High Energy Physics

Program Mission

The High Energy Physics (HEP) program of the Department of Energy (DOE) has the lead responsibility for Federal support of high energy physics research and supports fundamental research activities under the mandate provided in Public Law 95-91 which established the Department. The High Energy Physics program is a key element in the Science and Technology component of the DOE Strategic Plan, supporting several of the strategies which make up that component. This program is also one of the identified elements in the Secretary's Performance Agreement with the President, and is an integral part of the Department's fundamental research mission. The program is directed at understanding the nature of matter and energy at the most fundamental level, and the basic forces which govern all processes in nature. Fundamental research provides the necessary foundation that ultimately enables the Nation to progress in its science and technology capabilities, to advance its industrial competitiveness, and to discover new and innovative approaches to our energy future.

The high quality of the research in this program is continuously evaluated through the use of merit based peer review and scientific advisory committees.

Program Goal

Provide new insights into the nature of energy and matter to better understand the natural world.

Program Objectives

- *To continue to support high quality research*—Support high quality university and laboratory based high energy physics research, both theoretical and experimental. Experimental research is primarily performed by university scientists using particle accelerators located at major laboratories in the U.S. and abroad.
- *To effectively operate the department's high energy physics accelerator facilities*—Provide optimal and cost effective operation for research of the Fermi National Accelerator Laboratory, and the Stanford Linear Accelerator Center. The Alternating Gradient Synchrotron (AGS) complex at the Brookhaven National Laboratory was transferred to the Nuclear Physics (NP) program during FY 1999. HEP use of the AGS will continue on an incremental cost basis.
- *To continue to provide world class research facilities*—Plan for and build new, state-of-the-art research facilities that allow researchers to advance the forefront of the science of high energy physics. Support essential improvements and upgrades at the major accelerator laboratories. Manage the commissioning of the Fermilab Main Injector project, the initial operation of the B-factory at SLAC and the continuation of the new experimental facility at Fermilab called Neutrinos at the Main Injector (NuMI).
- *To continue to provide the program's technological base*—Support long-range accelerator and detector R&D required to provide the advanced concepts and technologies that are critical to the long-range viability of high energy physics research.

- *To continue to pursue international collaboration on large high energy physics projects*—Using the management and control systems already put into place, work to successfully carry out the planned and agreed to collaboration with CERN on the Large Hadron Collider (LHC) project. Work to explore and pursue other opportunities for effective and beneficial international collaborative activities.

Performance Measures

Performance measures related to basic science activities are primarily qualitative rather than quantitative. The scientific excellence of the High Energy Physics program is continually reevaluated through the peer review process. Some specific performance measures are:

- Quality of scientific results and plans as indicated by expert advisory committees, recognition by the scientific community, and awards received by DOE-supported High Energy Physics researchers. The results of these reviews and other quality measures will be used to determine programmatic directions aimed at maintaining the world leadership position of the U.S. high energy physics program.
- Sustained achievement in advancing knowledge, as measured by the quality of the research based on results published in refereed scientific journals, and by the degree of invited participation at national and international conferences and workshops.
- Operation of research facilities in a manner that meets user requirements, as indicated by achieving performance specifications while protecting the safety of the workers and the environment, and by the level of endorsement by user organizations; operating facilities that are used for research at the forefront of science; and operating facilities reliably and according to planned schedules. In FY 2001, High Energy Physics will be operating the B-factory at SLAC, the Main Injector for the Tevatron at Fermilab, and using the AGS at BNL.
- Progress on achieving luminosity and operational efficiency for the B-factory at SLAC as measured by comparison with stated project goals.
- Progress on maintaining luminosity and operational efficiency for the Tevatron at Fermilab in its new mode of operation with the recently completed Main Injector.
- The upgrade of scientific facilities will be managed to keep them on schedule and within cost.
- Deliver on the scheduled U.S./DOE commitments to the international Large Hadron Collider project.
- Review at least 80 percent of the research projects by appropriate peers; continue to select research projects through a merit-based competitive process.
- Meet on time and within budget the scheduled U.S. DOE commitments to the international Large Hadron Collider project as reflected in the latest international agreement and corresponding plan.
- Make progress on the Neutrinos at the Main Injector project as measured by accomplishment of scheduled milestones as detailed in the benchmark plan.
- High Energy Physics plans and research will be recognized as outstanding by expert advisory committees such as the High Energy Physics Advisory Panel (HEPAP) and through other rigorous peer review. Additionally, the scientific results will be recognized through the awards received by its researchers and by the broader scientific community.

Significant Accomplishments and Program Shifts

- The long range planning study of the High Energy Physics program was prepared in 1998 by a Subpanel of the High Energy Physics Advisory Panel (HEPAP), (Gilman report). Their report is entitled "Planning for the Future of U.S. High-Energy Physics." The Subpanel's recommendations were considered carefully in preparing this budget.
- In FY 1999, the following performance goals were fully met:
  - Continue collaborative efforts with NASA on space science and exploration.
  - Deliver on the 1999 US/DOE commitments to the international LHC project.

Research and Technology

- In FY 1997, a test of a superconducting accelerator-style magnet fabricated at Lawrence Berkeley National Laboratory (LBNL) achieved a field strength of greater than 11 teslas in a new rectangular geometry with no quenches. This is a significant accomplishment in the effort to advance technology for future accelerators.

The following were accomplished in FY 1999:

- Measurement, by teams of university and laboratory scientists working at Fermilab, of the mass and production properties of the top quark was accomplished. This is the last, and by far the heaviest, of the fundamental building blocks of matter (quarks) whose existence was predicted by the Standard Model of elementary particles. The mass of the top quark is now measured more accurately than that of any of the other quarks. Further refinement of this result are continuing, and will improve even more with data from the upcoming run of the Tevatron with the newly upgraded Main Injector.
- The world's most precise measurement was made, by a team of university and laboratory scientists working at Fermilab, of the mass of the W boson. This result is now considerably more precise than the best measurement from LEP. It will improve even more with data from the upcoming run of the Tevatron with the newly upgraded Main Injector.
- The world's highest precision single measurement of the weak mixing angle, a fundamental parameter of the Standard Model, was made by a group of university and laboratory scientists working at SLAC with the Stanford Large Detector (SLD). The final result from the final data run has now been obtained.
- The observation was made, by the international CDF collaboration working at Fermilab, of the existence and properties of the B meson containing a charmed quark. This discovery completes the theoretically predicted family of B mesons.
- The observation of direct violation of CP symmetry in the decays of K mesons was made by a team of university and laboratory scientists working at Fermilab. More data is being analyzed to refine this result.
- The observation was made for the first time ever by the KTeV collaboration of the predicted decay of the kaon into a pair of pions and an electron-positron pair. Further refinement of this result was achieved.
- A major advance in theoretical physics was achieved when it was shown and verified that all of the known "string" theories are equivalent. This greatly reduces the number of possible theories which

describe all of the known forces including gravity. Further work toward delineating the underlying theory from which all string theories originate is continuing at a fast pace.

- A SLAC 30 GeV electron beam was directed down a 1.5 meter Lithium plasma creating a plasma wave that exhibited an accelerating gradient of greater than 0.5 GeV per meter, a record in this highly speculative program that may have a potential of approaching10's of GeV per meter accelerating gradient eventually.

- At the g-2 experiment at BNL, designed to study the magnetic properties of the muon, the most precise measurement of the anomalous magnetic moment has been obtained. Initial data collection has been completed and more data is being analyzed. Even more data should become available over the next two years. The experimenters are confident that they will achieve the world's best measurements of the anomalous magnetic moment and lifetime of the muon in both positive and negative charge states. If the final results agree with the standard model, this will place significant limits on new physics beyond the standard model.

- DOE is entering into an exciting and expanding partnership with NASA in the area of Particle Astrophysics. R&D for the Antimatter in Space (AMS) and Gamma Large Area Space Telescope (GLAST) experiments has been underway for some time. Preliminary consideration is being given to the SuperNova Acceleration Probe (SNAP) experiment. These experiments, and others that may be proposed, will provide important new information about cosmic rays and the rate of expansion of the universe which will in turn lead to a better understanding of dark matter, dark energy, and the original big bang.

- Evidence of neutrino mass and quantum mixing was obtained in a U.S.-Japanese experiment with the Super-Kamiokande experiment in Japan. Further data and refinement of these results was achieved. Long baseline neutrino beam experiments in Japan and at Fermilab are underway to verify these results.

High Energy Physics Facilities

- The final data collection with the Fermilab 800 GeV fixed-target program is being completed in FY 2000, and in FY 2001 the prime focus of the Fermilab program will turn to research using the Tevatron collider with the higher luminosity of the new Main Injector.

- The B-factory at SLAC was brought into full operation during FY 2000, and in FY 2001 will be operated for the BaBar experiment to collect data aimed at understanding matter-antimatter asymmetry as evidenced in the B-meson systems.

- The Alternating Gradient Synchrotron at BNL was transferred to the Nuclear Physics program for operation as the injector for the RHIC facility during the 3rd quarter of FY 1999. Beginning in FY 2000 AGS operation for High Energy Physics experiments is on an incremental cost basis. Limited operation of the AGS for HEP research is continuing on a non-interfering and incremental cost basis. The high priority muon magnetic moment experiment is taking data in FY 2000 and will be completed during FY 2001. A follow-on rare kaon experiment has been approved and will have a shake-down run in FY 2001.

- The Department is continuing research and development which will provide the basis for a reviewable technical design and cost estimate for a large electron-positron (antielectron) collider called the Next Linear Collider (NLC). The international high energy physics community has determined that such a machine is complementary to the Large Hadron Collider (LHC) now under construction at the CERN Laboratory outside of Geneva, Switzerland, and essential if the issues of the physics beyond the Standard Model are to be effectively addressed. A formal endorsement was supplied in August 1999 in a statement on Linear Colliders issued by the International Committee of Future Accelerators (ICFA), sponsored by the Particles and Fields Commission of the International Union on Pure and Applied Physics (IUPAP):

> *"Scientific panels charged with studying future directions for particle physics in Europe, Japan, and the United States have concluded that there would be compelling and unique scientific opportunities at a linear electron-positron collider in the TeV energy range. Such a facility is a necessary complement to the LHC hadron collider now under construction at CERN. Experiment results over the last decade from the electron-positron colliders LEP and SLC combined with those from the Tevatron, a hadron collider, have led to this worldwide consensus.*
>
> *ICFA recommends continued vigorous pursuit of the accelerator research and development on a linear collider in the TeV energy range, with the goal of having designs complete with reliable cost estimates in a few years. We believe that an electron-positron collider optimized for the new physics should be built in a timely way with international participation."*

The technical basis for the advantages of electron-positron colliders is the precision associated with the fact that electrons and positrons are point particles (unlike the protons used in the LHC which are composites of three quarks), the more favorable secondary particle backgrounds, and the polarization (alignment of spin) of the electrons which adds a dimension of physics exploration not available with the LHC.

The R&D program is directed at a center-of-mass energy capability in the 500 to 1000 GeV (1 TeV) range, expandable to 1.5 TeV. This choice is based on the recommendations provided by the February 1998 report of the DOE HEPAP Subpanel on Planning for the Future of High Energy Physics which stated (Executive Summary):

> *"The Subpanel recommends that SLAC continue R&D with Japan's KEK toward a common design for an electron-positron linear collider with a luminosity of at least* 10^{34} $cm^{-2}s^{-1}$ *and an initial capability of 1 TeV in the center of mass, extendible to 1.5 TeV. The Subpanel recommends that SLAC be authorized to produce a Conceptual Design Report for this machine in close collaboration with KEK."*
>
> *"This is not a recommendation to proceed with construction. A decision on whether to construct a linear collider should only follow the recommendation of a future subpanel convened after the CDR is complete. The decision will depend on what is known about the technology of linear colliders and other potential facilities, costs, international support, and advances in our physics understanding."*

The specific goals of the present NLC R&D program include developing new technologies that enable a higher performance, lower cost machine; carrying out systems engineering, value engineering, and risk analysis studies to identify additional R&D issues that could effect cost and performance and to down-select from available technologies; and using industrial firms to carry out R&D on key technologies, thus exploiting the special "design-for-manufacture" expertise available in industry and effecting technical transfer from the NLC R&D program to industry. In addition there is development of cost analysis and scheduling tools that can be used to guide the R&D

program by identifying cost driving technologies and that will be essential at such time as a Conceptual Design Report is authorized.

The NLC R&D activities to be supported by DOE are carried out by a national collaboration that includes SLAC as the principle laboratory, Fermilab as the major collaborator, and with significant contributions from Lawrence Berkeley National Laboratory and Lawrence Livermore National Laboratory. The R&D is also part of an international collaboration that includes the Japanese high energy physics center, KEK, through a SLAC-KEK inter-laboratory memorandum of understanding, and by less formal arrangements, with R&D groups at the German DESY Laboratory, CERN, and the Budker Institute in Russia.

The proposed DOE HEP funding is $17,000,000 in FY 1999, $17,400,000 in FY 2000, and $19,200,000 in FY 2001.

- Support for the Waste Management activities at LBNL is initiated in FY 2001 with a transfer of funds and responsibility from Environmental Management to HEP as the landlord for LBNL.

- The European Center for Nuclear Research (CERN) in Geneva, Switzerland has initiated the Large Hadron Collider (LHC) project. This will consist of a 7 on 7 TeV proton-proton colliding beams facility to be constructed in the existing Large Electron-Positron Collider (LEP) machine tunnel (LEP will be removed). The LHC will have an energy 7 times that of the Tevatron at Fermilab. Thus the LHC will open up substantial new frontiers for scientific discovery.

  Participation by the U.S. in the LHC program is extremely important to U.S. High Energy Physics program goals. The LHC will become the foremost high energy physics research facility in the world around the middle of the next decade. With the LHC at the next energy frontier, American scientific research at that frontier depends on participation in LHC. The High Energy Physics Advisory Panel (HEPAP) Subpanel on Vision for the Future of High-Energy Physics (Drell) strongly endorsed participation in the LHC, and this endorsement has been restated by HEPAP on several occasions.

  The physics goals of the LHC include a search for the origin of mass as represented by the “Higgs” particle, exploration in detail of the structure and interactions of the top quark, and the search for totally unanticipated new phenomena. Although LHC will have a lower energy than the Superconducting Super Collider (canceled in 1993), it has strong potential for answering the question of the origin of mass. The LHC energies are sufficient to test theoretical arguments for a totally new type of matter. In addition, history shows that major increases in the particle energy nearly always yield unexpected discoveries.

  DOE and NSF have entered into a joint agreement with CERN about contributions to the LHC accelerator and detectors as part of the U.S. participation in the LHC program to provide access for U.S. scientists to the next decade’s premier high energy physics facility. The resulting agreements were approved by CERN, the DOE and the NSF and were signed in December of 1997.

  Participation in the LHC project (accelerator and detectors) at CERN will primarily take the form of the U.S. accepting responsibility for designing and fabricating particular subsystems of the accelerator and of the two large detectors. Thus, much of the funding will go to U.S. laboratories, university groups, and industry for fabrication of subsystems and components which will become part of the LHC accelerator or detectors. A portion of the funds will be used to pay for purchases by

CERN of material needed for construction of the accelerator. As a result of the negotiations, CERN has agreed to make these purchases from U.S. vendors.

The agreement provides for a U.S. DOE contribution of $450,000,000 to the LHC accelerator and detectors over the period FY 1996 through FY 2004 (with approximately $81,000,000 being provided by the NSF). The DOE contribution is broken down as follows: detectors $250,000,000; accelerator $200,000,000 (including $90,000,000 for direct purchases by CERN from U.S. vendors and $110,000,000 for fabrication of components by U.S. laboratories).

The total cost of the LHC on a basis comparable to that used for U.S. projects is estimated at about $6,000,000,000. Thus the U.S. contribution represents less than 10 percent of the total. (The LHC cost estimates prepared by CERN, in general, do not include the cost of permanent laboratory staff and other laboratory resources used to construct the project.) Neither the proposed U.S. DOE $450,000,000 contribution nor the estimated total cost of $6,000,000,000 include support for the European and U.S. research physicists working on the LHC program.

The agreement negotiated with CERN provides for U.S. involvement in the management of the project through participation in key management committees (CERN Council, CERN Committee of Council, LHC Board, etc.). This will provide an effective base from which to monitor the progress of the project, and will help ensure that U.S. scientists have full access to the physics opportunities available at the LHC. The Office of Science has conducted a cost and schedule review of the entire LHC project and similar reviews of the several proposed U.S. funded components of the LHC. All of these reviews concluded the costs are properly estimated and that the schedule is feasible.

In addition to the proposed U.S. DOE $450,000,000 contribution and $81,000,000 NSF contribution to the LHC accelerator and detector hardware fabrication, U.S. participation in the LHC will involve a significant portion of the U.S. High Energy Physics community in the research program at the LHC. This physicist involvement has already begun. Over 500 U.S. scientists have joined the U.S.-ATLAS detector collaboration, the U.S.-CMS detector collaboration, or the U.S.-LHC accelerator consortium, and are hard at work helping to design the initial physics research program to be carried out at the LHC helping to specify the planned physics capabilities of the LHC accelerator and detectors, and helping to design and fabricate accelerator and detector components and subsystems.

Fabrication of LHC subsystems and components by U.S. participants began in FY 1998. Funding was provided in FY 1996 ($6,000,000) and FY 1997 ($15,000,000) for preliminary R&D, design and engineering work on the subsystems and components being proposed for inclusion in the agreement with CERN. This funding was essential in order to provide the cost and technical bases for the proposed U.S. responsibilities in LHC, and to be ready for rapid start to satisfy the anticipated timetable for the project. Funding in the amount of $35,000,000 was provided in FY 1998, $65,000,000 was provided in FY 1999, $70,000,000 was provided in FY 2000, and $70,000,000 will be provided in FY 2001 to support continuation of these R&D and design efforts, and the continuation of fabrication of those subsystems and components specified in the agreements with CERN.

The planned U.S. Funding for the LHC project is summarized below:

U.S. LHC Accelerator and Detector Funding

(dollars in thousands)

Fiscal Year	Department of Energy			National Science Foundation[a]
	Accelerator	Detector	Total	
1996[b]	2,000	4,000	6,000	0
1997[b]	6,670	8,330	15,000	0
1998[b]	14,000	21,000	35,000	0
1999	23,491	41,509	65,000	22,150
2000	33,206	36,794	70,000	15,900
2001	36,303	33,697	70,000	16,370
2002	31,200	38,800	70,000	16,860
2003	29,000	36,000	65,000	9,720
2004	24,130	29,870	54,000	0
Total	200,000[c]	250,000	450,000	81,000

Construction

- The Research Office Building project at SLAC was started in FY 2000. When completed in FY 2002, it will provide much needed office and laboratory space for the outside groups collaborating on the BaBar experiment.
- The Wilson Hall Safety Improvements Project at Fermilab is proceeding well and is on schedule for completion in FY 2001. The project is remediating structural deficiencies and addressing safety issues resulting from aging building components and systems.
- The Neutrinos at the Main Injector (NuMI) Project is proceeding on schedule. The project will provide a new neutrino beamline aimed at the Soudan Underground Laboratory in Soudan, Minnesota where the large MINOS detector will be installed to search for and study neutrino oscillations.

[a] The NSF funding has been approved by the National Science Board.

[b] The FY 1996 and FY 1997 LHC funding was for R&D, design and engineering work in support of the proposed U.S. participation in LHC. Beginning in FY 1998 funding was used for: fabrication of machine and detector hardware, supporting R&D, prototype development, and purchases by CERN from U.S. vendors.

[c] Includes $110,000,000 for LHC supporting R&D and accelerator components to be fabricated by U.S. laboratories and $90,000,000 for purchases by CERN from U.S. vendors.

Scientific Facilities Utilization

The High Energy Physics request includes $441,521,000 to maintain support of the Department's scientific user facilities. This investment will provide significant research time for several thousand scientists in universities, and other Federal laboratories. It will also leverage both Federally and privately sponsored research, consistent with the Administration's strategy for enhancing the U.S. National science investment. The proposed funding will support operations at the Department's two major high energy physics facilities: the Tevatron at Fermilab, and the B-factory at the Stanford Linear Accelerator Center (SLAC). The Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory (BNL), is now part of the Nuclear Physics (NP) funded Relativistic Heavy Ion Collider (RHIC) complex and is being operated for HEP purposes on a limited basis.

Funding of Contractor Security Clearances

In FY 1999, the Department divided the responsibility for obtaining and maintaining security clearances. The Office of Security Affairs, which was responsible for funding all Federal and contractor employee clearances, now pays only for clearances of Federal employees, both at headquarters and the field. Program organizations are now responsible for contractor clearances, using program funds. This change in policy enables program managers to make the decisions as to how many and what level clearances are necessary for effective program execution. In this way, it is hoped that any backlog of essential clearances which are impeding program success can be cleared up by those managers most directly involved. The Office of Science is budgeting $270,000 in FY 2000 and in FY 2001 for estimated contractor security clearances within this decision unit.

Workforce Development

The national laboratories, with significant High Energy Physics programs, provide a wide range of facilities and services for users, as well as maintaining their own scientific staffs which perform high-energy physics research in collaboration with outside users. Operating accelerators which provide beams for experiments is the primary service for users for Fermilab National Accelerator Laboratory, the Stanford Linear Accelerator Laboratory, and the Brookhaven National Laboratory. Other critical functions include providing technical staff and facilities for the design and fabrications of experiments, computing resources required to analyze the large data samples generated by experiments, research and development for future accelerators, and a host of services to support a large body of resident users, which includes graduate students, post-docs, and visiting faculty.

Scientific productivity is evaluated through peer review. The quality and importance of scientific results cannot be reduced to simple numerical measures of arbitrarily defined quantities. The Division of High Energy Physics conducts reviews of all aspects of the High Energy Physics program, including the programs and operations of the national laboratories. Experts in relevant areas participate in these reviews. The peer review process not only provides evaluations of the scientific productivity of various components of the High Energy Physics program, but also provides advice and suggestions for making improvements. Such guidance is critical in determining future programmatic directions so that the U.S. can maintain its place as a world leader in high-energy physics research. In FY 1999, 1,142 graduate students and post doc investigators were supported by HEP; 630 of those students and investigators were working at HEP user facilities.

Funding Profile

(dollars in thousands)

	FY 1999 Current Appropriation	FY 2000 Original Appropriation	FY 2000 Adjustments	FY 2000 Current Appropriation	FY 2001 Request
High Energy Physics					
Research and Technology	214,891	229,190	0	229,190	237,720
High Energy Physics Facilities	444,825	450,000	-10,147	439,853	444,610
Subtotal, High Energy Physics	659,716	679,190	-10,147	669,043	682,330
Construction	21,000	28,700	0	28,700	32,400
Subtotal, High Energy Physics	680,716	707,890	-10,147	697,743	714,730
Use of Prior Year Balances	-1,610[a]	0	0	0	0
General Reduction	0	-6,001	6,001	0	0
Contractor Travel	0	-1,771	1,771	0	0
Omnibus Rescission	0	-2,375	2,375	0	0
Total, High Energy Physics	679,106[b]	697,743	0	697,743	714,730[c]

Public Law Authorization:

Public Law 95-91, "Department of Energy Organization Act"

Public Law 103-62, "Government Performance Results Act of 1993"

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $13,972,000 which has been transferred to the SBIR program and $838,000 which has been transferred to the STTR program.

[c] Includes $5,500,000 for Waste Management activities at Lawrence Berkeley National Laboratory that was previously budgeted in FY 1999 and FY 2000 in the Environmental Management program.

Funding by Site

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Albuquerque Operations Office					
Los Alamos National Laboratory	870	860	800	-60	-7.0%
Albuquerque Operations Office	0	13	0	-13	-100.0%
Total, Albuquerque Operations Office.........	870	873	800	-73	-8.4%
Chicago Operations Office					
Argonne National Laboratory	9,679	9,702	11,055	+1,353	+13.9%
Brookhaven National Laboratory	69,514	30,990	38,844	+7,854	+25.3%
Fermi National Accelerator Laboratory .	296,713	286,253	282,730	-3,523	-1.2%
Princeton Plasma Physics Laboratory ..	120	120	120	0	0.0%
Chicago Operations Office..................	82,721	87,042	78,783	-8,259	-9.5%
Total, Chicago Operations Office...............	458,747	414,107	411,532	-2,575	-0.6%
Oakland Operations Office					
Lawrence Berkeley National Laboratory	26,706	33,627	37,786	+4,159	+12.4%
Lawrence Livermore National Laboratory	1,496	1,230	850	-380	-30.9%
Stanford Linear Accelerator Center	146,559	151,377	157,257	+5,880	+3.9%
Oakland Operations Office..................	34,967	38,290	33,342	-4,948	-12.9%
Total, Oakland Operations Office...............	209,728	224,524	229,235	+4,711	+2.1%
Oak Ridge Operations Office					
Oak Ridge Inst. for Science & Education	189	80	150	+70	+87.5%
Oak Ridge National Laboratory	240	240	240	0	0.0%
Oak Ridge Operations Office	250	214	197	-17	-7.9%
Total, Oak Ridge Operations Office	679	534	587	+53	+9.9%
Richland Operations Office					
Pacific Northwest National Laboratory ..	10	0	0	0	0.0%
Washington Headquarters	10,682	57,705	72,576	+14,871	+25.8%
Subtotal, High Energy Physics..................	680,716	697,743	714,730	+16,987	+2.4%
Use of Prior Year Balances.................	-1,610[a]	0	0	0	0.0%
Total, High Energy Physics.......................	679,106[b]	697,743	714,730[c]	+16,987	+2.4%

[a] Share of Science general reduction for use of prior year balances assigned to this program. The total general reduction is applied at the appropriation level.

[b] Excludes $13,972,000 which has been transferred to the SBIR program and $838,000 which has been transferred to the STTR program.

[c] Includes $5,500,000 for Waste Management activities at Lawrence Berkeley National Laboratory that was previously budgeted in FY 1999 and FY 2000 in the Environmental Management program.

Site Description

Argonne National Laboratory

Argonne National Laboratory in Argonne, Illinois, is a Multiprogram Laboratory located on a 1,700 acre site in suburban Chicago. ANL has a satellite site located in Idaho Falls, Idaho. High Energy Physics supports a program of physics research and technology R&D at ANL, using unique capabilities of the laboratory in the areas of accelerator R&D techniques and participation in the CDF and MINOS detector collaborations.

Brookhaven National Laboratory

Brookhaven National Laboratory is a Multiprogram Laboratory located on a 5,200 acre site in Upton, New York. High Energy Physics supports a program of physics research and technology R&D at BNL, using unique capabilities of the laboratory, including the Accelerator Test Facility and the capability for precision experimental measurement. High Energy Physics also makes limited use of the Alternating Gradient Synchrotron which is principally supported by the Nuclear Physics program.

Fermi National Accelerator Laboratory

Fermi National Accelerator Laboratory is a program-dedicated laboratory (High Energy Physics) located on a 6,800 acre site in Batavia, Illinois. Fermilab operates the Tevatron accelerator and colliding beam facility which consists of a four mile ring of superconducting magnets and is capable of accelerating protons and antiprotons to one TeV. Thus the Tevatron is the highest energy particle accelerator in the world, and has a unique capability for research at the energy frontier. Fermilab, together with SLAC, constitute the principal experimental facilities of the DOE High Energy Physics program.

Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory is a Multiprogram Laboratory located in Berkeley, California. The Lab is on a 200 acre site adjacent to the Berkeley campus of the University of California. High Energy Physics supports a program of physics research and technology R&D at LBNL, using unique capabilities of the laboratory primarily in the areas of participation in the BaBar collaboration, expertise in superconducting magnet R&D, world-forefront expertise in laser driven particle acceleration, and expertise in design of forefront electronic devices.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory is a Multiprogram Laboratory located on a 821 acre site in Livermore, California. High Energy Physics supports a program of physics research and technology R&D at LLNL, using unique capabilities of the laboratory primarily in the area of advanced accelerator R&D and participation in the B-factory project.

Los Alamos National Laboratory

Los Alamos National Laboratory is a Multiprogram Laboratory located on a 27,000 acre site in Los Alamos, New Mexico. High Energy Physics supports a program of physics research and technology R&D at LANL, using unique capabilities of the laboratory primarily in the area of theoretical studies, and computational techniques for accelerator design.

Oak Ridge Institute for Science and Education

Oak Ridge Institute for Science and Education is located on a 150 acre site in Oak Ridge, Tennessee. The High Energy Physics program supports a small effort at ORISE in the area of program planning and review.

Oak Ridge National Laboratory

Oak Ridge National Laboratory is a Multiprogram Laboratory located on a 24,000 acre site in Oak Ridge, Tennessee. The High Energy Physics program supports a small research effort using unique capabilities of ORNL primarily in the area of particle beam shielding calculations.

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory is a Multiprogram Laboratory located on 640 acres at the Department's Hanford site in Richland, Washington. The High Energy Physics program supports a small research effort using unique capabilities of PNNL in the area of low background experiments.

Princeton Plasma Physics Laboratory

Princeton Plasma Physics Laboratory is a program-dedicated laboratory (Fusion Energy Sciences) located on 72 acres in Princeton, New Jersey. The High Energy Physics program supports a small research effort using unique capabilities of PPPL in the area of advanced accelerator R&D.

Stanford Linear Accelerator Center

Stanford Linear Accelerator Center is a program-dedicated laboratory (High Energy Physics) located on 426 acres in Menlo Park, California. SLAC operates for High Energy Physics the newly completed B-factory, the SLAC Linear Collider with the Stanford Large Detector, and a program of fixed target experiments. All of these facilities make use of the two mile long linear accelerator, or linac. SLAC, together with Fermilab, constitute the principal experimental facilities of the DOE High Energy Physics program.

All Other Sites

The High Energy Physics program supports about 230 research groups at 106 colleges and universities located in 36 states, Washington, D.C., and Puerto Rico. The strength and effectiveness of the university-based program is critically important to the success of the program as a whole. These university based components of the HEP program provides access to some of the best scientific talent in the nation.

The High Energy Physics program also funds research at a small number of non DOE laboratories and non-government laboratories and institutes.

Research and Technology

Mission Supporting Goals and Objectives

The High Energy Physics program has two major subprograms. The Research and Technology subprogram provides support for the scientists who perform the research which is the core of the program, and the technology R&D, which is essential to maintain the accelerator and detector facilities at the cutting edge required for a successful research program. The High Energy Physics Facilities subprogram, described later, provides the large facilities – accelerators, detectors, colliding beam devices – needed for the research program.

The Physics Research category in the Research and Technology subprogram provides support for university and laboratory based research groups conducting experimental and theoretical research in high energy physics. This research probes the nature of matter and energy at the most fundamental level, and the characteristics of the basic forces in nature. Experimental research activities include: planning, design, fabrication and installation of experiments; conduct of experiments; analysis and interpretation of data; and publication of results. Theoretical physics research provides the framework for interpreting and understanding observed phenomena and, through predictions and extrapolations based on current understanding, identifies key questions for future experimental explorations. This subprogram supports research groups at more than 100 major universities and at 9 DOE laboratories.

The High Energy Physics Technology category in the Research and Technology subprogram provides the specialized advanced technology R&D required to sustain and extend the technology base and provide operational support for the highly specialized accelerators, colliding beams facilities, and detector facilities which are essential to the overall high energy physics program goal of carrying out forefront research. The objectives of this category include: 1) carrying out R&D in support of existing accelerator and detector facilities aimed at maintaining and improving their performance parameters and cost effectiveness; 2) carrying out R&D support of planned and proposed projects to maximize their performance goals and cost effectiveness; 3) carrying out R&D to transfer new concepts and technologies into practical application in the High Energy Physics context; and 4) carrying out R&D to search for and develop new concepts and ideas that could lead to significant enhancements for research capabilities or to significant cost savings in the construction and operation of new facilities. This category supports work primarily at the DOE labs, but also at universities, other federal labs, and in industry.

Performance Measures

- Quality of scientific results and plans as indicated by expert advisory committees, recognition by the scientific community, and awards received by DOE-supported High Energy Physics researchers. The results of these reviews and other quality measures will be used to determine programmatic directions aimed at maintaining the world leadership position of the U.S. high energy physics program.

- Sustained achievement in advancing knowledge, as measured by the quality of the research based on results published in refereed scientific journals, and by the degree of invited participation at national and international conferences and workshops.
- Review at least 80 percent of the research projects by appropriate peers; continue to select research projects through a merit-based competitive process.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Physics Research	149,207	158,368	156,170	-2,198	-1.4%
High Energy Physics Technology	65,684	70,822	74,331	+3,509	+5.0%
SBIR/STTR	0	0	7,219	+7,219	+100.0%
Total, Research and Technology	214,891	229,190	237,720	+8,530	+3.7%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001

Physics Research

Physics Research			
Universities	98,556	107,508	105,640
Fermilab	10,658	7,957	7,837
SLAC	12,094	11,635	11,715
BNL	8,198	9,997	9,842
LBNL	11,305	11,126	10,956
ANL	5,712	5,645	5,565
Other Physics Research	2,684	4,500	4,615
Total, Physics Research	149,207	158,368	156,170

- **Universities—**The University Program consists of groups at 102 universities doing experiments (79 universities) and theory (75 universities). These university groups plan, build, execute, analyze and publish results of experiments, train graduate students and post-docs; and provide theoretical concepts, simulations and calculations of physical processes involved in high energy physics. These university based research activities are described in more detail below. The recent HEPAP Subpanel (Gilman), recommended that the level of funding for the university

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
based portion of the program be substantially increased over inflation over the next two year period. Following this recommendation, the overall funding for the university program has been provided with a modest increase above inflation. This modest increase is composed primarily of an increase of $5,500,000 in the capital equipment allocated to the university program in High Energy Physics Facilities offset by the $1,868,000 decrease in operating funds shown below. The combination results in a 3.4% increase.			
▸ **University Research at Fermilab**—Some 56 DOE-funded universities participate in large international collaborations doing experiments at Fermilab. These experiments involve the CDF and D-Zero collider detectors, and the KTEV, FOCUS, MINOS, DONUT, and HYPER-CP experiments using external beams of kaons, photons, neutrinos and hyperons. Other experiments are performed in the antiproton accumulator. The experiments study the production and interaction of quarks and gluons as a probe for new particles such as the Higgs, search for evidence for the possible mass of the neutrino and for the transition of neutrinos among the various types, search for possible sources for the asymmetry of matter over antimatter in the universe, and a number of other topics. These universities help to fabricate the detectors, plan and execute the experiments, analyze data and publish the results. The participation has been and is expected to remain about constant, as activity related to 800 GeV fixed target experiments diminishes and Tevatron, MINOS, and other new experiments related activities increases.	25,705	28,045	27,555
▸ **University Research at SLAC**—Some 27 DOE-funded universities participate in large international collaborations doing experiments at SLAC. The experiments involve the BaBar detector and other smaller detectors for fixed target experiments. These experiments are investigating fundamental constituents of matter such as the b quark. In particular, the BaBar detector is being used to study the nature of CP violation in the B meson system.			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
These universities help to build the detectors, plan and carry out experiments, analyze the data and publish the results. The participation has been and is expected to remain about constant, as SLD diminishes, BaBar flourishes, and work on a future large linear collider continues.	10,420	11,370	11,170
▸ **University Research at BNL**—Some 10 DOE-funded universities participate in collaborative experiments at BNL. These experiments involve fixed targets and kaon or pion beams, colliding beams of protons (RHIC-SPIN) or nuclei (PHOBOS) at RHIC, and an external storage ring measuring the muon anomalous magnetic moment to high precision.	3,145	3,430	3,370
▸ **University Research at Cornell**—Some 11 university High Energy Physics groups with DOE funding participate in the electron-positron colliding beam experiments at Cornell's CESR facility utilizing the collaboratively built CLEO detector studying various aspects of b meson interactions and decay. They help to plan, build, execute, analyze and publish the experiments.	5,220	5,700	5,600
▸ **University Research not at Accelerators**—Some 29 DOE-funded universities are involved in High Energy Physics experiments not utilizing accelerators. These experiments, which are primarily in the areas of astrophysics and cosmology, include MACRO (Italy), Super-Kamiokande (Japan), KamLAND (Japan), SNO (Canada), CHOOZ (France), SOUDAN (Minnesota), CDMS (Stanford), GRANITE (Mt. Hopkins, Arizona), Palo Verde (Arizona) and AMS (Space Station). These university based research groups build the detectors, plan, and execute the experiment, analyze the data and publish the results.	8,050	8,780	8,630
▸ **University Research at Foreign Labs**—Universities funded by the DOE are doing experiments with international collaborations using facilities at foreign accelerator labs. Some 45 universities are conducting experiments at CERN (Switzerland), 11 at DESY (Germany), 10 at KEK (Japan), 1 at IHEP (Russia), 1 at BINP (Russia), and 2 at Beijing (China). This research addresses a wide range of fundamental			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
questions such as the search for the Higgs boson which may be a key to understanding the source of mass. They help to fabricate the detectors and experimental apparatus, plan and execute the experiments, analyze the data and publish the results.	21,805	23,790	23,375
‣ **University Research in Theory**—Some 75 universities with DOE funding participate in research in theoretical high energy physics. This effort is expected to remain about constant. They provide theoretical ideas, concepts, calculations and simulations of physical processes in high energy physics..	21,600	23,565	23,155
‣ **Other University Funding ¾** Primarily includes funding held pending completion of peer review of proposals that have been received, and funds to respond to new and unexpected physics opportunities. The Outstanding Junior Investigator program, that is intended to identify and provide support for highly promising investigators at an early stage in their careers, will continue at a level of about $400,000....	2,611	2,828	2,785
Total, Universities	98,556	107,508	105,640
▪ **Fermilab**—In FY 2001, the experimental physics research groups at Fermilab will be focused mainly on the following activities: data-taking with the upgraded CDF and D-Zero collider detector facilities, analysis of data taken in the 800 GeV fixed-target program, construction of the MINOS detector, construction of the CMS detector for the LHC. The theoretical particle physics and astrophysics groups will be working on a variety of theoretical topics.	10,658	7,957	7,837
▪ **SLAC**—The experimental physics research groups at SLAC will concentrate their efforts in FY 2001 on data-taking and analysis of data from the BaBar detector operating with the PEP-II accelerator facility, as well as completing the analysis of the data from the operation of the SLD detector. Fabrication of the Gamma Large Area Space Telescope (GLAST) will be a significant effort in FY 2001 in preparation for the launch projected to be in FY 2005. GLAST will study the very high energy cosmic rays reaching the earth before they have interacted in the			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
atmosphere. Some physics research will also be done by fixed target experiments. The theoretical physics group will continue to emphasize topics related to BaBar and the other SLAC experimental physics programs as well as tests of the Standard Model and Quantum chromodynamics (QCD).	12,094	11,635	11,715
▪ **BNL**—In FY 2001, the BNL experimental physics research groups will be primarily working on the D-Zero experiment, which will be taking data at Fermilab, and contributing to the fabrication of the ATLAS detector for the LHC. Data collection for the precision measurement of the anomalous magnetic moment of the muon will be completed. An upgraded rare kaon decay experiment at the AGS facility, will begin operation. The theoretical physics group will be working on a number of topics.	8,198	9,997	9,842
▪ **LBNL¾** In FY 2001, LBNL researchers will be focused on a number of research activities, including: data-taking with the CDF collider detector at Fermilab; data-taking with the BaBar detector at the PEP-II storage ring at SLAC; data-analysis on the HYPER-CP experiment will be underway; and fabrication of the ATLAS detector, primarily the silicon tracking system, for the LHC. The researchers will also be working on supernova measurements to establish values of cosmological parameters. Funding is included for the Particle Data Group at LBNL, which continues as an international clearinghouse for particle physics information.	11,305	11,126	10,956
▪ **ANL¾** The experimental high energy physics group will continue collaborating in research on the CDF at Fermilab, and ZEUS at the DESY/HERA facility in Hamburg, Germany. They also will be working on the fabrication of two major new detector facilities: the ATLAS detector for future use at CERN's LHC facility, and the MINOS detector at the Soudan site in Minnesota. The MINOS detector is part of the NuMI project and will use a neutrino beam from Fermilab. The theoretical physics group will continue their research in formal theory, collider phenomenology, and lattice gauge calculations	5,712	5,645	5,565

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
▪ **Other Physics Research¾** LLNL is involved in the BaBar detector, in the MINOS project, as well as non-accelerator experiments. ORNL is carrying out accelerator and beamline shielding studies. LANL is involved in theoretical studies and certain non-accelerator experiments. Includes funds for research activities that have not yet completed their peer review. Funding at $1,800,000 is planned for an expanded R&D effort on the SNAP experiment to clarify the design, feasibility and scientific capability of the proposed instrument to explore dark matter, dark energy and the expanding universe by measuring the velocity of distant supernovae. This category also includes funding of conferences, studies, and workshops	2,684	4,500	4,615
Total, Physics Research	149,207	158,368	156,170

High Energy Physics Technology

High Energy Physics Technology			
Fermilab	15,900	14,430	15,370
SLAC	19,520	19,595	23,115
BNL	6,290	6,255	5,215
LBNL	10,247	10,518	10,328
ANL	2,150	2,160	2,135
Universities	9,049	11,595	11,965
Other Technology R&D	2,528	6,269	6,203
Total, High Energy Physics Technology	65,684	70,822	74,331

- **Fermilab**
  - Accelerator R&D—Activities in FY 2001 include design of an improved proton source; design of an electron cooling system to improve the quality of an antiproton beam processed through the Recycler ring; R&D in support of the NuMI project; engineering R&D on and construction of quadrupole magnets for the LHC interaction regions; and R&D to lay the technology foundations, long term, for possible future

	(dollars in thousands)	
FY 1999	FY 2000	FY 2001

accelerators and experiments. The latter includes continuation of R&D on the NLC begun formally in the first quarter of FY 2000 by a memorandum of understanding between SLAC and Fermilab. Fermilab has assumed the principle R&D responsibility for the two main linac beam lines, including accelerating structures, supports, and instrumentation and control. A major SLAC and Fermilab collaborative R&D activity is application of the Fermilab developed permanent magnet technology throughout the entire NLC beam optics chain. Fermilab is also responsible for applying their expertise in conventional civil construction to issues that could significantly reduce the NLC construction cost. There will also be an expanded accelerator physics effort, in collaboration with SLAC, to more fully understand all aspects of the beam optics and beam transport for the NLC from the electron and positron sources to the electron-positron collision point. Longer range R&D addresses the feasibility and design issues for muon colliders/neutrino sources. A critical test issue is the demonstration of the feasibility of ionization cooling. The muon cooling experiment, for which Fermilab is lead laboratory and LBNL a major collaborator, is part of a national Muon Collider/Neutrino Source Collaboration (including ANL, BNL, Fermilab, LBNL and a number of universities) that is also addressing the second critical issue (at BNL) of an intense Muon target/source and extensive accelerator physics and accelerator and storage ring systems studies. Fermilab is also engaged in an advanced superconducting magnet and materials program (principally niobium tin) to develop magnetic optical elements for use in a muon collider/neutrino source and, in the very far term, a possible 100 TeV proton collider. The general Accelerator R&D activities are increased by about $1,530,000 reflecting the need to support the initial operation of the Tevatron with the new Main Injector/Recycler and the two upgraded detectors, and the need for a more significant effort, as outlined above, to look at long term facility options for Fermilab and for the national program. NLC R&D

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
will decrease by $500,000 to $1,200,000 in FY 2001. The muon collider R&D activities will remain constant in FY 2001.	8,540	8,430	9,460
‣ Experimental Facilities R&D: Activities in FY 2001 include: R&D on pixel silicon detectors and related R&D for a possible dedicated collider detector for studying B meson interactions; R&D on photon veto systems for an experiment searching for rare decays of kaons; R&D on radiation-hard materials such as diamond and silicon carbide to replace silicon micro strip detectors at high collision rates; R&D on specialized electronics for high event rates in numerous, high-density data channels; and developing parallel computing configurations, high speed networks, and high-capacity data storage systems for high data rates.	7,360	6,000	5,910
Total, Fermilab	15,900	14,430	15,370

- **SLAC**

  - Accelerator R&D—Activities in FY 2001 will focus on R&D issues central to the design of the Next Linear Collider (NLC), an electron-positron colliding beam facility to operate in the 500 GeV to 1 TeV center-of-mass energy regime upgradable to 1.5 TeV. The R&D activity at SLAC will focus on design and supporting engineering R&D on the electron and positron sources, damping rings, and connecting beam transport systems. Much of this work is done in collaboration with the Japanese laboratory for HEP, KEK. Technology development for the 11.4 Ghz high powered microwave sources that generate the power to accelerate electrons and positrons will continue with the goal of proving new, more cost effective technical approaches. Some of this R&D will be carried out through contracts placed with industry, exploiting the special “design for manufacture” expertise of industry and accomplishing technology transfer from SLAC to industry. Systems engineering, value engineering and risk analysis studies will be carried out to identify R&D opportunities to lower cost, exploit new technologies, and improve performance. There will be a major collaboration

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
activity with Fermilab to incorporate permanent magnet technology developed for the Fermilab Recycler into the NLC design. Expanded accelerator physics studies will explore the limits of machine performance, look for optimized beam optics and accelerating structure improvements. Some of this work is in collaboration with Fermilab, LBNL and LLNL. An important component of the FY 2001 SLAC program will be accelerator R&D in support of operation of the B-factory. Particular attention will be paid to finding ways to improve the collision luminosity from the design value of $3x10^{33}cm^{-2}s^{-1}$ to greater than $10^{34}cm^{-2}s^{-1}$. A program of general R&D into very advanced collider concepts will continue and will coordinate with the program in advanced accelerator physics that is exploring the potential of lasers, plasmas, and ultra high frequency microwave systems to accelerate charged particles at ultra high gradients. The advanced accelerator R&D will be given slightly increased priority relative to FY 2000. The NLC R&D will be funded at $16,500,000 in FY 2001. (An additional $500,000 is provided to LLNL in this category and $1,000,000 in capital equipment funding for NLC R&D needs is provided under High Energy Physics Facilities subprogram at SLAC).	17,620	17,500	22,050
‣ Experimental Facilities R&D—In FY 2001, the focus will be on instrumentation for physics studies in the center of mass collision energy range of 10 GeV to 5,000 GeV. This will include work to support and improve performance of BaBar, the newly operating B-factory detector, and a modest program of R&D, on developing preliminary designs for a detector to operate with a possible new electron-positron linear collider operating at the TeV center of mass energy scale	1,900	2,095	1,065
Total, SLAC	19,520	19,595	23,115

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
▪ **BNL**			
‣ Accelerator R&D—Activities in FY 2001 will include, R&D on new methods of particle acceleration such as laser acceleration and Inverse Free Electron Laser (IFEL) accelerators, primarily using the excellent capabilities of the BNL Accelerator Test Facility. BNL also has a major involvement in muon collider R&D, primarily in the area of the muon production target and collection systems. This target/capture R&D is critical for demonstrating the feasibility of a muon collider. In the BNL superconductor test facility the characterization of new high critical temperature superconductors as well as their special requirements for high field magnet fabrication should be better understood. R&D in support of AGS operation will continue at a low level, as needed, in relation to the HEP supported operation of the AGS.	5,215	5,180	4,155
‣ Experimental Facilities R&D—In FY 2001, semiconductor drift photo diodes for detection of photons of energies as low as 50 eV will be designed and produced. Development of radiation hardened monolithic electronics for a number of experiments will continue. Development of lead-tungstate crystals with improved light output will continue. Testing of the modules that constitute the ATLAS barrel calorimeters will begin.	1,075	1,075	1,060
Total, BNL	6,290	6,255	5,215

▪ **LBNL**

‣ Accelerator R&D—LBNL is a major contributor to accelerator and superconducting magnet R&D for advanced accelerator concepts, including the muon collider and the next linear collider. Development of these concepts is needed to advance the energy and luminosity frontiers to better understand the structure of matter. In FY 2001, preparations for muon cooling experiments, needed to confirm the practicality of a muon collider, will begin at Fermilab, using components developed at LBNL. The high-gradient,

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
all-optical, laser-plasma wakefield accelerator at LBNL will begin accelerating electron bunches........	7,577	7,858	7,708
‣ Experimental Facilities R&D—LBNL has an industry forefront capability for designing and producing custom state-of-the-art electronics, such as silicon vertex detectors, integrated circuit (IC) systems, and other components for high-energy particle detectors such as BaBar at the B-factory and the upgrades to CDF and D–Zero for the next, higher luminosity, runs at Fermilab. LBNL is also involved in developing computer programs for experimental data taking and analysis. In FY 2001, work will continue on large area charge-coupled devices and high-resolution imaging systems, plus the production and testing of IC systems..	2,670	2,660	2,620
Total, LBNL..	10,247	10,518	10,328
▪ **ANL**			
‣ Accelerator R&D—R&D will continue on the acceleration of electrons using structures with plasmas or structures made of dielectric materials called wakefield accelerators. Researchers have achieved predicted accelerating gradients at encouraging levels using this new technique. Results are expected in obtaining high accelerating gradients with greatly enhanced beam stability using dielectric structures, and planning is underway for an upgraded experimental capability to generate much higher accelerator gradients using plasmas in structures driven by intense bunches of electrons. Related theoretical work will also continue.	1,230	1,240	1,225
‣ Experimental Facilities R&D—In FY 2001 work will be underway on the MINOS detector, the ATLAS detector for the LHC, and a possible upgrade of the ZEUS detector at DESY.	920	920	910
Total, ANL..	2,150	2,160	2,135

▪ **Universities¾** The funding will provide for a program of high priority technology R&D at about 35 universities relevant to the development of particle accelerators. The R&D is aimed at breakthrough technologies;

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
superconductors for high-field magnets; laser and collective-effect accelerator techniques; novel, high-power radio frequency generators; muon colliders; theoretical studies in particle beam physics, including the non-linear dynamics of particle beams; and at lowering the cost and improving the performance of future experiments and facilities..	9,049	11,595	11,965
▪ **Other Technology R&D**—The funding will provide for a program of high priority technology R&D at a number of other federal laboratories and industrial sites relevant to the development of particle accelerators. The R&D is aimed at breakthrough technologies; superconductors for high-field magnets; laser and collective-effect accelerator techniques; novel, high-power radio frequency generators; theoretical studies in particle beam physics, including the non-linear dynamics of particle beams; and at lowering the cost and improving the performance of future experiments and facilities. Also includes the portion of the funding for R&D on future facility concepts that has not yet been allocated pending program office discussions and peer reviews that are underway.	2,528	6,269	6,203
Total, High Energy Physics Technology...............................	65,684	70,822	74,331
▪ **SBIR/STTR**— Includes $6,370,000 for SBIR, and $849,000 for STTR in FY 2001. Additional funding for the SBIR program is contained in the High Energy Physics Facilities subprogram...	0	0	7,219
Total, Research and Technology..	214,891	229,190	237,720

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
▪ **Physics Research**	
‣ Operating expenses for the University Physics Research program decrease $1,868,000. This is more than offset by the $5,500,000 increase in capital equipment allocated for universities under the High Energy Physics Facilities subprogram.	-1,868
‣ At Fermilab, a decrease of $120,000 in research activities.	-120
‣ At SLAC, an increase of $80,000 related to the increased level of activity resulting from initial operation of the B-factory.	+80
‣ Research decreases at BNL (-$155,000), LBNL (-$170,000), and ANL (-$80,000).	-405
‣ An increase in the funding is unallocated pending the completion of peer reviews and programmatic consideration.	+115
Total, Physics Research	-2,198
▪ **High Energy Physics Technology**	
‣ At Fermilab, an increase in the general Accelerator R&D of $1,530,000 to support work needed to fully integrate and utilize the capability provided by the new Main Injector; offset by decreases of $500,000 in next linear collider R&D and of $90,000 in Experimental Facilities R&D. Muon Collider R&D is held constant.	+940
‣ At SLAC, an increase in general Accelerator R&D of $2,250,000 to support work needed to increase the luminosity of the B-factory. It is expected that the luminosity can be increased by a factor of three above the design value. There is also an increase in next linear collider R&D of $2,300,000 to allow this work to proceed on the planned schedule. These increases are partially offset by a decrease in Experimental Facilities R&D of $1,030,000 resulting from the completion of the BaBar detector.	+3,520
‣ At BNL, a decrease in general Accelerator R&D of $1,025,000 reflecting partial completion of a program to enhance the R&D capabilities of the lab, and other reductions in Accelerator R&D and Experimental Facilities R&D.	-1,040
‣ Modest decreases at LBNL ($190,000) and ANL ($25,000).	-215
‣ The University Technology R&D program increases $370,000. This provides an increase of about 3% for the university based Technology R&D program.	+370
‣ In Other Technology R&D, there is a small decrease in other activities.	-66
Total, High Energy Physics Technology	+3,509

	FY 2001 vs. FY 2000 ($000)
▪ **SBIR/STTR**	
‣ An increase of $7,219,000 in the SBIR and STTR allocation. In FY 2000, the SBIR/STTR allocations were all in the High Energy Physics Facilities subprogram.	+7,219
Total Funding Change, Research and Technology	+8,530

The following table summarizes the above changes for R&D on possible future HEP facilities:

	(dollars in millions)		
	FY 1999	FY 2000	FY 2001
Next Linear Collider	17.0	17.4	19.2
Muon-Muon Collider	5.5	8.7	8.7

High Energy Physics Facilities

Mission Supporting Goals and Objectives

The High Energy Physics Facilities subprogram includes the provision and operation of the large accelerator and detector facilities, the essential tools that enable scientists in university and laboratory based research groups to perform experimental research in high energy physics. This subprogram includes funding for the operation and maintenance of the national laboratory research facilities including accelerators, colliders, secondary beam lines, detector facilities for experiments, experimental areas, computing, and computing networking facilities. It includes the costs of detector and accelerator components, personnel, electric power, expendable supplies, replacement parts and subsystems, inventories and waste management activities at Fermilab and SLAC and at LBNL beginning in FY 2001. General Plant Projects (GPP) funding is provided for minor new construction, other capital alterations and additions and for buildings and utility systems. Landlord General Purpose Equipment (GPE), and GPP funding for Brookhaven National Laboratory in FY 1999 and for Lawrence Berkeley National Laboratory in FY 2000 and FY 2001; Fermi National Accelerator Laboratory and Stanford Linear Accelerator Center are also included. Accelerator Improvement Project (AIP) funding support for additions and modifications to accelerator facilities that are supported by the High Energy Physics research program is also included.

The principal objective of the High Energy Physics Facilities subprogram is to maximize the quantity and quality of data collected for approved experiments being conducted at the High Energy Physics facilities. The ultimate measure for success in the High Energy Physics Facilities subprogram is whether the research scientists have data of sufficient quantity and quality to do their planned measurements or to discover new phenomena. The quality of the data is dependent on the accelerator and detector capabilities, and on the degree to which those capabilities are achieved during a particular operating period. The quantity of the data relates primarily to the beam intensity, the length of the operating periods, and the operational availability of the accelerator and detector facilities.

Performance Measures

- Progress on achieving luminosity and operational efficiency for the B-factory at SLAC as measured by comparison with stated project goals.
- Progress on achieving luminosity and operational efficiency for the Tevatron at Fermilab in its new mode of operation with the recently completed Main Injector.
- The upgrade of scientific facilities will be managed to keep them on schedule and within cost.
- In FY 2001, High Energy Physics will be operating the B-factory at SLAC, the Main Injector for the Tevatron at Fermilab, and the AGS at BNL, and will deliver on the scheduled U.S./DOE commitments to the international Large Hadron Collider project.
- Meet on time and within budget the scheduled U.S. DOE commitments to the international Large Hadron Collider project as reflected in the latest international agreement and corresponding plan.

Planned Accelerator Operations

	(in weeks)		
	FY 1999	FY 2000	FY 2001
Fermilab	38	29	22
SLAC	42	39	36
BNL	14	15	17

Funding Schedule

	(dollars in thousands)				
	FY 1999	FY 2000	FY 2001	$ Change	% Change
Fermi National Accelerator Lab	209,937	212,936	207,031	-5,905	-2.8%
Stanford Linear Accelerator Center	112,330	115,447	114,527	-920	-0.8%
Brookhaven National Laboratory	42,375	4,909	7,519	+2,610	+53.2%
Other Facility Support	10,273	16,982	27,338	+10,356	+61.0%
Large Hadron Collider	65,000	70,000	70,000	0	0.0%
Waste Management	4,910	4,910	10,410	+5,500	+112.0%
SBIR/STTR	0[a]	14,669	7,785	-6,884	-46.9%
Total, High Energy Physics Facilities	444,825	439,853	444,610	+4,757	+1.1%

Detailed Program Justification

(dollars in thousands)		
FY 1999	FY 2000	FY 2001

Fermilab

Provides support for operation, maintenance, improvement, and enhancement of the Tevatron accelerator and detector complex. This complex includes the Tevatron, that can operate in a collider mode with protons and anti-protons, or in a fixed target mode with protons only; the new Main Injector that will be completed and commissioned in FY 1999; the Booster; the Linac; and the Anti-proton Source and Accumulator. The Tevatron collider and the 800 GeV fixed target modes are mutually exclusive; however, a fixed target program at 120 GeV using the new Main Injector is possible in parallel with Tevatron collider operation. This complex also includes the two large colliding beams

[a] Excludes $13,972,000 which has been transferred to the SBIR program and $838,000 which has been transferred to the STTR program.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Detectors – CDF and D-Zero – and a number of fixed target experiments in the external beams areas.			
▪ **Operations**—Operation at Fermilab will include operation of the Tevatron in collider mode for about 22 weeks. This will be a major physics run with the higher intensity available from the new Main Injector and with the newly upgraded D-Zero and CDF detectors....................	167,129	175,507	172,773

Tevatron Operation

	(in weeks)		
	FY 1999	FY 2000	FY 2001
Fixed Target	22	6	0
Collider..	0	15	22
Commissioning	16	8	0
Total, Tevatron Operation..	38	29	22

▪ **Support and Infrastructure**— Capital equipment funding for the CDF and D-Zero Upgrade projects is significantly reduced (to $500,000 each) reflecting the planned completion of these two projects in FY 2001. Capital equipment for the MINOS detector is increased to $7,000,000. AIP is funded at $4,300,000 and GPP is funded at $4,800,000..	42,808	37,429	34,258
Total, Fermilab	209,937	212,936	207,031

SLAC

Provides for the operation, maintenance, improvement and enhancement of the accelerator and detector complex on the SLAC site. The accelerators include the electron linac, the NLC Test Accelerator and the B-factory completed in FY 1999. The detector facilities include BaBar, the detector for the B-factory, the End Station A experimental set-ups, and the Final Focus Test Beam. Also provides for maintenance of the laboratory physical plant.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
▪ **Operations**—Operations at SLAC in FY 2001 will concentrate heavily on about 36 weeks of strong utilization of the newly completed asymmetric B-factory colliding beam storage rings to maximize the data collected by the BaBar detector facility. This will be supplemented by a modest (8 weeks) fixed target research program in End Station A. The linac will serve as the injector of positrons and electrons to the B-factory storage rings during this time. This will be the priority research program at SLAC in FY 2001.	92,795	95,147	95,447

SLAC Operation

	(in weeks)		
	FY 1999	FY 2000	FY 2001
Fixed Target	10	15[a]	8[k]
B-factory Commissioning	16	0	0
B-factory Operation	16	39	36
Total, SLAC Operation	42	39	36

	FY 1999	FY 2000	FY 2001
▪ **Support and Infrastructure**—Includes funding for capital equipment, AIP and GPP needs. Capital equipment funding for GLAST, a MIE with a preliminary TEC of $28,000,000, is included at $3,300,000. Additional capital equipment funding for GLAST in the amount of $1,300,000 is included in the Other Facility Support activity detailed later. Capital equipment for NLC R&D is included at $1,000,000.	19,535	20,300	19,080
Total, SLAC	112,330	115,447	114,527

BNL

Provides support for the HEP related operation, maintenance, improvement, and enhancement of the AGS complex at BNL and its complement of experimental set ups. The AGS was transferred to the Nuclear Physics program during the 3rd

[a] Fixed Target operation in parallel with B-factory operation.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
quarter of FY 1999 to be supported and operated as part of the RHIC facility. In FY 2000 and beyond operation of the AGS for the HEP program is on an incremental cost basis.			
▪ **Operations**—Operation activities covered under this budget category include the incremental cost of running the AGS complex for HEP. Operation for High Energy Physics in FY 2001 will be for about 17 weeks to complete the muon magnetic moment experiment and for initial operation of the upgraded rare kaon decay experiment. The large decrease from FY 1999 to FY 2000 reflects the transfer of the AGS from HEP to NP ..	33,938	3,490	5,920

AGS Operation

	(in weeks)		
	FY 1999	FY 2000	FY 2001
AGS Operation for HEP..	14	15	17

▪ **Support and Infrastructure**—Includes capital equipment funding for the BNL HEP program. Included in FY 1999 only, landlord GPP and GPE funding.	8,437	1,419	1,599
Total, BNL...	42,375	4,909	7,519

Other Facility Support

- Includes $5,000,000 for the establishment of an enhanced capability for large scale computer modeling and simulation. The initial application will be to detail orbit calculations in accelerator magnet rings, and in the large scale numerical calculations of fundamental interactions such as those in quark-gluon collisions.

  Includes $1,950,000 for General Purpose Equipment and $3,500,000 for General Plant Projects at LBNL for landlord related activities.

  Includes capital equipment funding at ANL, LBNL, and some smaller DOE labs. Includes funding for a number of small activities including computer networking. Includes $5,500,000 in capital equipment funding for the

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
University physics research program. These funds will be used primarily for the non-accelerator projects summarized below.	10,273	16,982	27,338

- The Cryogenic Dark Matter Search (CDMS) detector will use cryogenic techniques to search for weakly interacting massive particles (WIMPS). WIMPS are proposed as a possible explanation for the "missing" mass in the universe. CDMS is being done by a collaboration of universities and laboratories. The detector will be installed in the Soudan II underground laboratory in northern Minnesota. The TEC for CDMS is $8,600,000.
- The Kamioka Liquid Scintillator Anti-Neutrino Detector (KamLAND), the largest low-energy antineutrino detector ever built, will be located in the Kamiokande mine in Japan. This detector will attempt to detect whether neutrinos have mass by searching for neutrino oscillations by studying the flux and energy spectra of neutrinos produced by Japanese commercial nuclear reactors. KamLAND is being done in collaboration with a number of Japanese groups. KamLAND is still undergoing program office review. The projected TEC for KamLAND is $3,000,000 to be provided by the HEP and NP programs.
- The Pierre Auger Project (Auger) is intended to detect and study very high energy cosmic rays using a very large array of surface detectors spread over 30,000 square kilometers. Auger is being done by a large international collaboration. The presently approved part of the project includes an array at a site in Argentina. The U.S. will provide only a modest portion of the cost of the Argentine array. The TEC for the U.S. portion of this phase of Auger is $3,000,000.
- The Very Energetic Radiation Imaging Telescope Array System (Veritas) will be a ground based high energy cosmic gamma ray detector designed to search for and study astrophysical gamma ray sources. As such, it will complement GLAST. The Veritas

	(dollars in thousands)	
FY 1999	FY 2000	FY 2001

collaboration includes both U.S. and foreign groups, and will be built at a site in Arizona. The TEC for the U.S. portion of Veritas is $6,000,000.

- The AntiMatter in Space (AMS) experiment was designed to detect antimatter and was operated on a space shuttle flight. The experiment performed well and the data are being analyzed. It is planned to upgrade the detector for a second shuttle flight. The TEC for the DOE portion of the AMS upgrade is $3,000,000.

Large Hadron Collider

In FY 1999 and FY 2000, funding was used for: R&D and measurement/testing on superconducting materials, cable, and wire; calculations and R&D on accelerator physics issues regarding the design, instrumentation, and prototypes of the magnets for the colliding beam intersection regions and RF accelerating regions. Activities on the detectors will include R&D and prototype development of subsystems such as tracking chambers, calorimeters, and data acquisition electronics.

The LHC work is being performed at various locations including 4 major DOE labs and more than 55 U.S. universities.

LHC Accelerator and Detector Funding Summary

(dollars in thousands)	FY 1999	FY 2000	FY 2001
High Energy Physics Facilities			
LHC			
Accelerator Systems			
Operating Expenses	1,205	740	2,200
Capital Equipment	14,195	19,360	15,600
Total, Accelerator Systems	15,400	20,100	17,800
Procurement from Industry	8,091	13,106	18,503
ATLAS Detector			
Operating Expenses	4,792	5,570	5,738
Capital Equipment	4,207	10,924	10,769
Total, ATLAS Detector	8,999	16,494	16,507
CMS Detector			
Operating Expenses	13,472	9,100	8,480
Capital Equipment	19,038	11,200	8,710
Total, CMS Detector	32,510	20,300	17,190
Total, LHC	65,000	70,000	70,000

(dollars in thousands)	FY 1999	FY 2000	FY 2001
▪ **Accelerator Systems**—In FY 2001, funding will support continued production of interaction region quadrupole magnets, dipole magnets, feedboxes, and absorbers; production of radio-frequency region dipole magnets; and completion of fabrication of the superconducting cable for these magnets. Production testing of wire and cable for the LHC main magnets and accelerator physics calculations will continue.	15,400	20,100	17,800
▪ **Procurement from Industry**—In FY 2001, funding will continue to support reimbursement to CERN for purchases from U.S. industry including superconducting wire, cable, and cable insulation materials.	8,091	13,106	18,503
▪ **ATLAS Detector**—In FY 2001, funding will support production of detector hardware and electronics. The barrel cryostat procurement for the liquid argon			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
calorimeter will be completed and procurement and testing will continue for the silicon strip electronics, and the transition radiation tracker electronics. Fabrication efforts will continue for the silicon strip modules, the forward calorimeter, the extended barrel tile calorimeter modules and submodules, the endcap monitored drift tubes, and the cathode strip chambers. Fabrication will be completed for the liquid argon calorimeter feed-throughs and motherboards and installation will begin.	8,999	16,494	16,507
▪ **CMS Detector**—In FY 2001, funding will support full rate production and testing of endcap muon system chambers and the procurement of the electronics and cables for the muon system. The hadron calorimeter barrel will be completed and delivered to CERN and the scintillator and brass absorber assembly will continue along with the testing of the associated electronics. The trigger designs will be completed and testing of the electronics will continue. The data acquisition system will complete prototyping efforts and continue test beam studies. The forward pixel system will complete advanced testing and prepare for production of readout chips and sensors.	32,510	20,300	17,190
Total, Large Hadron Collider	65,000	70,000	70,000
▪ **Waste Management ¾** Provides funding for packaging, shipment and disposition of hazardous, radioactive or mixed waste generated in the course of normal operations at Fermilab, SLAC, and beginning in FY 2001, LBNL. The laboratories continue to explore opportunities to reduce the volume of newly generated waste and its associated management and disposal costs.	4,910	4,910	10,410
▪ **SBIR/STTR ¾** In FY 1999, $13,972,000 was transferred to the SBIR program and $838,000 was transferred to the STTR program. Includes $13,839,000 for the SBIR program and $830,000 for the STTR program in FY 2000			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
and $7,785,000 for SBIR in FY 2001. The balance of the SBIR and STTR allocations for FY 2001 are included in the Research and Technology subprogram.	0	14,669	7,785
Total, High Energy Physics Facilities	444,825	439,853	444,610

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
▪ **Fermilab**	
‣ At Fermilab, a reduction of $2,734,000 in Operations resulting in a 7 week reduction in the projected running schedule as the upgraded CDF and D-Zero detectors are completed.	-2,734
‣ At Fermilab, increases of $1,132,000 in capital equipment funding for the MINOS detector and $4,931,000 in other capital equipment funding are offset by reductions of $4,879,000 in capital equipment funding for the CDF Upgrade, and $4,355,000 in capital equipment funding for the D-Zero Upgrade. The increase in other capital equipment is needed for anticipated hardware needs to correct problems appearing during the final commissioning of the Tevatron and Main Injector and to begin to meet second priority capital equipment needs in the laboratory that were deferred in previous years to make funding available for the large detectors.	-3,171
Total, Fermilab	-5,905
▪ **Stanford Linear Accelerator Center**	
‣ At SLAC, an increase of $300,000 in Operations. This only partly offsets the impact of inflation resulting in a decrease of 3 weeks in the projected running schedule..	+300
‣ At SLAC, the reduction of $1,220,000 in Support and Infrastructure is primarily a reduction in capital equipment funding reflecting an anticipated reduction in the need for new ancillary accelerator equipment since the B-factory is a new machine.	-1,220
Total, Stanford Linear Accelerator Center	-920

	FY 2001 vs. FY 2000 ($000)
▪ **Brookhaven National Laboratory**	
‣ At BNL, an increase of $2,430,000 to support AGS operation to complete the muon magnetic moment experiment and the initial testing of the rare kaon decay experiment in advance of full operation in FY 2002.	+2,430
‣ At BNL, an increase of $180,000 in capital equipment funding to support the planned upgrade of the rare kaon decay experiment.	+180
Total, Brookhaven National Laboratory	+2,610
▪ **Other Facility Support**	
‣ Decreases in capital equipment funding at ANL ($15,000) and LBNL ($45,000).	-60
‣ An increase in capital equipment funding provides funds primarily for fabrication of five non-accelerator major items of equipment assigned to the university based Physics Research program.	+5,500
‣ An increase of $5,000,000 to provide for the establishment of an enhanced capability for large scale computational modeling and simulation.	+5,000
‣ A reduction of $84,000 in the funds held in reserve pending completion of peer review and programmatic consideration.	-84
Total, Other Facility Support	+10,356
▪ **Waste Management**	
‣ In Waste Management, an increase of $5,500,000 reflecting the transfer of Waste Management responsibility at LBNL to the HEP budget from Environmental Management in FY 2001.	+5,500
▪ **SBIR/STTR**	
‣ A reduction of $6,884,000 in funding for SBIR and STTR reflecting the transfer of about half of the SBIR/STTR funding to the Research and Technology subprogram. The combined overall change in SBIR/STTR is $335,000.	-6,884
Total Funding Change, High Energy Physics Facilities	+4,757

Construction

Mission Supporting Goals and Objectives

This provides for the construction of major new facilities needed to meet the overall objectives of the High Energy Physics Program.

Performance Measures

- Make progress on the Neutrinos at the Main Injector project as measured by accomplishment of scheduled milestones as detailed in the benchmark plan.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Construction	21,000	28,700	32,400	+3,700	+12.9%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Neutrinos at the Main Injector (NuMI)¾ This project provides for the construction of new facilities at Fermilab and at the Soudan Underground Laboratory in Soudan, Minnesota that are specially designed for the study of the properties of the neutrino and in particular to search for neutrino oscillations. The FY 2001 funding is for construction of the neutrino production target, neutrino focusing horns, beam tunnel, underground detector and detector halls, and surface buildings at Fermilab.	14,300	22,000	23,000
Wilson Hall Safety Improvement Project (Fermilab)—This project provides for urgently needed rehabilitation of the main structural elements of Wilson Hall, and for urgently needed rehabilitation of windows, plumbing, the roof and the exterior of the building	6,700	4,700	4,200

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
SLAC Research Office Building—This project provides urgently needed office space for the substantial expansion of visiting scientists, or "users", resulting from the B-factory becoming operational. The visiting user population is projected to increase from 200 visitors per year to 1,100 visitors per year. The new building will provide about 30,000 square feet and will be completed in FY 2001	0	2,000	5,200
Total, Construction	21,000	28,700	32,400

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
▪ Continuation of the Fermilab NuMI project on the planned profile.	+1,000
▪ Provides for completion of the Wilson Hall Safety Improvement Project at Fermilab on the planned profile	-500
▪ Provides for completion of the Research Office Building on the planned profile.	+3,200
Total Funding Change, Construction	+3,700

Capital Operating Expenses & Construction Summary

Capital Operating Expenses

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
General Plant Projects	15,185	12,500	12,500	0	0.0%
Accelerator Improvements Projects........	7,231	8,900	8,880	-20	-0.2%
Capital Equipment.................................	92,315	89,167	84,329	-4,838	-5.4%
Total, Capital Operating Expense..........	114,731	110,567	105,709	-4,858	-4.4%

Construction Projects

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1999	FY 2000	FY 2001	Unapprop-riated Balance
98-G-304 Neutrinos at the Main Injector	76,200	5,500	14,300	22,000	23,000	11,400
99-G-306 Wilson Hall Safety Improvements......................................	15,600	0	6,700	4,700	4,200	0
00-G-307 SLAC Research Office Building..	7,200	0	0	2,000	5,200	0
Total, Construction...............................		5,500	21,000	28,700	32,400	11,400

Major Items of Equipment *(TEC $2 million or greater)*

(dollars in thousands)

	Total Estimated Cost (TEC)	Prior Year Approp-riations	FY 1999	FY 2000	FY 2001	Accept-ance Date
D-Zero Upgrade....................	57,902	44,092	8,455	4,855	500	FY 2001
CDF Upgrade	56,916	41,482	9,555	5,379	500	FY 2001
B-factory Detector (BaBar) [a]...	68,000	64,200	3,800	0	0	FY 1999
Large Hadron Collider — Machine	87,340	11,785	14,195	19,360	15,600	FY 2005
Large Hadron Collider — ATLAS Detector....................	56,416	6,198	4,207	10,924	10,769	FY 2005
Large Hadron Collider — CMS Detector.......................	70,125	5,517	19,038	11,200	8,710	FY 2005
MINOS................................	45,709	0	2,600	5,868	7,000	FY 2004
GLAST [b]..............................	28,000	0	0	3,000	4,600	FY 2005
Cryogenic Dark Matter Search (CDMS)	8,600	0	0	0[c]	1,750	FY 2007
KamLAND [d]..........................	3,000	0	0	0[n]	800	FY 2002
Auger..................................	3,000	0	0	0[n]	1,250	FY 2003
Veritas [e]	6,000	0	0	0[n]	1,500	FY 2005
Antimatter in Space (AMS) Upgrade	3,000	0	0	0[n]	1,000	FY 2003
Total, Major Items of Equipment		173,274	61,850	60,586	53,979	

[a] The funding for the B-factory detector reflects cost savings of about $20,000,000 resulting from contributions of components and subsystems by non-U.S. collaborating institutions.

[b] Total estimated cost is subject to further negotiations with NASA and potential foreign collaborators.

[c] These major items of equipment were recently reviewed and recommended for initiation in FY 2000. HEP currently plans to support these major items of equipment that were approved after the FY 2000 budget was submitted to Congress.

[d] Funding split equally between High Energy Physics and Nuclear Physics budgets. KamLAND is only being shown on High Energy Physics table to display total TEC of $3,000,000.

[e] Approval still pending Program Office peer-review.

98-G-304, Neutrinos at the Main Injector (NuMI), Fermi National Accelerator Laboratory, Batavia, Illinois

(Changes from FY 2000 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

Significant Changes

Total Project Cost and the Completion Date have been adjusted due to changes in the MINOS detector profile.

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 1998 Budget Request *(A-E and technical design only)*..........................	1Q '98	4Q '98	NA	NA	5,500	6,300
FY 1999 Budget Request (Preliminary Estimate)...	--	3Q '99	1Q '99	4Q '02	75,800	135,300
FY 2000 Budget Request	3Q '98	2Q '00	3Q '99	2Q '03	76,200	136,100
FY 2001 Budget Request	3Q '98	2Q '00	3Q '99	2Q '04	76,200	138,600

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Design & Construction			
1998	5,500	5,500	1,140
1999	14,300	14,300	5,846
2000	22,000	22,000	26,300
2001	23,000	23,000	27,000
2002	11,400	11,400	11,900
2003	0	0	4,014

3. Project Description, Justification and Scope

The project provides for the design, engineering and construction of new experimental facilities at Fermi National Accelerator Laboratory in Batavia, Illinois and at the Soudan Underground Laboratory at Soudan, Minnesota. The project is called NuMI which stands for Neutrinos at the Main Injector. The purpose of the project is to provide facilities that will be used by particle physicists to study the properties of neutrinos, which are fundamental elementary particles. In the Standard Model of elementary particle physics there are three types of neutrinos that are postulated to be massless and to date, no direct experimental observation of neutrino mass has been made. However, there are compelling hints from experiments that study neutrinos produced in the sun and in the earth's atmosphere that indicate that if neutrinos were capable of changing their type it could provide a credible explanation for observed neutrino deficits in these experiments.

The primary element of the project is a high flux beam of neutrinos in the energy range of 1 to 40 GeV. The technical components required to produce such a beam will be located on the southwest side of the Fermilab site, tangent to the new Main Injector accelerator at the MI-60 extraction region. The beam components will be installed in a tunnel of approximately 1 km in length and 6.5 m diameter. The beam is aimed at two detectors (MINOS) which will be constructed in experimental halls located along the trajectory of the neutrino beam. One such detector will be located on the Fermilab site, while a second will be located in the Soudan Underground Laboratory. Two similar detectors in the same neutrino beam and separated by a large distance are an essential feature of the experimental plan.

The experiments that are being designed to use these facilities will be able to search for neutrino oscillations occurring in an accelerator produced neutrino beam and hence determine if neutrinos do have mass. Fermilab is the only operational high energy physics facility in the U.S. with sufficiently high energy to produce neutrinos which have enough energy to produce tau leptons. This gives Fermilab the unique opportunity to search for neutrino oscillations occurring between the muon and the tau neutrino. Additionally, the NuMI facility is designed to accommodate future enhancements to the physics program that could push the search for neutrino mass well beyond the initial goals established for this project.

4. Details of Cost Estimate [a]

	(dollars in thousands)	
	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs	7,150	7,150
Design Management costs (0.0% of TEC)	10	10
Project Management costs (0.0% of TEC)	20	20
Total, Engineering design inspection and administration of construction costs (9.4% of TEC)	7,180	7,180
Construction Phase		
Buildings	8,320	8,320
Special Equipment	10,120	10,120
Other Structures	30,960	30,960
Construction Management (6.0% of TEC)	4,590	4,590
Project Management (2.8% of TEC)	2,170	2,170
Total, Construction Costs	56,160	56,160
Contingencies		
Design Phase (2.8% of TEC)	2,172	2,172
Construction Phase (14.0% of TEC)	10,688	10,688
Total, Contingencies (16.8% of TEC)	12,860	12,860
Total, Line Item Cost (TEC)	76,200	76,200

5. Method of Performance

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

[a] The annual escalation rates assumed for FY 1996 through FY 2002 are 2.5, 2.8, 3.0, 3.1, 3.3, 3.4, and 3.4 percent respectively.

6. Schedule of Project Funding

	(dollars in thousands)					
	Prior Years	FY 1999	FY 2000	FY 2001	Outyears	Total
Project Cost						
Facility Cost						
Total, Line item TEC............................	1,140	5,846	26,300	27,000	15,914	76,200
Other Project Costs						
Capital equipment [a]..............................	0	2,560	5,868	7,000	30,281	45,709
R&D necessary to complete construction [b]	1,260	40	0	0	0	1,300
Conceptual design cost [c]......................	830	0	0	0	0	830
Other project-related costs [d]..................	1,520	1,960	5,632	3,382	2,067	14,561
Total, Other Project Costs...........................	3,610	4,560	11,500	10,382	32,348	62,400
Total Project Cost (TPC).............................	4,750	10,406	37,800	37,382	48,262	138,600

[a] Costs to fabricate the near detector at Fermilab and the far detector at Soudan. Includes systems and structures for both near detector and far detector, active detector elements, electronics, data acquisition, and passive detector material.

[b] This provides for project conceptual design activities, for design and development of new components, and for the fabrication and testing of prototypes. R&D on all elements of the project to optimize performance and minimize costs will continue through early stages of the project. Specifically included are development of active detectors and engineering design of the passive detector material. Both small and large scale prototypes will be fabricated and tested using R&D operating funds.

[c] Includes operating costs for development of conceptual design and scope definition for the NuMI facility. Also includes costs for NEPA documentation, to develop an Environmental Assessment, including field tests and measurements at the proposed construction location.

[d] Include funding required to complete the construction and outfitting of the Soudan Laboratory for the new far detector by the University of Minnesota.

7. Related Annual Funding Requirements

(FY 2003 dollars in thousands)

	Current Estimate	Previous Estimate
Annual facility operating costs [a]	500	500
Utility costs (estimate based on FY 1997 rate structure) [b]	500	500
Total related annual funding	1,000	1,000
Total operating costs *(operating from FY 2003 through FY 2007)*	5,000	5,000

[a] Including personnel and M&S costs (exclusive of utility costs), for operation, maintenance, and repair of the NuMI facility.

[b] Including incremental power costs for delivering 120 GeV protons to the NuMI facility during Tevatron collider operations, and utility costs for operation of the NuMI facilities, which will begin beyond FY 2002.

99-G-306, Wilson Hall Safety Improvements Project, Fermi National Accelerator Laboratory, Batavia, Illinois

(Changes from FY 2000 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 1999 Budget Request	1Q '99	2Q '00	3Q '99	3Q '02	15,600	18,800
FY 2000 Budget Request	1Q '99	2Q '00	3Q '99	3Q '02	15,600	18,800
FY 2001 Budget Request	1Q '99	2Q '00	3Q '99	3Q '02	15,600	18,800

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Construction			
1999	6,700	6,700	674
2000	4,700	4,700	6,340
2001	4,200	4,200	6,990
2002	0	0	1,596

3. Project Description, Justification and Scope

Wilson Hall, constructed in 1972, is the central laboratory facility for the Fermilab site. It is a 17 story reinforced concrete building with a 16 story atrium. The great majority of its area is devoted to office space. In addition, the building contains the cafeteria, the communications center, medical office, some light industrial and shop areas, and an 800 seat auditorium.

The Wilson Hall Safety Improvements Project is a comprehensive project to remediate the deficiencies in this facility. Among the causes for the deficiencies are the age of the building and its systems, safety issues and updating to current code standards, and building components and systems that have reached their useful life expectancy.

The structural deficiencies are currently resulting in the ongoing safety issue of falling concrete debris in occupied areas of the building, and will eventually threaten the integrity of the entire facility. Additional spalling of the concrete could occur on the exterior faces of the building. The current glazing in the sloped window walls is not the code required safety glass. Breakage could result in the falling of sharp edged shards of glass into the atrium area. The quality of the existing drinking water is poor (taste & color) resulting in low usage which allows levels of lead and copper to exceed regulatory requirements.

The building structure portion of this project provides for the rehabilitation of the existing concrete structure at the crossover bays, which connect the two towers that comprise Wilson Hall. The joints between the crossover bays and tower are experiencing significant structural degradation, resulting in the ongoing safety issue of falling debris and the probability of continued deterioration of the joints. Recent computer analysis of the movement of the building structure has indicated that the joints need to be reworked to allow for the seasonal movement caused by temperature changes. This project will implement the solution to the joint erosion problem. It will consist of reconstructing the joints (assuring effective independent movement of each tower). Since a number of areas in the building will have restricted occupancy while the repairs are being made, this project will include the staff relocation required to accommodate the construction as part of Other Project Costs. At the completion of the structural joint repairs, a thorough exterior inspection will be conducted and any necessary repairs completed.

The building envelope portion of this project provides for the weatherproofing of components of the building shell that are currently allowing water penetration, the refurbishment of the existing skylight system, refinishing and partially reglazing the north and south curtain walls, and replacing the exterior entrances, including the entrance plaza:

Entry Plaza: The plaza that covers the "catacomb" area will have clear sealer applied to the sloped portions of the concrete walls enclosing the catacombs. The raised plaza portions will have waterproofing and pavers installed over the existing concrete. The existing paving at the entrance plaza will be removed and a new waterproof membrane and new paving will be installed.

North and South Curtain Wall: The north and south curtain walls of Wilson Hall are comprised of an anodized aluminum framing system that extends the full height of the building. The lower six floors of the system are sloped but do not have the current code required safety glazing. The finish of the aluminum framing is deteriorating and the system is allowing water penetration into the building. Safety glazing will be installed and the system will be repaired to resolve the water penetration.

4. Details of Cost Estimate [a]

	(dollars in thousands)	
	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs	840	920
Project Management costs (0.8% of TEC)	130	100
Total, Engineering design inspection and administration of construction costs (6.2% of TEC)	970	1,020
Construction Phase		
Buildings	8,520	8,850
Inspection, design and project liaison, testing, checkout and acceptance	810	870
Construction Management (10.6% of TEC)	1,660	1,820
Project Management (2.6% of TEC)	400	430
Total, Construction Costs	11,390	11,970
Contingencies		
Design Phase (1.6% of TEC)	250	170
Construction Phase (19.2% of TEC)	2,990	2,440
Total, Contingencies (20.8% of TEC)	3,240	2,610
Total, Line Item Cost (TEC)	15,600	15,600

5. Method of Performance

Overall project management, quality assurance, supervision of design and construction efforts and coordination with the U.S. Department of Energy for this project will be the responsibility of the Fermi National Accelerator Laboratory, through the Facilities Engineering Services Section (FESS). Design will be accomplished by a combination of FESS staff and consultant A/E fixed price contracts under the direction of the Facilities Engineering Services Section. Construction for project completion will be accomplished by means of one or more competitively bid, fixed price construction subcontracts. Construction Management and overall project management during the construction phase of this project will remain the responsibility of the Facilities Engineering Services Section of the Fermi National Accelerator Laboratory.

[a] The economic escalation rates from FY 1997 dollars for FY 1999 through FY 2001 are 5.3%, 2.9%, and 2.9% respectively from the Department Price Change Index FY 1999 Guidance, General Construction.

6. Schedule of Project Funding

(dollars in thousands)

	Prior Years	FY 1999	FY 2000	FY 2001	Outyears	Total
Project Cost						
Facility Cost						
Total, Line item TEC	0	674	6,340	6,990	1,596	15,600
Other Project Costs						
Conceptual design cost	1,100	0	0	0	0	1,100
Other project-related costs [a]	0	490	350	850	410	2,100
Total, Other Project Costs	1,100	490	350	850	410	3,200
Total Project Cost (TPC)	1,100	1,164	6,690	7,840	2,006	18,800

7. Related Annual Funding Requirements

	Current Estimate	Previous Estimate
Wilson Hall related annual costs	NA	NA
Incremental utility costs (estimate based on FY 1997 rate structure)	NA	NA
Total related annual funding *(operating from FY 2003 through FY 2007)* [b]	NA	NA

[a] Includes funding for relocation of tenants before and after the construction and rebuilding of their workspaces; refurbishment of existing elevators which will be used for construction purposes, and then restored to public use.

[b] No incremental annual operating costs will result from the completion of this project.

00-G-307, Research Office Building, Stanford Linear Accelerator Center, Stanford, California

(Changes from FY 2000 Congressional Budget Request are denoted with a vertical line [|] in the left margin.)

1. Construction Schedule History

	Fiscal Quarter				Total Estimated Cost ($000)	Total Project Cost ($000)
	A-E Work Initiated	A-E Work Completed	Physical Construction Start	Physical Construction Complete		
FY 2000 Budget Request	1Q '00	3Q '00	4Q '00	4Q '01	7,200	7,430
FY 2001 Budget Request	1Q '00	3Q '00	4Q '00	4Q '01	7,200	7,430

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
Construction			
2000	2,000	2,000	950
2001	5,200	5,200	6,250

3. Project Description, Justification and Scope

The new Research Office Building project will construct a two-story building with approximately 30,000 gross square feet that will provide permanent, energy efficient office and conference space to meet the needs of the Laboratory. The office building will be located immediately adjacent to and north of the existing SLAC Administrative and Engineering building in the central campus area of the Laboratory. The new government-owned facility described herein will be located on leased land. Features include fixed and flexible office areas, meeting rooms and conference facilities equipped with interior office furnishings. Conventional utilities, such as domestic water, sanitary sewer, HVAC, and electrical power, will be provided by short connections from existing services. Specialized utilities include HVAC control and equipment, telecommunication for video and computers, and the main electrical feed. Construction of this building may allow the demolition of several very old, temporary structures, totaling approximately 17,000 square feet.

This building will provide adequate facilities for the BaBar experimental program. This experimental program is critical to delivering the scientific understanding necessary to the success of the DOE's and the Nation's long-term science objective of maintaining the U.S. high energy physics program at the forefront of basic research.

With the increasing level of activity associated with the BaBar collaboration and SLAC's on-going high energy physics (HEP) experimental program, SLAC's space requirements are projected to exceed the capacity of currently existing office and meeting facilities. The BaBar experiment, which began operation in FY 1999, projects a large influx of users who will require adequate office and support space. SLAC expects to host approximately 1,100 HEP users per year as the BaBar experiment ramps up to full scale operations. The BaBar collaboration itself, consists of over six hundred users from around the world representing over seventy institutions. Office and meeting space is urgently needed to meet the demand created by this mega-collaboration. In the past, SLAC has only had about 200 collaborators/users in residence at any one time. Even at this level, most are housed in less than adequate facilities (the user community has become ever more vocal about this in the past year or two). In the BaBar era, SLAC expects substantially more users to be in residence and, as a national user facility, SLAC needs to be in a position to provide adequate space for them.

SLAC has investigated leasing and conversion alternatives to meet the projected need for office space but none has been judged to be as cost effective or satisfactory as the addition of the new office building. It was determined that there was insufficient off-site office space available nearby for leasing (12,000 square feet with a rental cost of $1,000,000 per year was available). Conversion of existing temporary and permanent facilities is not cost effective because the cost of renovation and necessary seismic and ADA work is roughly equal to the cost of new construction and the resulting space is inferior to new space specifically designed for office use. Additionally, valuable industrial space would be lost.

The use of substandard facilities could meet approximately two-thirds of this projected need but at substantial cost for necessary remedial work. With improved operating and energy efficiencies, it is estimated that the annual operating costs for this 30,000 square foot building will be equal to the current operating costs of the 17,000 square feet of temporary space to be removed.

If the new Research Office Building is not constructed, operating efficiencies and cost savings cannot be achieved, existing temporary structures, which are maintenance intensive and energy inefficient cannot be eliminated, the cost of seismic and ADA retrofitting will not be avoided, and parking will continue to be an operational deficiency in the main Computer Center area. Vehicular and pedestrian safety will not be improved. Commitments made to Stanford University and the SLAC HEP user population will not be met. An estimated $2,000,000 of avoidable costs will be incurred.

4. Details of Cost Estimate [a]

	(dollars in thousands)	
	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs	419	419
Design Management costs (1.4% of TEC)	98	98
Project Management costs (1.4% of TEC)	98	98
Total, Design Phase (8.5% of TEC)	615	615
Construction Phase		
Building	4,727	4,727
Specialized Utilities	519	519
Standard Equipment	496	496
Construction Management (1.6% of TEC)	113	113
Project Management (1.2% of TEC)	85	85
Total, Construction Costs	5,940	5,940
Contingencies		
Design Phase (0.8% of TEC)	61	61
Construction Phase (8.1% of TEC)	584	584
Total, Contingencies (9.0% of TEC)	645	645
Total, Line Item Cost (TEC)	7,200	7,200

5. Method of Performance

Construction and procurement shall be accomplished by fixed price subcontracts on the basis of competitive bidding. Design and inspection shall be performed by the laboratory and contracted Architect-Engineers.

[a] Escalated to mid-point of construction with a factor of 1.0611. Allocated Indirects included in costs.

6. Schedule of Project Funding

(dollars in thousands)

	Prior Years	FY 1999	FY 2000	FY 2001	Outyears	Total
Project Cost						
Facility Cost						
Design	0	0	615	0	0	615
Construction	0	0	335	6,250	0	6,585
Total Facility Costs (TEC)	0	0	950	6,250	0	7,200
Other Project Costs						
Conceptual design cost	0	30	0	0	0	30
Other project related costs [a]	0	0	0	200	0	200
Total, Other Project Costs	0	30	0	200	0	230
Total Project Cost (TPC)	0	30	950	6,450	0	7,430

7. Related Annual Funding Requirements

(FY 2002 dollars in thousands)

	Current Estimate	Previous Estimate
Annual facility maintenance/repair costs [b]	39	34
Incremental utility costs [c]	41	36
Total related annual funding	80	70
Total Operating costs (operating from FY 2003 through FY 2007)	400	350

[a] Includes funding for demolition of temporary structures; paving.

[b] Includes costs for janitorial services.

[c] Includes incremental utility costs for electric power and water.