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Volume 4 of 7

Congressional Budget Request

General Science and Research
Uranium Enrichment
Geothermal Resources Development Fund

Volume 4

FY 1987

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

February 1986

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

URANIUM ENRICHMENT

GEOTHERMAL RESOURCES DEVELOPMENT FUND

VOLUME 4

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DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

(in thousands of dollars)

	FY 1985 Actual BA	FY 1986 Estimate BA	FY 1987 Request BA
Appropriations Before The Energy and Water Development Subcommittees:			
Energy Supply Research and Development	1,967,490	1,696,298	1,254,162
Uranium Enrichment	237,956	190,512	---
General Science and Research	724,860	655,928	773,400
Atomic Energy Defense Activities ..	7,322,321	7,231,664	8,230,000
Departmental Administration	128,602	150,319	151,082
Alaska Power Administration	3,233	3,245	2,881
Bonneville Power Administration ...	284,771	330,000	276,100
Southeastern Power Administration .	35,744	---	19,647
Southwestern Power Administration .	31,208	29,191	25,337
Western Area Power Administration .	218,230	195,910	240,309
Western Area Power Emergency Fund .	---	---	---
Federal Energy Regulatory Commission	54,543	41,989	20,325
Nuclear Waste Fund	327,669	499,037	769,349
Geothermal Resources Development Fund	121	69	72
Subtotal, Appropriations Before the Energy and Water Development Subcommittees	$11,336,748	$11,024,162	$11,762,664

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

(in thousands of dollars)

	FY 1985 Actual BA	FY 1986 Estimate BA	FY 1987 Request BA
Appropriations Before Interior and Related Agencies Subcommittees:			
Alternative Fuels Production	$ 1,169,895	$ ---	$ ---
Clean Coal Technology	---	---	---
Fossil Energy Research and Development	289,048	311,954	82,767
Naval Petroleum and Oil Shale Reserves	156,874	13,002	127,108
Energy Conservation	457,436	427,512	39,433
Energy Regulation	27,139	23,423	21,850
Emergency Preparedness	6,045	5,750	6,044
Strategic Petroleum Reserve	2,049,550	107,533	---
Energy Information Activities	60,919	57,724	59,651
Subtotal, Interior and Related Agencies Subcommittees	4,216,906	946,898	336,853
Subtotal, Energy and Water Development Subcommittees	11,336,748	11,024,162	11,762,664
Subtotal, Department of Energy	15,553,654	11,971,060	12,099,517
Permanent - Indefinite Appropriations:			
Payments to States	1,052	570	570
Total, Department of Energy	$15,554,706	$11,971,630	$12,100,087

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1985 FTE USAGE	FY1986 CONGR REQ	FY1987 -FY86	FY1987 CONGR REQ
ENERGY & WATER SUBCOMMITTEE				
HEADQUARTERS	4,865	4,965	-18	4,947
FIELD	9,133	9,185	111	9,296
SUBCOMMITTEE TOTAL	13,998	14,150	93	14,243
INTERIOR SUBCOMMITTEE				
HEADQUARTERS	1,353	1,304	-166	1,138
FIELD	907	896	-226	670
SUBCOMMITTEE TOTAL	2,260	2,200	-392	1,808
GRAND TOTAL	16,258	16,350	-299	16,051
ADJUSTMENT		-132	-198	-330
ADJUSTED TOTAL	16,258	16,218	-497	15,721

DEPARTMENT OF ENERGY
F Y 1987 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1985 FTE USAGE	FY1986 CONGR REQ	FY1987 -FY86	FY1987 CONGR REQ
10:ENERGY SUPPLY RESEARCH AND DEV	937	934	-34	900
HEADQUARTERS	811	820	-28	792
FIELD	126	114	-6	108
15:URANIUM ENRICHMENT	69	66	1	67
HEADQUARTERS	58	55	1	56
FIELD	11	11	0	11
20:GENERAL SCIENCE AND RESEARCH	37	39	0	39
HEADQUARTERS	37	39	0	39
25:ATOMIC ENERGY DEFENSE ACTIVITI	2,618	2,702	131	2,833
HEADQUARTERS	496	518	9	527
FIELD	2,122	2,184	122	2,306
30:DEPARTMENTAL ADMINISTRATION	3,307	3,332	-5	3,327
HEADQUARTERS	1,721	1,726	0	1,726
FIELD	1,586	1,606	-5	1,601
34:ALASKA POWER ADMINISTRATION	37	38	0	38
FIELD	37	38	0	38
36:BONNEVILLE POWER ADMIN	3,510	3,480	0	3,480
FIELD	3,510	3,480	0	3,480
38:SOUTHEASTERN POWER ADMIN	38	40	0	40
FIELD	38	40	0	40
42:SOUTHWESTERN POWER ADMIN	186	186	0	186
FIELD	186	186	0	186
46:WESTERN AREA POWER ADMIN	1,181	1,160	0	1,160
FIELD	1,181	1,160	0	1,160
50:WAPA - COLORADO RIVER BASIN	219	219	0	219
FIELD	219	219	0	219
52:FEDERAL ENERGY REGULATORY COMM	1,617	1,659	0	1,659
HEADQUARTERS	1,617	1,659	0	1,659
54:NUCLEAR WASTE FUND	238	292	0	292
HEADQUARTERS	123	147	0	147
FIELD	115	145	0	145
56:GEOTHERMAL RESOURCES DEV FUND	2	1	0	1
HEADQUARTERS	2	1	0	1
65:FOSSIL ENERGY RESEARCH AND DEV	714	700	-161	539
HEADQUARTERS	151	135	-26	109
FIELD	563	565	-135	430
70:NAVAL PETROL & OIL SHALE RES	104	104	-9	95
HEADQUARTERS	23	23	0	23
FIELD	81	81	-9	72
75:ENERGY CONSERVATION	333	352	-134	218
HEADQUARTERS	208	227	-79	148
FIELD	125	125	-55	70
80:EMERGENCY PREPAREDNESS	74	71	0	71
HEADQUARTERS	74	71	0	71
81:ECONOMIC REGULATION	377	340	-50	290
HEADQUARTERS	377	340	-50	290
85:STRATEGIC PETROLEUM RESERVE	178	152	-32	120
HEADQUARTERS	40	27	-5	22
FIELD	138	125	-27	98
90:ENERGY INFORMATION ACTIVITIES	480	481	-6	475
HEADQUARTERS	480	481	-6	475
94:ADVANCES FOR CO-OP WORK	2	2	0	2
FIELD	2	2	0	2
GRAND TOTAL	16,258	16,350	-299	16,051
ADJUSTMENT		-132	-198	-330
ADJUSTED TOTAL	16,258	16,218	-497	15,721

General Science and Research

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

VOLUME 4

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High Energy Physics

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

HIGH ENERGY PHYSICS

VOLUME 4

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DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
HIGH ENERGY PHYSICS
GENERAL SCIENCE AND RESEARCH
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
High Energy Physics					
Physics Research					
Operating Expenses..	$106,300	$106,268	$106,268	$118,600	$+12,332
Subtotal...........	106,300	106,268	106,268	118,600	+12,332
Facility Operations					
Operating Expenses..	172,715	175,095	175,095	213,400	+38,305
Capital Equipment...	58,700	69,984	69,984	77,500	+ 7,516
Construction........	114,000	55,049	55,049	41,700	-13,349
Subtotal...........	345,415	300,128	300,128	332,600	+32,472
High Energy Technology					
Operating Expenses..	90,200	88,462	88,462	95,500	+ 7,038
Subtotal...........	90,200	88,462	88,462	95,500	+ 7,038
Total					
Operating Expenses..	369,215 a/	369,825	369,825	427,500	+57,675
Capital Equipment...	58,700	69,984	69,984	77,500	+ 7,516
Construction........	114,000	55,049	55,049	41,700	-13,349
Total High Energy Physics..............	$541,915 a/b/c/	$494,858 c/d/e/f/	$494,858	$546,700	$+51,842
Staffing					
FTP/Total FTEs.......	(Reference General Science Program Direction Decision Unit)				

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

a/ FY 1985 total does not include $3,720,000 transferred to the SBIR program.
b/ FY 1986 total reflects a reduction of $2,165,000 for ADP general reduction.
c/ Totals reflect a reduction of $4,000,000 in FY 1985, $7,500,000 in FY 1986 and $8,000,000 in FY 1987 for management initiative savings.
d/ FY 1986 total includes $6,000,000 transfer of appropriation.
e/ FY 1986 total reduced by $22,042,000 in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).
f/ $200,000 has been transferred to Assistant Secretary for Environmental Safety and Health.

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer. (1)	General Reduction (2)	Management Initiatives (3)	Pay Cost Restoration (4)	FTE General Reduction (5)	Gramm-Rudman-Hollings (6)	ES&H Transfer/ Reprogramming (7)	Subtotal (8)	Comparability Adjustments (9)	Total (10)
High Energy Physics (ER)										
Physics Research										
Operating Expenses	$111,300	$ -300				$ -4,732		$106,268		$106,268
Subtotal	111,300	-300				-4,732		106,268		106,268
Facility Operations										
Operating Expenses	187,800	-4,700				-7,805	-200	175,095		175,095
Capital Equipment	73,100	---				-3,116	---	69,984		69,984
Construction	55,500	2,000				-2,451	---	55,049		55,049
Subtotal	316,400	-2,700				-13,372	-200	300,128		300,128
High Energy Technology										
Operating Expenses	92,400	---				-3,938	---	88,462		88,462
Subtotal	92,400	---				-3,938	---	88,462		88,462
Subtotal, High Energy Physics.	520,100	-3,000				-22,042	-200	494,858		494,858
General Reductions:										
Operating Expenses	-5,000	5,000								
Capital Equipment	---	---								
Construction	2,000	-2,000								
Total, General Reductions	-3,000	3,000								
Management Initiatives:										
Operating Expenses										
Capital Equipment										
Construction										
Total, Management Initiatives										
Pay Restoration										
Use of Prior Year Balances (HEP)										
Operating Expenses										
Capital Equipment										
Construction										
Total, Prior Year Bal. (HEP)										

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
HIGH ENERGY PHYSICS
(In thousands of dollars)

1986 Appropriation enacted..	$516,900
1986 Gramm-Rudman reduction..	- 22,042
1986 adjusted..	$494,858
o Funding required to maintain constant level of program activity..	+ 29,692
o Substantial increase in facility operations funding............ - First operation of two new world-class HEP facilities -- Tevatron collider - world's highest energy proton-antiproton collider -- SLC - world's highest energy electron-positron collider - Reduced operation of other HEP accelerator capabilities - Average facility utilization near the 50% level	+ 27,790
o Physics research at a level consistent with the operating level of facilities..	+ 5,960
o Continuation of advanced technology R&D for accelerators and detectors..	+ 1,730
o Capital equipment, with special emphasis on needs at Fermilab for Tevatron I detectors and at SLAC for SLC detector..........	+ 3,320
o Construction at reduced level of effort........................ - Continuation of Fermilab Central Computing Upgrade (+11,000) - Continuation of construction on AGS Accumulator/Booster (+1,470) - AIP & GPP at about constant level of effort (+1,500) - Reduced requirements for construction of Tevatron I and SLC in FY 1986 (-30,620)	- 16,650
1987 budget request	$546,700

High Energy Physics

The High Energy Physics program supports basic research which seeks to discover the fundamental constituents of matter and to understand the laws of nature that govern the behavior of matter and energy. Past discoveries and new understanding resulting from these activities have helped lay the foundation for much of the highly technological world in which we live.

The Department of Energy provides over 90% of the Federal support for this most basic scientific endeavor, and serves as Executive Agent for the national program. The Department has responsibility for planning for the national program, with the goals of achieving a forefront and productive program and maintaining a competitive world leadership position for the United States.

During this century, the forefront of scientific investigation has advanced to studies of ever more fundamental constituents of matter, from research on molecules to research on atoms, atomic nuclei, the constituents of nuclei (protons and neutrons), and recently on even more elemental objects called quarks and leptons. The framework for understanding all natural phenomena has rested on the belief that they can be described in terms of four fundamental forces and a small set of basic constituents of all matter. The "electromagnetic" force describes how atoms are formed from nuclei and electrons and how molecules are formed from atoms, and is the cornerstone to understanding the periodic table of elements, chemistry, electronic communication and biological processes. The "weak nuclear" force describes processes such as the radioactive decay of unstable nuclei and the interactions of neutrinos. The "strong nuclear" force describes how the sun and stars produce so much energy and, together with the weak nuclear force, explains the relative abundances of the chemical elements. The "gravitational" force describes falling objects, orbiting celestial bodies, the formation of black holes, and the large scale features of the universe such as the clustering of galaxies.

One facet of the recent great progress in science has been the conceptual unification of the weak nuclear and electromagnetic forces into a single force -- the electroweak force. Recent conclusive experimental evidence for the existence of the W and Z particles, the carriers of the weak force, together with the earlier discoveries of weak neutral currents and of particles with heavy quark constituents, confirm major predictions of this conceptual unification. The electromagnetic and weak nuclear forces can now be viewed in a natural way as different aspects of a single electroweak force. The 1979 Nobel Prize in Physics was awarded to three theoretical high energy physicists (including S. Glashow and S. Weinberg from the U.S.) for their work toward this unification. The experiment at CERN in which the W and Z particles were discovered, and for which C. Rubbia and S. Van der Meer received the 1984 Nobel Prize in Physics, included DOE-supported U.S. participants. Recent experimental evidence contains tantalizing hints that may signal a breakthrough to new physics beyond the electroweak unification, and could shed light on the mechanism responsible for the unification.

There is now a theory of the strong nuclear force, called quantum-chromodynamics, which is based on the same principles as the electroweak theory. As a result there is strong anticipation that the unification of the strong nuclear and electroweak forces into one "grand unified" force is possible, reducing the number of basic types of force in nature to two. The picture of nature which is presented in terms of the unified electroweak force, quantum chromodynamics, and the quark and lepton constituents is called the Standard Model.

The enormous energy scale at which grand unification is anticipated to occur can be derived from basic theoretical techniques for whose development the 1982 Nobel Prize in Physics was awarded to K. Wilson, a U.S. theoretical physicist. The ideas involved in grand unification can be used to give possible explanations for the observed excess of matter relative to antimatter in our universe. Other possibilities arising from grand unification models are that protons, which were previously thought to be absolutely stable, may eventually decay; that neutrinos, which were previously thought to be massless, may in fact have a mass; and that isolated magnetic poles of enormous mass (perhaps a billion times that of a proton) may exist. The 1980 Nobel Prize in Physics was awarded to two U.S. high energy physicists, J. Cronin and V. Fitch, for experimental research which indicated that certaim elemental processes are not exactly reversible. This lack of exact reversibility, together with the mechanism involved in proton decay, may be combined to explain the observed excess of matter relative to antimatter in the universe. Special emphasis in the high energy physics experimental program is focused on testing various predictions of the grand unified theories. Any verification of these predictions by the experiments currently in progress would be a truly major scientific breakthrough.

These new concepts also have profound implications for astrophysics, where they help provide an understanding of how the universe evolved from the postulated primordial big bang to its present state, and whether the universe will expand forever or perhaps contract again in the distant future to another fireball. Interesting scenarios of the early expansion of the universe are being formulated which outline possible explanations to account for the matter, energy and disorder in the universe. Recent discoveries and planned investigations in high energy physics provide crucial experimental input to these developments.

The ultimate goal of this type of research is to incorporate the gravitational force into the framework of unification, thereby bringing all of the basic forces into a single unified framework. Exactly what new insight will follow from the various stages of unification cannot be predicted in any detail. However, one can certainly anticipate profound changes in the way we think about matter and energy and the physical universe, and this in turn will result in many changes and benefits analogous to those which followed the unification of electricity and magnetism by Maxwell late in the 19th century and the unification of matter and energy by Einstein early in this century.

Progress in high energy physics research is based on a complex and continuing interplay of advances in experiment, theory and technology. Each of these areas is strongly dependent for its progress on the advancement of the other two. High energy physics experiments expand the horizons of theoretical and technical knowledge, and the range of possible experiments is determined by technological as well as conceptual capabilities and limitations. Physicists frequently have to invent new and unique apparatus and novel techniques in order to carry out the experiments of greatest interest, thereby contributing directly to the advanced technological resources of the country.

To probe into the depths of matter -- into the domain of quarks, gluons, and other new particles -- it is most effective to use intense beams of very energetic particles, which are only available from high energy particle accelerators. By studying the results of the violent collisions of these accelerated particles with other particles, in a dense fixed target or in another beam of high energy particles, information is acquired about the constituents of the particlesd about the forces which act within and between them, and about the transformations which occur between matter and energy.

The high energy particle accelerator and colliding beam facilities to be operated by the Department in FY 1987 include: the Tevatron collider at the Fermi National Accelerator Laboratory (Fermilab) providing 900 GeV on 900 GeV proton-antiproton collisions; the SLC collider at the Stanford Linear Accelerator Center (SLAC) providing 50 GeV on 50 GeV electron positron collisions; the Tevatron superconducting magnet proton synchrotron at Fermilab providing proton beams of about 800 GeV and numerous secondary beams for fixed target experiments; the 50 GeV linear electron accelerator at SLAC providing injected beams for the PEP storage ring (15 GeV on 15 GeV) and for the SPEAR storage ring (4 GeV on 4 GeV), in addition to the SLC mentioned above; and the 30 GeV proton synchrotron, the Alternating Gradient Synchrotron (AGS), at Brookhaven National Laboratory (BNL). Each of these DOE accelerator centers provides a unique set of experimental research capabilities, complementary to the others. As an ensemble they provide the foundation for a comprehensive forefront national program in high energy physics research.

A major part of the funding of the high energy physics program is required to meet the direct needs of the accelerator laboratories to develop, maintain and operate the major accelerator, colliding beam and detector facilities. The facilities at these laboratories provide the primary source of experimental data for high energy physics research in this country; about 75% of this research is carried out by university-based scientists. In this sense, most of the funding provided to the accelerator laboratories also can be considered as necessary indirect support to the university research programs.

At Fermilab, the world's first superconducting high energy accelerator has routinely operated, delivering 800 GeV protons to serve a number of fixed target experiments. The Tevatron I project, which provides the capability for operating the superconducting synchrotron as a 900 GeV on 900 GeV proton-antiproton colliding beam storage ring, is scheduled for first operation for research late in FY 1986. The Tevatron I has already had a successful pre-operating test. The Tevatron II project, scheduled for completion in FY 1986, provides a number of new and upgraded secondary beam enclosures and experimental halls for the fixed target research programs. Many of the capabilities provided by Tevatron II are already in operation.

At SLAC, the principal emphasis in recent years has been the systematic study of electron-positron collisions at center of mass energies between 3 GeV and 30 GeV. An important extension of this capability will be provided by the Stanford Linear Collider (SLC), which is to commence operation for research in FY 1987. This project has as a major goal the development and demonstration of the fundamental technical feasibility of using linear accelerators with precisely controlled, high intensity, micron-sized beam pulses to provide a reliable source of high luminosity electron-positron collisions. The successful demonstration of the SLC capabilities will be a major achievement in advanced accelerator technology and a critical early step toward a new generation of electron-positron colliders at energies well beyond those which would be considered feasible with circular colliders. Successful operation of the SLC in FY 1987 will also provide access to a previously unexplored physical domain, giving the first opportunity to study the scientifically important physics made possible by the anticipated copious production of the Z^0 boson in these high energy electron-positron collisions at energies near 100 GeV.

At BNL, the research program will make use of the recently developed unique capability for accelerating high energy polarized protons in the energy range up to 26 GeV, and also of new and upgraded secondary beam lines and detectors for a new generation of rare K-decay experiments which will test certain important theoretical predictions.

The SLC and Tevatron colliders will provide forefront research facilities for the next several years. By the mid 1990's, however, the U.S. High Energy Physics program will need new accelerator capabilities if it is to remain at the scientific frontier. Although electron-positron linear colliders show promise for the future, the technologies required for a significant step forward in energy and luminosity need much development and such a machine is not expected to be practical for at least 15 to 20 years. By contrast, the technology for a very high energy superconducting proton-proton collider is in hand and such a machine is the logical next step in the program.

Thus R&D efforts for the future of the high energy physics program are being focused on a large proton-proton collider with an energy of 20 TeV (trillion electron volts) per beam and high luminosity, up to $10^{33}cm^{-2}sec^{-1}$. Recent rapid progress in particle physics, including the discovery of the W and Z particles, has emphasized the importance of experiments in the mass range up to several TeV where new phenomena are expected, including new forms of matter with unique properties. Although the Standard Model agrees well with most experimental data, there are critical unanswered questions which can only be explored at higher energy. The 20 TeV proton beam energy would allow an exploration of this new physics domain. The new facility would have immense physics potential for truly major advances in understanding the fundamental nature of matter. It would operate in an energy domain where there are no existing or planned facilities anywhere in the world, and it would assure a world competitive U.S. high energy physics program from the mid-1990's into the next century. Such a project has been made technically possible by the outstanding successes of the substantial U.S. High Energy Physics R&D efforts in superconducting magnet technology, demonstrated most specifically by the successful operation of the Tevatron superconducting magnet synchrotron at Fermilab.

Accelerator R&D related to the next generation proton collider, called the Superconducting Super Collider (SSC), was initiated in 1984, largely as a redirection of efforts from earlier planned accelerator R&D. The 1984 work included R&D on technical options (particularly with regard to superconducting magnets), cost reduction studies, and a Reference Designs Study (RDS) which established technical feasibility and developed credible preliminary cost and schedule estimates. Research and development activities in FY 1985 included R&D to confirm RDS assumptions; cost reduction studies; further R&D on superconducting magnet designs to provide the technical basis for selection of the magnet type which would yield the best performance at the lowest facility cost; studies to refine the definition of the scope of the facility and to develop a cost performance optimized design; and development of a technical site criteria report. In FY 1986, SSC related research and development includes advanced accelerator R&D to develop a cost/performance optimized design for the selected type of superconducting magnet, to develop cost effective techniques for fabrication of full length superconducting magnets, and to develop conceptual systems designs. This program will provide the technical information for an in-depth Departmental review of plans and designs for an SSC this summer. The direction and emphasis of the accelerator R&D program, especially the work on superconducting accelerator magnets and associated systems, in FY 1987 will depend on the results of this review.

In addition to research carried out using high energy accelerators in the U.S., the Department's high energy physics program supports experiments which use the capabilities of unique foreign accelerators and also some experiments which do not require beams from particle accelerators. The research carried out at facilities overseas takes advantage of unique research opportunities offered by foreign accelerator facilities which have capabilities not available in the U.S. There is a long history of successful and mutually beneficial international cooperation in high energy physics which includes participation by scientists from one region doing experiments on accelerators in another region. Access is on the basis of the scientific merit of proposals and without charge for use of the facilities. The research using particles from non-accelerator sources includes studies of very rare processes such as the theoretically predicted decay of the proton, and searches for neutrino mass and isolated magnetic monopoles. The proton decay experiments employ large detector systems located in deep underground laboratories to provide an environment with a very low level of background radiation.

The FY 1987 request for operating expenses is $427,500,000. The major feature of the program in FY 1987 will be the first operation for research of the proton-antiproton colliding beam capability provided by Tevatron I, and of the 50 GeV on 50 GeV electron-positron colliding beam capability provided by the SLC. The program will also include operation and research utilization of the recently upgraded fixed target facilities at Fermilab; of the BNL AGS with its fixed target program including rare kaon decay experiments and its unique high energy polarized proton beam, and of the SLAC PEP and SPEAR colliding beam facilities. There are major incremental costs associated with operation of the new world forefront Tevatron and SLC collider facilities. These two new research capabilities ensure a world leading position for the U.S. program. The request brings these new research facilities into operation and accommodates an overall facility utilization level near 50 percent. The request provides continuing support for university based groups including user group efforts at U.S. and foreign accelerators, non-accelerator experiments, and theoretical research efforts. The FY 1987 program also includes funding for a continuation of advanced technology accelerator and detector R&D.

The FY 1987 capital equipment request of $77,500,000 meets the high priority needs for the detectors required to implement strong research programs based upon the new capabilities provided by the Tevatron proton-antiproton collider at Fermilab and by the SLC electron-positron collider at SLAC. The equipment request for FY 1987 is essential to make it possible for these new detectors to be completed in FY 1989 and thereby permit most effective utilization of the new U.S. High Energy Physics facilities being completed in FY 1986 at Fermilab and SLAC.

The FY 1987 request for construction funds is $41,700,000. This program includes continued work on upgrading of the central computing capability at Fermilab ($14,157,000) which is required for the analysis of the large volume of new physics data coming from the Tevatron program, to continue construction of the AGS Accumulator/Booster at BNL ($3,500,000) and to complete construction of the SLC ($976,000) and Tevatron I ($367,000). Funds are also requested for Accelerator Improvement Projects (AIP) ($11,500,000), and for General Plant Projects (GPP) ($11,200,000).

The AIP projects are essential on an annual level of effort basis for maintaining the reliability and efficiency, as well as the scientific effectiveness, of the existing accelerator facilities. Needs for AIP funding will increase in FY 1987 with the major new facilities coming into operation at Fermilab and SLAC. GPP projects are required to keep the general plant of the laboratories, including buildings, utilities and roads, in viable operating condition. The High Energy Physics program has the responsibility to provide for the full GPP needs of the multi-program Brookhaven National Laboratory as well as those of the single-purpose laboratories, Fermilab and SLAC.

The High Energy Physics program is described in terms of three subprograms: Physics Research, Facility Operations and High Energy Technology. Although these three functions within the program are discussed as separate sub-programs, they are not independent. Each is coupled to the other two and cannot exist separately. The close interaction and dynamic nature of these three subprograms may require that some adjustments among them be permitted during the year in order to ensure the most effective program and the best use of overall program funds.

The High Energy Physics program supports numerous university research contracts in which there is substantial cost sharing by the universities. The universities provide their contributions in a number of ways, such as partial salaries to investigators, provision of laboratory space and machine and electronic shop facilities, computing time and/or equipment, and direct funding contributions for services and equipment. The High Energy Physics program encourages such cost sharing policies to achieve maximum utilization of available Federal funds. In addition, there is cost sharing in a number of experiments by foreign participants, including substantial contributions to major detectors such as the Japanese and Italian support of the Collider Detector Facility (CDF) at Fermilab.

Physics Research	FY 1985	FY 1986	FY 1987 Request
Operating Expenses..........................	$106,300	$106,268	$118,600

The Physics Research subprogram includes the support of university- and laboratory-based research groups for the planning, preparation and execution of experiments, and for the measurement, analysis, interpretation, and dissemination of experimental results. It also supports the research of university- and laboratory-based theoretical physicists engaged in both phenomenological and formal areas of theoretical study.

Experiments in high energy physics generally require the use of large particle accelerators, together with complex detection apparatus, to study the results of the collisions of high energy particles. The DOE-supported accelerators and experimental facilities are located at three central laboratories, where they are made available to qualified scientists on the basis of the scientific merit and promise of their research projects. About 75 percent of the research done with these central facilities is performed by university-based physicists. Because of the size and complexity of a typical high energy physics experiment, users from a number of institutions frequently collaborate on a given experiment. These research teams typically include a mix of physicists, engineers, technicians, and graduate students. After a research proposal to the laboratory is accepted, the research teams participate in the design and fabrication of detectors and provide manpower for the experiment during the data-taking phase at the laboratory. There is usually significant interaction and assistance from laboratory staff, and use of laboratory support facilities, for each experiment. The entire process, from conception of the experiment to publication of results, typically takes up to five years if no major new detector is involved; if major detector design and fabrication is involved, the duration can be several years longer. U.S. user group participation in experiments utilizing unique capabilities and opportunities at foreign laboratories such as DESY (West Germany), CERN (Western Europe), and KEK (Japan) is also supported. Studies of some of the important fundamental problems in high energy physics are being carried out in experiments which do not involve the use of high energy accelerators. While experiments to search for proton decay currently represent the largest of the non-accelerator experimental efforts, there are other experiments, both proposed and in operation, including searches for free quarks, magnetic monopoles, neutrino mass, and neutrino-less double beta decay.

Theoretical research provides a framework for understanding the results of experimentation and provides suggestions for new measurements important for advancement of understanding. Experiments test existing theory and provide the basis for extensions, revisions and modification of the theoretical framework and understanding. Because of this strong interplay between, and interdependence of, experimental and theoretical research, experimental and theoretical research groups often work closely together. High energy theoretical research presently has a strong focus on the development of a unified description of the forces in nature through generalized quantum field theories. An increasingly successful trend in theoretical research is the use and development of large-scale computing facilities to explore numerical solutions of candidate theories which are not amenable to analytic methods, along with the development of more powerful numerical and analytical techniques.

The Physics Research Subprogram also includes an Outstanding Junior Investigator program which provides research support for outstanding untenured high energy physicists who might otherwise have to leave the field due to lack of availability of permanent academic positions. This small program is very important for encouraging some of the best young scientists to remain in this field of research, and thus bears importantly on the long range vitality of the field.

The FY 1987 budget request of $118,600,000 for Physics Research is necessary to maintain the capability of the university and laboratory research groups to participate effectively in today's more complex experiments, particularly those using the new capabilities at Fermilab and SLAC; to provide a level of effort reasonably matched with the planned level of facility utilization; and to maintain the important theoretical research and non-accelerator high energy physics research programs.

Distribution by Facility

	FY 1985	FY 1986	FY 1987 Request
Fermi National Accelerator Laboratory (Fermilab)	$ 9,603	$ 9,382	$ 10,300
Brookhaven National Laboratory (BNL)...............	7,100	6,989	7,600
Stanford Linear Accelerator Center (SLAC).........	11,106	10,818	11,900
Argonne National Laboratory (ANL)................	4,920	4,787	5,300
Lawrence Berkeley Laboratory (LBL)...............	8,400	8,454	9,200
Universities and Other Agency Laboratories.......	65,171	65,838	74,300
Total Physics Research..........................	$106,300	$106,268	$118,600

Fermi National Accelerator Laboratory

In FY 1987 $10,300,000 is requested for the support of the Fermilab in-house research effort. This level will permit continued physics research activity by Fermilab scientists, most of which is done in collaboration with university-based groups from across the country. In this mode, the Fermilab staff participate in forefront research while simultaneously providing a crucial support and liaison function for the many university users of the Fermilab facilities. A major focus of their research efforts will be the unique new opportunities for fixed target research becoming available with completion of the full set of beams and targets provided by Tevatron II construction, and for colliding beam research becoming available with the new Tevatron collider facilities.

The major lines of research to be pursued by Fermilab scientists in FY 1987 will be searches for new particles, studies of nucleon structure and constituents, and exploration of the electroweak force through neutrino interactions. The 900 GeV capability of the superconducting synchrotron, in conjunction with the upgraded and new fixed target experimental facilities, as well as the new proton-antiproton colliding beam capability, will offer many highly promising new and unique opportunities for research advances. Major experiments will study: W and Z production and searches for new phenomena in colliding beam experiments; the properties of jets of particles produced with high transverse momentum; the dimuon spectrum resulting from energetic proton collisions with a fixed target; the direct production of single photons in hadronic collisions; the characteristics of interactions of neutrinos at the higher energies now available; the substructure of nucleons using the superconducting "Chicago Cyclotron" magnetic spectrometer; and the creation of charmed and heavier quark states by photons and hadrons in experiments at new higher energies. The requested funds also include support for the Fermilab theoretical physics research program, including a small effort which explores the interface region between astrophysics and high energy physics.

Brookhaven National Laboratory

In FY 1987 $7,600,000 is required for the BNL research groups. The research capabilities at the AGS are unique, since no other accelerator covers this intermediate range of beam energies or provides similar beams of high energy polarized protons. Major research thrusts during FY 1987 will be the study of the interactions of polarized beams on both unpolarized and polarized targets utilizing the high energy polarized beam capability at the AGS, a search for neutrino oscillations, and a program of innovative studies of rare K decays. Most of this work will be performed at the AGS in collaboration with university based groups. A complementary program of theoretical analyses of experimental results and more formal theoretical studies will also be pursued.

Stanford Linear Accelerator Center

In FY 1987 $11,900,000 is requested for support of SLAC physics research groups. The first experiments at the new SLC facility will begin with the upgraded Mark II detector. The SLC experimental program will initially concentrate on studies of the Z^0 and its decay modes. PEP is expected to operate at a new record high luminosity in FY 1987 and provide excellent opportunities for new discoveries with the upgraded TPC detector. Higher precision experiments including precision measurements of electroweak asymmetries and particle lifetimes will be emphasized. Analysis of data from the SPEAR detector (Mark III) will continue concentrating on states in the Psi region to obtain a more detailed understanding of charmed quark matter. The theoretical program at SLAC includes phenomenological studies, as well as studies of fundamental issues concerning properties of the basic forces, the constituents of matter and the unification of forces.

Argonne National Laboratory

In FY 1987 $5,300,000 is requested for the ANL physics research program. ANL scientists will be participating in the analysis phase of experiments done with the HRS detector at PEP. They are also playing a major role in the study of proton-antiproton collisions with the CDF detector at Fermilab and preparation for use of the polarized proton beam at Fermilab. They also are major participants in the Soudan II nucleon decay experiment. The ANL physicists collaborate closely in these activities with university research groups and, together with the unique ANL laboratory capabilities, provide an important technical service base for these groups. The high energy theoretical physics group at ANL focuses on the study and formulation of phenomenological models for strong interactions.

Lawrence Berkeley laboratory

The request provides $9,200,000 in FY 1987 for the LBL research programs to maintain an approximately constant overall level of activity. These funds are required for participation of the LBL research groups in experiments at SLAC, Fermilab and other laboratories. LBL scientists will play a major role in the first experiments at SLC, using the upgraded Mark II magnetic detector. LBL plays a lead role in the experimental program at PEP using the Time Projection Chamber (TPC). Groups of physicists from LBL are also playing important roles in both major detector facilities at the Tevatron collider. An important part of the LBL program is the Particle Data Center, which is the only such capability in the U.S. and which provides a valuable service function for the U.S. and worldwide high energy physics communities. Modest support for high energy astrophysics experiments in 3 degree Kelvin background radiation, supernova detection and observation, and studies of compact stellar objects are expected to continue. These experiments provide important data on elementary processes and complement other high energy physics experiments. Theoretical physics at LBL will continue to emphasize the investigation of elementary particle interactions, the fundamental structure of matter, and topics in advanced accelerator physics.

Universities and other Agency Laboratories

The Physics Research request for FY 1987 provides $74,300,000 for the support of the university-based experimental and theoretical research groups and for high energy physics research programs at the Ames Laboratory, Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest Laboratories (PNL). This amount is required to permit these research groups to participate effectively as users at U.S. accelerator laboratories and unique foreign facilities to perform complex forefront fixed target and colliding beam experiments; to perform new forefront non-accelerator experiments; to conceive and test innovative ideas for the next generation of experiments; and to carry out theoretical and phenomenological analyses.

The Department supports approximately 115 experimental and 65 theoretical high energy physics research groups at 90 universities across the nation, as well as the research efforts at Ames, LANL, ORNL and PNL. DOE university-based high energy experimental groups are engaged in many forefront experiments in various stages of progress, collecting data from the U.S. accelerators at BNL, Cornell, Fermilab, and SLAC, and also from European accelerators at the European Laboratory for Particle Physics (CERN) and the Deutsches Elektronen-Synchrotron (DESY), from the Japanese TRISTAN facility at KEK, and from non-accelerator settings (e.g., deep mines for proton decay). Such well-conceived and carefully executed experiments provide the basis for progress in the field. The theoretical program includes a variety of activities ranging from abstract theoretical considerations to phenomenological studies. This work includes development of powerful methods for calculating lattice gauge formulations of quantum chromodynamics, and for predicting the results of electroweak interactions and model unification theories.

	FY 1985	FY 1986	FY 1987 Request
Facility Operations			
Operating Expenses..............................	$172,715	$175,095	$213,400
Capital Equipment................................	58,700	69,984	77,500
Construction..	114,000	55,049	41,700
Total Facility Operations......................	$345,415	$300,128	$332,600

Facility Operations supports the many activities required to operate, maintain, equip, and construct the high energy accelerators, colliding beam facilities, experimental areas, secondary beams, large multi-user detector facilities, and central computing facilities which are essential to the pursuit of experimental high energy physics research.

	FY 1985	FY 1986	FY 1987 Request
Operating Expenses	$172,715	$175,095	$213,400

The operating expenses portion of Facility Operations provides funding for the accelerator and experimental facility operating crews and support personnel, the electric power, and the expendable materials and supplies required for these activities which are concentrated at the three DOE high energy accelerator centers located at BNL, Fermilab and SLAC. These accelerator facilities provide the beam time for the research work of most of the high energy physics experimental research groups in the U.S., including many who receive their direct research support from the National Science Foundation (NSF). The accelerator and colliding beam facilities required for research in high energy physics are large, complex, and expensive. Hence, they are few in number and are operated at central locations as national facilities which are made available to those physicists whose research proposals are judged to have the highest scientific promise and merit.

The complementary capabilities at the three accelerator centers provide the essential variety in types of particle beams, particle energies and beam intensities for a productive U.S. high energy physics program. At Fermilab, the superconducting magnet Tevatron provides intense beams of protons with energies up to 800 GeV and various types of secondary particle beams with the high energies and high intensities needed for forefront fixed target experiments. In FY 1987, the 900 GeV on 900 GeV proton-antiproton colliding beam facility provided by Tevatron I will be in operation for research for the first time. At BNL, the AGS provides protons with energies up to 30 GeV in the primary beam, high energy polarized proton beams, secondary particle beams, and neutrino beams, for use in fixed target experiments. At SLAC, the two-mile linear accelerator provides both electrons and positrons at energies up to 50 GeV, for High Energy Physics research at the new Stanford Linear Collider (SLC) (50 GeV on 50 GeV), the PEP storage ring facility (15 GeV on 15 GeV) and the SPEAR storage ring facility (4 GeV on 4 GeV).

In FY 1987 there are major incremental costs required to initiate operation for research of the new Tevatron proton-antiproton colliding beam facility at Fermilab and of the unique new SLC electron-positron collider capability at SLAC. The funding request in FY 1987 will provide for these new needs while permitting an average overall utilization level for HEP facilities near the 50 percent level. Good utilization of these new research capabilities is essential to a world competitive position for the U.S. program. In order to support the first research utilization of these two new world forefront capabilities at Fermilab and SLAC, operation of the AGS at BNL, of the PEP and SPEAR facilities at SLAC, and of the fixed target facilities at Fermilab, will be reduced.

Operating Expenses
Distribution by Facility

	FY 1985	FY 1986	FY 1987 Request
Fermilab....................................	$ 83,268	$ 84,536	$100,700
BNL....................................	35,865	35,710	38,400
SLAC....................................	50,835	49,783	68,600
LBL....................................	700	718	800
Other....................................	2,047	4,348	4,900
Total Facility Operations....................	$172,715	$175,095	$213,400

Fermi National Accelerator Laboratory

The FY 1987 request for Facility Operations at Fermilab is $100,700,000. There are major incremental costs at Fermilab associated with first operation for research of the world forefront Tevatron collider facility. Initiation of the colliding beam experiments requires operation of the new antiproton source; this is a major facility in its own right, including a complex target facility and two new storage ring accelerators. The superconducting magnet accelerator will be operated about six months for research in FY 1987. Operation of the entire expanded sequence of accelerators at Fermilab (Cockroft-Walton preaccelerator, linac, booster, main ring, superconducting Tevatron ring and antiproton source storage rings) will require $60,700,000. The FY 1987 program is expected to include three months of operation in the fixed target research mode at energies of about 800 GeV energy, and three months for colliding beam research. In addition about one month will be required for change-over and start up activities. Operation of the laboratory's extensive set of secondary beams, fixed target detectors, colliding beam detectors and central computing facilities will require $40,000,000. During operations for the fixed target program, about ten secondary beam lines will provide a variety of intense high energy particle beams for research use, and about 14 different experiments are expected to take data. The Fermilab fixed target research program in FY 1987 will exploit the availability of secondary particle beams of higher energies and, in most cases, higher intensities than are available anywhere else in the world. It is a world unique and truly forefront program which has high priority within the national high energy physics program. The colliding beams research program will provide the first data for the new Collider Detector at Fermilab (CDF), and simultaneously for three other small colliding beams experiments. This will provide the first exploration of subnuclear phenomena near 2000 GeV collision energies.

Brookhaven National Laboratory

In FY 1987 $38,400,000 is requested for operation of the AGS and associated experimental facilities. This will result in a somewhat reduced level of operation relative to FY 1985 and FY 1986. Of this amount, $19,500,000 is needed for accelerator operations and $18,900,000 is needed for experimental facility operations. This will support about a six month level of machine operations. The FY 1987 operating program is expected to to be divided among slow extracted beam operation, polarized proton beam operation, and fast extracted beam operation for neutrino experiments. During the slow beam operations, approximately eight experiments will be taking data simultaneously, emphasizing the high priority rare kaon decay experiments. Also included are lease costs for the CAD/CAM computer system. In addition, the AGS will also be operated for heavy ion research which is funded by the Nuclear Physics program.

Stanford Linear Accelerator Center

$68,600,000 is requested in FY 1987 for Facility Operations at SLAC. Of the request, $40,700,000 is for the operation of the linear accelerator, SLC, PEP, and SPEAR, and $27,900,000 is for the operation of the experimental areas, detector facilities and the central computer facility (including lease costs for the IBM 3081-X and upgrades). There are major incremental costs at SLAC in FY 1987 to bring the world forefront SLC collider into first operation. The linac presently operates mostly at 60 pulses per second for injection into the PEP and SPEAR colliders; however, research operation of the SLC requires operation of the linac at 120 pulses/second. This increased pulse rate results in a large increase in power usage and in the rate of klystron and thyratron replacements. These effects, combined with the rapidly rising electric power rates from WAPA (nearly 50 percent from FY 1985 to FY 1987) and the need to purchase some power from PG&E during 120 pulses/second operation, result in the large incremental cost for SLC operation. The current plan is to operate the linear accelerator for High Energy Physics for about six months. During the 2-1/2 months for SLC commissioning the linac would operate mostly at 60 pulses/second, while during the 3-1/2 months of physics research with SLC it would operate mostly at 120 pulses/second. Research utilization of the SLC will require operation of the upgraded Mark II detector and the associated collider experimental hall. Operation of PEP is expected to continue at higher luminosity with an improved TPC detector. To permit funding for the commissioning and first operation of SLC, operations of the SPEAR and PEP storage rings will be significantly reduced in FY 1987. SPEAR will remain available for use by the Stanford Synchrotron Radiation Laboratory which is supported by the Basic Energy Sciences Program.

Lawrence Berkeley Laboratory

The request provides $800,000 for support of LBL's participation in the operation of the Time Projection Chamber (TPC) detector facility at PEP. LBL provides engineers, computer scientists, technicians, and physicists who are responsible for reliable operation of the TPC.

Other

In FY 1987, $4,900,000 is requested for special process spares and common use stores inventories and other specialized activities to meet requirements for effective operation of the accelerator laboratories. An adequate complement of spares and specialized replacement parts is essential to avoid unnecessary disruptions to the operating schedule in the event of component failures. These very complex and advanced technology facilities require many components that are not off-the-shelf items but must be custom made in advance if they are to be readily available when a replacement part is needed. In FY 1987 there are increased needs to provide adequate spares support for the new facilities at Fermilab and SLAC.

	FY 1985	FY 1986	FY 1987 Request
Capital Equipment............................	$ 54,700	$ 69,984	$ 77,500

Capital Equipment funding is required to provide the secondary beam line components, particle detection apparatus, portable shielding, and data analysis systems essential to do high quality, forefront high energy physics experiments. It is also required for replacement of accelerator and detector facility components that have worn out or become obsolete. A proper complement of detectors and secondary beams is essential for effective utilization and operation of the major high energy physics accelerator and colliding beam facilities. The world forefront detectors required for more effective utilization of the new and unique research capabilities of both the Tevatron and the SLC colliders have total costs in the vicinity of $50 million and require about five years to fabricate.

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 100 tons or more are not uncommon; and electronics systems with hundreds of thousands of data channels are typically required for major detectors. A time span of as much as five years is often involved from design, through fabrication, to installation, checkout, and operation of these large systems. Examples of specific items of equipment needed include: beam transport magnets and 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.

In FY 1987, $77,500,000 is requested to meet the most urgent capital equipment needs of the program, with particular emphasis on the major world forefront detectors required for adequate utilization of the new colliding beam research capabilities coming into operation at Fermilab and SLAC. The needs for the D-Zero detector for the second experimental area at the Tevatron collider, and for the first fully scoped detector for the SLC (the SLD), are given special emphasis to make it possible for these new detectors to be completed in FY 1989. At Fermilab it will be necessary to upgrade the first colliding beam detector (CDF) and to upgrade the secondary beams and detectors required for experiments using the fixed target capabilities. At SLAC it will be necessary to upgrade the TPC detector for second generation experiments. At BNL, there are major capital equipment needs related to the large rare kaon decay detectors. There are also needs for university users, for non-accelerator experiments, and for U.S. participation in international collaborative experiments at unique foreign facilities.

High Energy Physics
Summary of Capital Equipment by Laboratory

	FY 1985	FY 1986	FY 1987 Request
Fermilab..	$ 27,540	$ 31,115	$ 30,500
BNL..	4,497	4,978	5,200
SLAC...	9,070	14,552	21,000
LBL..	1,730	1,436	1,600
ANL..	1,280	747	700
Other DOE laboratories and universities.......	10,683	13,422	14,300
General Purpose Equipment (BNL)...............	3,900	3,734	4,200
Total Capital Equipment.......................	$ 58,700	$ 69,984	$ 77,500

Fermi National Accelerator Laboratory

In FY 1987, $30,500,000 is requested for capital equipment for the Fermilab program. Needs for FY 1987 progress on the D-Zero colliding beam detector which is planned for completion in FY 1989 account for $12,500,000 of the request. Another major need ($8,500,000) is for the secondary beam lines and detectors which are essential for good utilization of the Fermilab fixed target research capabilities. The request also includes $3,500,000 for upgrades to the CDF colliding beam detector.

Summary of Capital Equipment Request for Fermilab

	FY 1987 Request
Detectors for Effective Utilization of Tevatron I................	$ 16,000
D-Zero detector..	12,500
CDF detector upgrade...	3,500
Detectors and Secondary Beams for Fixed Target Program...........	$ 8,500
Detectors for fixed target experiments...........................	4,700
Secondary beam line components and shielding.....................	3,800
Base Program Needs...	$ 6,000
Accelerator related equipment items..............................	1,800
Support equipment for experimental program.......................	1,600
General computing equipment......................................	1,700
Technical support and site operations equipment..................	900
Total..	$ 30,500

Several new and upgraded detectors need to be completed and brought into operation during FY 1987 for the fixed target program. The requested $4,700,000 for fixed target detectors includes $1,200,000 for approved experiments in the Neutrino Area, $2,100,000 for experiments in the Proton Area, and $1,400,000 for experiments in the Meson Area.

Several secondary beam line facilities need to be upgraded with new technical components in FY 1987. The major requirements for secondary beam transport lines include magnets, control systems and instrumentation, cryogenics for the superconducting magnets and shielding. A total of $3,800,000 is requested for such secondary beam equipment, of which the major efforts on new beams will include completion of the hyperon beam ($700,000), the polarized proton beam ($600,000) and the new higher energy pion beams in the Meson Area ($1,300,000) and the Proton Area ($500,000). The remainder of the requested funds will be used for upgrades to about five existing beams.

Two major colliding beam detectors (one for each major interaction hall) are being fabricated at Fermilab to conduct research at the unprecedented reaction energies scheduled to become available for the first time late in 1986, when the Tevatron collider becomes operational. The Collider Detector at Fermilab (CDF) being assembled at the B-Zero interaction region of the Tevatron will be ready for research operation near the end of FY 1986. It will provide the first studies of new physics at reaction energies in the 2000 GeV range. The $3,500,000 requested for CDF in FY 1987 will provide upgrades whose need is indicated by early pre-operating experience. Fabrication of the second colliding beam detector, to be installed at the D-Zero interaction region of the Tevatron, was initiated in FY 1985. The $12,500,000 requested in FY 1987 for the D-Zero colliding beam detector will permit major progress on this detector and will maintain a schedule that makes it possible for the D-Zero detector to be completed in FY 1989.

The numerous and technologically advanced accelerator and cryogenic systems at Fermilab require replacement items of capital equipment in order to maintain good operating condition and for the replacement of worn out and obsolete units. Items needed include components of the power, vacuum, RF, controls and cryogenic systems. Equipment needed for the R&D programs is included in this category. A network of small emulators and microprocessors, to provide more efficient access by users to the Fermilab central computing complex, is also required in FY 1987. The request also provides for the standardized electronics modules and other items of support equipment provided from a centralized pool for experimental users, as well as for technical support and site operations equipment such as machine tool replacements.

Brookhaven National Laboratory

The FY 1987 request of $5,200,000 for BNL includes $4,700,000 for needs of the ongoing AGS physics program. This includes $3,000,000 for detection equipment for the BNL physics research groups, a major part of which is for the rare kaon decay experiments; $1,100,000 for components for secondary beam line modifications; $300,000 for controls and instrumentation in various parts of the AGS complex; and $300,000 for the instrumentation pool which provides modules of standardized electronic apparatus which are available to all AGS users on the basis of need. The remaining $500,000 is for equipment needed to support the advanced accelerator R&D programs.

Stanford Linear Accelerator Center

The request of $21,000,000 in FY 1987 is required to meet equipment needs related to the SLAC linear accelerator, the SPEAR and PEP storage rings, the associated experimental detection facilities, work on a fully scoped detector (SLD) for use at SLC, and the SLAC advanced accelerator R&D programs.

The request includes $14,500,000 for progress on the first full-scope SLC detector, the SLD, designed specifically for experiments at 50 GeV on 50 GeV. This detector will include high resolution calorimetry and excellent particle identification over a large solid angle, as well as the ability to identify short-lived particles by the measurement of their path length prior to decay. The FY 1987 request is needed to maintain a schedule that makes it possible for this state-of-the-art detector to be completed in FY 1989.

The $6,500,000 requested for other activities includes completion of the modification of the PEP lattice for increased luminosity and upgrading of the TPC detector. Also included are minor upgrades of the Mark II detector at SLC. Other needs to be met from this request include equipment needs in support of SLAC's advanced accelerator research and development effort, including work on advanced concepts with potential application to future linear colliders; improvements to the central computing system and its associated network, and general laboratory support equipment.

Lawrence Berkeley Laboratory

A total of $1,600,000 is requested for capital equipment needs at LBL in FY 1987. The physics research program requires $900,000 for the support of experiments at SLAC, Fermilab, and for a double beta-decay experiment. The advanced accelerator R&D effort requires $500,000 for equipment related to LBL's efforts on antiproton cooling, on very high field superconducting accelerator magnets, and on special purpose computing devices used in performing orbit tracking calculations for advanced accelerator design. There is also a need for $200,000 for equipment in support of the advanced detector development program.

Argonne National Laboratory

A total of $700,000 is requested for ANL capital equipment needs in FY 1987. This equipment will support ANL's participation in a variety of experiments, including the new polarized proton beam experiments at Fermilab and the Soudan II proton decay experiment.

Other DOE Laboratories and Universities

A total of $14,300,000 is requested to meet the capital equipment needs of other DOE laboratories and universities. The $13,000,000 requested for university programs in FY 1987 is required for experimental detection and data analysis equipment. These funds support the major apparatus needs of the experimental research programs of the university users for experiments at U.S. and foreign accelerator laboratories, and for non-accelerator experiments such as searches for nucleon decay, neutrino oscillations, double beta decay, magnetic monopoles, and studies of very high energy processes produced by cosmic radiation.

Included in the $13,000,000 are major equipment needs ($6,500,000) for user groups participating in electron-positron colliding beam experiments presently in the preparation stage at the LEP facility at CERN, in electron-proton colliding beam experiments at the German HERA facility, and at the TRISTAN colliding beam experimental program at KEK in Japan. There are needs ($2,500,000) for non-accelerator experiments such as the proton decay searches which are operated in deep mines. There are direct funding needs of the university programs ($1,200,000) for apparatus for experiments utilizing fixed target and colliding beam capabilities at Fermilab; for experiments at the SLC and PEP Colliders at SLAC; for utilization of the high intensity capability of the AGS at BNL for neutrino oscillation, rare kaon decay and polarized beam experiments. On-line computer equipment, interfacing components and peripherals, which are an integral part of experimental detector systems, and small computer systems used in scanning, measuring, and data analysis, are also required by the university experimental groups. In addition, theoretical groups based at universities have a requirement for special computing capability for some types of theoretical research such as lattice gauge calculations. These needs require $800,000. Also included is $2,000,000 for a mainframe for data reduction for the LEP 3 experiment.

The FY 1987 request also includes $750,000 for equipment needed in support of the advanced accelerator R&D efforts and $550,000 for Ames Laboratory for detector components to be used in experiments at the LEP facility at CERN.

General Purpose Equipment (BNL)

The High Energy Physics program provides funding for all general purpose equipment requirements at BNL. In FY 1987, $4,200,000 is requested for this multipurpose equipment, which is essential to the proper day-to-day operations at the Laboratory. Included are all the needs of the Laboratory's service and support divisions, central scientific computing facility and central shops, as well as equipment required to respond to health, safety, security, and environmental needs. It is important that obsolete and worn-out equipment be replaced in order to promote efficient, safe laboratory operations, to increase productivity, and to avoid high maintenance costs.

	FY 1985	FY 1986	FY 1987 Request
Construction..................................	$114,000	$ 55,049	$ 41,700

A total of $41,700,000 in construction funding for high energy physics projects is requested in FY 1987. The projects are:

Project Title	Project No.	FY 1987 Request	Total Estimated Cost
Tevatron I (Fermilab)........................	81-E-218	$ 367	$ 84,000
SLC (SLAC)....................................	84-ER-133	976	115,400
Central Computing Upgrade (Fermilab)..........	86-R-104	14,157	24,100
AGS Accumulator/Booster (BNL)...d.............	86-R-105	3,500	26,400
Accelerator Improvement Projects (AIP).......	87-R-101	11,500	11,500
General Plant Projects (GPP)......d..........	87-R-102	11,200	11,200
		$ 41,700	

The construction request includes funding to continue the upgrade of the central computing capability at Fermilab and the AGS Accumulator/Booster at BNL, for completion of Tevatron I and SLC, and for accelerator improvements and modifications and general plant projects which are needed on an annual basis to maintain the efficiency, reliability and scientific effectiveness of the laboratories.

Tevatron I

The Tevatron I project at Fermilab will provide the facilities needed for a 1000 GeV on 1000 GeV proton-antiproton colliding beam capability. This will be accomplished by producing intense counter-rotating beams of protons and antiprotons in the Energy Saver superconducting magnet ring and bringing them into collision to produce about 2000 GeV of reaction energy, the highest available in the world. Specifically, the project includes: 1) additional refrigeration and radio frequency accelerating structures so that the Energy Saver ring can operate at 1000 GeV for proton-antiproton colliding beams; 2) an antiproton source; and 3) two experimental areas suitable for detectors to study the results of very high energy proton-antiproton collisions. The $367,000 requested in FY 1987 is the final project funding. Additional details are provided in the Construction project data sheet.

Stanford Linear Collider (SLC)

The SLC project at SLAC, will provide: 1) systems for producing intense electron and positron bunches; 2) small storage ring and beam pulse compressor to increase the density of the electron and positron bunches; 3) two semicircular arcs of small aperture magnets, housed in appropriate enclosures to bring the electron and positron beams into head-on collisions; 4) special focusing systems near the beam interaction point, including the necessary housing and associated experimental hall and staging area; and 5) the instrumentation and control systems to operate these systems.

The SLC project will accelerate beams of electrons and positrons simultaneously in the linear accelerator, separate them and transport them through two semicircular arcs at the end of the linac and then bring them into head-on collision. Successful development of the SLC will provide an essential demonstration of the technical feasibility of the new linear collider concept, which is a critical step toward future cost effective extensions of electron-positron reaction energies beyond the maximum energy practical with circular colliders. In addition, when completed in 1986, the SLC will be the first electron positron colliding beam system in the world capable of achieving an energy of 100 GeV in the center-of-mass system and is expected to produce copious quantities of the recently discovered Intermediate Vector Boson (Z^0), one of the carriers of the electroweak force. The detailed study of the Z^0 is one of the major, exciting areas of physics research indicated by present theories. The project benefits in a major way from the use of the existing 2-mile linac and supporting facilities at SLAC. The $976,000 requested in FY 1987 is the final project funding. Additional details are provided in the construction project data sheet.

Fermilab Central Computing Upgrade

Significantly upgraded central computing capabilities and capacity are required at Fermilab in order to accommodate the data acquisition rates required for forefront experiments with the new research facilities becoming operational with completion of the Tevatron construction program. The primary source of this requirement is the antiproton-proton colliding beams capability of the Tevatron, and the two major associated new detector facilities. This new research program will generate unprecedented volumes of data requiring extensive analysis and computation in order to extract the important physics results. Experiments using the higher energies and produce much higher data rates than previously experienced. Effective utilization of these new research facilities requires significantly improved computing capability at Fermilab. A recent study emphasized the urgency of the central computing upgrade to meet these needs.

The total estimated cost of this project is $24,100,000. The project was initiated with $2,968,000 in FY 1986. The concrete exterior structure of the building is to be completed with those funds. The $14,157,000 requested in FY 1987 will permit major progress on this facility, including completion of the building and the acquisition of much of the additional central processing units, peripheral data storage devices, and interfaces to user terminals. The FY 1987 request is essential to permit completion of the computing upgrade on a time scale appropriate for effective research output from the Tevatron. Final funding is planned for FY 1988. Additional details on this project are provided in the construction project data sheet entitled "Central Computing Upgrade" (Project No. 86-R-104).

AGS Accumulator/Booster (BNL)

The accumulator/booster is a 1 GeV intermediate injector to the AGS which will provide a cost effective enhancement of the capabilities of the AGS for high energy physics experiments and also for heavy ion research. It will increase the space charge limit of the AGS, permitting the intensity of proton beams to be increased by a factor of 4 (to 5 x 10^{13} protons/pulse); increase the intensity for polarized protons by a factor of 20 (to about 4 x 10^{11} protons/pulse) by permitting the accumulation of many linac pulses in the booster before injection into the AGS; and will provide the ability to fully strip and accelerate heavy ions up to mass 200 for injection into the AGS.

The increased proton beam intensity will be extremely valuable for important rare kaon decay studies and for medium energy neutrino studies for which the AGS is a world leading facility. It will also permit simultaneous operation of slow extraction and fast extraction systems, thereby permitting neutrino experiments to operate simultaneously with other experiments and considerably enhancing the cost effectiveness of AGS operations. The increase in intensity for the unique polarized proton capability of the AGS is especially important for experiments at large momentum transfer where event rates fall off rapidly. The accumulator/booster will also extend the heavy ion capability of the AGS to ions of mass 200 (gold) compared to the present limit of mass 32 (sulfur).

The TEC of the project is $26,400,000. The project was initiated with $1,915,000 appropriated in FY 1986; $3,500,000 is requested in FY 1987 to continue the project. The remaining funding is scheduled for FY 1988 and FY 1989. Additional details on this project are provided in the Construction project data sheet entitled "AGS Accumulator/Booster" (Project No. 86-R-105).

Accelerator Improvement Projects

A total of $11,500,000, which maintains an approximately constant overall level of effort, is required for Accelerator Improvement Projects (AIP) to be distributed as follows: Fermilab ($5,900,000); BNL ($2,500,000); and SLAC ($3,100,000). AIP funds are required on an annual basis to provide essential modifications and upgrades of the existing accelerator and colliding beam facilities for the purpose of ensuring their scientific effectiveness and improving their operating economy and efficiency.

It is necessary to provide new or modified research capabilities on short notice in order to accommodate the special needs of new high priority experiments. These changes are often required on a time scale much shorter than the normal two to three year Federal budget cycle. As a consequence, AIP funds are essential to permit a rapid and flexible response essential to meet the most urgent of such needs and maintain a highly effective program.

There are special needs for AIP funds at Fermilab because of the very large scale and scope of the laboratory which includes a series of seven accelerators, storage rings and pre-accelerators, as well as the extended cryogenics facilities, beam extraction systems, secondary beam lines and experimental facilities, all of which make up the complex Tevatron facility. Also in FY 1987 there will be additional accelerator facilities requiring such funds at the SLAC complex following completion of the SLC. Additional details on the AIP needs at each of the three accelerator laboratories are provided in the construction project data sheet entitled "Accelerator Improvements and Modifications" (Project No. 87-R-101).

General Plant Projects

General Plant Projects (GPP) funds are for upgrading, modification, and improvement of the general laboratory plant at BNL, Fermilab and SLAC. GPP funds are required for projects such as utilities, support buildings, roads, shops, on-site fire fighting capability, etc., and, although small compared to the capitalized value of the plant, are essential to keeping it in efficient operating condition. The FY 1987 request totals $11,200,000 for an approximately constant level of GPP at the following laboratories: Fermilab ($3,300,000), BNL ($6,000,000), and SLAC ($1,900,000). It is noted that at BNL the High Energy Physics Program has the responsibility to provide funding for all of the GPP needs of this multi-program laboratory. Additional details are provided in the construction project data sheet entitled, "General Plant Projects, Various Locations" (Project No. 87-R-102).

	FY 1985	FY 1986	FY 1987 Request
High Energy Technology			
Operating Expenses	$ 90,200	$ 88,462	$ 95,500

Progress in forefront scientific research is strongly linked to advances in technology. The performance capability of the facilities and instrumentation available to researchers affects the ability to make significant advances. Development of new accelerator and detector capabilities and of new better types of instrumentation depends not only on the development and application of new advanced technologies but also frequently requires extension of the underlying scientific and engineering principles. Research in high energy physics requires some of the most complex and technologically advanced research facilities ever built. The development of applicable supporting technology not only in response to the needs of research but also in anticipation of them is an essential feature for the DOE supported program in high energy physics.

The High Energy Technology subprogram has the specific goal of providing the technological base for improving the scientific effectiveness, reliability and efficiency of existing facilities and for extending the scientific capability of the experimental research program through new concepts and new, advanced facilities. As a byproduct, work carried out under the High Energy Technology R&D subprogram frequently pushes forward or opens up new technological frontiers, thereby contributing significantly to the national technology base and to many specific needs in other areas of science, technology and medicine. In order to sustain an effective technology R&D effort that is both responsive to the needs of and stimulates the basic physics research programs, it is necessary also to pursue a vigorous theoretical research effort into the physics and engineering principles underlying the concepts and operation of these facilities; to conduct forefront R&D in selected, promising areas of applicable technology; to develop and prove emerging ideas and concepts; and to transform these ideas and concepts into practical devices and techniques for use in physics research and elsewhere.

The High Energy Technology subprogram is subdivided into two major areas: Accelerator R&D and Experimental Facility R&D. The first is concerned with the production of particle beams and the second with the utilization of those beams for physics research. Specifically, accelerator R&D is concerned with the science and technology fundamental to charged particle accelerators, colliding beam systems, beam extraction, and primary beam transport systems. Its goal is to develop new and improved concepts, techniques, and devices of direct application to the acceleration, storage, and transport of particle beams to be used for probing the innermost depths of matter and energy. The end products are particle beams of higher energy, increased intensity, longer stored lifetime, greater brightness (more particles per unit transverse beam area), lower cost and greater diversity. Experimental facility R&D is concerned with the targets, secondary beam transport systems, detection apparatus, and data processing systems directly involved in the physics experements. It focuses on developing new and improved means for generating, splitting, and transporting secondary particle beams; on inventing and developing new types of instrumentation required for detecting and studying the characteristics of particle interactions produced in experiments; and on devising advanced processing techniques for the collection and analysis of data gathered in experiments.

While the purpose and thrust of the technology R&D subprogram is to ensure and extend the technology base vital to the progress of high energy physics research, the results of the advanced R&D effort frequently find significant application in other scientific and engineering disciplines. Thus, advances in the understanding of charged particle beam technology have contributed to the development of high power radiofrequency tubes, electron microscopes, semiconductor manufacture, and x-ray sources. Standardized instrumentation systems sponsored and developed by the high energy physics program, such as the recently completed FASTBUS, have become national and international standards used in other research disciplines, industrial process control and artificial intelligence. Pattern recognition methods developed for bubble chamber scanning in high energy physics were essential in the development of Computer Assisted Tomography (CAT) scanners. Superconducting magnet technology and pattern recognition methods have been applied to the new Nuclear Magnetic Resonance (NMR) devices which are expected to revolutionize medical diagnostics.

The High Energy Technology R&D activities are concentrated primarily at five DOE supported national laboratories, although an important part is carried out by universities, other laboratory and non-profit institutions, and industrial firms. The FY 1987 request of $95,600,000 for the High Energy Technology Subprogram includes a program of R&D studies in support of upgrades to maintain the scientific effectiveness of existing accelerator, colliding beam, detector and experimental facilities; in support of ongoing construction projects; and to develop very advanced concepts and techniques with potential application to future acceleration and detection facilities. The FY 1987 request includes continued R&D studies on superconducting magnets for accelerators and their optimization for future accelerators including materials development, cryogenics and manufacturability studies. Also included are magnet systems studies such as vacuum, instrumentation and control systems, and the effects on these systems and on the magnets themselves, of operating a series of magnets as a system. Important accelerator physics studies include non-linear beam dynamics, both analytical and by tracking, and the production and maintenance of brighte low emittance beams.

The studies on superconducting magnets and systems and their optimization are a high priority need for the future viability of the program. The U.S. breakthrough in superconducting magnet technology, represented most dramatically by the successful operation of the Tevatron, signifies that no future high energy proton or hadron accelerator can competitively be built anywhere without the use of superconducting magnet technology. Further, electron accelerators with capabilities significantly beyond those of the SLAC SLC and the CERN LEP machine will require new accelerator techniques and methods which are expected to require many years of R&D before coming to fruition. Thus, any new frontier high energy accelerator for the near future is expected to require the use of superconducting magnets and R&D and optimization of these magnets for future facilities has high priority. The results of the advanced accelerator R&D program for the next generation particle collider through FY 1986 will provide the technical information for an in-depth Departmental review of an SSC type facility. Those results can be expected to have a strong impact on the direction and emphasis of the FY 1987 R&D studies particularly in the area of superconducting magnets and systems.

	FY 1985	FY 1986	FY 1987 Request
High Energy Technology			
Fermi National Accelerator Laboratory..........	$ 27,735	$ 23,360	$ 24,900
Brookhaven National Laboratory.................	19,305	18,956	20,200
Stanford Linear Accelerator Center.............	16,585	15,509	16,400
Argonne National Laboratory....................	1,681	1,436	1,700
Lawrence Berkeley Laboratory...................	8,190	7,850	8,600
Other DOE laboratories and universities........	16,704	21,351	23,700
	$ 90,200	$ 88,462	$ 95,500*

*Allocations tentative pending departmental review of SSC.

Fermi National Accelerator Laboratory

A total of $24,900,000 is requested for Fermilab in FY 1987 for technology R&D. Of the FY 1987 request, $16,200,000 is for accelerator R&D, and $8,700,000 is for experimental facilities R&D.

Operation of the superconducting magnet ring as a proton-antiproton collider in a totally new energy regime is scheduled to begin late in FY 1986. An extensive R&D program to understand and optimize the properties and performance of the antiproton source and of the Tevatron as a storage ring will be required. Properties of the Tevatron operating with simultaneously circulating beams of protons and antiprotons will be studied with the object of improving reliability, efficiency and luminosity. The operational characteristics of the antiproton source will also be studied with the aim of improving overall performance and luminosity of the collider. Prototypes of an improved lens for the antiproton target, of higher frequency stochastic cooling systems, and of higher capability instrumentation and control systems will be fabricated and tested. R&D will be carried out to investigate ways to increase the brightness of the antiproton source, and on the feasibility of a pre-booster to improve the beam intensity of the Tevatron. R&D on advanced technologies for accelerator and colliding beam systems will also be carried out. R&D on improved superconducting magnets, cryostats and systems will continue.

As Fermilab begins to exploit the research capabilities made available by completing Tevatron I and II, there will be a special focus in the experimental facilities R&D program on the development of higher performance beam transport, targeting and beam splitting apparatus and on improved particle detectors for experiments to more effectively utilize the higher energy fixed target research capabilities. R&D will be needed in support of colliding beam experiments and detectors; particularly the new D-Zero detector. Improved triggering techniques, computer software and special on-line graphics capabilities will be developed. An important component of these efforts will be R&D aimed at improvements in computer techniques and systems. More advanced software for data collection, data reduction and graphical display of results will be required. The program will also include studies to develop advanced detector concepts.

Brookhaven National Laboratory

The FY 1987 request includes $20,200,000 for technology R&D at BNL. Of this, $17,400,000 is for accelerator R&D, and $2,800,000 for experimental facilities R&D.

The accelerator R&D related to the AGS has the goal of maintaining and improving the operating effectiveness and the scientific capability of the AGS. There will be a special effort directed toward achieving a major increase in AGS accelerated beam intensity, and improvements to the polarized beam capability. Advanced R&D on new accelerator concepts and technologies will also be pursued, with particular emphasis on studies of superconducting technology capitalizing on BNL's expertise in this area.

The experimental facilities R&D will focus on new detector and beam line developments aimed primarily at improving the unique capabilities at the AGS for polarized beam experiments, low energy neutrino studies, and rare kaon decay processes. The program also includes an effort on development of advanced detector concepts.

Stanford Linear Accelerator Center

A total of $16,400,000 is requested in FY 1987 for technology R&D at SLAC. The FY 1987 request includes $8,600,000 for support of accelerator R&D and $7,800,000 for experimental facility R&D.

In FY 1987 the SLC project will be brought into operation for research; supporting R&D will concentrate on optimizing performance and reliability and improving luminosity. Special areas of study will include development of methods for enhancing positron beam intensity; problems of stability of high current micron-sized beam pulses in the linear accelerator during acceleration; beam transport to focus the beams of electrons and positrons to a tiny spot and bring them into head-on collision; methods to control and analyze the collisions of the very high intensity micron-sized electron and positron pulses; and development of techniques for acceleration of polarized electrons.

The balance of the accelerator R&D funds will be directed toward improvements in performance, reliability, and operating efficiency of the linear accelerator and the SPEAR and PEP colliding beam devices, and toward advanced concepts. Advanced concept R&D activities at SLAC will include development of high gradient accelerating structures, development of very high power pulsed radio frequency sources, theoretical and experimental studies of new and advanced concepts of linear accelerator systems, development of advanced beam instrumentation and control devices, and development of special beam transport systems for micron sized beams.

Experimental facility R&D at SLAC in FY 1987 will be directed primarily toward the development of advanced detectors for future experiments at the SLC and PEP. Particular emphasis will be placed on R&D in support of the SLD detector.

[illegible]ey Laboratory

[illegible]t [illegible] f [illegible]iested in FY 1987 for technology R&D at LBL. Of this [illegible]t [illegible]ised to support advanced accelerator R&D, including studies of [illegible] high field superconducting magnets, collaborative studies with Fermilab and [illegible]hers on stochastic cooling techniques, and work on novel accelerator concepts such [illegible] the two-beam electron accelerator concept.

The experimental facilities R&D request of $2,800,000 is to support development of a hadron calorimeter for a major proton-antiproton experiment at Fermilab; studies of advanced detectors for use with linear colliders in collaboration with SLAC; work to improve the performance of experimental apparatus at SLAC and Fermilab; and a major initiative for the development of advanced detector concepts utilizing the special expertise of LBL in this area.

Argonne National Laboratory

A total of $1,700,000 is required for ANL in FY 1987. Of that amount, $750,000 is for accelerator R&D and $950,000 is for experimental facilities R&D.

The high energy accelerator R&D at ANL for FY 1987 is expected to be directed primarily towards work on advanced accelerator concepts, particularly on the so-called wakefield devices.

Experimental facilities R&D is expected to concentrate on research and development for new types of particle detectors; further developments of the CDF; and the development of new types of polarized targets.

Other DOE Laboratories and Universities

In FY 1987, $23,700,000 is requested to support other advanced technology programs. The request provides the increase required for the SBIR assessment and an increase of about $400,000 each for advanced detector and advanced accelerator R&D. The work under this part of the technology R&D subprogram is carried out by universities, laboratories and industry. This program presently supports contracts with about 30 institutions. The work covers a very broad spectrum of topics related to accelerators, colliding beams and detectors. The work includes studies to improve upon and optimize previously available techniques and those which seek to develop entirely new techniques. As part of optimization of available techniques, effort includes work on superconducting magnets, including materials development, cryogenics, and manufacturing techniques; other magnets systems, such as vacuum, instrumentation and control systems; and accelerator physics topics such as nonlinear beam dynamics including beam-beam effects, studies both analytically and by tracking, and the production and maintenance of bright, low emittance beams.

There are also significant needs for advanced detector R&D to develop detectors that can extend the range of investigations at present facilities and operate effectively at future accelerators and colliders. R&D is needed to develop radiation hardened detector systems and electronics which can survive in the high radiation environment near the collider interaction point at high luminosity; triggering systems and data reduction systems to handle the high event rates; and techniques for pattern recognition and time tagging and tracking of complex, high multiplicity, overlapping events.

There is also a strong need to develop new accelerator techniques, which derives from the necessity of optimizing the cost of constructing and operating the large, modern accelerator and colliding beam facilities. While there are no known physics or technology reasons why present acceleration techniques cannot be extended to much higher energies than facilities now operating or planned, the size and associated cost of much higher energy facilities based on known technology could become prohibitive.

As a consequence, resources are being directed toward discovering and developing new concepts of charged particle acceleration that are more cost effective and give higher final particle energies in devices that are smaller and more energy efficient than existing ones. Representative lines of research include collective methods of particle acceleration, wake field accelerators, laser acceleration of electrons, theories of non-linear dynamics, collective effect and space charge induced phenomena, very high frequency and high power radio frequency sources, and very high field superconducting magnets. A number of these programs are reaching the point where significant experiments and prototype fabrication are required to verify predictions and guide future R&D studies. A substantial effort in this area is critical to make it possible to provide the required future high energy physics accelerator and experimental facility capabilities in a cost effective manner.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois

2. Project No.: 81-E-218

3. Date A-E work initiated: 1st Qtr. FY 1981

3a. Date physical construction starts: 4th Qtr. FY 1982

4. Date Construction ends: 4th Qtr. FY 1987

5. Previous cost estimate: $82,500
Less amount for PE&D: 0
Net cost estimate: $82,500
Date: October 1984

6. Current cost estimate: $84,000
Less amount for PE&D: 0
Net cost estimate: $84,000
Date: October 1985

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1981	$ 2,000	$ 2,000	$ 2,000	$ 1,211
1982	18,000	14,100	14,100	4,182
1983	18,000	18,000	18,000	11,845
1984	20,000	20,000	20,000	29,517
1985	21,300	21,300	21,300	19,794
1986	4,700	8,233	8,233	13,000
1987	0	367	367	4,451

8. Brief Physical Description of Project

This project provides for:

1. the modification of the superconducting Tevatron accelerator ring so that it can be used as a 1 TeV proton on 1 TeV antiproton colliding-beam storage ring;
2. two experimental areas to provide facilities for simultaneous high energy physics experiments; and
3. the construction of an antiproton production, cooling and accumulation system.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois

2. Project No.: 81-E-218

8. Brief Physical Description of Project (continued)

Additional satellite refrigerators are required to operate the superconducting Tevatron ring near the full energy of 1 TeV because superconductors, as they approach full magnetic field, will make the transition from the superconducting to normal state with decreasing amounts of energy deposited in them. Thus, extra cooling will prevent quenches of the superconducting ring at full energy. Additional rf cavities and other special devices are required to simultaneously accelerate and store protons in one direction and antiprotons in the opposite direction, and to optimize the collision configuration.

Two experimental areas to house high energy physics colliding beam detectors will be an integral part of the Fermilab Main Ring tunnel. The design of the experimental areas will allow the rapid efficient introduction of large detectors into the beams. To accomplish this, there will be separate detector assembly areas. The project also provides an overpass for the conventional magnet ring, to deflect it over the detector at one of the experimental areas.

The Fermilab scheme for production and collection of antiprotons uses the present accelerators, up to and including the main ring conventional magnet synchrotron, plus two additional new storage rings. The first of these is the debuncher ring, operating at about 8 GeV energy, which will have a large acceptance for antiprotons and will be used to debunch the beam as it comes from the antiproton production target. The second ring is the accumulator which will be used for cooling of the antiproton beam after it emerges from the debuncher, and for accumulating the antiprotons. The term "cooling of a particle beam" means reducing the energy spread of the beam. This cooling is particularly important for producing an accelerator quality beam from the dilute beam of secondary particles emerging from the antiproton production target. The accumulator will collect the antiprotons from about ten thousand targeting cycles. It then increases their density by stochastic cooling until the antiproton beam is intense enough to transfer into the Tevatron ring, where it will be accelerated and brought into collision with a counter-rotating proton beam. The project includes construction of the debuncher ring, the enclosures for the two rings, associated beam transport enclosures and the target station.

The research detectors required for experiments will be funded as capital equipment items. The major detector for the B-Zero Area is being fabricated over the period from FY 1981 through FY 1986. Substantial participation and financial assistance is being contributed by the Japanese, and also by Italian collaborators. The total DOE funding contribution for this detector is currently planned to be about $35,000,000. Work on a major detector for the D-Zero Area began in FY 1985. Effective analysis of the large volumes of data to be generated by the TeV I will require an upgrading of Fermilab computing capacity and capability.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois

2. Project No.: 81-E-218

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

When protons and antiprotons are stored in the superconducting Tevatron ring and brought into collision, the reaction energy available for particle production will be about 2000 GeV. This is almost 50 times greater than the reaction energy which is available at Fermilab when 1000 GeV protons strike a fixed target, although the interaction rates of the colliding beams are much lower than those of the fixed target program. This reaction energy will be sufficiently high to produce the W and Z intermediate vector bosons, which are the carriers of the weak nuclear force, and to study their properties. The data from experiments done at Fermilab and at other high energy acceleraters have shown that the proton behaves as though it were made up of constituents. Past experience has clearly demonstrated that extending particle physics investigations into new, much higher reaction energies has proven to be of immense scientific value. A compelling scientific expectation is the likelihood of discovering totally unexpected phenomena at this new world record reaction energy.

10. Details of Cost Estimate

		Item Cost	Total Cost
a. Engineering, design and inspection at 17% of construction costs..			$10,100
b. Construction costs..........			60,100
1. Conventional construction..........		$24,300	
a. Experimental areas..........	$11,600		
b. Ring and beam line housing..........	12,700		
2. Special facilities..........		35,800	
a. Antiproton source..........	23,500		
b. Accelerator components..........	12,300		
c. Contingency at 20% of above costs..........			13,800
Total..........			$84,000

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.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois
2. Project No.: 81-E-218

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

	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	Total
a. Total project costs:								
1. Total facility costs:								
(a) Construction line item...	$1,211	$ 4,182	$11,845	$29,517	$19,794	$13,000	$ 4,451	$ 84,000
Total facility costs.....	$1,211	$ 4,182	$11,845	$29,517	$19,794	$13,000	$ 4,451	$ 84,000
2. Other project costs:								
(a) Direct R&D operating costs necessary to complete construction...	2,221	3,337	13,268	21,262	7,000	1,075	0	48,163
(b) Capital equipment in support of R&D..........	621	368	702	357	293	0	0	2,341
Total other project costs	$2,842	$ 3,705	$13,970	$21,619	$ 7,293	$ 1,075	$ 0	$ 50,504
Total project costs (Items 1 & 2)........ ..	$4,053	$ 7,887	$25,815	$51,136	$27,087	$14,075	$ 4,451	$134,504

b. Total related incremental annual funding requirements (estimated life of project: 20 years)

1.	Facility operating costs..........	$- 3,000*
2.	Programmatic operating expenses directly related to the facility..........	2,500
3.	Capital equipment not related to construction but related to the programmatic effort in the facility..........	3,000
4.	GPP, AIP programmatic costs..........	500
	Total other related annual funding requirements..........	$ 3,000

*Reference item 13.b. for explanation.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois 2. Project No.: 81-E-218

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 - Studies of stochastic cooling techniques will continue. R&D on the antiproton production target system and the accumulator ring are now in progress. R&D on other elements of the project, to optimize performance and minimize the costs of various subsystems, will continue through the late stages of construction.

(b) Other project-related costs - The items included in these costs are magnets, power supplies, electronics and other general equipment to support a.2(a) above.

b. Total related annual funding requirements - It is assumed that after Tevatron I comes into operation approximately one-half of Fermilab accelerator operations time will be for colliding beams. This means that the fixed target experimental areas will not be operating one-half of each year. During the colliding beam operating period, there will be a net reduction of power consumption at Fermilab of about 15 Megawatts compared to running full time for fixed target experiments, which corresponds to a savings of about $3,000,000 over six months at current power rates. The programmatic effort in the facility will require approximately 30 additional people, and additional material and supplies are required to effectively operate the facility. The acquisition of research detectors for Tevatron I will be made with capital equipment funds. In the future, it is anticipated that major detector upgrades will be required about every three years. GPP and AIP funds will be required as experience in operating the new antiproton source and utilizing the Tevatron as a storage ring indicates specific areas where improvements would be more beneficial.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

3. Date PE&D initiated: 2nd Qtr. FY 1980

3a. Date physical construction starts: 1st Qtr. FY 1984

4. Date Construction ends: 2nd Qtr. FY 1987

5. Previous cost estimate: $114,272,000
Less amount for PE&D: 2,272,000
Net cost estimate: $112,000,000
Date: October 1983

6. Current cost estimate: $117,672,000
Less amount for PE&D: 2,272,000
Net cost estimate: $115,400,000
Date: November 1984

7. Financial Schedule:

Fiscal Year	Authorizations	Appropriations	Obligations	Costs
1984	$ 32,000	$ 32,000	$ 32,000	$ 23,094
1985	60,500	60,500	60,500	49,552
1986	21,924	21,924	21,924	39,000
1987	976	976	976	3,754
Total	$115,400	$115,400	$115,400	$115,400

8. Brief Physical Description of Project

The SLAC Linear Collider (SLC) is a new type of electron-positron colliding beam facility which is an important step toward reducing the cost of very high energy electron-positron colliding beam devices to permit extension of the upper limit in energy above that which is at present fiscally feasible. The SLC will be constructed on non-government owned property at the Stanford Linear Accelerator Center (SLAC) which is located on Stanford University property. Its operation is based on the acceleration, in the linac, of an intense positron bunch and an intense electron bunch to energies of approximately 50 GeV each. At the end of the linac, the two bunches are injected in opposite directions into two arcs of magnets, arriving at a collision point where an effective interaction energy of approximately 100 GeV is achieved. After the collision point, the particles are disposed of and not used again. Because the beam is used only once, the magnets in the ring can have small aperture and, hence, low cost. Compared to storage rings, the single pass collider system operates at a relatively low repetition rate but makes up for the low collision frequency by the extremely high current densities which can be achieved at the collision point.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC) Stanford Linear Accelerator Center (SLAC) Stanford, CA	2. Project No. 84-ER-133

8. Brief Physical Description of Project (continued)

The main components of the SLC are the energy upgrade of the SLAC linac; a transport system from the end of the linac to the small aperture magnet arcs; the magnet arcs themselves which includes the special focusing systems required near the interaction point; the necessary beam housing; an experimental hall and staging area; a high power positron production target at the 2/3rd point of the linac; a positron booster; a transport system from the positron target back to the injection end of the linac; a high peak current electron gun; two small storage rings, called damping rings, to reduce the emittances of the electron and positron beams by radiation damping; pulse compressors to reduce the length of the bunches in the storage rings before injection back into the linac; and the necessary instrumentation and control systems.

Since the SLC involves a new type of colliding beam system, its operation and the function of the various components are described below. A bunch of positrons containing approximately 5×10^{10} particles is injected into the SLAC linac. A single intense electron bunch, also of 5×10^{10} particles, is injected into the linac approximately 20 meters behind the positron bunch. A second electron bunch is injected behind the first intense electron pulse. This second electron bunch is used for the production of a new positron bunch. The first two bunches are accelerated in the linac to an energy of about 50 GeV. At the end of the linac a splitter takes the leading intense positron and the first electron bunch and starts them around the two magnet arcs in opposite directions. The function of the arcs is to transport the electron and positron bunches to a collision area where they collide head-on. In the collision area a collection of special lenses focuses the beams to a cross section of about 2 micron diameter at the collision point. After the beams pass through each other at the collision point they are disposed of and not used again.

The second electron bunch, which travels down the linac behind the electron and positron bunches, is deflected out of the linac at the two-thirds point and is directed onto a positron production target. Positrons from this production target are boosted to an energy of around 0.2 GeV by a short section of linac and transported by a separate magnetic-optical system back to the injector end of the main linac. There they and two new electron bunches from the electron gun/injection system are boosted to an energy of approximately 1.2 GeV and put into damping rings. In the damping rings the size of the beams decreases through synchrotron radiation damping to the appropriate value for re-injection into the main linac. The damping time for positrons is longer than the approximately 8 milliseconds between pulses of the collider system and, therefore, this ring must store two bunches simultaneously. The positron bunch which has been stored for the longest time is the one which is ejected from the damping ring and injected into the linac for the next pulse. During the time the .2 GeV positron beam is traveling back to the injector end of the linac, the high current electron gun produces two short pulses of electrons.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

8. Brief Physical Description of Project (continued)

These are timed to arrive at the injector just after the .2 GeV positron bunch. All three bunches of particles are accelerated in tandem through the first 100 M of the linac to 1.2 GeV energy. The positron bunch is switched to the positron damping ring and the two electron bunches into the electron damping ring. At the start of the next cycle one of the positron bunches and the two electron bunches are extracted from the damping rings, compressed longitudinally to a length of about 1 mm and injected into the linac. This total process is then repeated over and over again at the repetition rate of the linac.

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

The SLC has two goals. First, it will develop and serve as a first test of a new colliding beam technique. This is a critical step toward achieving electron-positron collisions at much higher center-of-mass energies at lower cost per GeV than the technology used up to now -- that of the Colliding Beam Storage Rings (CBSR). Second, the SLC will increase the center-of-mass energy available for electron-positron experiments by a factor of about three above that now available at existing electron-positron CBSR's. The relatively low cost of the SLC, itself, is achieved by virtue of the fact that it uses the existing 2-mile linac.

The highest energy electron-positron colliding beam storage rings now in existence are the PEP Project at SLAC and PETRA at Hamburg, West Germany with center-of-mass energies of around 30-40 GeV respectively. The next step in circular colliders is the LEP machine, now being built by CERN physicists and engineers, which will achieve a maximum center-of-mass energy of about 120 GeV, initially with conventional radio frequency (RF) and subsequently as high as 240 GeV with superconducting RF. The version with conventional RF is estimated to cost about 1 billion Swiss Francs in 1981 value, not including labor costs.

In order to make use of the existing single linac at SLAC, the SLC has two arcs of magnets to guide the electron and positron bunches in different directions from the linac to the collision point. At the planned 50 GeV beam energy level the synchrotron radiation emitted in these magnets has a negligible effect on the total power required to operate the facility, while allowing it to be based on a single linac rather than two linacs. This project will not only provide critical input for a new accelerator technology, which promises to reduce costs for future generations of electron-positron machines, but will also contribute to a better understanding of the physical world through the important new experiments which it will make possible.

1. Title and location of project: Stanford Linear Collider (SLC) Stanford Linear Accelerator Center (SLAC) Stanford, CA
2. Project No. 84-ER-133

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

From recent research, a new theoretical concept has emerged which interprets both the weak and electromagnetic forces as different manifestations of one basic force. This concept is a form of gauge theory; the simplest form is the "standard model" of Weinberg and Salam. All of the variants of the gauge theory have one or more heavy particles which interact with the electron-positron system in the same basic way as does the ordinary zero mass photon. It is the interaction of this heavy gauge particle (Z^0) and its charged companions (W^+ and W^-) that is responsible for the properties of what is called the weak interaction. The gauge theories have had such success in explaining apparently unrelated facts that they are generally believed to be correct.

The SLC is designed to have a total energy large enough to copiously produce the neutral gauge particles, resulting in many hundreds of events per hour. The decay of these Z^0's into quarks, leptons, and perhaps other more exotic particles, will give a vast amount of information about a broad spectrum of basic physics questions ranging from the number of elementary building blocks which make up our world, and to the conditions in the early universe when it was only a few seconds old. The first evidence for the gauge particles has been found at the CERN antiproton-proton collider, but production rates are so low that experiments on this machine can give only a small fraction of the important, detailed information that can be obtained from the SLC.

Funds for detection apparatus to be used for high energy physics experiments with the SLC are included in the capital equipment budget. Equipment funds are being used to upgrade an existing detector (Mark II) previously used for lower energy experiments at PEP and for a new detector designed specifically for SLC physics. The Mark II upgrade ($11M) will be completed in FY 1986 so as to be available for physics research when SLC comes into operation early in FY 1987. Work on the new detector, called SLD, was initiated in FY 1985. SLD is expected to be completed by FY 1990, with a total DOE cost of about $40M.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

10. Details of Cost Estimate

	Item	Total Cost
A. ED&I (Excludes previously funded Plant Engineering & Design ED&I) @ 20% of construction costs, item B.		$ 16,500
B. Construction Cost:		84,000
1. Site Work, Utilities, and Structures including a) Experimental Hall; b) Collider Housing, and c) Linac-Collider Connection Tunnels.....	$ 25,500	
2. Accelerator components: a) Electron and Positron Sources; b) Energy Upgrade; c) Collider Arcs; and d) Focusing, Damping and Control Systems	58,500	
C. Standard Equipment (Cranes)		400
D. Contingency @ approximately 14% of above costs		14,500
E. Total		$115,400

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

11. Method of Performance

Design of conventional facilities will be accomplished by subcontracts. Design of technical components will be by the operating contractor (SLAC). To the extent feasible, construction procurement and installation will be accomplished by fixed-price subcontracts awarded on the basis of competitive bidding.

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

	Prior Years	FY 1984	FY 1985	FY 1986	FY 1987	Total
A. Total Project Costs:						
1. Total Facility Costs:						
(a) Construction Line Item	$ 0	$23,094	$49,552	$39,000	$ 3,754	$115,400
(b) PE&D	2,272	0	0	0	0	2,272
(c) Expense Funded Equipment	0	0	0	0	0	0
(d) Inventories	0	0	0	0	0	0
Total Direct Costs	2,272	23,094	49,552	39,000	3,754	117,672
2. Other Project Costs:						
(a) R&D Necessary to Complete Construction	0	9,867	6,713	3,736	0	20,316
(b) Other Project Related Costs:						
(i) R&D Related Capital Equipment	0	412	300	350	0	1,062
Total Other Project Funding	0	10,279	7,013	4,086	0	21,378
Total Project Costs (Items 1 & 2)	$ 2,272	$33,373	$56,565	$43,086	$ 3,754	$139,050

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

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

B. Other Related Incremental Annual Costs in FY 1986 dollars (Estimated life of project: 10 years)

1. Facility operating costs (including incremental power costs)	$13,600
2. Programmatic operating expenses directly related to the facility	2,500
3. Capital equipment not related to construction but related to the programmatic effort in the facility	500
4. GPP or other construction related to programmatic effort in the facility	400
Total related incremental annual costs in FY 1986 dollars	$17,000

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

A. Total Facility

(a) Construction Line Item (no narrative required)

(b) PE&DT- The SLC is a totally new kind of colliding beam system, and although the basic technology involved is well understood, the project has benefited immeasurably from Plant Engineering and Design (PE&D) funding to more firmly establish component costs and conventional facility costs and schedules. The project was provided with $300,000 of PE&D funding in FY 1980, $750,000 in FY 1981, $907,000 in FY 1982, and $315,000 in FY 1983. The FY 1980 PE&D money funded a preliminary geological study of the site, preliminary tunnel and experimental hall design, and the study of alternative site layouts. The FY 1981 PE&D funding was allocated to more detailed structural design (Title I) of the linac/collider and connecting tunnels. In June 1981, SLAC retained the services of Tudor Engineering as an A/E firm to perform Title I and Title II design on the SLC project. The FY 1982 and FY 1983 PE&D funding supported completion of Title I and partial Title II design for SLC conventional facilities.

1\. Title and location of project: Stanford Linear Collider (SLC)
Stanford Limear Accelerator Center (SLAC)
Stanford, CA

2\. Project No. 84-ER-133

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

(c) Expense Funded Equipment - none anticipated for this project.

(d) Inventories - no inventories are anticipated for this project.

2\. Other Project Funding

(a) R&D Necessary to Complete - funds provided in High Energy Physics Research, Accelerator Research and Development.

(b) Other Related Funding Provide the capital equipment and plant funding needed in support of the R&D effort.

B. Total Related Funding Requirements:

The programmatically useful lifetime of the facility is estimated to be about 10 years.

1. Facility operating costs include the incremental costs of accelerator operations, experimental area operations, and related research and development efforts. These costs are for salaries, electric power, materials and supplies, with the dominant cost element being the electric power charges.

2. Programmatic Operating Expenses Directly Related to the Facility - this estimate is for high energy physics research to be performed by SLAC in-house physicists or physicists from the user community.

3. Capital Equipment Related to the Programmatic Effort in the Facility - this estimate is for general capital equipment needed to support research at the facility. It will provide for upgrading research detectors, data recording and analysis instrumentation and miscellaneous laboratory instruments. It does not provide for any major detection system.

4. GPP or Other Construction Related to Programmatic Effort - this estimate is a general "level of effort" which would provide for minor structures and utility extensions as well as modifications and improvements (AIP) of the facility to maintain its scientific effectiveness and productivity.

5. Other Costs - no narrative required.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

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

2. Project No.: 86-R-104

3. Date A-E work initiated: 1st Qtr. FY 1986

3a. Date physical construction starts: 2nd Qtr. FY 1986

4. Date construction ends: 4th Qtr. FY 1988

5. Previous cost estimate: $23,900
Less amount for PE&D:
Net Cost estimate: $23,900
Date: November 1984

Current cost estimate: $24,100
Less amount for PE&D: 0
Net cost estimate: $24,100
Date: August 1985

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1986	$ 23,900	$ 2,968	$ 2,968	$ 2,000
1987	0	14,157	14,157	9,000
1988	0	6,975	6,975	13,100
Total	$ 23,900	$ 24,100	$ 24,100	$ 24,100

8. Brief Physical Description of Project

The proposed project is comprised of two parts:

a) The acquisition of a major computing capacity and capability upgrade, including additional central processers, additional disc and tape storage devices, and additional interfaces to support both online user terminals and access to special purpose data processors designed for the particular requirements of high energy physics data analysis.
b) A building to house the upgraded central computing system and support personnel.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project:	Central Computing Upgrade Fermi National Accelerator Laboratory Batavia, Illinois	2. Project No.: 86-R-104

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

a. Central Computing System Upgrade

Fermilab's central computing facility serves a wide variety of needs, the major ones being the analysis of data from experiments, theoretical physics calculations, accelerator design calculations, and stress analysis and magnetic field calculations used in the design of magnets and other equipment. A large central computing facility has proven itself to be the most cost effective solution to these computing needs in terms of hardware and software support, utilization of peripherals, and flexibility of computer configurations. The Fermilab central computing facility represents the only major facility of this kind which is accessible to the U.S. university participants in Fermilab experiments for the analysis of their data. At present the Fermilab central computing facility consists of three Cyber 175 computers. A lease-purchase contract for additional hardware will increase the total capacity to the equivalent of seven Cyber 175's in the period FY 1984 - FY 1986. However, an evaluation of the projected computing load has indicated that another increase in the computing capacity of at least a factor of five will be needed in FY 1986 - FY 1987. This increase in load is primarily due to the large additional data analysis requirements of the new colliding beam detectors for Tevatron I. The computer system upgrade requested here will meet these new needs, and will be chosen to provide the basis for growth during the remainder of the 1980's as the accelerator intensity improves and the experiments are refined.

b. Building to house Upgraded Central Computing System

Since 1973 Fermilab's central computing system, tape storage, and on-line computer maintenance have been housed in Wilson Hall. Growth in subsequent years has now led to a degree of congestion which is severely affecting the efficiency and reliability of these operations. Since additional space in Wilson Hall to house additional computing hardware is unavailable, it is proposed to move these activities to a separate building specifically designed for this usage, where it will also be much easier to provide proper security for the very high value equipment which is involved.

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No.: 86-R-104

10. Details of Cost Estimate

		Part A Computer Upgrade Total Cost	Part B Building Item Cost	Part B Building Total Cost
a. Engineering, design and inspection at 2.3% of Procurement and Installation (Part A) and 10.6% of construction costs (Part B)..		$ 300		$ 700
b. Construction costs..				6,800
1. Improvements to land including road, parking & landscaping...			$ 300	
2. Building..			6,400	
a. Basic Structure................	$3,800			
b. Mechanical......................	1,600			
c. Electrical......................	900			
d. Conveying System (Elevator)....	100			
3. Utilities..			100	
4. Procurement..		13,500		
5. Installation...		200		
Subtotal..		$14,000		7,500
c. Contingency at approximately 11% of the above cost for Part A and 15% for Part B..		1,500		1,100
Total Estimated Cost by Part..............................		$15,500		$ 8,600
Total Estimated Cost......................................				$24,100

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No.: 86-R-104

11. Method of Performance

Design of conventional and special facilities will be by the operating contractor. To the extent feasible, construction, procurement, and installation will be accomplished by fixed-price subcontracts awarded on the basis of competitive bidding.

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

	FY 1986	FY 1987	FY 1988	Total
a. Total project costs				
1. Total facility costs				
a. Construction line item...........	$ 2,000	$ 9,000	$13,100	$24,100
2. Other project costs				
a. Existing equipment relocation....	0	50	50	100
Total project costs..................	$ 2,000	$ 9,050	$13,150	$24,200

b. Other related annual funding requirements (estimated life of project: 25 years)

1. Building maintenance and operating cost (including power)..................................	$ 600
2. Programmatic operating expenses directly related to the computing facility..............	12,000
3. Capital equipment not related to construction but related to the programmatic effort in the computing facility..	1,500
4. GPP or other construction related to programmatic effort in the facility.......n........	0
Total related annual funding requirements............................n..n...n.........	$14,100
Less: Costs associated with the operation of the existing computing facility in its present location..	- 9,900
Net incremental annual costs resulting from the construction of the new building and the operation of the upgraded computing facility. ....n..	$ 4,200

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No.: 86-R-104

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

a. Total project costs:

1. Construction Line Item (No Narrative Required)

2. Other project costs
   a. Existing equipment relocation - the existing computing equipment presently located in Wilson Hall will be relocated to the new building as construction is completed, at an estimated cost of $100,000.

b. Total related annual funding requirements. It is estimated the facility will be used 25 years for its programmatic purpose.

1. Facility operating costs. The major elements comprising the annual operating costs are electricity for lighting and air conditioning, natural gas for heating and labor for custodial and maintenance.

2. Programmatic operating expenses directly related to the facility. The estimate given here is based on the cost of the programmatic effort presently being provided for the existing facility.

3. Capital equipment not related to construction but related to the programmatic effort in the facility. This represents an appropriate funding level for central computer system enhancements.

4. GPP - No narrative required.

5. General - The net incremental costs to operate the upgraded facility are shown in item 12 at $4,200,000. The present Fermilab central computing facility is currently operational in its Wilson Hall location and would incur an annual expense of about $9,900,000 in FY 1986. These costs would continue if the upgrade were not undertaken. The incremental costs cover items such as additional personnel, hardware and software maintenance charges, custodial, maintenance, and repair needs for the building, as well as utility costs. It has been assumed that the electrical power cost at the new facility will be partially offset by savings at Wilson Hall.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

3. Date A-E work initiated: 1st Qtr. FY 1986

3a. Date physical construction starts: 3rd Qtr. FY 1986

4. Date Construction ends: 4th Qtr. FY 1989

5. Previous cost estimate: none

6. Current cost estimate: $26,400
Less amount for PE&D: 0
Net cost estimate: $26,400
Date: May 1985

7. Financial Schedule

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1986	$ 2,000	$ 1,915	$ 1,915	$ 1,100
1987	24,400	3,500	3,500	3,500
1988	0	16,085	16,085	12,100
1989	0	4,900	4,900	9,700

8. Brief Physical Description of Project

The Accumulator/Booster (A/B ring) is a rapid cycling synchrotron that acts as a booster injector to the Alternating Gradient Synchrotron (AGS) for both protons and heavy ions and as an accumulator and injector for polarized protons. Protons and polarized protons will be injected into the A/B ring at 200 MeV from the existing linac and accelerated to 1.0 GeV for injection into the AGS. Heavy ions will be injected into the A/B ring and accelerated to a maximum energy which depends on the particular heavy ion, then stripped and injected into the AGS. The transfer line to carry the heavy ions from the Tandem Van de Graaff to the AGS is under construction and will be finished during FY 1986.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

8. Brief Physical Description of Project

The Accumulator/Booster will have a circumference of 201 meters which is equal to 1/4 that of the AGS. This will allow efficient, synchronous bucket-to-bucket transfer of beam from the A/B ring to the AGS. The balance of the machine is designed with the objective of making it simple, relatively inexpensive, capable of accelerating protons to about 1 GeV, capable of accumulating polarized protons, and capable of accelerating heavy ions.

The lattice chosen is a FODO arrangement with bending magnets missing from every other cell. The Accumulator/Booster will utilize separated function magnets. This will minimize end effects in a lattice which has such a small packing factor. Magnetic field cycling requirements are up to 4 kG at 10 Hz rate for 1 GeV protons and 12 kG at 1 Hz rate for heavy ions. The heavy ion acceleration aspect is the determining constraint on the magnet specifications. The power supply requirements for both cases are almost identical. The tune and aperture of the ring are chosen to avoid depolarizing resonances, to match to the admittance of the AGS, and to be flexible enough to accommodate research and development of devices and techniques for the acceleration and storage of polarized protons. To cover the ion velocities of approximately 0.04 to 0.875 of the speed of light, the rf system consists of three cavities, one for protons and two for heavy ions, each covering a different frequence range.

The A/B ring will be housed in a ring building located in the vee formed by the junction of the 200 KeV linac building and the old 50 MeV linac building. This is very close to the AGS injection system and near the end of the transfer line from the Tandem. The existing 50 MeV linac building will serve as part of the A/B ring enclosure as well as house all power supplies necessary for this project. It will also serve as an assembly and staging area for ring elements prior to installation in the tunnel. Most of the ring will be located in a tunnel to be constructed north of the 50 MeV linac building, and two penetrations will enable the remaining 75-feet to be in the linac building itself. For most of the ring, the structural concrete and five feet of earth fill will provide the necessary radiation shielding.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
   Brookhaven National Laboratory
   Upton, NY

2. Project No.: 86-R-105

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

The Accumulator/Booster will improve the performance and capabilities of the AGS for (1) normal proton operation, (2) operation with polarized protons and (3) operation with heavy ions. In each of these three modes of operation, the increased capability will have direct and immediate benefits by making accessible areas of science not previously accessible or by significantly increasing the data collection rate for the experimental program already planned and underway at the AGS.

(1) Normal Proton Research

When operating for normal proton research, the Accumulator/Booster will be used to accelerate protons to 1.0 GeV for injection into the AGS. At present injection is at 200 MeV. Injection at the higher energy will increase the space charge limit for the circulating beam and result in an increase of the extracted proton beam intensity by a factor of four to about 5×10^{13} protons per pulse.

For over two decades the Alternating Gradient Synchrotron has produced a steady flow of important physics, including major discoveries such as CP violation, the muon neutrino, the omega minus, the J/Psi, and the first charmed baryon. Today this machine is still the center of a vigorous research program, with experiments studying quantum chromodynamics via the search for glueballs and hard scattering exclusive reactions, searching for neutrino oscillations, and pushing the limits of the most complete theory, quantum electrodynamics, by measuring the vacuum polarization. In preparation are studies of extremely rare K decays via flavor changing neutral currents, which probe beyond the standard model to test very high energy theories like supersymmetry and technicolor. The increased beam intensity provided by the Accumulator/Booster will enhance this entire program but is of special importance to the rare K decay experiments.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

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

(2) Polarized Proton Research

When operating for polarized proton research, the Accumulator/Booster will be used to accumulate 20-30 linac pulses for subsequent injection into the AGS. This will increase the extracted polarized proton beam intensity by the same factor of 20-30. The polarized proton beam intensity which is available initially at the AGS will be adequate for the initial round of experiments, but the follow-on experiments will be limited by the available beam intensity. Much higher intensities are required to fully explore the physics of spin-dependent phenomena at AGS energies. The Accumulator/Booster, with the present polarized proton source, will result in a beam intensity of about 2×10^{11} protons per pulse.

The AGS has been modified to allow the acceleration of polarized protons. Initial research operation at low energy occurred late in FY 1984. The polarized proton beam intensity which is available initially at the AGS will be adequate for the initial round of experiments, but the follow-on experiments will be limited by the available beam intensity. The projected factor of 20 improvement will substantially improve the quality and cost effectiveness of the presently planned experimental program and allow consideration of new experiments where the increased beam intensity would be essential.

(3) Heavy Ion Research

When operating for heavy ion research, the Accumulator/Booster will accelerate partially stripped heavy ions from the existing Tandem Van de Graaff. The ions emerging from the Accumulator/Booster will have sufficient energy to allow them to be fully stripped with high efficiency before injection into the AGS. Because of the vacuum system considerations the AGS can only accelerate fully stripped heavy ions; the maximum energy available from the Tandem itself is such that only light ions (sulfur and below) can be fully stripped. The transfer line project which is presently underway will make available at the AGS beams of fully stripped high energy heavy ions up to sulfur. The Accumulator/Booster coupled with the Tandem will extend the heavy ion capability of the AGS to include heavy ions up to gold. The accelerated beam intensity of 2×10^9/pulse for Au, as an example, is a factor of 10^5 greater than presently available at any other machine at energies greater than 1 GeV/amu. For the particular example of Au, the accelerated beam intensity is at the calculated space charge limit of the A/B ring.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

10. Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, design and inspection at 31% of construction cost (17% of conventional construction and 33% of special facilities)		$	$ 5,100
b. Construction Cost			16,900
1. Conventional Construction		2,000	
Tunnel and utilities	$ 2,000		
2. Special Facilities and Accelerator Systems		14,900	
Magnets	5,500		
Magnet power supplies	2,600		
Other Systems	6,800		
c. Contingency at approximately 20% of above cost			4,400
Total estimated costs			$26,400

*Based on Completed Conceptual Design.

11. Method of Performance

Building design will be on the basis of a negotiated AE contract and its construction will be a competitively obtained lump sum contract. Design, assembly, and testing of the special facilities and accelerator system will be done by the staff of the Brookhaven National Laboratory. Component parts, wherever posible, will be fabricated by industry under fixed-priced competitively-obtained procurement actions.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

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

a. Total project costs	FY 1986	FY 1987	FY 1988	FY 1989	Total
1. Total facility costs					
(a) Construction line item............	$ 1,100	$ 3,500	$12,100	$ 9,700	$26,400
Total facility costs..............	$ 1,100	$ 3,500	$12,100	$ 9,700	$26,400
2. Other project costs					
(a) R&D necessary to complete construction.....................	200	200	100	0	500
Total other project costs.........	200	200	100	0	500
Total project costs (Item 1 & 2)...........	$ 1,300	$ 3,700	$12,200	$ 9,700	$26,900

b. Other related annual funding requirements (in FY 1987 dollars)

1. Facility operating costs..	$ 1,100
2. Capital equipment not related to construction..	100
Total related annual funding requirements..	$ 1,200

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

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 costs

(a) R&D necessary to complete construction - includes development of beam instrumentation, controls concepts and computer software at a cost of $500,000.

b. Total related annual funding requirements

1. Operating costst- There will be an annual requirement for additional FTE's with additional materials, supplies and support services associated with the physics program.

2. Capital equipment not related to construction but related to the programmatic effort in the facility - These equipment funds will provide continual utilization growth of the facility through the acquisition of: new detectors monitoring equipment, and controls improvement, and general purchase capital items for the operating program.

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GENERAL SCIENCE AND RESEARCH
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.: 87-R-101

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 3rd Qtr. FY 1987

4. Date Construction ends: 2nd Qtr. FY 1989

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

6. Current cost estimate: $11,500
Less amount for PE&D: 0
Net cost estimate: $11,500
Date: May 1985

7. Financial Schedule

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1987	$11,500	$11,500	$11,500	$ 4,700
1988	0	0	0	5,900
1989	0	0	0	900

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. 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.

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

2. Project No.: 87-R-101

8. Brief Physical Description of Project (continued)

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

Brookhaven National Laboratory.. $2,500,000

Funds are requested for modifications, improvements and additions to the Alternating Gradient Synchrotron (AGS) and its related experimental facilities. Items planned include: Replacement of preaccelerators with a high current RFQ accelerator; installation of a transverse and longitudinal damping system; upgrade of the linac injection system; upgrade of primary proton target stations for high intensity, beam shielding, and improvements to the AGS control system.

Fermi National Accelerator Laboratory.. $5,900,000

Funds requested are for modifications, improvements and additions to the Fermilab accelerator facilities (which includes the linear accelerator, booster synchrotron, main ring, Tevatron and antiproton source rings) and to the switchyard, beam lines, target facilities and experimental areas.

Modifications to the accelerator facilities are expected to include: Low beta magnet and power supply system improvements incorporating the improved superconducting materials now available; upgrade of the Cryogenic Accelerator including improved magnet and cryogenic systems; accelerator controls improvements to provide for more sophisticated control systems for the Accelerator complex, including the Linac, Booster, Main Ring, Tevatron and Anti-protron source; improved instrumentation to cope with the increased demands made on the accelerator system by antiprotron production, colliding beam operations and fixed target operations.

Modifications to the experimental facilities are expected to include: Upgrading of beam line diagnostics and control systems and beam line improvements including magnets, power supplies and enclosures to accommodate new beamlines and experiments; additional shielding for the secondary beam enclosures in the experimental area; provisions for secondary beam energy upgrade; and modifications to provide improved test beam facilities.

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No.: 87-R-101

8. Brief Physical Description of Project (continued)

Stanford Linear Accelerator Center (SLAC)... $3,100,000

Funds are requested for modifications, improvements and additions to the SLAC linear accelerator and PEP colliding beam facilities, and to the associated experimental facilities. Items now planned for FY 1987 include: Provide for replacement of sub-booster klystrons and associated modulators with microwave solid-state amplifiers; provide for extended linac quadrupole focusing to control emittance growth; improve steering and position monitors; improvements necessary to produce polarized electrons and control vertical and horizontal polarization; provide upgrades to instrumentation and control systems to improve operating efficiency.

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

Accelerator improvements 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. 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 some of 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.: 87-R-101

10. Details of Cost Estimate

a. Engineering, design and inspection and component assembly and installation	$11,500
Total Estimated Cost	$11,500

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

11. Method of Performance

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

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GENERAL SCIENCE AND RESEARCH
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.: 87-R-102

3. Date A-E work initiated: 1st Qtr. FY 1987

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

4. Date Construction ends: 2nd Qtr. FY 1989

5. Previous cost estimate: none
Date: none

6. Current cost estimate: $11,200
Less amount for PE&D: 0
Net cost estimate: $11,200
Date: May 1985

7. Financial Schedule

Fiscal Year	Obligations	Costs FY 1985	FY 1986	FY 1987	After FY 1987
Prior Year Projects	XXXXXXX	$ 4,040	$ 2,300	$ 0	$ 0
1985	10,200	2,800	4,600	2,800	0
1986	9,957	0	2,100	4,800	3,057
1987	11,200	0	0	2,600	8,600
		$ 6,840	$ 9,000	$10,200	$11,657

8. Brief Physical Description of Project

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

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

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations   2. Project No.: 87-R-102

8. Brief Physical Description of Project (continued)

Brookhaven National Laboratory		$6,000
Building Addition - Alternating Gradient Synchrotron	$250	
Water Controls Upgrade - Alternating Gradient Synchrotron	200	
Storage Building Construction - Alternating Gradient Synchrotron	350	
Water System Improvements - Alternating Gradient Synchrotron	250	
Applied Science Laboratory Conversion	150	
Increased Power Supply to Experimental Laboratory	300	
Sanitary System Extension, Phase I	900	
Asbestos Removal, Various Facilities	800	
Construction of Safeguards and Emergency Services Building	500	
Closure for Former Waste Disposal Site	300	
Communication System Improvement	200	
Construction of Supply and Material Warehouse	900	
Replacement of Water Main, Phase II	600	
Various Projects (less than $100,000 each)	300	
Fermi National Accelerator Laboratory		$3,300
Main Ring Road Improvements	350	
Service Building Improvements	500	
Utility Improvements	450	
Addition to the Experimental Areas Operations Center	800	
Meson Detector Building Improvements	450	
Improvements to Industrial Buildings	500	
Various Projects (less than $100,000 each)	250	

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations 2. Project No.: 87-R-102

8. Brief Physical Description of Project (continued)

Stanford Linear Accelerator Center.. $1,900*

Stanford Positron Electron Asymmetric Ring trestle replacement.....................	100
Replacement of heating, ventilating and air conditioning equipment................	400
Replacement of hot water system piping..	200
Replacement of roofing at major buildings...	300
Addition to Main Control Building...	900

*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.

The funds requested for FY 1987 are estimated as follows:

Brookhaven National Laboratory	$ 6,000
Fermi National Accelerator Laboratory	3,300
Stanford Linear Accelerator Center	1,900
Total Estimated Cost	$11,200

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.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations   2. Project No.: 87-R-102

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 [illegible] tractor 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.