis of D-Zero data is expected to provide important new physics results.
	$ 7,710	$ 7,840	$ 8,290
ANL and LBL	Experimental groups at these two laboratories collaborate with university groups to propose, construct, and operate frontier high energy physics experiments. Major efforts for ANL presently are concentrated at Fermilab, at HERA in Germany, and at the SOUDAN-2 proton decay experiment in Minnesota; those for LBL are focused at CDF and D-Zero at Fermilab, and at Mark II and the Time Projection Chamber (TPC) at SLAC. Both ANL and LBL have strong theoretical groups, with ANL putting particular emphasis on phenomenology closely tied to experimental results. LBL maintains an astrophysics group and operates the Particle Data Center. Both labs are major collaborators in the Solenoidal Detector Collaboration,	The activity level at these two laboratories remains steady. ANL leadership of the U.S. participation in the ZEUS electron-proton experiment at HERA/DESY continues as construction is completed and commissioning begins. ANL also provides a major role in instrumentation and analysis for the CDF detector and continued leadership of both the polarized scattering program at Fermilab and the SOUDAN-2 proton decay experiment. LBL continues its strong participation in both the D-Zero and CDF detectors at Fermilab and will continue to have a major role in analysis of Mark II and TPC data. At both ANL and LBL, work on the Large Solenoid Detector continues to move toward a complete technical proposal.	Experimental groups at both ANL and LBL will concentrate on taking and analyzing data from detectors at colliding beam facilities with beams of energies and intensities previously unavailable. The ANL program will include the ZEUS electron-proton detector at DESY in Hamburg and CDF at Fermilab. The LBL program will include both CDF and D-Zero at Fermilab. The SOUDAN-2 detector, with leadership from ANL, will be in its final year of construction. A large fraction of the effort at both labs given to detector development will be focused on the Large Solenoid Detector which has been selected to be one of the first experiments at the SSCL.

III. Physics Research (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
ANL and LBL (Cont'd)	working on the design and technical development of components for the Large Solenoid Detector proposed for the SSC.		
	$ 15,700	$ 16,255	$ 17,190
Universities and Other Labs	This program supports experimental and theoretical research groups at about a hundred universities and four other DOE laboratories throughout the nation. The university groups participate in experiments at the major U.S. 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.	Groups at universities and other DOE laboratories 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.	Groups at universities and other DOE laboratories (including scientists at SSC lab) will participate in major experiments at U.S. and foreign laboratories. Also, many of the groups will engage in planning and R&D activities in preparation for experiments at the SSC. Important new experiments will continue initial running, including: the SLD experiment at the SLC (SLAC); the D-Zero experiment at the Tevatron (Fermilab); and, the ZEUS experiment at HERA (DESY). Also, the precision measurement of the muon's anomalous magnetic moment will be in final stages of preparation at BNL, as will the MACRO experiment (Italy), the SOUDAN II experiment (Minnesota), and the DUMAND experiment (Hawaii). The manpower, technical, and computational capabilities of leading universities will be increased somewhat to better analyze the voluminous data produced by cutting edge experiments.
	$ 86,963	$ 92,305	$ 103,090
Physics Research	$ 131,068	$ 137,020	$ 150,370

DEPARTMENT OF ENERGY
FY 1992 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 and maintenance 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, replacement parts and subsystems, and inventories. The major DOE supported facilities to be operated in FY 1992 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) with the newly commissioned AGS booster. The world forefront SLAC SLC and Fermilab Tevatron accelerators will both be operated for physics for most of FY 1992.

II. A. Summary Table: Facility Operations

Program Activity	FY 1990 Enacted	FY 1991 Enacted	FY 1992 Request	% Change
Fermilab Operations	$ 129,780	$ 129,515	$ 136,930	+ 6
SLAC Operations	85,250	85,400	90,290	+ 6
BNL-AGS Operations	36,825	38,535	42,240	+ 10
Other Operations	5,472	6,920	6,230	- 10
Total, Facility Operations	$ 257,327	$ 260,370	$ 275,690	+ 6

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory	$ 36,825	$ 38,535	$ 42,240	+ 10
Fermi National Accelerator Laboratory	$ 129,780	$ 129,515	$ 136,930	+ 6
Stanford Linear Accelerator Laboratory	$ 85,250	$ 85,400	$ 90,290	+ 6

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

Program Activity	FY 1990	FY 1991	FY 1992
Facility Operations			
Fermilab Operations	The superconducting Tevatron will be operated for research for 28 weeks during FY 1990. The first several 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 source 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. Five of the sixteen major experiments will complete data taking this year. 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 26 weeks. This will be a continuation of the fixed target research program and the test beam activities begun in 1990. All but four of the sixteen approved fixed target experiments at Fermilab will fully complete their data-taking during this year, and those four will accumulate significant quantities of new research data. When operations for research end in the summer of 1991, major efforts will commence in preparation for operations of the antiproton-proton colliding beam research program for FY 1992. This will require that the two massive collider detector facilities at Fermilab be moved into their respective interaction regions and made ready for operation. These are the seasoned and recently upgraded CDF detector facility, and the newly completed and complementary D-Zero detector facility.	The Tevatron is scheduled to be operated for the colliding beam research program for a 38 week long period starting early in FY 1992. The data-taking will utilize the two major Fermilab collider detector facilities, CDF and D-Zero. The proton and antiproton beams will for the first time be prevented from colliding anywhere except at these two detectors, thus enhancing the luminosity provided for them. The CDF detector has been significantly upgraded since its last run and will have a higher data rate capability than before. FY 1992 will be the first operating period for the new D-Zero detector facility. Having two detectors simultaneously in operation will effectively double the physics utilization of the Tevatron collider relative to previous runs. Considerably increased luminosity will also be available to each detector facility, so that data taking at unusually high rates is anticipated for this FY 1992 operating period. The Tevatron will have to be shut down late in FY 1992 in order to accomplish installation work related to completion of the Linac Upgrade construction project.
	$ 129,780	$ 129,515	$ 136,930

III. Facility Operations (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
SLAC Operations	Because of the need to realign SLC after the October 1989 earthquake, 9 - 10 weeks of SLC running has been devoted to machine physics. It is expected that about 16 weeks at 120 pulses per second (pps) will be devoted to a major data taking run with the Mark II detector. PEP with the TPC detector is expected to run about 13 weeks. Includes continuation of computer lease.	SLAC has scheduled about 20 weeks of SLC operation divided between continued accelerator and beam studies (at 10 and 60 pps) to achieve higher luminosity and physics running (at 120 pps) for physics research. Although the Mark II detector will continue during the first month, most of the physics running will be with the superior SLD detector. Polarized beams in SLC are expected to be regularly available by the end of FY 1991. Includes continuation of computer lease.	SLAC has scheduled about 22 weeks of SLC operations at 120 pps for physics research. It is planned to operate PEP concurrently with SLC for 18 weeks. Polarized beams in SLC are expected to be regularly available during the 1992 running. With significantly improved luminosity, polarized beams in the SLD are expected to yield important new physics results. Includes continuation of computer lease.
	$ 85,250	$ 85,400	$ 90,290
BNL-AGS Operations	The AGS is scheduled to operate for about 16 weeks of slow extracted beam for high energy physics. 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 23 weeks.	The AGS will operate for about 14 weeks for high energy physics. Rare kaon decay experiments will continue. Other experiments during this time will include two searches six-quark states and there will be tests of calorimeter modules for SSC detectors. About 10 weeks of heavy ion physics funded by Nuclear Physics is also planned. Total AGS operation in FY 1991 would be about 24 weeks.	The AGS is expected to operate for about 16 weeks of slow extracted beam. The AGS accumulator booster will be commissioned enhancing the intensity of the proton beams by about a factor of four. As planned, rare kaon decay experiments should begin to yield significant direct tests of the Standard Model. The enhanced intensity will also aid the muon anomalous magnetic moment experiment. Testing of SSC detector modules will continue. About 10 weeks of heavy ion physics, funded by Nuclear Physics is also planned. Total AGS operation in FY 1992 would be about 26 weeks.
	$ 36,825	$ 38,535	$ 42,240
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. Funding for the SBIR assessment has been removed.	Includes computer networking activities and funding for the SBIR assessment on the HEP program.	Continuation of FY 1991 program at about the same level of effort. Includes computer networking activities and funding for the SBIR assessment on the HEP program.

III. Facility Operations (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
Other Operations (Cont'd)	Implemented plans for the Energy Sciences Network (ESNET) project as identified in the Applied Mathematical Sciences subprogram of the Basic Energy Sciences program. This subprogram's share for the implementation of ESNET was $1,085.	Upgrades of ESNET to conform to the National Research and Education Network Standards will continue to be implemented; funding will be shared among ER programs that benefit from ESNET. This subprogram's share is $1,085.	ESNET will be fully supported in the Applied Mathematical Sciences subprogram of the Basic Energy Sciences Program.
	$ 5,472	$ 6,920	$ 6,230
Facility Operations	$ 257,327	$ 260,370	$ 275,690

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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 research capabilities. There is also a strong longer term focus on development of advanced concepts leading to greater performance capability and more cost effective operation of accelerator and detector facilities. Includes theoretical studies of accelerator physics; exploration of new concepts for particle acceleration, storage, and transport; and fabrication and testing of apparatus based on these studies. Also includes studies of new types of detectors and improved detector performance, for example: improved particle identification, improved precision in delineating tracks and locating vertices, decrease in susceptibility to degradation of performance caused by nuclear radiation, etc. The High Energy Physics Technology program is carried out primarily in the DOE laboratories, but with a significant program of advanced concept development in universities and industry. Since the limits of present accelerator technology are being reached by present generations of existing and planned machines (SSC, LEP at CERN), a strong effort focuses on a search for new accelerator technologies applicable to the long term needs (beyond the year 2000) for high energy physics research.

II. A. Summary Table: High Energy Technology

Program Activity	FY 1990 Enacted	FY 1991 Enacted	FY 1992 Request	% Change
Fermilab	$ 15,905	$ 15,870	$ 17,280	+ 9
SLAC	14,960	14,900	16,250	+ 9
BNL	13,575	12,370	12,080	- 2
LBL	8,025	8,465	8,950	+ 6
Universities, Other Laboratories, and Other Contractors	16,257	17,750	19,270	+ 9
Total, High Energy Technology	$ 68,722	$ 69,355	$ 73,830	+ 6

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory	$ 13,575	$ 12,370	$ 12,080	- 2
Fermi National Accelerator Laboratory	$ 15,905	$ 15,870	$ 17,280	+ 9
Lawrence Berkeley National Laboratory	$ 8,025	$ 8,465	$ 8,950	+ 6
Stanford Linear Accelerator Laboratory	$ 14,960	$ 14,900	$ 16,250	+ 9

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

Program Activity	FY 1990	FY 1991	FY 1992
High Energy Technology			
Fermilab	R&D is directed at improving the energy, intensity and luminosity of the Tevatron. This includes R&D in support of the Linac Upgrade project and work on a new radio frequency quadrupole preinjector, evaluation of improved accelerating structures, tests 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 is underway as is a program to improve performance of the antiproton source. A major emphasis during this period is 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 system is the original warm iron magnet Main Ring. A second, related emphasis is on R&D for future luminosity improvements for the superconducting Tevatron storage ring. R&D in support of detector facilities includes 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 continues. This includes work on the linac low energy injection system and on booster accelerator 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 rates will be raised by improving beam cooling hardware, raising production target performance by sweeping the proton beam, increasing target beamline particle acceptance, and improving controls. A program to lower Tevatron temperature by 0.5 K and reach 1000 GeV studied over recent years will now start to be implemented. 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 special efforts begun in FY 1990 on luminosity improvements, much of which involve studies for the new 150 GeV 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.	R&D efforts will continue on components and technologies required to increase the energy, extracted beam intensity, and the colliding beam luminosity of the superconducting Tevatron. There will be a major R&D effort related to the new Main Injector construction project in connection with final design of the Main Injector ring dipole magnets and their power supplies, special quadrupole magnets, control systems, and the radiofrequency accelerating systems. Work will continue on low-beta insertions and the beam separation system, supporting operation with more than six bunches in the Tevatron, as well as work on antiproton source cooling systems, controls, and diagnostics. The last year of R&D associated with the Linac Upgrade will continue with a view to completing the project and beginning commissioning studies. R&D is also included on improvements to beam transport, targeting system designs, and new particle detection techniques. Studies for future improvements to the Collider Detector at Fermilab (CDF) and D-Zero detectors, and for advanced data handling and computing systems, will also continue.

III. High Energy Technology (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
Fermilab (Cont'd)	$ 15,905	$ 15,870	$ 17,280
SLAC	An expanded program of R&D is directed toward the luminosity improvements necessary to support full physics utilization of the SLC with polarized electron beams. Studies of advanced collider concepts increase as prototype accelerator and final focus components are proposed and evaluated. Development continues on high power microwave sources and high gradient accelerating structures. R&D will be done in support of a Final Focus Test Beam 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 (B factory) were begun.	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, particularly with polarized electrons, 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 in support of the technology for TeV linear colliders, endorsed by a 1990 HEPAP study, will continue with development of several new high power microwave sources operating at frequencies of 11 GHz or higher and power levels 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 Beam facility begun in FY 1990 to study electron and positron beams of nanometer radii needed in very high energy linear colliders. Studies for an ultra high luminosity B factory design and operation, also endorsed by the 1990 HEPAP study, will intensify. The generic activities in support of detector technology development will continue.	A strong R&D program to support improved operation of the SLC for physics research using polarized electrons will continue. Consistent with HEPAP recommendations, R&D on advanced Accelerator concepts needed for development of linear colliders in the TeV range will build on machine studies carried out with SLC, initial operation of the Final Focus Test Beam facility (scheduled for completion in FY 1992), advanced theoretical studies, and work on development of new and more cost-effective high power microwave sources with a view to developing an integrated system. R&D will continue on development of high powered, highly efficient microwave sources operating at or above 11 GHz. R&D on an ultra high luminosity B factory utilizing the PEP storage ring, as recommended by HEPAP, will continue. Generic R&D to develop detector technology needed to do physics research in a very high luminosity, high radiation environment will continue.
	$ 14,960	$ 14,900	$ 16,250

III. High Energy Technology (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
BNL	Program includes continued R&D support 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 g-2 value; and for completion of the Advanced Test Facility for laser accelerator studies, and preparation of experiments to test these and other new acceleration methods.	Continued R&D programs to improve AGS operation, commission the Booster accelerator and integrate it into the physics program; improvement of particle detectors, beam lines and targets for AGS experiments; expanded support to begin a program of experiments with the Advanced Test Facility to test new acceleration concepts and high brightness radiation sources. Reduction in funding for the generic magnet R&D program reflecting a shift in emphasis away from HEP applications.	Continuation of R&D programs to improve flexibility, reliability and economy of AGS operation and to reduce radiation levels and maintenance requirements; improvement of particle detectors, beam lines and targets for AGS experiments. With completion of the AGS Booster, R&D related to that machine is greatly reduced. An expanded program of experiments in new acceleration concepts with the Advanced Test Facility and to further develop ultra bright radiation sources is planned. Additional reduction in funding for the generic magnet R&D program.
	$ 13,575	$ 12,370	$ 12,080
LBL	R&D program focuses on superconducting magnet technology; beam instrumentation and cooling; accelerator theory; the physics of the relativistic klystrons; the two-beam accelerator concept; and on advanced detector components, systems and instrumentation. Studies begin on the special physics issues relevant to very high luminosity colliding beam devices.	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; physics of very high luminosity colliders with a special focus on electron-positron "B-factory" colliders as recommended by the recent HEPAP subpanel and R&D on advanced detector systems.	R&D continues at nearly a constant level of effort on high-field superconducting magnet technology; beam instrumentation and cooling; advanced accelerator theory and experiment; advanced high power microwave sources and the two-beam acceleration concept; physics of very high luminosity colliders; and R&D on advanced detector systems.
	$ 8,025	$ 8,465	$ 8,950

III. High Energy Technology (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
Universities, Other Laboratories, and Other Contractors	This subprogram supports a broad range of topics in advanced accelerator and detector technologies needed to ensure a strong future experimental research capability in high energy physics. Research carried out in universities, industry, research institutes, and other government research centers (e.g. NIST, NRL, etc.) addresses topics ranging from development of improved superconductors through new and advanced accelerator concepts, such as the use of lasers and collective effect phenomenon to accelerate charged particles, 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 superconducting material to accelerator magnets will be started. A concerted effort will be made to search for promising new charged particle beam acceleration concepts. First major tests of advanced accelerator concepts identified as feasible in prior year R&D will be undertaken at the advanced accelerator test facilities established as a user center at BNL. R&D on advanced, generic technology essential for large detectors operating at high event rates will be expanded to its planned level. Funding for the SBIR assessment has been removed.	FY 1991 will see full effort on significant new program activities started in FY 1990. The ANL wakefield accelerator experiments, high power microwave power source test facility at LLNL, the accelerator test facility and laser accelerator experiments at BNL, and the high brightness electron source at UCLA should all be in final development or first operation. These and other R&D activities in U.S. universities, industry, research institutes, and other government resource centers will continue to search for new concepts and technologies on which high energy physics research in the 21st century will depend. In addition, important work will continue on superconducting materials for very high field superconducting magnets and on new and innovative approaches to designing and building such magnets. R&D will also continue on the generic technology essential for future detectors with a particular focus on the needs for high luminosity proton-proton and electron-positron colliders. Also includes funding for the SBIR assessment.	Continuation of the FY 1991 program. Focus continues to be on utilization of the special resources of universities, industry, not for profit research institutes, and government laboratories to address a broad spectrum of technology development important to the very long term future productivity of the physics research program. Major tests of new charged particle acceleration schemes should be in progress at the advanced test facility established at BNL and on a new wakefield test facility at ANL. Work on very high field superconducting magnets will continue. R&D will continue on advanced, generic technology essential for future detectors. Also includes funding for the SBIR assessment.
	$ 16,257	$ 17,750	$ 19,270
High Energy Technology	$ 68,722	$ 69,355	$ 73,830

DEPARTMENT OF ENERGY
FY 1992 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 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 1992 to significant upgrades of the CDF and D-Zero detectors in order to utilize effectively the increased Tevatron luminosity resulting from the expected completion of the Linac Upgrade project.

II. A. Summary Table: Capital Equipment

Program Activity	FY 1990 Enacted	FY 1991 Enacted	FY 1992 Request	% Change
Fermilab	$ 29,860	$ 29,795	$ 31,500	+ 6
SLAC	21,850	19,895	21,040	+ 6
BNL	5,440	6,860	7,250	+ 6
Universities and Other Laboratories	22,675	22,190	23,460	+ 6
BNL- General Purpose Equipment	4,240	4,250	4,490	+ 6
Total, Capital Equipment	$ 84,065	$ 82,990	$ 87,740	+ 6

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory	$ 5,440	$ 6,860	$ 7,250	+ 6
Fermi National Accelerator Laboratory	$ 29,860	$ 29,795	$ 31,500	+ 6
Stanford Linear Accelerator Laboratory	$ 21,850	$ 19,895	$ 21,040	+ 6

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

Program Activity	FY 1990	FY 1991	FY 1992
Capital Equipment			
Fermilab	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 many 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 ($4,100). Upgrades to accommodate the increased Tevatron collider luminosity expected in the near future will also be made ($2,700); significant upgrades to the CDF calorimetry and electronics, and an extension to larger acceptance of the massive muon detection systems, will be carried out ($7,100); modifications, improvements and new detector and secondary beam components in support of the fixed target research programs ($6,900); 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 ($4,950); 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. ($4,045).	In preparation for the significantly increased luminosity to be provided in the next Tevatron collider run in 1993, due in part to completion of the Linac Upgrade project, both of the collider detector facilities require upgrades of their particle tracking systems and data acquisition electronics. In addition, the CDF detector facility will need to upgrade and improve its plug calorimeters and forward muon detection systems ($8,400 total); and the D-Zero detector facility will need more extended scintillator veto arrays and a new silicon-based vertex detector system ($6,200 total). The next fixed target run, expected to start in late 1993, will also benefit from increased intensity Tevatron beams. The fixed target experimental program is planned to be consolidated and reconfigured ($7,800); equipment additions will continue for the Fermilab computing systems both in the experimental areas and in the central computing facility ($4,950); equipment for the support of the entire accelerator complex, for R&D efforts, for the extended cryogenic and controls systems, and for general site-related needs ($4,150).
	$ 29,860	$ 29,795	$ 31,500

III. Capital Equipment (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
SLAC	Major emphasis on completing the SLD detector with strong expectation of reaching high luminosity late in FY 1990 ($6,500); upgrade polarization capability of SLC beams ($1,500) 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 ($2,250).	Major emphasis on completely commissioning the SLD detector and providing needed support for SLC ($4,300); support for Advanced Accelerator R&D ($9,200); computing hardware ($3,465); and general laboratory equipment including new machine tools, and HVAC upgrades. ($2,930)	Major emphasis on equipment needs in completely commissioning the high luminosity polarized beam capability and the SLD detector for full physics operations ($4,125); second polarized source ($1,350); support for advanced accelerator R&D ($7,300); new experiments ($1,000); new mainframe computer ($3,500); other computing hardware ($1,500); and general laboratory equipment including new machine tools and completion of upgrade of HVAC distribution system ($2,265).
	$ 21,850	$ 19,895	$ 21,040
BNL	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 muon anomalous magnetic moment (g-2) experiment ($1,530); support for rare kaon decay experiments ($1,340); support for other experiments ($1,250); beam line components ($1,050); accelerator R&D ($730); and general AGS support ($960).	Continuation of muon anomalous magnetic moment (g-2) experiment ($1,920); support for rare kaon decay and other experiments ($2,200); beam line components ($1,440); accelerator R&D ($730); and general AGS support ($960).
	$ 5,440	$ 6,860	$ 7,250
Universities and Other Laboratories	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 and upgrades 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. Several new experiments are anticipated involving precision measurements of particle properties and/or non-accelerator experiments on high energy particle astrophysics. Funding will be provided to meet, in part, ongoing need for upgrade of computer and other data analysis equipment, as well as infrastructure equipment for design and fabrication of experimental equipment, in order that university-based physicists fully and actively contribute to high energy	The U.S. ZEUS Collaboration will conduct a full program of electron-proton collider research at the new HERA accelerator in Hamburg, W. Germany. It is anticipated that there will be several new experiments involving precision measurements of particle properties and/or non-accelerator experiments on high energy particle astrophysics. Funding will be provided to meet, in part, ongoing need for upgrade of computer and other data analysis equipment, as well as advanced equipment for design and fabrication of experimental equipment, in order that university-based physicists fully and actively contribute to high energy physics research on campus. Hardware

III. Capital Equipment (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
Universities and Other Laboratories (Cont'd)		physics research on campus.	for advanced accelerator concept experiments at the BNL-ATF and the ANL wakefield test facility are included. Includes funding for MIT-LEPICS computer upgrade.
	$ 22,675	$ 22,190	$ 23,460
BNL- General Purpose Equipment	Provides general purpose equipment for the entire laboratory. Includes upgrades to central computing facility.	Provides general purpose equipment for the entire laboratory.	Provides general purpose equipment for the entire laboratory.
	$ 4,240	$ 4,250	$ 4,490
Capital Equipment	$ 84,065	$ 82,990	$ 87,740

DEPARTMENT OF ENERGY
FY 1992 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 1990 Actual	FY 1991 Estimate	FY 1992 Request	% Change
Accelerator Improvements and Modifications...	$13,838	$14,535	$15,805	+ 9
Fermilab Linac Upgrade.......................	4,634	12,000	6,166	-49
General Plant Projects.......................	11,729	12,317	13,398	+ 9
AGS Accumulator/Booster......................	4,915	0	0	0
Fermilab Main Injector.......................	0	0	43,450	--
Total High Energy Physics Construction	$35,116	$38,852	$78,819	+103

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

Program Activity	FY 1990	FY 1991	FY 1992
Construction			
Accelerator Improvements and Modifications	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.	Increased funding in response to the continuing large need for modifications to maintain and improve the technical capability and operational efficiency of the accelerator complexes.
	$ 13,838	$ 14,535	$ 15,805
Fermilab Linac Upgrade	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.	All of the klystron power sources will be installed and prepared for use. The final sets of copper accelerating cavities will be completed and moved into the Linac gallery. During the last 3 months of the fiscal year, the Tevatron complex will be shut down for the installation of the full complement of new cavity modules. The new components will be installed, connected, aligned and brought into operation. By the end of FY 1992 it is anticipated that commissioning of the upgraded Linac will be well underway. Full operational status and project completion will be accomplished by mid-FY 1993.
	$ 4,634	$ 12,000	$ 6,166
General Plant Projects	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.	Increased funding in response to accumulated operational, environmental, and safety needs.
	$ 11,729	$ 12,317	$ 13,398
AGS Accumulator/Booster	Complete all construction activities.	No activity.	No activity.
	$ 4,915	$ 0	$ 0

III. Construction (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
Fermilab Main Injector	No activity.	No activity.	This construction project will provide a replacement accelerator which will greatly increase the numbers of protons and antiprotons which can be injected into the superconducting Tevatron and then accelerated to world record high energies. All of the presently existing detector facilities at Fermilab, both for the collider and for the fixed target research programs, will thereby have greatly expanded research capabilities. In particular the first experimental observation of the long sought Top quark will become very likely at Fermilab if its mass is within the expected range. The Main Injector will also make it possible for an extended set of particle beams for the testing and calibration of SSC detector components and subsystems to be operated year round and without interference with the ongoing Tevatron research programs. The construction project will begin with an intense engineering design effort, both on technical components and on civil engineering. As the design work is completed, contracts will be let for the first construction activities and for the long lead time procurements of materials. Physical construction during FY 1992 will include extensive site preparations and the initiation of the ring enclosure concrete work. The ring dipole magnet and power supply construction work will be started, and the fabrication and assembly efforts will be staffed and optimized for rapid, high quality and cost effective operations.
	$ 0	$ 0	$ 43,450

III. Construction (Cont'd):

Program Activity	FY 1990	FY 1991	FY 1992
Construction	$ 35,116	$ 38,852	$ 78,819

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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 1991 Appropriated	FY 1992 Request	Unappropriated Balance	TEC
GPE-103	General Plant Projects	$ ---	$ ---	$ 13,398	$ 0	$ 13,398
92-G-304	Accelerator Improvements and Modifications	---	---	15,805	0	15,805
90-R-104	Fermilab Linac Upgrade	4,634	12,000	6,166	0	22,800
92-G-302	Fermilab Main Injector	---	---	43,450	133,800	177,800
Total, High Energy Physics Construction		$ 4,634	$ 12,000	$ 78,819	$133,800	XXX

DEPARTMENT OF ENERGY
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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: GPE-103 General Plant Projects
Various locations

Project TEC: $13,398
Start Date: 3rd Qtr. FY 1992
Completion Date: 2nd Qtr. FY 1994

2. Financial Schedule:

Fiscal Year	Appropriated	Obligations	Costs
1992	$13,398	$13,398	$ 4,500
1993	---	---	6,800
1994	---	---	2,098

3. Narrative:

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

(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 timely response to environmental and safety needs, maintaining the productivity, increasing the operational cost effectiveness, and ensuring that necessary support services are available to the research program.

(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	$ 6,198
Fermi National Accelerator Laboratory	4,140
Stanford Linear Accelerator Center	3,060
Total Estimated Cost................	$13,398

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

High Energy Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 92-G-304 Accelerator Improvements and Modifications
Various Locations

Project TEC: $15,805
Start Date: 2nd Qtr. FY 1992
Completion Date: 2nd Qtr. FY 1994

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1992	$ 15,805	$ 15,805	$ 3,900
1993	---	---	6,100
1994	---	---	5,805

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	$ 3,100
Fermi National Accelerator Laboratory	7,880
Stanford Linear Accelerator Center	4,825
Total Estimated Cost...............	$15,805

DEPARTMENT OF ENERGY
FY 1992 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: 92-G-302 Fermilab Main Injector
Batavia, Illinois

Project TEC: $177,800
Start Date: 1st Qtr. FY 1992
Completion Date: 4th Qtr. FY 1996

2. Financial schedule:

Fiscal Year	Appropriations	Obligations	Costs
1992	$ 43,450a/	$ 43,450a/	$ 29,550a/
1993	44,000	44,000	40,000
1994	44,000	44,000	43,000
1995	44,000	44,000	46,000
1996	1,800	1,800	18,800

3. Narrative:

(a) This project provides for the construction of a new replacement accelerator to provide particles for injection into the existing Fermilab superconducting Tevatron accelerator, and also for direct delivery to the existing 800 GeV fixed target experimental and test beam areas.

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

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

4. Total Project Funding (BA):

	Prior Years	FY 1991	FY 1992 Request	To Complete
Construction........................	$ 0	$ 0	$43,450a/	$133,800
Capital Equipment...................	0	200	400	400
Operating Expenses..................	0	300	7,100	10,800

a/ Reflects savings of $550,000 BA and $450,000 BO due to proposed Davis Bacon Amendment.

DEPARTMENT OF ENERGY
FY 1992 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. FY 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	FY 1992 Request	To Complete
Construction........................	$ 0	$ 4,634	$12,000	$ 6,166	$ 0
Capital Equipment...................	150	100	100	50	0
Operating Expenses..................	2,470	2,100	800	720	690

DEPARTMENT OF ENERGY
FY 1992 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 1992

3a. Date physical construction starts: 3rd Qtr. FY 1992

4. Date construction ends: 2nd Qtr. FY 1994

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

6. Current cost estimate: $13,398
Less amount for PE&D: 0
Net cost estimate: $13,398
Date: May 1990

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1992	$ 13,398	$ 13,398	$ 13,398	$ 4,500
1993	0	0	0	6,800
1994	0	0	0	2,098

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.

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No.: GPE-103

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		$6,198
Building Addition - Accelerator Development Dept	$ 300	
Building Expansion - Accelerator Development Dept	500	
Building Improvement - Accelerator Development Dept	300	
Road Improvement - Accelerator Development Dept	200	
New Storage Building - AGS Dept	400	
Experimental Building - AGS Dept	500	
Building Expansion - AGS Dept	300	
Laboratory Conversions - Applied Science Dept	1,100	
Laboratory Renovations - Biology Dept	200	
Hot Cell Improvement - Medical Dept	300	
Building Addition - Nuclear Energy Dept	300	
Office Addition - Nuclear Energy Dept	200	
Storage Building Construction - NSLS Dept	400	
Building Addition - NSLS Dept	500	
Building Construction - Physics Dept	600	
Fire Detection System Improvements - AGS Experimental Buildings	98	
Fermi National Accelerator Laboratory		$4,140
Northwest Addition to CDF	$ 1,200	
Facilities Management Building - West Addition	1,200	
Gas and Flammable Liquid Storage Shed	350	
Fire Department Addition	200	
East Addition to D-Zero	1,190	

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		$3,060*
Lighting Upgrade	$ 155	
Linac Substation Control Center Upgrade	680	
Transportation Group Facility	430	
New Substation for SLD Collider Hall	630	
Replace Cooling Tower	1,165	

*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	$ 6,198
Fermi National Accelerator Laboratory	4,140
Stanford Linear Accelerator Center	3,060
Total Estimated Cost	$13,398

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.

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FY 1992 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.: 92-G-304

3. Date A-E work initiated: 2nd Qtr. FY 1992

3a. Date physical construction starts: 3rd Qtr. FY 1992

4. Date construction ends: 2nd Qtr. FY 1994

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

6. Current cost estimate: $15,805
Less amount for PE&D: 0
Net cost estimate: $15,805
Date: May 1990

7. Financial Schedule:

Fiscal year	Authorization	Appropriations	Obligations	Costs
1992	$15,805	$15,805	$15,805	$ 3,900
1993	0	0	0	6,100
1994	0	0	0	5,805

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.: 92-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.. $3,100

Funds are requested for modifications, improvements, and additions to the Alternating Gradient Synchrotron (AGS) and its related experimental facilities. Items planned include: improvements to Booster Dynamical Tracking System and Pulse-to-Pulse Modulation, upgrade to Linac Instrumentation and AGS RF system, and construction of larger aperature extraction kickers.

Fermi National Accelerator Laboratory.................................. $7,880

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: preaccelerator upgrade; accelerator central control improvements; accumulator stacktail cooling system improvements; linear accelerator accelerating tank improvements; central control system improvements; superconducting and conventional magnet improvements; and switchyard improvements.

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 a new 150 GeV experimental area.

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

2. Project No.: 92-G-304

8. Brief Physical Description of Project (continued)

Stanford Linear Accelerator Center (SLAC).................................. $4,825

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 1992 include: Linac improvements; modulator and power supply upgrades; modifications to the beam switchyard; upgrade of injector; and SLC control system upgrade.

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.: 92-G-304

10. Details of Cost Estimate

a. Engineering, design and inspection and component assembly and installation............ $15,805

Total estimated cost... $15,805

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

11. Method of Performance

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

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FY 1992 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 Main Injector
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 92-G-302

3. Date A-E work initiated: 1st Qtr. FY 1992

3a. Date physical construction starts: 1st Qtr. FY 1992

4. Date construction ends: 4th Qtr. FY 1996

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

6. Current cost estimate: $177,800
Less amount for PE&D: 0
Net cost estimate: $177,800
Date: March 1990

7. Financial Schedule

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1992	$177,800	$ 43,450a/	$ 43,450a/	$ 29,550a/
1993	0	44,000	44,000	40,000
1994	0	44,000	44,000	43,000
1995	0	44,000	44,000	46,000
1996	0	1,800	1,800	18,800

8. Brief Physical Description of Project

This project provides for the construction of a new accelerator, designated the Main Injector, to replace the aging Fermilab Main Ring. It will provide particles for injection into the existing Fermilab superconducting Tevatron accelerator as well as for direct delivery to the existing fixed target experimental and test beam areas. The accelerator is 3.3 km in circumference and is capable of accelerating protons and antiprotons to 150 GeV. It is constructed using conventional iron core magnets. Also provided are five new beamlines required to tie the Main

a/ Reflects savings of $550,000 BA and $450,000 BO due to proposed Davis Bacon Amendment.

8. Brief Physics Description of Project (Continued)

Injector into the existing accelerator complex, and to provide slow extracted beam to the A-zero Transfer Hall from where it can be directed toward the fixed target experimental areas to support a 120 GeV fixed target research program, and also to provide particle beams for the testing and calibration of SSC detector components and subsystems. Many technical components will be recycled from the existing Main Ring, including quadruple magnets, some power supplies and correction magnets, radio frequency (RF) systems, some controls components, and diagnostic devices.

The Main Injector will be located on the southwest side of the Fermilab site, tangent to the existing Tevatron at the F-zero straight section.

Specifically provided for in the scope of the project are:

a. Construction of the 3.3 km ring enclosure, service buildings, utilities, and new technical components required including dipole magnets, power supplies, and vacuum systems.

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

c. Construction of technical components required to implement the delivery of 120 GeV beam from the Main Injector to the A-zero Transfer Hall.

d. Modifications to the Tevatron F-zero straight section for installation of the 150 GeV proton and antiproton transfer lines.

e. Construction of a new Industrial Building to house the assembly of magnets and other components.

f. Construction of a new sub-station and 345KV power lines for delivery of power to the Main Injector.

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

2. Project No.: 92-G-302

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

The primary purpose of this project is to greatly increase the luminosity which can be delivered to the two existing collider detector facilities, and thereby make very likely the discovery at Fermilab of the top quark, the last unobserved fundamental particle building block forming the basis of our current understanding of the basic structure of all matter. Increasing the luminosity available at the Fermilab Proton-Antiproton Collider to about $50x10^{30}cm^{-2}sec^{-1}$ will almost guarantee first observation of the top quark at Fermilab if its mass lies within the range 100-250 GeV/c^2, as is indicated by all present data. A second important purpose is to provide an expanded capability for 120 GeV beams for physics research and to provide year-round beams for the testing and calibration of SSC detector components and subsystems.

Fermilab is the only operational high energy physics facility in the world which has sufficiently high energy capability to produce Top quarks. The Main Injector is designed to support a luminosity delivered to the experimental detectors of as much as $50x10^{30}cm^{-2}sec^{-1}$, and to improve the data collection efficiency of the CDF and D-Zero detectors through elimination of Main Ring background radiation. The project will also increase the number of protons which can be delivered to the Tevatron for acceleration and delivery to the fixed target experimental areas, and provide 120 GeV protons to these fixed target experimental areas for testing and calibration of SSC detector components during Tevatron collider operations for physics research.

The Fermilab Proton-Antiproton Collider has achieved a peak luminosity of $2x10^{30}cm^{-2}sec^{-1}$. The primary programmatic goal at Fermilab is to increase the luminosity delivered to the experimental detectors by at least a factor of 25. A luminosity of $50x10^{30}cm^{-2}sec^{-1}$ would maximize the likelihood of discovery of the Top quark. Increasing the luminosity requires increasing the number of protons and antiprotons available in the collider. Measures are currently being taken to increase the luminosity by a factor of about 5. However, following implementation of these improvements, the 20-year old Main Ring accelerator will remain the only bottleneck restricting further luminosity increases. The Main Injector is designed to remove this bottleneck and provide the final boost of luminosity into the required very high range.

The substantial improvement in performance results from the large effective aperture of the Main Injector ring and its fast cycle rate. Protons from the 8 GeV Booster, presently delivered to the Main Ring, will be delivered to the new Main Injector instead. The Booster currently has an aperture which is significantly larger than that of the Main Ring. The aperture of the Main Injector is designed to be 30% larger than the aperture of the Booster. This is achieved through tighter focussing, improved field quality, and the elimination of overpasses installed in order to bypass the CDF and D-Zero detectors. It is anticipated that the Main Injector will be capable of accelerating as many as $3x10^{13}$ protons for antiproton production, and it is designed to cycle to 120 GeV in 1.5 seconds, as compared to 2.6 seconds for the existing Main Ring. As a result we expect the total number of protons per cycle deliverable from the Main Injector to increase by three times, and the number of protons per second deliverable to the antiproton production target will increase by five times. These increases, and the luminosity goal of $50x10^{30}cm^{-2}sec^{-1}$, will not be achieved immediately upon completion and commissioning of the Main Injector, but will require months of operational experience with the new facility.

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No.: 92-G-302

10. Details of Cost Estimate

	Item Cost	Total Cost
a. EDI&A at 18% of construction costs		$ 21,700
b. Main Injector construction costs		120,500
1. Conventional construction	$ 43,900	
2. Special facilities	76,600	
c. Contingency at approximately 25% of above cost		35,600
Total estimated cost		$177,800

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

a. Total project costs	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996	Total
1. Total facility costs							
(a) Construction line item	$ 0	$29,550	$40,000	$43,000	$46,000	$18,800	$177,800
	$ 0	$29,550	$40,000	$43,000	$46,000	$18,800	$177,800
2. Other project costs							
(a) R&D costs necessary to complete construction	$ 300	$ 7,100	$ 4,900	$ 900	$ 400	$ 0	$ 13,600
(b) Pre-operating costs	0	0	0	0	1,400	3,200	4,600
(c) Capital equipment	200	400	300	100	0	0	1,000
Total other project costs	$ 500	$ 7,500	$ 5,200	$ 1,000	$ 1,800	3,200	$ 19,200
Total project costs	$ 500	$37,050	$45,200	$44,000	$47,800	$22,000	$197,000

1. Title and location of project:	Fermilab Main Injector Fermi National Accelerator Laboratory Batavia, Illinois	2. Project No.:	92-G-302

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

b. Total related incremental annual funding requirements (estimated life of project: 20 years)	
1. Power costs for Main Injector slow spill operations	$4,300
2. Experimental Areas operating costs for 120 GeV slow spill beam	1,200
Total incremental annual funding	$5,500

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

a. Total project costs
   1. Total facility cost
      (a) Construction line item - explained in items 8,9,10
   2. Other project costs
      (a) Direct R&D operating costs - This will provide for the design and development of new components and for the fabrication and testing of prototypes. R&D on all elements of the project, in order to optimize performance and minimize costs, will be concentrated in the first two years. Specifically included are the development of the high current dipole magnet, the associated power supply system, and the special length quadrupoles required in the Main Injector and the beamlines. A subsystem of the Main Injector magnet and power supply systems will be developed and tested in-situ prior to cessation of Main Ring operations.
      (b) Pre-operating costs - Includes preparation of recycled Main Ring components for re-installation into the Main Injector, plus personnel and power costs for a several month commissioning period.
      (c) Capital equipment - Includes test instruments, electronics, and other general equipment to support 12.a.1 and 12.a.2.a.

b. Total incremental funding requirements - We assume that the Fermilab Tevatron complex will continue its fixed target and collider programs, with each running about 40% of the time, during which the Main Injector is also supplying 120 GeV slow spill beams to the external experimental areas. The Main Injector replaces the existing Main Ring in all its functional roles, and is designed to require about the same amount of power to operate for antiproton production as the existing Main Ring. However, the Main Injector slow spill operation for SSC test beams and 120 GeV physics experiments will use more power and, when operated about 80% of the time, will require an increase in power costs of about $4.3M annually.

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

2. Project No.: 92-G-302

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

The beamlines will require supplemental funding for materials, supplies and personnel for these 120 GeV operations. This is estimated to be an additional $1.2M annual increment. The incremental operating costs in 12.b reflect solely the demands of delivering 120 GeV protons to the Fermilab fixed target experimental areas and to the SSC detector test beams throughout the Tevatron collider and fixed target operating periods.

(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

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

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

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

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

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.