DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH

OVERVIEW

NUCLEAR PHYSICS

The Nuclear Physics program of the Department of Energy (DOE) has the lead responsibility for Federal support of nuclear physics research and supports basic research activities under the mandate provided in Public Law 95-91 which established the Department and in conformance with the developing National Energy Strategy. The primary goal of the program is to understand the structure of atomic nuclei and the fundamental forces required to hold their constituents in place. Nuclear processes determine the essential physical characteristics of our universe and the composition of the matter which forms it. The science of nuclear physics has spawned many diverse technologies such as nuclear medicine, nuclear power, nuclear fusion and nuclear weapons. These technologies have matured to the point where they now operate almost independently of the basic research program. Nevertheless, vital interactions still occur in the development of advanced concepts, in the transfer of improved theoretical models, in the common development of instrumentation, and in the need for more precise nuclear physics data in selected areas. Nuclear Physics accelerators generate many of the radioisotopes used for medical diagnoses and support several cooperative programs in biomedical research and atomic physics. They provide the framework for the training of Health Physicists who are especially dedicated to the maintenance of a radiation-free environment. Over one half of the 80 new Ph.D.'s produced each year in the DOE Nuclear Physics program will find careers in these associated areas. In addition, the Nuclear Data program within Nuclear Physics generates, evaluates, and disseminates information such as neutron cross sections in active support and collaboration with these programs.

However, the major activity and vitality of the field focuses upon an ever improving fundamental understanding of the material and forces of nature. These activities are an essential component of the National Energy Strategy in fortifying the foundations of the nation's scientific and technological base. Over the years, many theoretical models have been developed to describe the structure of the nucleus and its behavior. These models have progressed from simple mechanical models of surface vibrations and rotations to sophisticated descriptions of meson-nucleon interactions. Scientists now know that nucleons (neutrons and protons, the constituents of the nucleus), are composed of smaller constituents called quarks. Based on the ways quarks are confined together in groups of three to make nucleons, or groups of two to make mesons, a more fundamental theory of the nuclear force called quantum chromodynamics (QCD) is emerging. The incorporation of QCD concepts deepens our understanding of nuclear structure and interactions and provides significant new challenges to the experimental program. Many of the characteristics and implications of the new QCD formulation of the nuclear force are addressed by the research programs both of nuclear physics and its daughter science, high energy physics. However, the Nuclear Physics program uniquely approaches the problems by testing the theoretical predictions in the medium of extended nuclear matter provided by nuclei composed of many nucleons. A growing number of problems of mutual interest to nuclear physics and astrophysics include measurements or calculations of supernovae, neutron stars, solar neutrinos, heavy cosmic rays, and the continuing problem of stellar nuclear abundances. Of special current interest are measurements of the solar neutrino flux which permits the measurement of small neutrino masses. The ability of relativistic heavy ion collisions to create a quark-gluon plasma, simulating a stage of evolution of the universe that ended ten millionths of a second after the initial "big bang", will play an increasing role in the program.

The strategy of the program is to address the most pressing scientific questions in nuclear physics with new theories, equipment and facilities while maintaining an effective balance between competing and diverse program elements. Essential guidance is provided by the Nuclear Physics Program plan, which is based on the 1989 Long Range Plan for Nuclear Science developed by the Nuclear Science Advisory Committee (NSAC). Key elements of the plan are reflected in this budget.

The program is centered around an active experimental research program which is continually evaluated and revised to focus on the most basic scientific questions. Necessary for proper conduct of this research are efforts in nuclear theory, design and fabrication of sophisticated detectors and the development and training of creative and skilled personnel. Central to the program are the construction, operation and maintenance of the accelerator facilities which provide the beams of particles with which the experiments are performed. In some areas of nuclear physics, questions are addressed at universities by accelerators dedicated to in-house research, or smaller facilities at some national laboratories. However, many of the newly emerging fundamental problems in nuclear science require large modern facilities designed for the research use of the entire nuclear community.

The DOE Nuclear Physics program supports over 85 percent of the U.S. program of basic research in nuclear physics. In FY 1993 it will maintain a vigorous research program, focusing on current problems of high scientific and technological interest and pointing towards exploitation of the new major facilities. Many of the scientists supported by the Nuclear Physics program plan carry out experiments and conduct research at DOE supported and other U.S. and foreign accelerator facilities. The strong university component which forms the central core of the facility user activity is augmented by an NSF effort of comparable size. In FY 1991, about 250 scientists, including 40 graduate students, did experiments at the Bevalac at the Lawrence Berkeley Laboratory and a similar number make use of the Tandem/AGS at the Brookhaven National Laboratory. About 320 visiting scientists used the multiple beams available at the LAMPF facility at the Los Alamos National Laboratory for one or more experiments in FY 1991. Already, 245 physicists from 60 institutions have submitted 47 research proposals to the Continuous Electron Beam Accelerator Facility (CEBAF). From these proposals an initial program of experiments has been selected to be carried out when the facility comes into operation. The present focus is on the involvement of the user community in equipment fabrication. About 200 scientists from outside of CEBAF are already actively participating in the design of experiments to be carried out in the three experimental halls. At the Relativistic Heavy Ion Collider (RHIC) under construction at Brookhaven National Laboratory, letters of intent to design and fabricate detectors have been received representing over 300 scientists from 50 universities and laboratories throughout the world. Decisions on the initial complement of detectors will be made in FY 1992.

Special emphasis is placed on use of the upgraded electron beams at the Massachusetts Institute of Technology and the Tandem/AGS high energy heavy ion beams at Brookhaven National Laboratory (BNL). Priorities within the program will be set to accommodate students and postdoctoral fellows in nuclear physics and to reflect more accurately the highest program priorities and new scientific areas in physics with electron beams, relativistic heavy ion research, studies of high spin state, and solar neutrino research. An important component is the role of university facilities in attracting young scientists, many of which perform their research at off-campus user facilities. National laboratory and university accelerators will be operated for maximum program effectiveness with selected capital equipment detector projects to optimize facility productivity. Detector projects include continuation of the segmented gamma ray detector for nuclear structure physics (Gammasphere) and joint participation with Canada and the United Kingdom in the Sudbury Neutrino Observatory (SNO) project. The Institute for Nuclear Theory, sited in FY 1990 at the University of Washington, will continue its development in FY 1993 with new forefront scientific programs and the creation of additional mechanisms for effective interaction with the entire nuclear physics community.

In FY 1993, the largest construction project in the Nuclear Physics program will be the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory as major superconducting magnet procurements continue. Construction funding for CEBAF will be past its peak; the primary activities on the accelerator components will be assembly and installation. There will be significant activity in the design and fabrication of experimental detectors for both facilities in FY 1993. These two projects received the highest priority for support in the NSAC Long Range Plan for Nuclear Science.

As part of adjusting to constrained funding profiles, operations of the Holifield Heavy Ion Research Facility at Oak Ridge National Laboratory, for nuclear physics research, and the Fast Neutron Generator at Argonne National Laboratory for nuclear data measurements will be terminated.

Funding is provided to operate the Bevalac at Lawrence Berkeley Laboratory and LAMPF at Los Alamos National Laboratory in order to complete experiments in progress or approved for FY 1993. A transition plan will be developed with the Nuclear Physics community to permit an orderly phaseout.

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

LEAD TABLE

Nuclear Physics

| Activity | FY 1991 Enacted | | FY 1992 Enacted | | FY 1993 Base | FY 1993 Request | Program Change Request vs Base Dollar | Program Change Request vs Base Percent |
|---|---|---|---|---|---|---|---|---|
| Operating Expenses | | | | | | | | |
| Medium Energy Nuclear Physics | $97,284 | | $108,100 | d/ | $108,100 | $111,400 | $3,300 | 3% |
| Heavy Ion Nuclear Physics | 70,583 | | 74,700 | | 74,700 | 67,900 | (6,800) | -9% |
| Low Energy Nuclear Physics | 25,947 | | 28,391 | | 28,391 | 26,100 | (2,291) | -8% |
| Nuclear Theory | 13,100 | | 14,000 | | 14,000 | 14,800 | 800 | 6% |
| Capital Equipment | 24,100 | | 30,000 | | 30,000 | 32,200 | 2,200 | 7% |
| Construction | 79,699 | | 99,199 | d/ | 99,199 | 111,100 | 11,901 | 12% |
| TOTAL | $310,713 | | $354,390 | | $354,390 | $363,500 | $9,110 | 3% |
| Summary | | | | | | | | |
| Operating Expenses | ($206,914) | a/ | ($225,191) | | ($225,191) | ($220,200) | ($4,991) | -2% |
| Capital Equipment | (24,100) | | (30,000) | | (30,000) | (32,200) | 2,200 | 7% |
| Construction | (79,699) | | (99,199) | | (99,199) | (111,100) | 11,901 | 12% |
| Total Program | ($310,713) | b/c/ | ($354,390) | | ($354,390) | ($363,500) | $9,110 | 3% |
| Staffing (FTEs) | (Reference General Science Program Direction) | | | | | | | |

Authorizations:
P.L. 95-91, "Department of Energy Organization Act" (1977)

a/ Total has been reduced by $2,612,000 ($915,000 Medium Energy, $345,000 Heavy Ion, $1,352,000 Low Energy) reprogrammed to Energy Supply for SBIR.

b/ Total has been reduced by sequester of $4,073 in accordance with Senate Report 101-378.

c/ Total has been reduced by $17,400,000 for General Reduction.

d/ Does not reflect proposed reprogramming of $6,500,000 from Medium Energy to CEBAF construction project.

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

SUMMARY OF CHANGES

Nuclear Physics

| | |
|---|---|
| FY 1992 Enacted Appropriation | $ 354,390 |
| Adjustments - Increased personnel costs | 0 |
| FY 1993 Base | 354,390 |
| - Funding required to maintain a constant overall level of program activity | + 9,860 |
| **Medium Energy Nuclear Physics** | |
| - Conduct medium energy physics research and operations at approximately constant level of activity with increased level of support for the CEBAF and MIT/Bates laboratories | - 700 |
| **Heavy Ion Nuclear Physics** | |
| - Conduct Heavy Ion research and operations at approximately constant level of activity except for Bevalac and AGS operations | - 9,564 |
| **Low Energy Nuclear Physics** | |
| - Continue low energy operations and research at approximately constant level of activity and continue the nuclear data program at a substantially reduced level of activity | - 3,341 |
| **Nuclear Theory** | |
| - Maintain overall level of activity with continued emphasis on preparation of theoretical guidance for experimental results using new Institute of Nuclear Theory at the University of Washington | + 282 |

Capital Equipment

| | |
|---|---|
| - Provide for initiation of special beam lines for R&D on RHIC detectors at BNL, procure components for the High Resolution Spectrometer and CLAS Spectrometer at CEBAF, and provide general purpose equipment for laboratory-wide needs of Lawrence Berkeley Laboratory. Reduce level of other instrumentation efforts at LAMPF and the Bevalac..... | + 1,090 |

Construction

| | |
|---|---|
| - Maintain level of effort for AIP and GPP.................................................. | - 1,767 |
| - Continue Continuous Electron Beam Accelerator Facility (CEBAF) project at planned level.................................................................. | - 8,800 |
| - Continue Relativistic Heavy Ion Collider (RHIC) construction project at slightly less than the planned level.............................................................. | + 22,050 |
| FY 1993 Congressional Budget Request............................................... | $ 363,500 |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Medium Energy Nuclear Physics

The Nuclear Physics Program supports the basic research necessary to identify and understand the fundamental features of atomic nuclei and their interactions. The Medium Energy Nuclear Physics subprogram supports operations and research at accelerator facilities with sufficient primary beam energy to produce pi mesons (pions) using projectiles no more massive than alpha particles. In addition, the subprogram supports nuclear physics experiments at accelerators operated by other DOE programs (e.g., High Energy Physics and Basic Energy Sciences) and at other unique domestic or foreign facilities. Two national accelerator facilities are operated entirely under the Medium Energy subprogram - the Clinton P. Anderson Meson Physics Facility (LAMPF) at Los Alamos National Laboratory and the Bates Linear Accelerator Center operated by the Massachusetts Institute of Technology. These accelerator facilities serve a nationwide community of scientists from over 100 American institutions, of which over 90% are universities. At proton facilities, support is provided for wide-ranging research activities on the scattering of protons and pions, weak interactions, muonic and pionic atoms, selective excitation of proton/neutron states, and giant resonances. At electron facilities, support is provided for high resolution studies of the electric and magnetic structure of nuclei, the motion of pions inside nuclei, and the role of excited states of nucleons in nuclear structure. R&D activities required for the construction of the Continuous Electron Beam Accelerator Facility (CEBAF) and preparation for operation of the laboratory are also carried out under the Medium Energy subprogram. A transition plan will be developed with the Nuclear Physics community to permit an orderly phaseout of LAMPF.

II. A. Summary Table: Medium Energy Nuclear Physics

| Program Activity | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| Research | | | | |
| LAMPF-Based Research | $ 10,936 | $ 11,452 | $ 8,562 | - 25 |
| Bates Based Research | 3,396 | 3,644 | 3,623 | - 1 |
| CEBAF-Based Research | 11,744 | 12,181 | 15,767 | + 29 |
| Research at Other Sites | 11,013 | 12,723 | 12,878 | + 1 |
| Subtotal, Research | $ 37,089 | $ 40,000 | $ 40,830 | + 2 |
| Operations | | | | |
| LAMPF Operations | $ 39,900 | $ 41,600 | $ 43,900 | + 6 |
| Bates Operations | 7,295 | 7,500 | 9,400 | + 25 |
| CEBAF Operations | 12,060 | 18,700 | 17,070 | - 9 |
| Other Operations | 940 | 300 | 200 | - 33 |
| Subtotal, Operations | $ 60,195 | $ 68,100 | $ 70,570 | + 4 |
| Total, Medium Energy Nuclear Physics | $ 97,284 | $ 108,100 | $ 111,400 | + 3 |

II. B. Major Laboratory and Facility Funding

| | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| Continuous Electron Beam Accelerator Facility ... | $ 23,110 | $ 23,270 | $ 28,070 | + 21 |
| Los Alamos National Laboratory .................. | $ 46,400 | $ 48,330 | $ 50,600 | + 5 |
| Massachusetts Institute of Technology ........... | $ 10,625 | $ 10,963 | $ 13,100 | + 19 |

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

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Medium Energy Nuclear Physics | | | |
| Research | | | |
| LAMPF-Based Research | Continue use of The Medium Resolution Spectrometer (MRS) and the Neutron Time of Flight Facility (NTOF) with polarized beams. Use energy spread compressor on the Low Energy Pion (LEP) channel and begin experiments. Design new neutral meson spectrometer. | Continue use of MRS and NTOF with polarized beams. Use High Resolution Spectrometer (HRS). Use energy spread compressor on LEP channel for experiments. Assemble new neutral meson spectrometer. | Continue and complete planned high priority research programs. Extract maximum information from use of new detectors; MEGA, LSND, and neutral meson spectrometer. Prepare for termination of all Nuclear Physics operations. |
| | Continue R&D activities for new neutrino experiment and detector. | Develop new Liquid Scintillator Neutrino Detector, LSND. Plan use for neutrino-proton scattering and higher sensitivity neutrino oscillation studies. | |
| | Do selected high mass studies of neutron-rich isotopes on the Time-of-Flight Isochronous Spectrometer Facility (TOFI). | Do selected high mass studies of neutron-rich isotopes on TOFI. Investigate ways to improve intrinsic mass resolution to enable mass measurements of fission products. | |
| | Continue data taking on rare muon decay experiment with a more complete partial MEGA detector. The electron detection arm and part of the photon detection arm will be complete. | Complete detector and perform preliminary sensitivity data accumulation on the MEGA experiment. | |

III. Medium Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| LAMPF-Based Research (Cont'd) | Continue nuclear structure and reaction mechanism studies. Plan R&D efforts for an improved neutral meson spectrometer. | Continue nuclear structure and reaction mechanism studies. | |
| | The total for LAMPF-Based Research is derived as follows. Of the $6,500 medium energy research budget at LANL, $731 is for research carried out by LANL scientists at locations other than LAMPF, leaving $5,769 for in-house use of LAMPF. To this is added $5,167 of direct medium energy research funds to outside users for their LAMPF research programs. | The total for LAMPF-Based Research is derived as follows. Of the $6,730 medium energy research budget at LANL, $731 is for research carried out by LANL scientists at locations other than LAMPF, leaving $5,999 for in-house use of LAMPF. To this is added $5,453 of direct medium energy research funds to outside users for their LAMPF research programs. | The total for LAMPF-Based Research is derived as follows. Of the $6,700 medium energy research budget at LANL, $1,965 is for research carried out by LANL scientists at locations other than LAMPF, leaving $4,735 for in-house use of LAMPF. To this is added $3,827 of direct medium energy research funds to outside users for their LAMPF research programs. |
| | $ 10,936 | $ 11,452 | $ 8,562 |
| Bates Based Research | Expand coincidence measurements with polarized electron beams. Emphasize form factor experiments using spin observables. Utilize new out-of-plane detection techniques and polarized targets. Begin building focal plane polarimeter for the proton spectrometer (OHIPS) in the South Hall. | Continue coincidence measurement program with polarized electron beams. Emphasize form factor experiments using spin observables utilizing new OHIPS focal plane polarimeter. Begin testing components for experiments with the South Hall Ring Experiment internal targets. | Continue coincidence measurement program with polarized electron beams. Emphasize form factor experiments using spin observables utilizing new OHIPS focal plane polarimeter. Perform experiments with the South Hall Ring Experiment internal targets. |
| | Expand high precision measurements with the Energy Loss Spectrometer System (ELSSY) and continue low level of research in South Hall as South Hall Ring Experiment installation continues. | Continue high precision measurements with ELSSY while completing South Hall Ring installation and prepare for research in South Hall utilizing newly completed South Hall Ring Experiment. | Continue high precision measurements with ELSSY and begin research in South Hall utilizing newly completed South Hall Ring Experiment. |
| | Continue R&D on behavior of polarized beams in stretcher rings and on design of detector components for use in the South Hall. | Continue R&D on behavior of polarized beams in stretcher rings and on design of detector components for use in the South Hall. | Complete R&D on behavior of polarized beams in stretcher rings and on design of detector components for use in the South Hall. |

III. Medium Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Bates Based Research (Cont'd) | The total for Bates-based research is derived as follows. Of the $3,330 medium energy research budget at MIT, $1,233 is for research carried out by MIT scientists at locations other than Bates, leaving $2,097 for in-house use of Bates. To this is added $1,299 of direct medium energy research funds to outside users for their Bates research programs. | The total for Bates-based research is derived as follows. Of the $3,463 medium energy research budget at MIT, $1,181 is for research carried out by MIT scientists at locations other than Bates, leaving $2,181 for in-house use of Bates. To this is added $1,463 of direct medium energy research funds to outside users for their Bates research programs. | The total for Bates-based research is derived as follows. Of the $3,700 medium energy research budget at MIT, $1,110 is for research carried out by MIT scientists at locations other than Bates, leaving $2,590 for in-house use of Bates. To this is added $1,033 of direct medium energy research funds to outside users for their Bates research programs. |
| | $ 3,396 | $ 3,644 | $ 3,623 |
| CEBAF-Based Research | Continue work on cryomodule diagnostics. Carry out 25 MeV front-end test and extend test to 45 MeV. Operate Central Helium Liquefier. Staff Machine Control Center around the clock. | Carry out testing of North Linac components and associated RF, cryogenic, and facility safety systems. | Carry out testing of North and South Linac components, beam handling system, and associated RF, cryogenic, and facility safety systems. Begin commissioning of North Linac and assembly of South Linac. Machine control center staffed around the clock. |
| | Expand data acquisition system with additional workstations. | Utilize data acquisition system for testing of components and systems during accelerator assembly. | Utilize data acquisition system for testing of components and systems during accelerator assembly. Expand Local Area Network (LAN). |
| | Continue testing and prototyping of experimental area components. Begin experimental equipment assembly. | Assemble and begin testing of experimental equipment components. Emphasis will be on completion of Hall C and Hall A detectors to be ready for data taking upon completion of commissioning of the accelerator in early 1995. | Assemble and test experimental equipment components. Emphasis will be on completion of Hall C and Hall A detectors to be ready for data taking upon completion of commissioning of the accelerator in early 1995. The CLAS detector in Hall B will be complete as soon as possible thereafter. |
| | Continue superconducting research activities and strengthen theoretical efforts. | Continue superconducting research activities and strengthen theoretical efforts. | Continue superconducting research activities and strengthen theoretical efforts. Outside experimental research will be curtailed to concentrate on facility completion. |

III. Medium Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| CEBAF-Based Research (Cont'd) | The total for CEBAF-Based Research is derived as follows. Of the $11,050 medium energy research budget at CEBAF, $774 is for research carried out by CEBAF scientists at locations other than CEBAF, leaving $10,276 for in-house use of CEBAF. To this is added $1,468 of direct medium energy research funds to outside users for their CEBAF research programs. | The total for CEBAF-Based Research is derived as follows. Of the $11,000 medium energy research budget at CEBAF, $770 is for research carried out by CEBAF scientists at locations other than CEBAF, leaving $10,230 for in-house use of CEBAF. To this is added $1,951 of direct medium energy research funds to outside users for their CEBAF research programs. | The total for CEBAF-Based Research is derived as follows. Of the $11,000 medium energy research budget at CEBAF, $770 is for research carried out by CEBAF scientists at locations other than CEBAF, leaving $10,230 for in-house use of CEBAF. To this is added $5,537 of direct medium energy research funds to outside users for their CEBAF research programs. |
| | $ 11,744 | $ 12,181 | $ 15,767 |
| Research at Other Sites | Begin second phase of rare kaon decay experiments. Complete equipment installation and start taking data for H-particle search at Brookhaven National Laboratory (BNL). | Continue data taking phase and analysis of H-particle search at BNL. | Complete data taking phase and continue analysis of H-particle search at Brookhaven National Laboratory's Alternating Gradiant Synchotron. |
| | Take part in experiment NE-18 at the Stanford Linear Accelerator Center (SLAC) using End Station A. | Support experiment NE-18 using End Station A at SLAC. | Retain possibility of doing experiments using End Station A at SLAC. |
| | Begin joint Nuclear Physics/High Energy Physics spin structure function experiment at CERN involving five U.S. Nuclear Physics university groups. | Contine spin structure function experiment at CERN. Experiment should help solve the mystery of which of the sub-nuclear structures (quarks and gluons) carry the known spins of the nucleons. | Continue spin structure function experiment at CERN. Experiment should help solve the mystery of which of the sub-nuclear structures (quarks and gluons) carry the known spins of the nucleons. |
| | Continue xenon based St. Gotthard double beta decay experiment. | Continue xenon based St. Gotthard double beta decay experiment. | Conclude xenon based St. Gotthard double beta decay experiment. |
| | Expand experimental program to planned operating level of group using the Laser Electron Gamma Source (LEGS) facility at Brookhaven National Laboratory (BNL) and broaden the LEGS experimental effort to include users from universities and other laboratories. Begin measurements on helium-3. | Establish full utilization of the LEGS facility at BNL. Commence measurements of the delta resonance. | Utilize the LEGS facility at BNL. Continue experimental program and examine use as a user facility. |

III. Medium Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| Research at Other Sites (Cont'd) | Conduct program of selected nuclear physics experiments at other facilities including Fermilab, TRIUMF (Canada), PSI (Switzerland), and NIKHEF (Netherlands), and VEPP3 (Russia). | Conduct program of selected nuclear physics experiments at other facilities including Fermilab, TRIUMF (Canada), PSI (Switzerland), and NIKHEF (Netherlands), and VEPP3 (Russia). | Conduct program of selected nuclear physics experiments at other facilities including Fermilab, TRIUMF (Canada), PSI (Switzerland), NIKHEF (Netherlands), and VEPP3 (Russia). |
| | $ 11,013 | $ 12,723 | $ 12,878 |
| Subtotal, Research | $ 37,089 | $ 40,000 | $ 40,830 |
| Operations | | | |
| LAMPF Operations | Operate accelerator and facilities about 1900 hours for nuclear physics research with a reduced number of secondary beams operating simultaneously. | Operate accelerator and facilities for about 1900 hours for nuclear physics research with about seven secondary beams operating simultaneously. | Operate accelerator and facilities for about 1900 hours for Nuclear Physics research with about seven secondary beams operating simultaneously. Prepare for possible phaseout of all Nuclear Physics operations. |
| | Provide beams for approximately 35 nuclear physics experiments involving about 280 scientists. | Provide beam for approximately 33 nuclear physics experiments involving about 270 scientists. | Provide beam for approximately 33 nuclear physics experiments involving about 270 scientists. |
| | Utilize newly installed computers for remote analysis capability. | Operate with high intensity polarized ion source and polarized targets. | Operate with high intensity polarized ion source and polarized targets. |
| | $ 39,900 | $ 41,600 | $ 43,900 |
| Bates Operations | Operate accelerator and facilities about 1200 hours for nuclear physics research. | Operate accelerator and facilities about 500 hours for nuclear physics research during assembly and commissioning of new South Hall Ring. | Operate accelerator and facilities about 2000 hours for nuclear physics research including new experiments using the new South Hall Ring. |
| | Provide beam for approximately 5 experiments involving about 45 scientists. | Provide beam for approximately 3 experiments involving about 30 scientists. | Provide beam for approximately 10 experiments involving about 100 scientists. |
| | Operate accelerator at 1 GeV for required experiments during selected operating cycles during the year. | Operate accelerator at 1 GeV for required experiments during selected operating cycles during the year. | Operate accelerator at 1 GeV for required experiments during selected operating cycles during the year. |
| | Continue installation and testing of components for South Hall Ring Experiment. | Complete installation and testing of components for South Hall Ring Experiment. | Initiate experiments utilizing the combination of the newly-completed South Hall Ring and Linac. |

III. Medium Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Bates Operations (Cont'd) | $ 7,295 | $ 7,500 | $ 9,400 |
| CEBAF Operations | Provide for startup of laboratory operations and accelerator commissioning. Carry out Front-End-Test of the injector in the accelerator tunnel at 25 MeV. Extend test to 45 MeV. | Provide for startup of laboratory operations and accelerator commissioning. Operate and test sections of the full injector and the North Linac along with associated systems. Funding level includes $6.5 million, which is proposed for reprogramming to the CEBAF construction project. | Provide partial support for startup of laboratory operations and accelerator commissioning. Operate and test major sections of the full injector and the North and South Linacs along with associated systems such as the central refrigerator, rf system, safety systems, beam monitors, and computer controls. |
| | $ 12,060 | $ 18,700 | $ 17,070 |
| Other Operations | Provide some operations support of the Nuclear Physics Injector (NPI) at SLAC. | Suspend operation of NPI at SLAC. | Continue suspension of operation of NPI at SLAC. |
| | Provide general operations support of medium energy programs. | Terminate other operations support. | Provide general operations support of medium energy programs. |
| | $ 940 | $ 300 | $ 200 |
| Subtotal, Operations | $ 60,195 | $ 68,100 | $ 70,570 |
| Medium Energy Nuclear Physics | $ 97,284 | $ 108,100 | $ 111,400 |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Heavy Ion Nuclear Physics

The Heavy Ion Research subprogram is aimed at understanding the behavior of nuclear matter over an ever increasing range of excitation energy, nuclear density, angular momentum, and deformation. These conditions are created in nucleus-nucleus collisions induced by beams of heavy ions. The heavy ion beams are produced by highly sophisticated accelerators located at three large universities (Texas A&M, Yale, University of Washington) and three National laboratories (Argonne, Brookhaven, and Lawrence Berkeley). At low bombarding energies, studies include the high spin behavior of cool nuclear matter leading to severe deformation and eventually fission. Especially intriguing are close encounters of the heaviest nuclei which lead to unexplained spontaneous electron and positron production. The nuclear dynamics of complex phenomena including the evolution of the compound nucleus, deep-inelastic scattering and projectile multifragmentation are studied at intermediate bombarding energies. Radioactive beams are produced to study properties of exotic nuclei out to the very limits of stability. At higher energies, exploration is made of the nuclear matter equation of state for hot dense nuclear matter and the deconfinement of hadronic matter into the quark-gluon plasma. Operation of the Holifield Heavy Ion Research Facility (HHIRF) at Oak Ridge National Laboratory as a national user facility will be terminated, and operations at the Bevalac at Lawrence Berkeley Laboratory will be reduced in preparation for possible phaseout. Research programs at national laboratories will be assessed to accommodate to reduced funding.

II. A. Summary Table: Heavy Ion Nuclear Physics

| Program Activity | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| Research | | | | |
| LBL Bevalac Research.......................... | $ 6,215 | $ 6,250 | $ 6,795 | + 9 |
| BNL Tandem/AGS Research....................... | 9,340 | 9,700 | 9,745 | 0 |
| National Laboratory Research.................. | 9,520 | 10,110 | 9,960 | - 1 |
| University Research........................... | 9,546 | 11,140 | 12,885 | + 16 |
| Subtotal, Research | $ 34,621 | $ 37,200 | $ 39,385 | + 6 |
| Operations | | | | |
| LBL Bevalac Operations........................ | $ 16,945 | $ 17,545 | $ 9,900 | - 44 |
| BNL Tandem/AGS Operations..................... | 8,080 | 8,450 | 7,200 | - 15 |
| University Accelerator Operations............. | 2,042 | 2,145 | 2,405 | + 12 |
| Other Operations (including ANL, LBL, ORNL)... | 8,895 | 9,360 | 9,010 | - 4 |
| Subtotal, Operations | $ 35,962 | $ 37,500 | $ 28,515 | - 24 |
| Total, Heavy Ion Nuclear Physics | $ 70,583 | $ 74,700 | $ 67,900 | - 9 |

II. B. Major Laboratory and Facility Funding

| | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| Argonne National Laboratory (East) .............. | $ 6,570 | $ 6,800 | $ 6,800 | 0 |
| Brookhaven National Laboratory .................. | $ 17,420 | $ 18,150 | $ 16,945 | - 7 |
| Lawrence Berkeley National Laboratory ........... | $ 26,755 | $ 28,250 | $ 21,185 | - 25 |
| Lawrence Livermore National Laboratory .......... | $ 145 | $ 150 | $ 150 | 0 |
| Los Alamos National Laboratory .................. | $ 925 | $ 960 | $ 960 | 0 |
| Oak Ridge National Laboratory ................... | $ 6,970 | $ 6,980 | $ 6,310 | - 10 |

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

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Heavy Ion Nuclear Physics | | | |
| Research | | | |
| LBL Bevalac Research | Continue construction and testing of Equation of State (EOS) Time Projection Chamber (TPC), and studies with the Dilepton Spectrometer (DLS) of the pp and pd reactions at 1.5 and 4.9 GeV. Continue analysis of streamer chamber pion data from gold on gold runs and phase out this activity. Continue use of Heavy Ion Spectrometer System (HISS) for radioactive beam, fragmentation, and central collision neutron production studies. Continue studies of multi-fragmentation at Low Energy Beam Line. Continue analysis of data obained at CERN, and participation in FY 1991 NA35 run. Continue work directed towards development of an experiment at RHIC, including R&D efforts. | Begin EOS TPC studies of multifragmentation and the nuclear equation of state at high densities and temperatures. With the DLS complete pp and pd measurements, and begin calcium on calcium studies. Finish analysis of streamer chamber data. Continue studies of incomplete fusion and multifragmentation at Low Energy Beam Line and elsewhere. Continue participation in the CERN NA35 experiment by providing electronics and manpower during runs. Continue work directed towards development of an experiment at RHIC, including R&D efforts. | Conduct a research program appropriate for phaseout of Bevalac Operations. Optimize data acquisition for the Time Projection Chamber (TPC) and the Dilepton Spectrometer (DLS) and analysis of data obtained. Continue studies of intermediate energy reactions, investigating energy deposition, multifragmentation, and fusion processes at other facilities. Continue involvement in the CERN NA35/NA49 experiment by participation in runs, analysis of data, and design of electronics for a lead beam experiment in FY 1994. Continue work directed towards development of an experiment at RHIC, including R&D efforts. |
| | $ 6,215 | $ 6,250 | $ 6,795 |

III. Heavy Ion Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| BNL Tandem/AGS Research | Continue program at AGS in E859 by studying two-particle interferometry (pion-pion and kaon-kaon), analysis of existing data taken in E802, and begin upgrade of detector for gold beams. In E814 take data with full detector system, continue analysis of proton and silicon (Si) beam data on nuclear stopping and energy flow, and begin upgrade of system for gold beams. In E810 take multiparticle data with Time Projection Chamber (TPC), continue analysis of previous data, and plan for gold beam upgrade. Continue E858 experiment measuring anti-particle production. Continue RHIC R&D at about $6.6 million, and participate in development of an experiment at RHIC. | At BNL continue relativistic heavy ion program at AGS with emphasis on implementing experiments suitable for gold beam studies. These experiments will extend to heavier systems measurements of energy flow, nuclear stopping, two-particle correlations, strangeness production, as well as possible searches for strange matter and production rates of anti-particles. Continue analyses of data obtained in previous runs with protons and silicon beam experiments, E810, E802 (E859), E814, and E858, as well as others. Continue RHIC R&D efforts at a level of about $7.0 million. Participate vigorously in the development of proposals for RHIC experiments. | Continue the relativistic heavy ion program at the BNL/AGS at about level funding. In the first gold beam experiments, carry out experiments which will provide information about the energy flow, nuclear stopping, strangeness and anti-particle production, limits on strangelet production, and the spatial-time evolution of reaction dynamics in heavier system collisions. Continue R&D directed at RHIC accelerator and detector projects at a level of about $7.2 million. Continue work directed towards designing, and implementing experiments at RHIC. |
| | $ 9,340 | $ 9,700 | $ 9,745 |
| National Laboratory Research | At ANL continue active experimental program at ATLAS with emphasis on physics research that utilizes the heavy beams available. Start operation of the Fragment Mass Analyser (FMA) to address new physics questions. Begin tests and measurements with the ATLAS Positron-Electron Experiment (APEX). Continue activities related to the Gammasphere detector. | At ANL continue research program at ATLAS utilizing the heavy ion species and intense high quality beams that are unique to this facility. Continue program with the FMA to address the broad range of new physics that it makes assessable, particularly when coupled with the ANL/Notre Dame Gamma Ray Detector. Begin APEX program to study the origin of the anomalous electron-positron peaks observed in heavy nucleus collisions. Continue to support the implementation of Gammasphere. | At ANL, continue the experimental program at ATLAS, with emphasis on those classes of studies that exploit the unique beam capabilities and instrumentation available at ATLAS. Continue FMA program to address physics of interest. Continue measurements with APEX addressing the question of the origin of the electron-positron peaks observed in heavy nucleus nucleus collisions. Continue to provide support in the planning and construction of Gammasphere. |

III. Heavy Ion Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| National Laboratory Research (Cont'd) | Continue the research program at the 88" Cyclotron for HERA high spin studies utilizing the newly installed data acquisition and analysis system. Continue other studies with emphasis on the new classes of measurements possible with the heavier mass and higher intensity beams available from the Advanced Electron Cyclotron Resonance (ECR) source. Continue activities related to fabrication of Gammasphere. | At LBL, continue experimental program at the 88" Cyclotron, including the high spin and transuranic nuclei studies. Emphasis should be placed on utilizing the new ion species available from the Advanced ECR source. Research manpower will be allocated for the coordination of activities related to the fabrication, installation, and operation of Gammasphere. | Continue the experimental program at the LBL 88" Cyclotron, including the high spin and transuranic nuclei studies. Begin measurements with early implementation phase of Gammasphere to address physics questions of high priority. Emphasis will be placed on providing necessary support to keep the Gammasphere Project on schedule so as to be completed in FY 1994. |
| | Continue experimental program at HHIRF, including high spin and nuclear reaction mechanism studies. Continue activities related to fabrication of Gammasphere. Continue high energy photon studies at HHIRF and elsewhere. Participate in CERN experiment and in planning for lead (Pb) beam experiment. Continue efforts on R&D for RHIC detector, and in the development of an experiment at RHIC. | At ORNL, continue experimental program, including high spin and nuclear reaction mechanism studies. Continue activities related to fabrication, and installation of Gammasphere. Continue giant dipole resonance and bremsstrahlung studies utilizing the BaF2 array. Continue relativistic heavy ion program, including analysis of CERN data, RHIC detector efforts, and planning for an experiment at RHIC. | At ORNL, continue experimental program directed at nuclear structure and reaction mechanisms at other facilities. Continue activities related to fabrication, and installation of Gammasphere. Continue measurements of energetic photons in giant resonance and bremsstrahlung studies. Continue relativistic heavy ion program at CERN by participation in data acquisition and analysis. Continue efforts in R&D directed towards a RHIC detector, and involvement in the development of an experiment for RHIC. Support implementation of a new Radioactive Ion Beam (RIB) facility. |
| | At LANL, continue participation in CERN experiment studying particle-pair correlations in heavy ion reactions. Complete phaseout of involvement in E814 at AGS. Participate in R&D and plans for an experiment at RHIC. | At LANL, continue participation in the CERN experiment. Continue participation in RHIC detector R&D. Take an active role in the development of an experiment at RHIC. | At LANL, continue participation in the CERN experiment. Continue participation in RHIC detector R&D. Take an active role in the development of an experiment at RHIC. |

III. Heavy Ion Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| National Laboratory Research (Cont'd) | At LLNL, finish up analysis of Bevalac experiment data. Participate in BNL/A experiment E859 studying meson correlation in silicon induced reactions. Continue efforts on detector R&D for RHIC and participate in the development of an experiment at RHIC. | At LLNL, continue involvement in E859 and begin efforts for upgrading experiment for gold (Au) beam measurements in FY 1993. Continue efforts on detector R&D for RHIC, and participate in the development of an experiment at RHIC. | At LLNL, begin data taking in experiment E866 with gold (Au) beams, and participate in analysis of data from E859. Continue efforts on detector R&D for RHIC, and participate in the development of an experiment at RHIC. |
| | $ 9,520 | $ 10,110 | $ 9,960 |
| University Research | Continue strengthening university user research at national laboratory facilities where unique opportunities exist. With the upgraded Yale tandem, the University of Washington superconducting linac booster, and the Texas A&M superconducting cyclotron continue studies of nuclear structure, reaction mechanism, and questions of astrophysics interest. Emphasis should be placed on utilization of the new systems obtained and on continuing to improve detector capabilities. | Continue strengthening university user research at national laboratory facilities where unique opportunities exist, in particular with major detector systems such as Gammasphere. At upgraded university facilities (ie; Yale, University of Washington, and Texas A&M) continue nuclear physics studies which are appropriate and which exploit the capabilities of each facility for research and education. Emphasis should continue to be placed on utilization of detector systems acquired and on improving detector capabilities at all accelerator facilities. | Continue university user research at national laboratory facilities, especially where unique capabilities exist. At the upgraded university accelerators at Yale, University of Washington, and Texas A&M the nuclear research programs will continue to carry out nuclear physics studies which are appropriate for the facility and which exploit the inherent strengths of each facility for research and education. Emphasis should continue to be placed on the utilization of the new detectors acquired and on improving instrumentation capabilities at all accelerator facilities. |
| | Upgrades of ESNET to conform to the National Research and Education Network Standards will continue to be pursued and will be shared among ER programs that benefit from ESNET. | ESNET will be fully supported in the Applied Mathematical Sciences subprogram of the Basic Energy Sciences Program. | ESNET will be fully supported in the Applied Mathematical Sciences subprogram of the Basic Energy Sciences Program. |
| | $ 9,546 | $ 11,140 | $ 12,885 |
| Subtotal, Research | $ 34,621 | $ 37,200 | $ 39,385 |
| Operations | | | |

III. Heavy Ion Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| LBL Bevalac Operations | Continue facility operation for nuclear physics and biomedical (one third time) research at about 3000 hours. Use full compliment of beamlines for program at Heavy Ion Spectrometer System (HISS), DiLepton Spectrometer (DLS), radioactive beams, and the Low Energy Beamline. Make initial tests of the Equation of State (EOS) Time Project Chamber (TPC). Phase-out streamer chamber facility. Continue upgrades of experimental areas and improvements of beam qualities. SuperHILAC to continue to serve as dedicated injector for Bevalac. | Continue facility operation for nuclear physics and biomedical research at about 2800 hours. Use full compliment of beamlines for program with DLS, the EOS TPC, radioactive beams, and at the Low Energy Beamline, with emphasis on a strong program utilizing the newly completed instrumentation. Provide scheduling that optimizes the nuclear physics experimental program. | Funds are provided for specific Bevalac operation to finish highest priority experiments and for decommissioning activities. |
| | $ 16,945 | $ 17,545 | $ 9,900 |
| BNL Tandem/AGS Operations | Continue to operate Tandem/AGS system for heavy ion research, providing up to 6 weeks for experimental program with beams up to silicon. Continue to provide additions to accelerator systems for future operation with gold beams. Begin commissioning phase of operation of AGS Booster. | Pursue heavy ion commissioning of the AGS Booster and operate Tandem/AGS for heavy ion research with up to 8 weeks for experimental program. Provide the necessary support to insure the implementation of the new gold beam experiments for FY 1993. Support construction of test beamline for RHIC detector R&D. | Continue Tandem/Booster/AGS operations so as to provide gold beams for an experimental program. Provide support for implementation and initiation of new gold beam experiments. Continue support of construction of RHIC Test Beamline. |
| | $ 8,080 | $ 8,450 | $ 7,200 |
| University Accelerator Operations | Provide for continuing operation of heavy ion research programs at the three university accelerator facilities by providing a large range of ion species and energies. At Yale tandem, provide light heavy-ion beams to upgraded detectors in order to carry out a broad nuclear physics program. At the University of Washington superconducting linac booster provide light heavy-ions for in-house programs including new detector systems. Provide light to medium mass heavy-ions at low to intermediate energies for research program at the Texas A&M | Provide heavy ion beams and support for carrying out nuclear physics research at the three major university accelerator facilities using large range of ions and energies. At the Yale tandem, provide light heavy-ions to an expanded array of detectors to carry out a broad nuclear physics research program. At the University of Washington superconducting linac booster, provide beams for a diverse in-house program. At the Texas A&M superconducting cyclotron, provide light to medium mass heavy-ions at low to intermediate energies for nuclear | At the three major university accelerator facilities continue to provide heavy-ion beams and support for carrying out a broad, diverse nuclear physics research program. At the Yale tandem, and the University of Washington superconducting linac booster, provide a broad range of light heavy-ion beams to experiments using an expanded array of detector systems. At the Texas A&M superconducting cyclotron, use the Electron Cyclotron Resonance (ECR) source to provide an expanded range of heavy-ion species at low and intermediate energies for a |

III. Heavy Ion Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| University Accelerator Operations (Cont'd) | superconducting cyclotron. | physics program and install and use new detector systems installed. | research program using newly installed experimental instrumentation. |
| | $ 2,042 | $ 2,145 | $ 2,405 |
| Other Operations (including ANL, LBL, ORNL) | Complete upgrade of the ANL ATLAS facility for uranium beam capabilities. Provide heavy ion beams for a research program that utilizes existing detector systems. Support installation of Atlas Positron-Electron Experiment (APEX) for coincidence measurements. Provide beams for research at the LBS 88" Cyclotron, utilizing the newly developed Advanced Electron Cyclotron Resonance (ECR) ion source for production of heavy beams. Provide beams at HHIRF to carry out research program with existing detector systems. Continue phaseout activities at one of these three facilities. | Continue improvements of components of the ANL ATLAS facility to optimize the performance and reliability for heavy ion acceleration. Provide heavy ion beams up to uranium for research utilizing all detector systems, including the Fragment Mass Analyzer (FMA) and APEX. At the LBL 88" Cyclotron, continue R&D on ECR source and provide beams for research program. Support installation of Gammasphere. At ORNL HHIRF provide beams for a reduced program with emphasis on completion of existing projects in preparation of phase out of user operations in FY 1993. Continue support of computer and design efforts for Gammasphere. Initiate activities directed towards implementing a Radioactive Ion Beam (RIB) facility. | Continue improvements of components of the ANL ATLAS facility to optimize the performance and reliability for heavy ion acceleration. Provide beams up to uranium for a research program which includes FMA and APEX measurements. At the LBL 88" Cyclotron, continue R&D on the Advanced ECR source and provide beams for a research program including experiments of the early implementation phase of Gammasphere. At HHIRF at ORNL, complete orderly phase out of user operations and focus effort on the development of a Radioactive Ion Beam (RIB) facility. Continue support of computer and design efforts for Gammasphere. |
| | No activity. | No activity. | In an effort to manage administrative costs more closely, the PSO/Office Directors' share of FTE-dependent costs for space, supplies, and telecommunications are included in this budget and will be transferred during the execution year. |
| | $ 8,895 | $ 9,360 | $ 9,010 |
| Subtotal, Operations | $ 35,962 | $ 37,500 | $ 28,515 |
| Heavy Ion Nuclear Physics | $ 70,583 | $ 74,700 | $ 67,900 |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Low Energy Nuclear Physics

The basic research part of this subprogram emphasizes experimental investigations at low energies into: the behavior of nucleons within the environment of the nucleus as well as the behavior of the entire ensemble of nucleons acting in consort; nuclear reaction mechanisms; and experimental tests of fundamental symmetries. The last of these categories can often be accomplished without the use of accelerators such as the study of neutrinos from the sun. University-based research is an important feature of the Low Energy Program. Since most of the required facilities are relatively small, they are appropriate for siting on university campuses, where they provide excellent opportunities for hands-on training of nuclear experimentalists, many of whom after obtaining Ph.D.'s, contribute to nuclear technology development of interest to the DOE. The nuclear data part of this subprogram has as its goal the establishment and maintenance of an accurate, complete, and accessible nuclear data information base to meet the needs of the DOE nuclear technologies, which include: nuclear waste management, biomedical and environmental applications of radioactive materials, fission energy, fusion energy, fundamental nuclear research, and nuclear explosives development.

II. A. Summary Table: Low Energy Nuclear Physics

| Program Activity | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| Research | | | | |
| Research at University Facilities............ | $ 3,024 | $ 3,149 | $ 3,310 | + 5 |
| Research at National Laboratory Accelerators.. | 3,170 | 3,295 | 3,225 | - 2 |
| Research at Reactors......................... | 1,067 | 910 | 910 | 0 |
| Other Research............................... | 4,242 | 5,866 | 5,870 | 0 |
| Subtotal, Research | $ 11,503 | $ 13,220 | $ 13,315 | + 1 |
| Operations | | | | |
| Accelerator Operations....................... | $ 3,225 | $ 3,350 | $ 3,585 | + 7 |
| Subtotal, Operations | $ 3,225 | $ 3,350 | $ 3,585 | + 7 |
| Nuclear Data | | | | |
| Nuclear Data Measurements.................... | $ 6,530 | $ 6,803 | $ 4,100 | - 40 |
| Nuclear Data Compilation and Evaluation....... | 4,689 | 5,018 | 5,100 | + 2 |
| Subtotal, Nuclear Data | $ 11,219 | $ 11,821 | $ 9,200 | - 22 |
| Total, Low Energy Nuclear Physics | $ 25,947 | $ 28,391 | $ 26,100 | - 8 |

II. B. Major Laboratory and Facility Funding

| | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| Ames Laboratory | $ 204 | $ 0 | $ 0 | 0 |
| Argonne National Laboratory (East) | $ 3,010 | $ 3,125 | $ 2,090 | - 33 |
| Brookhaven National Laboratory | $ 3,810 | $ 3,960 | $ 3,345 | - 16 |
| Idaho National Engineering Laboratory - EG&G | $ 340 | $ 350 | $ 360 | + 3 |
| Lawrence Berkeley National Laboratory | $ 2,420 | $ 2,515 | $ 2,845 | + 13 |
| Lawrence Livermore National Laboratory | $ 235 | $ 245 | $ 350 | + 43 |
| Los Alamos National Laboratory | $ 1,725 | $ 1,790 | $ 1,660 | - 7 |
| Oak Ridge National Laboratory | $ 4,845 | $ 5,035 | $ 3,365 | - 33 |

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

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Low Energy Nuclear Physics | | | |
| Research | | | |
| Research at University Facilities | At Texas A&M, experimental studies of the electroweak interaction using the (d, He-3) reaction will concentrate on intermediate mass nuclei in the Fe region, which are important for nucleosynthesis in stellar formation, and on Zr-90, which is important for the electroweak sum rule; at Duke, spin-spin cross sections will be made using cryogenic targets of polarized hydrogen and polarized solid He-3; at Washington, the new high intensity polarized ion source and higher energy beams will be used to study the scattering of polarized protons with emphasis on backward angle spin structure measurements. | At Texas A&M, begin the development of a high-resolution polarized neutron beam to be used with the proton spectrometer for (n,p) studies of the weak interaction; at Duke, use high-intensity beams of polarized positive ions from the high-efficiency ECR ionizer of the new polarized ion source to measure the spin sensitivity of nuclear reactions between very light nuclei at very low energies, of astrophysical interest; at Washington, use the new polarized ion source and booster to study a variety of nuclear structure problems and to search for violations of fundamental symmetries. | At Texas A&M complete development of a high-resolution 160 MeV polarized neutron beam to be used with the proton spectrometer for (n,p) studies of the weak interaction. At Duke, extend measurements to the higher beam energies provided by new accelerator tubes and charging system; emphasize tests of fundamental symmetries. These include searches for quantum systems which display chaotic behavior, charge symmetry breaking and additional evidence of parity violation in the nucleus. At Washington use the polarized ion source and booster to study a variety of nuclear structure problems and to search for violations of fundamental symmetries. |
| | $ 3,024 | $ 3,149 | $ 3,310 |

III. Low Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Research at National Laboratory Accelerators | Continue low energy research at the three national laboratories. At ANL, continue low energy heavy ion research at ATLAS; at LBL, use the 88-Inch Cyclotron to provide light ions for the astrophysics group, which will now be heavily involved in work, including materials selection and radioactivity assessment, for the Sudbury Neutrino Observatory (SNO) collaboration; at ORNL, continue experiments with the Nuclear Orientation Facility (NOF) at the on-line isotope seperator (UNISOR) to determine complete level schemes for odd-mass nuclei. | Continue low energy research at the three national laboratories. At ANL, heavy ion research will continue; at LBL, a broad program of nuclear astrophysics will be pursued, with the main effort devoted to the SNO collaboration (described below, under Other Research); at ORNL, use of the NOF will be extended to nuclear quadrupole orientation and Nuclear Magnetic Resonance (NMR) experiments. | Continue low energy research at three of the national laboratories. At ANL, low energy heavy ion research will continue; at LBL the main effort will be devoted to the SNO collaboration (described below under Other Research). At the 88-Inch Cyclotron, additional work will be performed in order to evaluate the possible existence of a 17 KeV neutrino, for which some evidence was found in beta decay experiments. At ORNL, assist in development of the RIB facility and study possible transfer of unique detectors, such as the helium dilution refrigerator, to an alternate site. |
| | $ 3,170 | $ 3,295 | $ 3,225 |
| Research at Reactors | Continue to support the BNL nuclear structure research, which may have to be moved overseas; continue the precision neutron mass lifetime measurements at the NIST (formerly, NBS). At BNL, if the HFBR resumes operation, TRISTAN and capture gamma programs will continue, with studies of the p-n interaction, nuclear symmetries, test of the shell model, and measurements of properties of nuclei crucial to the understanding of nucleosynthesis. | Continue the BNL nuclear structure research. As the HFBR resumes operation, the TRISTAN on-line isotope separater will be used in conjunction with recently developed fast timing techniques to measure level lifetimes for important gamma-ray transitions below 500 KeV. Proposals will be developed to begin collaborative work at the University of Cologne, and at Daresbury Lab, England. At the NIST, the precision neutron lifetime measurement will be completed; plans for further fundamental neutron measurements will be developed. | Continue both the nuclear structure research at BNL and the fundamental neutron measurements at the NIST. The next experimental project proposed at the NIST cold neutron beam facility will be the Time Reversal Symmetry Violation Experiment, with collaborators from Los Alamos National Laboratory and Harvard University. At BNL, use the TRISTAN on-line isotope separator on the HFBR to study isotopes of interest to astrophysics problems. Initiate studies of isotopes important to safety related issues such as emergency core cooling and reactor decay heat calculations. |
| | $ 1,067 | $ 910 | $ 910 |

III. Low Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Other Research | Begin U.S. participation in the construction of the large detector for the Canadian-US-UK Sudbury Neutrino Observatory project, with increased funding for participants at LANL, LBL, and University of Pennsylvania. Continue support for BNL participation in the GALLEX and LANL participation in the Soviet-American Gallium Experiment (SAGE). Support will end for the University of Pennsylvania's participation in the completed KAMIOKANDE experiment which confirmed that neutrinos come from the direction of the sun, and in fewer numbers than predicted by theory. | Continue support for solar neutrino research, chiefly the Sudbury Neutrino Observatory (SNO) and gallium experiments. The SAGE experiment is giving very interesting results - but clearly more checks on the chemistry involved are needed. | Continue support for solar neutrino research, chiefly at the Sudbury Neutrino Observatory (SNO), Soviet-American Gallium Experiment (SAGE), and Gallium Experiment (GALLEX) projects. For the SNO project, LANL has major responsibilities for R&D on the large acrylic vessel for the 1,000 tons of heavy water, on data-acquisition codes, and for acquisition of photomultipliers and computer hardware; LBL, for the design and fabrication of the critical radioactivity-free support structure for the many thousands of photomultipliers that will surround the heavy water; and at Penn, for optimization of the photomultipliers and development and acquisition of photomultiplier tube bases, signal processing electronics, and software organization and development. The participation of LANL scientists in the Soviet American Gallium Experiment (SAGE) at the underground lab in the USSR will diminish as the operation of the detection system becomes routine and early results are published. |
| | $ 4,242 | $ 5,866 | $ 5,870 |
| Subtotal, Research | $ 11,503 | $ 13,220 | $ 13,315 |
| Operations | | | |

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Accelerator Operations | Continue support for the accelerator facilities at Duke University and, together with the Heavy Ion program, those at Texas A&M and the University of Washington; continue support, together with the Heavy Ion program, of national facilities at ANL and LBL. | Continue support for the accelerator facilities at Duke University and, together with the Heavy Ion program, those at Texas A&M and the University of Washington; continue support, together with the Heavy Ion program, of national facilities at ANL and LBL. | Continue support for the three university accelerator facilities located at Duke University, Texas A&M Univ. and the Univ. of Washington. Provide support for low energy operations at national laboratory facilities, at ANL (ATLAS) and LBL (88-Inch Cyclotron) and development of a Radioactive Ion Beam (RIB) facility at ORNL. These facilities support most of the low energy nuclear physics research activities described in the preceding discussion of the research program. |
| | $ 3,225 | $ 3,350 | $ 3,585 |
| Subtotal, Operations | $ 3,225 | $ 3,350 | $ 3,585 |
| Nuclear Data | | | |
| Nuclear Data Measurements | Continue neutron cross-section measurements at the ORNL/ORELA, ANL/FNG, and LANL/WNR. At ORELA, commission the large BaF2 photon-multiplicity detector, and begin measurements of the capture-to-fission ratios. Begin capture cross-section measurements using the redesigned detection system. The NIST (formerly NBS) experimenters, with the shut-down of their linear accelerator, will continue a measurement effort at the ORELA and WNR. At ANL, continue activation cross section measurements and begin neutron scattering measurements for high-temperature metals that are of interest for space-power applications. At LANL, phase out the successfully completed fusion reaction measurement program and continue measurements at WNR. | Continue experiments at the Oak Ridge Electron Linear Accelerator (ORELA) using the new photon-multiplicity detector to obtain unadjusted differential measurements of capture-to-fission ratios for the first time, and which are required to meet accuracy requirements of reactor designers. Use a carefully redesigned capture cross-section measurement system to redo important structural materials. ORELA measurements will include gamma-ray production from materials incorporated in superconducting magnets, of interest to the Office of Fusion Energy (OFE) and others. At the ANL/Fast Neutron Generator (FNG), continue difficult measurements of cross sections for the production of long-lived activities, which are of interest to the Office of Fusion Energy for reactor materials selection, and continue neutron scattering measurements for | Using results of DOE's Nuclear Advisory Committee's (NSAC's) study of National Nuclear Data Needs in the 1990's (NNDN-90), strengthen high priority components, such as integrated national cross section modelling capabilities, and phase out or consolidate lower priority components. Continue university based measurements of cross-sections for higher energy neutrons, in particular for (n,p) and (n, alpha) reactions, to derive level density information for use in calculations of cross sections of importance to multiple users such as fusion and nuclear explosion technologies. At ORELA, modify program to accommodate lower funding profile and initiate user support for measurements such as the gamma-ray production from materials incorporated in superconducting magnets of interest to the Office of Fusion Energy (OFE); cease operations and research at the |

III. Low Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Nuclear Data Measurements (Cont'd) | | high-temperature metals. At the WNR, continue measurements of cross sections for higher energy neutrons, in particular for (n,p) and (n,alpha) reactions, to derive level density information for use in calculations of cross sections of importance to fusion and weapons technologies. | ANL/Fast Neutron Generator. Introduce other cost saving measures to lower funding profile. |
| | $ 6,530 | $ 6,803 | $ 4,100 |
| Nuclear Data Compilation and Evaluation | Continue the Cross Section Evaluation Working Group (CSEWG) to be able to remain responsive to data needs and to continue improvements in accuracy, coverage, and format for the applied Evaluated Nuclear Data File (ENDF). Continue international cooperative efforts under the auspices of the NEA and IAEA. Continue support for the NAS/NRC Panel on Basic Nuclear Data Compilation, and their efforts to modernize the evaluation and dissemination of nuclear structure and decay data. | Continue the compilation and evaluation activities to improve the nuclear data libraries, their access, and the methods of their production. Give increased attention to the Data Request List, including outreach and followup activities. Continue participation in the Working Group on International Evaluation Cooperation to maintain the coordination of nuclear data evaluation activities and free exchange of the results. Continue to support the IAEA project to develop an international Fusion Energy Nuclear Data Library (FENDL), to assist in the design of an International Thermonuclear Experimental Reactor (ITER). Continue support of the NAS/NRC Panel's activities with respect to Evaluated Nuclear Structure Data File (ENSDF) and the Nuclear Data Sheets, with attention given to identifying needs for nuclear structure and decay data. | Based on priorities identified in recent reviews, place emphasis on electronic data access and assessment capabilities and increase nuclear cross section modelling activities, restructure aspects of the compilation and evaluation activities to improve nuclear data libraries, their access, and the methods of their production. Continue participation in the Working Group on International Evaluation Cooperation to maintain the coordination of nuclear data evaluation activities and free exchange of the results. Continue support for U.S. contributions to the IAEA International Nuclear Data efforts. Support activities with respect to modernization of the nuclear data information system by replacement with more effective electronic data dissemination techniques to be developed at LBL and discontinuance of hard copy Nuclear Data Sheets. Support expansion of electronic data bases as vehicle for timely and cost effective compilation and dissemination of assessed nuclear properties. Address assessed cross section code files and modernization of National Data Networking at LLNL. |

III. Low Energy Nuclear Physics (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Nuclear Data Compilation and Evaluation (Cont'd) | No activity. | No activity. | In an effort to manage administrative costs more closely, the PSO/Office Director's share of FTE-dependent costs for space, supplies, and telecommunications are included in this budget and will be transferred during the execution year. |
| | $ 4,689 | $ 5,018 | $ 5,100 |
| Subtotal, Nuclear Data | $ 11,219 | $ 11,821 | $ 9,200 |
| Low Energy Nuclear Physics | $ 25,947 | $ 28,391 | $ 26,100 |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Nuclear Theory

The purpose of research in theoretical nuclear physics is to obtain a unified description of atomic nuclei. The research ranges from relating the description of elementary constituent particles and the fundamental forces connecting them, to accounting for the collective interactions of the nucleus as a whole. The long-range objectives of the Nuclear Theory subprogram are to obtain a comprehensive understanding of the foundations of nuclear matter at the most fundamental level, in terms of the properties of the constitutent quarks and gluons, as well as the relation between the nucleons in the environment of the nucleus as a whole. These objectives are approached by interpreting results from nuclear physics experiments and by predicting phenomena and relationships to test this description. The understanding of nuclear phenomena is prerequesite for a description of the material foundations of the universe, including astrophysics phenomena such as the formation of the elements in stars and supernovae. Much of nuclear theory requires extensive use of supercomputer capabilities.

II. A. Summary Table: Nuclear Theory

| Program Activity | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| Nuclear Theory | $ 13,100 | $ 14,000 | $ 14,800 | + 6 |
| Total, Nuclear Theory | $ 13,100 | $ 14,000 | $ 14,800 | + 6 |

II. B. Major Laboratory and Facility Funding

| | | | | |
|---|---|---|---|---|
| Argonne National Laboratory (East) | $ 935 | $ 1,024 | $ 855 | - 17 |
| Brookhaven National Laboratory | $ 1,083 | $ 1,210 | $ 1,100 | - 9 |
| Continuous Electron Beam Accelerator Facility | $ 125 | $ 129 | $ 135 | + 5 |
| Lawrence Berkeley National Laboratory | $ 1,050 | $ 1,090 | $ 955 | - 12 |
| Los Alamos National Laboratory | $ 1,070 | $ 1,110 | $ 925 | - 17 |
| Oak Ridge National Laboratory | $ 900 | $ 940 | $ 800 | - 15 |

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

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| Nuclear Theory | Continue new research efforts in preparation for future experimental results from the Continuous Electron Beam Accelerator Facility (CEBAF) and the Relativistic Heavy Ion Collider (RHIC). These efforts are emphasizing the description of nuclei in terms of the underlying quark-gluon substructure of nuclear matter, including understanding of nuclear forces and phase transitions in nuclear matter. Develop forefront programs at the new Nuclear Theory Institute at the University of Washington. Create new Institute mechanisms for effective interaction with the entire nuclear physics community. Continue broad program of theoretical research on properties of atomic nuclei, understanding of nuclear forces, and expand the understanding of the forces at play in neutron proton interactions and symmetries in nuclei. Establish task oriented activities at national laboratories such as BNL and LBL which will address high impact problems such as RHIC related physics and nuclei under extreme conditions. | Continue broad program of theoretical research on properties of atomic nuclei particularly aimed at the understanding of nuclear forces. Provide a more fundamental understanding of the forces involved in the interaction between protons and neutrons as well as their further manifestations such as symmetries in nuclei. Continue new theory research efforts aimed at aiding the preparation for future experiments at the Continuous Electron Beam Accelerator Facility (CEBAF), the Relativistic Heavy Ion Collider (RHIC), and the Gammasphere facility and interpretation of expected results from planned experiments. These require the development of theories that address the description of nuclei in terms of their underlying quark-gluon substructure of nuclear matter, including the understanding of nuclear forces and phase transitions in nuclear matter. Continue development of research programs at the new Institute of Nuclear Theory at the University of Washington. Support its interaction with the entire nuclear community that will provide such activities as a workshops on critical areas. Pursue forefront activities at national laboratories which will address high impact problems such as RHIC related physics and nuclei under extreme conditions. | Continue development of forefront research programs at the Institute of Nuclear Theory (INT) at the University of Washington (Seattle). Support interaction with the entire nuclear community by providing such activities as workshops on critical areas. Strengthen the broad range university based program of theoretical research on properties of atomic nuclei particularly aimed at the understanding of nuclear forces. Provide support for theory research that leads to a more fundamental understanding of nuclear forces involved in the interaction between protons and neutrons as well as their further manifestations such as symmetries in nuclei. Continue new theory research efforts aimed at aiding the preparation for future experiments at the Continuous Electron Beam Accelerator Facility (CEBAF), the Relativistic Heavy Ion Collider (RHIC), and provide interpretation of unexpected results from planned experiments. These require the development of theories that address the description of nuclei in terms of their underlying quark-gluon substructure of nuclear matter, including the understanding of nuclear forces and phase transitions in nuclear matter. Consolidate National Laboratory portion of the program in order to accommodate increased university activity while continuing to give strong theory support to Nuclear Physics highest priorities. |
| | $ 13,100 | $ 14,000 | $ 14,800 |
| Nuclear Theory | $ 13,100 | $ 14,000 | $ 14,800 |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Capital Equipment

Capital equipment funds are needed to provide for particle detection systems, for data acquisition and analysis systems, and for instrumentation to improve performance of Nuclear Physics accelerators. These funds are essential for effective utilization of the national accelerator facilities operated by the Nuclear Physics program. In addition, the program has landlord responsibility for providing general purpose capital equipment at the Lawrence Berkeley Laboratory.

II. A. Summary Table: Capital Equipment

| Program Activity | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| BNL | $ 3,090 | $ 3,375 | $ 3,285 | - 3 |
| CEBAF | 2,700 | 5,400 | 11,100 | +106 |
| LBL | 1,490 | 3,100 | 1,680 | - 46 |
| LANL | 2,910 | 3,340 | 1,025 | - 69 |
| ANL | 1,182 | 850 | 780 | - 8 |
| MIT/Bates | 1,694 | 1,725 | 1,450 | - 16 |
| ORNL | 1,023 | 1,400 | 985 | - 30 |
| University Laboratories | 879 | 1,000 | 1,000 | 0 |
| Sudbury Neutrino Observatory | 2,836 | 2,703 | 3,000 | + 11 |
| Gammasphere | 4,400 | 4,300 | 5,000 | + 16 |
| Lawrence Berkeley Laboratory - GPE | 1,515 | 1,700 | 1,870 | + 10 |
| Other | 381 | 1,107 | 1,025 | - 7 |
| Total, Capital Equipment | $ 24,100 | $ 30,000 | $ 32,200 | + 7 |

II. B. Major Laboratory and Facility Funding

| | | | | |
|---|---|---|---|---|
| Argonne National Laboratory (East) | $ 1,182 | $ 850 | $ 780 | - 8 |
| Brookhaven National Laboratory | $ 3,090 | $ 3,375 | $ 3,285 | - 3 |
| Continuous Electron Beam Accelerator Facility | $ 2,700 | $ 5,400 | $ 11,100 | +106 |
| Lawrence Berkeley National Laboratory | $ 3,005 | $ 4,800 | $ 3,550 | - 26 |
| Los Alamos National Laboratory | $ 2,910 | $ 3,340 | $ 1,025 | - 69 |
| Massachusetts Institute of Technology | $ 1,694 | $ 1,725 | $ 1,450 | - 16 |
| Oak Ridge National Laboratory | $ 1,023 | $ 1,400 | $ 985 | - 30 |

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

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Capital Equipment | | | |
| BNL | Complete commissioning of the 2 GeV/c kaon beam line and complete the construction of two H-particle search experiments. Begin construction of several AGS heavy ion experiments that will use the gold beam which will be available from the AGS Booster Synchrotron. In particular, experiment E866 will utilize the single-arm magnetic spectrometer system originally built for E802, but now requires a second forward spectrometer as well as a new tracking system for the higher rates and multiplicities. At LEGS modify the liquid hydrogen target for E2/M1 and polarizability experiments. | Continue construction of AGS heavy ion experiments for use with gold beams. This includes experiment E866 and two smaller experiments, E877 and E878. Start running of H-particle search experiments on the kaon beam line. At LEGS complete the construction of the E2/M2 and polarizability experiments. | Complete construction of initial experiments which utilize the new AGS gold beam. Nuclear reactions with the gold beam present very exciting physics opportunities, but also present major experimental difficulties. It can be expected that there will be about four times as many particles (about 1,000) in a central gold on gold collision compared to a silicon on gold collision. This large multiplicity places very difficult experimental constraints on the number and segmentation of the detectors. At LEGS, complete instrumentation that will extend gamma-ray energy ranges up to 390 MeV. |
| | $ 3,090 | $ 3,375 | $ 3,285 |
| CEBAF | Initiate procurement of components for the High Resolution Hadron Spectrometer in Hall A, including large dipole and quadrupole magnets. Continue upgrade of facility-wide computer systems with Unix-based CPUs and work stations. Procure electronic measurement equipment for use in testing RF systems. Procure mechanical support equipment such as machine shop equipment, leak detectors and residual gas analyzers. | Continue procurement of components for the High Resolution Hadron Spectrometer in Hall A, including support frame and floor plates. Provide components for the CEBAF Large Acceptance Spectrometer (CLAS) in Hall B, including the six coil toroidal superconducting magnet and long lead time items for the detector systems. Continue expansion of Unix-based CPUs and upgrade VAX systems with additional memory, disk drives, tape units, and archival storage system. Procure mechanical support equipment such as turbo pump stations and electrical equipment such as network analyzers. | Continue construction of the CLAS spectrometer in Hall B with procurement of components for drift chambers, scintillation counters, Cerenkov counters, calorimeter, tagging system, data acquisition system and the beam line. CLAS is a large acceptance magnetic spectrometer especially designed for experiments that require the detection of several uncorrelated particles in the hadronic final state. Complete procurement of components for the High Resolution Hadron Spectrometer in Hall A, including parts for the detector system. This spectrometer permits a major program of coincidence experiments in which both scattered electrons and hadrons are detected under conditions of high momentum resolution. Continue expansion of Unix-based CPUs and upgrade VAX systems with additional memory, disk drives, and tape units. Procure general test |

III. Capital Equipment (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| CEBAF (Cont'd) | | | equipment such as oscilloscopes, digital multimeters, pulse generators and fast electronic modules in support of experimental equipment prototype testing. |
| | $ 2,700 | $ 5,400 | $ 11,100 |
| LBL | Complete assembly of a new experimental apparatus (based on a time projection chamber (TPC) in the HISS magnet) for investigating the equation of state (EOS) of nuclear matter. Build a neutron hodoscope to be used with the HISS facility for projectile fragmentation experiments with neutron-rich secondary beams. Begin development of second generation, highly integrated read-out electronics for a TPC in a relativistic heavy ion experiment at CERN. | Commission the EOS TPC detector and begin initial experiments. Begin fabrication of the read-out electronics for the CERN lead beams experiment. Procure a carbon 14-doped germanium detector to search for a massive neutrino emitted in the beta decay of carbon 14. | Complete fabrication of the read-out electronics for the CERN lead beams experiment, which also serves as a full scale test of the electronics integration in preparation for designing detectors for RHIC experiments. The CERN experiment will study the signals of various identified hadrons in a search for the deconfinement transition of Lattice QCD. Assemble a high performance data analysis system (using high-speed, closely-coupled RISC-based computer processors) for processing data from the CERN lead beams experiment and the EOS TPC. |
| | $ 1,490 | $ 3,100 | $ 1,680 |
| LANL | Begin fabrication of the Neutral Meson Spectrometer (NMS) and the Liquid Scintillator Neutrino Detector (LSND) to provide significant new physics capabilities for the LAMPF experimental program. Begin full experimental program with the pion beam energy-spread compressor. Develop a farm of computer work stations for data acquisition use by the MEGA experiment. Continue to modernize the accelerator control system by developing a distributed data processing system in which the control computers are connected by ethernet. | Continue construction of the highest priority experimental apparatus in anticipation of termination of the LAMPF research program in FY 1994. Improve data analysis system at LAMPF by adding eight millimeter tape storage and high capacity intermediate disk storage. Procure equipment for large collaborative experiments conducted at facilities away from Los Alamos such as relativistic heavy ion experiments and measurement of the solar neutrino flux. | Complete construction and begin use of the highest priority experimental apparatus in coordination with an orderly phaseout of Nuclear Physics sponsored research at LAMPF. Procure equipment for experiments conducted at facilities away from Los Alamos such as relativistic heavy ion experiments, measurements of the solar neutrino flux, and studies of meson and hypernuclear physics. |

III. Capital Equipment (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| LANL (Cont'd) | $ 2,910 | $ 3,340 | $ 1,025 |
| ANL | Complete installation of the electron-positron experiment APEX, which studies the origin of sharp e-p coincidence peaks observed in very heavy ion collisions. APEX exploits high-intensity heavy-mass beams available from the ATLAS accelerator. Provide for on-going research needs at ATLAS, for equipment needed for ATLAS accelerator operations, and for the maintenance of the Fast Neutron Generator used by the Nuclear Data program. | Provide for on-going research needs at ATLAS, for equipment needed for ATLAS accelerator operations (such as helium compressors), for equipment for polarized internal gas targets used by the medium energy research group and for the maintenance of the Fast Neutron Generator used by the Nuclear Data program. | Provide for on-going research needs at ATLAS, for equipment needed for ATLAS accelerator operations and equipment for polarized internal gas targets to perform lepton scattering experiments at storage ring facilities. Upgrade the data acquisition system at ATLAS to handle complex experiments planned for the APEX and FMA experimental systems. |
| | $ 1,182 | $ 850 | $ 780 |
| MIT/Bates | At MIT/Bates procure RF equipment (klystrons, modulators and drivers) for the South Hall Ring Experiment (SHRE) to compensate for energy loss due to synchrotron radiation. Continue construction of a polarized He3 internal target system for SHRE, procuring vacuum equipment and Helmholtz coils. Continue with construction of focal-plane polarimeter for OHIPS spectrometer. | At MIT/Bates complete procurement of control system hardware and electronics for the SHRE in preparation for experiments with the first electron beam from the ring. Included are readout electronics packages for x-y monitors, lutes, toroids, and synchrotron light monitors. Complete the essential components for the SHRE internal target with the purchase of high-speed turbo-molecular pumps. Complete OHIPS focal-plane polarimeter by purchasing the remainder of the wire chamber readout system. | Begin fabrication of new selected detectors for the internal target facility which are fully able to exploit the polarization capability of the beam and target. Share construction costs for the support frame for the Out of Plane Spectrometer (OOPS), a joint DOE/NSF project. OOPS will permit measurement of interference structure functions in coincidence electron scattering experiments in the South Experimental Hall. |
| | $ 1,694 | $ 1,725 | $ 1,450 |

III. Capital Equipment (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| ORNL | Complete procurement of components for the Recoil Mass Spectrometer (RMS). The RMS will detect nuclides with specific mass and atomic charge emitted in heavy ion induced reactions at zero degrees relative to the beam direction. Provide equipment for relativistic heavy ion research, including equipment needed to develop detectors for RHIC. Procure ORELA maintenance items including klystrons. | Provide equipment for relativistic heavy ion research at CERN and BNL. Procure BaF2 high energy photon detectors for the research program. Upgrade Holifield computer system with additional work stations for theoretical calculations and analysis of experimental data. Procure ORELA maintenance items including klystrons. | Provide equipment for relativistic heavy ion research at CERN and BNL, for nuclear structure research at outside facilities, and for other on-going needs of the research program. Procure ORELA maintenance items including klystrons. |
| | $ 1,023 | $ 1,400 | $ 985 |
| University Laboratories | Continue upgrade of instrumentation at university laboratories. Construct experimental equipment as follows: Texas A&M University (computer system upgrade), TUNL (Compton-suppressed gamma-ray spectrometers and magnetic spectrograph detector system), University of Washington (equipment for complete measurement of A = 8 beta decays), and Yale University (Compton polarimeter and computer system upgrade). | Continue instrumentation upgrade at university accelerator laboratories to increase amount of first-rate experimental equipment. | Continue instrumentation upgrade at university laboratories with construction of devices such as low- and high-energy gamma detectors, Compton-suppression gamma-ray spectrometer, and data analysis facilities. |
| | $ 879 | $ 1,000 | $ 1,000 |
| Sudbury Neutrino Observatory | Begin fabrication of detector for the Sudbury Neutrino Observatory (SNO). Procure low radioactivity glass and let contract for manufacture of photomultiplier tubes (PMT). Design PMT support structure. | Continue fabrication of detector for the Sudbury Neutrino Observatory. Receive and test photomultiplier tubes, and begin fabrication of PMT support structure. | Continue fabrication of detector for the Sudbury Neutrino Observatory. SNO is located in a deep underground mine at Sudbury, Ontario and is a collaborative Canadian, U.S. and U.K. project, using heavy water as its principal sensitive medium. This unique world-class facility for neutrino astrophysics has a very high potential for fundamental discoveries in solar physics and in the properties of neutrinos. Begin installation of PMT support frame in mine cavity. Assemble and test photomultiplier tubes, bases and cables. The U.S. share of the detector project is $11.9 million in |

III. Capital Equipment (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| Sudbury Neutrino Observatory (Cont'd) | | | actual year dollars over four years. Fabrication was initiated in FY 1991. The entire SNO project has a capital cost estimate of about $44 million and will make use of a valuable store of 1,000 tons of Canadian heavy water. |
| | $ 2,836 | $ 2,703 | $ 3,000 |
| Gammasphere | Begin fabrication of Gammasphere, a large high-resolution gamma-ray facility for the study of high-spin nuclear physics. Gammasphere will be sited initially at Lawrence Berkeley Laboratory's 88-Inch Cyclotron facility. Begin procurement of the germanium detectors and BGO Compton-suppressor elements. Begin detailed design of the detector support frame and the specialized electronics. | Continue fabrication of Gammasphere, receiving delivery of the first germanium detectors and BGO elements. Begin physics use of the first detectors with temporary electronics and support system. Fabricate hemispherical support frame, procure electronics and data handling system. | Continue fabrication of Gammasphere, a world-class high-resolution gamma-ray facility for the study of nuclear structure at high angular momentum, finite temperature and large deformation. Gammasphere is designed to observe high-multiplicity coincidence events which are crucially important for the analysis of complex gamma-ray spectra. Five-fold coincidence events will be 8,000 times more intense than any existing high-resolution detector system. The system consists of 110 large Compton-suppressed germanium detectors. The instrument will address a broad range of nuclear physics such as superdeformed nuclei, damping, giant resonances, symmetries in nuclei, correlations in nuclear reactions, fundamental interactions, and certain astrophysics questions. Gammasphere has a total estimated cost (TEC) of $17.7 million in actual year dollars. Fabrication was initiated in FY 1991. |
| | $ 4,400 | $ 4,300 | $ 5,000 |

III. Capital Equipment (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
|---|---|---|---|
| Lawrence Berkeley Laboratory - GPE | Provide general purpose equipment at Lawrence Berkeley Laboratory, for which the Nuclear Physics program has landlord responsibility, such as trucks, forklifts and a bus for the Motor Vehicle group; cartridge tape controllers and drives, ultrasonic crack detectors for the Administrative Division; and pool of scientific work stations and related servers, lab-wide network accessible printing system, fibre optics computer network lines, disk upgrade for the central computing facility, and a postscript typesetter for the Information and Computing Science Division. | Provide general purpose equipment such as motor vehicles and data processing equipment for the Administrative Division; equipment for laboratory-wide video capability, switches for the LBLnet, and a fiber optical data network for the Information and Computing Sciences Division; and CAD/CAM workstations and drafting plotters, tooling for surface-mount integrated circuit technology, digital test and measurement equipment for the Engineering Division. | Provide general purpose equipment for needs in these areas: LBL motor vehicle pool, general administration, sitewide institutional plant equipment, information and computing sciences, engineering, and ES&H activities. Examples of equipment requested include buses and trucks, data processing equipment used in administrative functions, dedicated computer network file server, cooling towers, emergency generators, mass storage devices for scientific computing, color workstations for illustrations in publications, CAD/CAM workstations and drafting plotters, equipment to develop programmable logic arrays, radioactive waste compactor, solvent recycler, and whole body counter. |
| | $ 1,515 | $ 1,700 | $ 1,870 |
| Other | Provide equipment for smaller programs at other national laboratories (INEL, LLNL, NIST, SLAC) including portions of the nuclear data measurements program. | Provide equipment for smaller programs at other national laboratories (INEL, LLNL, SLAC) including portions of the nuclear data measurements program, and more rapid completion of high priority experimental systems. | Provide equipment for nuclear data program at INEL, LLNL and smaller programs at other national laboratories, and for more rapid completion of high priority experimental systems. |
| | No activity. | No activity. | In an effort to manage administrative costs more closely, the PSO/Office Directors' share of FTE-dependent costs for space, supplies, and telecommunications are included in this budget and will be transferred during the execution year. |
| | $ 381 | $ 1,107 | $ 1,025 |
| Capital Equipment | $ 24,100 | $ 30,000 | $ 32,200 |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Construction

II. A. Summary Table: Construction

| Program Activity | FY 1991 Enacted | FY 1992 Enacted | FY 1993 Request | % Change |
|---|---|---|---|---|
| Continuous Electron Beam Accelerator Facility (CEBAF)........................................ | $ 58,499 | $ 41,800 | $ 33,000 | - 21 |
| Relativistic Heavy Ion Collider (RHIC).......... | 13,500 | 49,350 | 71,400 | + 45 |
| Accelerator Improvements and Modifications...... | 3,780 | 4,100 | 3,200 | - 22 |
| General Plant Projects.......................... | 3,920 | 3,949 | 3,500 | - 11 |
| Total, Construction | $ 79,699 | $ 99,199 | $ 111,100 | + 12 |

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

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| Construction | | | |
| Continuous Electron Beam Accelerator Facility (CEBAF) | Continue end station construction and fabrication of research equipment. Continue fabrication of cavities and cryostats. Continue procurement of arc magnets and power supplies. Assemble, test, and install components. | Complete end station construction. Complete installation of accelerator and end station cryogenic transfer lines. Begin detector installation. Install and begin pre-operational checkout of North Linac and begin assembly of South Linac. Complete accelerator control software. Funding level does not reflect the proposed $6.5M reprogramming to CEBAF construction from Medium Energy (CEBAF) operations. | Complete installation of beam switchyard magnets and power supplies. Complete RF system. Continue detector installation. Continue operational checkout of North linac and assembly of South Linac. |
| | $ 58,499 | $ 41,800 | $ 33,000 |
| Relativistic Heavy Ion Collider (RHIC) | Start construction of RHIC with emphasis on procurement of superconducting dipole, quadrupole, and sextupole magnets for the accelerator arcs. Initiate procurement of long-lead time items for vacuum, cryogenic and beam instrumentation systems. | Continue construction of RHIC with main emphasis on procurement of superconducting dipole, quadrupole and sextupole magnets for the accelerator arcs. Complete preliminary design of major detectors. | Continue construction of RHIC with procurement of superconducting dipole, quadrupole and sextupole magnets for the accelerator arcs. Initiate procurement of components for other accelerator systems including cryogenic piping and power supplies. Initiate detailed design of major detectors and begin procurement of long-lead detector components such as spectrometer magnets. |
| | $ 13,500 | $ 49,350 | $ 71,400 |
| Accelerator Improvements and Modifications | Essential modifications and upgrades on an annual basis to maintain and improve the reliability and efficiency of accelerators and experimental facilities. Annual AIP expenditure is less than 1% of total Federal investment in these facilities. | Approximately same level of effort as FY 1991. This includes construction of components for the Radioactive Beam Facility at ORNL. | Reduced level of effort in coordination with an orderly phaseout of operations at LAMPF and Bevalac. Construct components for the Radioactive Beam Facility at ORNL. ($2,400 TEC) |
| | $ 3,780 | $ 4,100 | $ 3,200 |

III. Construction (Cont'd):

| Program Activity | FY 1991 | FY 1992 | FY 1993 |
| --- | --- | --- | --- |
| General Plant Projects | Essential additions, modifications, and improvements on an annual basis to maintain safety and effectiveness of general laboratory plant and support facilities. | Approximately same level of effort as FY 1991. | Reduced level of effort in coordination with an orderly phaseout of operations at LAMPF. |
| | $ 3,920 | $ 3,949 | $ 3,500 |
| Construction | $ 79,699 | $ 99,199 | $ 111,100 |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

Nuclear Physics

IV. A. Construction Project Summary

| Project No. | Project Title | Total Prior Year Obligations | FY 1992 Appropriated | FY 1993 Request | Unappropriated Balance | TEC |
|---|---|---|---|---|---|---|
| GPE-300 | General Plant Projects | $ --- | $ --- | $ 3,500 | $ --- | $ 3,500 |
| 93-G-302 | Accelerator Improvements and Modifications | --- | --- | 3,200 | --- | 3,200 |
| 91-G-300 | Relativistic Heavy Ion Collider | 13,500 | 49,350 | 71,400 | 272,350 | 406,600 |
| 87-R-203 | Continuous Electron Beam Accelerator Facility | 215,310 | 48,300 | 33,000 | 16,590 | 313,200 |
| Total, Nuclear Physics Construction | | $ 228,810 | $ 97,650 | $ 111,100 | $288,940 | XXX |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Nuclear Physics

IV. B. Plant Funded Construction Project

1. Project title and location: GPE-300 General Plant Projects
Various locations

Project TEC: $ 3,500
Start Date: 1st Qtr. FY 1993
Completion Date: 2nd Qtr. FY 1995

2. Financial schedule:

| Fiscal Year | Appropriated | Obligations | Costs |
|---|---|---|---|
| 1993 | $ 3,500 | $ 3,500 | $ 1,200 |
| 1994 | 0 | 0 | 1,800 |
| 1995 | 0 | 0 | 500 |

3. Narrative:

(a) General Plant Projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required at the Lawrence Berkeley Laboratory, and the Massachusetts Institute of Technology (Bates Linear Accelerator Center). GPP projects focus on general laboratory facilities whereas the AIP projects focus on the technical facilities.

(b) These projects are required for the general maintenance, modification and improvement of the overall laboratory plant and include minor new construction, capital alterations and additions, and improvements to buildings and utility systems. These projects are essential for maintaining the productivity, increasing the operational cost effectiveness, and ensuring that necessary support services are available to the research program at the DOE-owned facilities.

(c) A description and listing of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheets. Some of these may be located on non-Government owned property. The following is a list of the proposed FY 1993 funding for the various locations:

| | |
|---|---|
| Lawrence Berkeley Laboratory | $ 3,355 |
| Massachusetts Institute of Technology (Bates Linear Accelerator Center) | 145 |
| Total Estimated Cost.................... | $ 3,500 |

4. Total Project Funding (BA):

| | Prior Years | FY 1992 | FY 1993 Request | To Complete |
|---|---|---|---|---|
| Construction | $ 0 | $ 0 | $ 3,500 | $ 0 |
| Capital Equipment | 0 | 0 | 0 | 0 |
| Operating Expenses | 0 | 0 | 0 | 0 |

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Nuclear Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 93-G-302 Accelerator Improvements and Modifications
Various locations

Project TEC: $ 3,200
Start Date: 1st Qtr. FY 1993
Completion Date: 2nd Qtr. FY 1995

2. Financial schedule:

| Fiscal Year | Appropriated | Obligations | Costs |
|---|---|---|---|
| 1993 | $ 3,200 | $ 3,200 | $ 2,200 |
| 1994 | 0 | 0 | 800 |
| 1995 | 0 | 0 | 200 |

3. Narrative:

(a) Accelerator Improvement Projects provide for additions, modifications, and improvements to research accelerators and ancillary experimental facilities. The requested projects are necessary to maintain and improve reliability and efficiency of operations and to provide new experimental capabilities as required for execution of planned nuclear physics research programs. Funds for these projects are needed annually to provide increased performance levels and increased serviceability, thereby decreasing facility downtime, improving the productivity and cost effectiveness of the program.

(b) A description and listing of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheets. Some of these may be located on non-Government owned property. The following is a list of the proposed FY 1993 funding for the various locations:

| | |
|---|---|
| Argonne National Laboratory | $ 300 |
| Brookhaven National Laboratory (AGS/Tandem) | 1,300 |
| Lawrence Berkeley Laboratory | 300 |
| Massachusetts Institute of Technology (Bates Linear Accelerator Center) | 500 |
| Oak Ridge National Laboratory | 800 |
| Total Estimated Costs.................... | $ 3,200 |

4. Total Project Funding (BA):

| | Prior Years | FY 1991 | FY 1992 | FY 1993 Request | To Complete |
|---|---|---|---|---|---|
| Construction | $ 0 | $ 0 | $ 0 | $ 3,200 | $ 0 |
| Capital Equipment | 0 | 0 | 0 | 0 | 0 |
| Operating Expenses | 0 | 0 | 0 | 0 | 0 |

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Nuclear Physics

IV. C. Plant Funded Construction Project

1. Project title and location: 91-G-300 Relativistic Heavy Ion Collider
Brookhaven National Laboratory
Upton, New York

Project TEC: $ 406,600
Start Date: 1st Qtr. FY 1991
Completion Date: 4th Qtr. FY 1997

2. Financial schedule:

| Fiscal Year | Appropriated | Obligations | Costs |
|---|---|---|---|
| 1991 | $ 13,500 | $ 13,500 | $ 6,000 |
| 1992 | 49,350 | 49,350 | 41,400 |
| 1993 | 71,400 | 71,400 | 63,000 |
| 1994* | 90,000 | 90,000 | 88,100 |
| 1995* | 90,000 | 90,000 | 90,900 |
| 1996* | 72,000 | 72,000 | 78,000 |
| 1997 | 20,350 | 20,350 | 39,200 |

3. Narrative:

(a) The Relativistic Heavy Ion Collider (RHIC) facility will be a unique, world-class research facility with opposing colliding beams that provide collision energies of 100 GeV/AMU per beam for heavy ions as massive as gold. RHIC will use the existing Alternating Gradient Synchrotron (AGS) and Tandem Van de Graaff complex as an injector. The new accelerator will be built in the existing Colliding Beam Accelerator (CBA) tunnel (3.8 km circumference) at BNL, and will utilize the experimental halls, support building, and liquid helium refrigerator from the partially completed CBA project.

(b) RHIC will be dedicated to the study of nuclear matter at very high temperatures and densities where the quark-gluon degrees of freedom are expected to be directly revealed. The machine will accelerate ions with atomic masses spanning the periodic table, with the collision energies of 100 GeV/AMU for the heaviest ions, and even higher energies for lighter ions. In such collisions, experimenters will be able to study extended volumes of hadronic matter with energy densities more than ten times that of the nuclear ground state, thus creating in the laboratory conditions that are similar to those of the expanding universe moments after the Big Bang. Ultra-relativistic heavy ion collisions are probably the only means of producing such energy densities under controlled laboratory conditions, and offer a unique avenue for both nuclear and particle physicists to test theories of the strong interaction at the high energy density limit. This is the threshold at which hadronic matter is predicted to lose its identity as a collection of neutrons and protons, and to undergo a phase transition to a plasma of quarks and gluons.

(c) Construction of RHIC will proceed in an expeditious manner, consistent with available funds. FY 1993 construction funds will be used for procurement of superconducting dipole, quadrupole and sextupole magnets for the accelerator arcs, procurement of cryogenic distribution system, magnet electrical system, and accelerator control system. Initiate procurement of long lead detector component, and initiate detailed design of detectors.

4. Total Project Funding (BA):

| | Prior Years | FY 1991 | FY 1992 | FY 1993 Request | To Complete |
|---|---|---|---|---|---|
| Construction | $ 0 | $13,500 | $49,350 | $71,400 | $272,350 |
| Capital Equipment | 0 | 0 | 0 | 0 | 0 |
| Operating Expenses | 21,450 | 6,614 | 7,000 | 7,200 | 60,536 |

* Outyear amounts reflect funding levels higher than amounts contained in the OMB passback. The funding of these outyear requirements will be addressed in the next budget cycle.

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)
KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY
Nuclear Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 87-R-203 Continuous Electron Beam Accelerator Facility
Newport News, Virginia

Project TEC: $313,200*
Start Date: 2nd Qtr. FY 1987
Completion Date: 1st Qtr. FY 1995

2. Financial schedule:

| Fiscal Year | Appropriated | Obligations | Costs |
|---|---|---|---|
| 1987 | $ 16,200 | $ 16,200 | $ 7,842 |
| 1988 | 33,500 | 33,500 | 41,858 |
| 1989 | 44,500 | 44,500 | 29,086 |
| 1990 | 62,611 | 62,611 | 53,441 |
| 1991 | 58,499 | 58,499 | 62,000 |
| 1992 | 48,300* | 48,300 | 61,100 |
| 1993 | 33,000 | 33,000 | 37,500 |
| 1994 | 16,590 | 16,590 | 20,373 |

3. Narrative:

(a) The Continuous Electron Beam Accelerator Facility (CEBAF) is a single purpose, basic nuclear physics research facility based on a four billion electron volt (GeV) electron linear accelerator that is capable of providing high intensity, continuous (i.e., not pulsed) electron beams. The facility will include the experimental areas needed to conduct basic nuclear research, and buildings to house the accelerator complex and its operation and maintenance activities. The facility will possess a complement of equipment for initial experiments and supporting facilities to exploit the capabilities of the accelerator.

(b) CEBAF will be the only facility in the world capable of producing electron beams that simultaneously meet the criteria of high energy, high intensity, and continuous nature necessary to advance the frontiers of nuclear physics. CEBAF's electron accelerator with its capability of providing beams at any energy in the range 0.5 to 4 GeV, is designed to study the largely unexplored transition between the nucleon-meson and the quark-gluon description of nuclear matter.

(c) Construction of CEBAF will continue in an expeditious manner, consistent with available funds. FY 1993 construction funds will be used to complete installation of beam switchyard magnets and power supplies. Complete RF system. Continue operational checkout of North linac and assembly of South Linac.

4. Total Project Funding (BA):

| | Prior Years | FY 1991 | FY 1992 | FY 1993 Request | To Complete |
|---|---|---|---|---|---|
| Construction | $156,811 | $58,499 | $48,300 | $33,000 | $16,590 |
| Capital Equipment | 3,979 | 1,440 | 1,600 | 1,600 | 3,200 |
| Operating Expenses | 53,279 | 23,234 | 23,330 | 28,217 | 60,900 |

* The CEBAF construction project data sheets reflect a rebaselining of the project and a proposed reprogramming of $6.5M from CEBAF operations to CEBAF construction in FY 1992.

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
NUCLEAR PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

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

2. Project No. GPE-300

3a. Date A-E work initiated: 1st Qtr. FY 1993

4a. Date physical construction starts: 2nd Qtr. FY 1993

4b. Date construction ends: 2nd Qtr. FY 1995

5. Previous Const. cost estimate: None
Total Project Cost: None

6. Current Const. cost estimate: $3,500
TECC: 3,500
TPC: 3,500

7. Financial Schedule:

| Fiscal Year | Appropriations | Obligations | Costs |
|---|---|---|---|
| 1993 | $ 3,500 | $ 3,500 | $ 1,300 |
| 1994 | 0 | 0 | 1,700 |
| 1995 | 0 | 0 | 500 |

8. Brief Physical Description of Project

This project provides for minor new construction, other capital alterations and additions, and for improvements to land, buildings, and utility systems. Where applicable, the request also includes the cost of installed capital equipment integral to a subproject. No significant R&D program is anticipated as a prerequisite for design and construction.

| | |
|---|---|
| 1. Title and location of project: General plant projects various locations | 2. Project No. GPE-300 |

8. Brief Physical Description of Project (Continued)

Lawrence Berkeley Laboratory....................................$3,355

Requirements include: installation of both firm and interruptible electrical power to Building 88, rehabilitation of low voltage breaker at Building 51, construction of new cooling tower for Building 66 and rehabilitation of cooling tower at Building 62, renovate Building 62 and 74 elevators, replacement of Building 70 emergency generator, replacement of Building 70/90 12 kV electrical cables, replacement of PCB-filled capacitors, rehabilitation of Building 62 laboratories, construction of Building 50 library addition, refurbishing of Building 50 auditorium, rehabilitation of Building 70A HVAC, upgrading of Building 70 fire separation partitions, replacement of items on backlog list of aged plant mechanical equipment, construction of several more cooling towers, and rehabilitation of many building interiors sitewide.

Massachusetts Institute of Technology
(Bates Linear Accelerator Center)..............................$ 145

Construct a monorail crane for access to the South Experimental Hall. The crane will move large equipment (up to 15 tons) over the new South Hall ring tunnel to the currently blocked loading door of the South Experimental Hall.

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

The distribution of funds requested for FY 1993 is as follows:

| | |
|---|---|
| Lawrence Berkeley Laboratory.......................................................... | $ 3,355 |
| Massachusetts Institute of Technology (Bates Linear Accelerator Center)............. | 145 |
| Total Estimated Cost.......................................................... | $ 3,500 |

| 1. Title and location of project: General plant projects various locations | 2. Project No. GPE-300 |
|---|---|

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

Since needs and priorities may change, other subprojects may be substituted for those listed and some of these may be located on non-Government owned property.

10. Details of Cost Estimate

See description, item 8. The estimated costs are preliminary and, in general, indicate the magnitude of each program. These costs include engineering, design, and inspection.

11. Method of Performance

Design will be by contractor staff or on the basis of negotiated architect-engineer contracts. To the extent feasible, construction and procurement will be accomplished by firm fixed-price contracts and subcontracts on the basis of competitive bidding.

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
NUCLEAR PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

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

2. Project No. 93-G-302

3a. Date A-E work initiated: 1st Qtr. FY 1993

4a. Date physical construction starts: 2nd Qtr. FY 1993

4b. Date construction ends: 2nd Qtr. FY 1995

5. Previous cost estimate: None
Total Project Cost: None

6. Current cost estimate: $ 3,200
TECC: 3,200
TPC: 3,200

7. Financial Schedule:

| Fiscal Year | Appropriations | Obligations | Costs |
|---|---|---|---|
| 1993 | $ 3,200 | $ 3,200 | $ 2,200 |
| 1994 | 0 | 0 | 800 |
| 1995 | 0 | 0 | 200 |

8. Brief Physical Description of Project

This project provides for additions, modifications, and improvements to major research accelerators and ancillary experimental facilities. The requested funds are necessary to maintain and improve reliability and efficiency of operations, and to provide new experimental capabilities as required for execution of planned research programs.

Listed below are the laboratories and a description of each subproject:

| | |
|---|---|
| 1. Title and location of project: Accelerator improvement and modifications, various locations | 2. Project No. 93-G-302 |

8. Brief Physical Description of Project (Continued)

Argonne National Laboratory (ATLAS)............................ $ 300

Provide for various modification to the ATLAS linac which improve reliability and optimize it for acceleration of very heavy beams such as uranium. These include modifying the velocity profile by changing characteristics of five resonators, improving the helium cooling of one cryostat near the front of the linac, and continuing the upgrade of the fast tuners on the resonators.

Brookhaven National Laboratory (AGS/Tandem Heavy Ion Facility). $ 1,300

As part of a general upgrade of the AGS for heavy ion operation, continue to replace segments of the RF system with ones which have a wider frequency range needed to accelerate the heaviest ions. Improve the instrumentation in the Tandem/AGS heavy ion transfer line by adding beam profile monitors, beam position monitors, and low intensity radiation monitors near the bending magnets.

Lawrence Berkeley Laboratory (88-Inch Cyclotron).............. $ 300

The performance of the cyclotron will be improved by adding the following components: (1) a large helium cooled cryo-panel in the vacuum tank to decrease residual gas pressure by a factor of two or more; and (2) a fast beam chopper that will be able to pulse the beam off in the 100 ns to 1 microsecond range. The chopper will be synchronized with the RF time structure of the beam and will transmit one pulse in N beam pulses to the experiment, where N is 2 to 10.

| | |
|---|---|
| 1. Title and location of project: Accelerator improvement and modifications, various locations | 2. Project No. 93-G-302 |

8. Brief Physical Description of Project (Continued)

Massachusetts Institute of Technology
(Bates Linear Accelerator Center)............................ $ 500

The electron linac and recirculator will be upgraded to improve reliability, reproducibility and operability. As part of this upgrade the accelerator control system will be modernized with new device controllers, RF switchers, and local area computers. The polarized electron source will be upgraded by replacement of the electron gun with one of better design.

Oak Ridge National Laboratory (Radioactive Ion Beam Facility... $ 800

Construct components that will enable the 25-MV tandem accelerator and the ORIC cyclotron to function as a Radioactive Ion Beam Facility. The goal is to use light-ion beams from ORIC that will bombard a thick target in order to produce nuclear reactions leading to radioactive products. These will be ionized, mass separated and then accelerated by the 25-MV tandem. Components that must be constructed are the target/ion source and the mass separator on a 300-kV high voltage platform, and connecting beam lines. The facility will provide beams of a variety of radioactive ion species, e.g., 12.7 MeV/nucleon for fluorine-17 and 5.3 MeV/nucleon of bromine-76. The upgrade project has a total estimated cost of $2,400,000 ($600,000 in FY 1992, $800,000 in FY 1993, and $1,000,000 in FY 1994.

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

Argonne National Laboratory (ATLAS)

The design of the ATLAS linac was optimized to best accelerate ions in the lower half of the periodic table. When the positive-ion injector is complete, the research program at ATLAS will focus on studies with the heaviest nuclear projectiles including uranium. A number of relatively small changes in the linac can substantially improve the research capabilities of the machine, especially with respect to the important experiment APEX.

Brookhaven National Laboratory (AGS/Tandem)

The AGS upgrade program is designed to provide a machine that will satisfactorily perform as a source of heavy ions both for fixed target experiments and for operation as an injector to RHIC. The demands on the performance of the RF system will increase significantly when the new AGS Booster provides heavy beams to the AGS. To meet these

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

2. Project No. 93-G-302

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

demands the high level and low level RF hardware must be fundamentally upgraded. Operating experience with the heavy ion transfer line has shown that the beam instrumentation is not optimum, and that by adding additional multiwire profile monitors and moving three existing ones, the tune of the beam line can be significantly improved.

Lawrence Berkeley Laboratory (88-Inch Cyclotron)

The improved vacuum will increase the transmission of accelerated heavy ions by reducing beam loss due to residual gas in the vacuum tank. This beam loss is especially significant for high charge state ions above mass 100. The Advanced ECR ion source can extend the cyclotron's mass range to mass 200 at 5 MeV/nucleon, but better vacuum is required to get adequate intensities for use with Gammasphere. The fast beam chopper will allow the study of short half-life nuclear states with life times of 100 ns or greater. It will be particularly useful for studies of high spin states using the Gammasphere detector.

Massachusetts Institute of Technology (Bates Linear Accelerator Center)

The modifications proposed are designed to achieve a stable, high-quality, high-current operation of the accelerator. The new control system will improve reliability and provide the capacity to diagnose and document machine operation. These changes will permit safe operation with higher beam currents by minimizing the chance of beam missteering. The existing polarized electron gun lacks vacuum integrity and cannot handle higher power operation.

Oak Ridge National Laboratory (Radioactive Ion Beam Facility)

Transformation of the ORIC cyclotron and the ORNL 25-MV tandem into a Radioactive Ion Beam Facility will open up a unique area of research in the world in one of the "hot" new areas of nuclear physics. Some of the research areas that will become available are: (1) study of the properties of proton rich nuclei of astrophysical interest, (2) access to new regions of exotic nuclear shapes such as hyperdeformation (3:1 ratio of the major to minor axis), and (3) properties of nuclei near the proton-drip line such as new double-closed shell nuclei, heavy self-conjugate and mirror nuclei. This project is a very cost effective way to quickly create a radioactive ion beam facility.

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

2. Project No. 93-G-302

10. Details of Cost Estimate

a. Engineering, design, inspection, construction, procurement, component assembly, and installation...... $ 3,200

Total Estimated Cost................................. $ 3,200

The estimated cost of the programs at each laboratory are preliminary and, in general, indicate the magnitude of each program. Since needs and priorities may change, other subprojects may be substituted for those listed.

11. Method of Performance

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

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
NUCLEAR PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Relativistic Heavy Ion Collider
Brookhaven National Laboratory
Upton, New York

2. Project No. 91-G-300

3a. Date A-E work initiated: 1st Qtr. FY 1991

3b. A-E work (Title I & II) duration 6 months

4a. Date physical construction starts: 2nd Qtr. FY 1991

4b. Date construction ends: 4th Qtr. FY 1997

5. Previous Const. cost estimate: $397,000
Total Project Cost: 499,100

6. Current Const. cost estimate: $406,600
TECC: 406,600
TPC: $509,400

7. Financial Schedule

| Fiscal Year | Appropriations | Obligations | Costs |
|---|---|---|---|
| FY 1991 | $ 13,500 | $ 13,500 | 6,000 |
| FY 1992 | 49,350 | 49,350 | 41,400 |
| FY 1993 | 71,400 | 71,400 | 63,000 |
| FY 1994* | 90,000 | 90,000 | 88,100 |
| FY 1995* | 90,000 | 90,000 | 90,900 |
| FY 1996* | 72,000 | 72,000 | 78,000 |
| FY 1997 | 20,350 | 20,350 | 39,200 |

8. Brief Physical Description of Project

The Relativistic Heavy Ion Collider (RHIC) facility will be a unique, world-class research facility with opposing colliding beams that provides collision energies of 100 GeV/AMU per beam for heavy ions as massive as gold. RHIC will use the existing Alternating Gradient Synchrotron (AGS) and Tandem Van de Graaff complex as an injector. The new accelerator will be built in the existing Colliding Beam Accelerator (CBA) tunnel (3.8 km circumference), and will utilize the experimental halls, support building and liquid helium refrigerator from the partially completed CBA project.

* Outyear amounts reflect funding levels higher than amounts contained in the OMB passback. The funding of these outyear requirements will be addressed in the next budget cycle.

1. Title and location of project: Relativistic Heavy Ion Collider
Brookhaven National Laboratory, Upton, New York

2. Project No. 91-G-300

8. Brief Physical Description of Project (continued)

The collider consists of two rings of superconducting magnets for accelerating and storing beams at variable energies up to 100 GeV/AMU for the heaviest ions. The collider will have the flexibility of using the full range of ion species from protons to gold which will be available from the AGS. With protons, energies of up to 250 GeV in each beam are expected. The capability for collisions between different masses in each ring will be provided. The collider is expected to have an average luminosity (a measure of the collision rate) of about $10^{26}$ $cm^{-2}$ $sec^{-1}$ for gold-on-gold collisions at full energy.

Most of the conventional construction for the collider exists, including a ring tunnel and an operating helium refrigeration system. The existing Collider Center (50,000 sq. ft. of usable area) will contain the accelerator control center, offices, technical shops, and refrigeration plant.

The existing tunnel configuration provides for six experimental areas where the circulating beams cross. Three of the experimental areas presently have completed experimental halls and support buildings for utilities. Another experimental area is an "open area" complete with support buildings and is suitable for experiments that use internal stationary targets. New construction is needed at two areas to close gaps in the ring. The standard tunnel cross section and support buildings will be constructed. Some general site work such as the paving of roads and the stabilization of the berm will also be provided.

The funds requested will provide an initial complement of research detectors at beam intersection regions necessary for the first-round research program with the high-energy heavy-ion collider.

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

RHIC is a two-ring colliding beam accelerator dedicated to the study of nuclear matter at very high temperatures and densities where the quark-gluon degrees of freedom are expected to be directly revealed. The purpose of RHIC is to accelerate, store, and bring into collision two circular beams of very high energy heavy ions. For the heaviest ions (e.g., nuclei of gold atoms) the energies will range up to 100 GeV/AMU in each of the two colliding beams, providing a total collision energy which exceeds by more than an order of magnitude the capability of any other existing or proposed accelerator of heavy nuclear beams.

1. Title and location of project: Relativistic Heavy Ion Collider Brookhaven National Laboratory, Upton, New York | 2. Project No. 91-G-300

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

In such collisions experimenters will be able to study extended volumes of nuclear matter with energy densities greater than 10 times that of the nuclear ground state, achieving conditions of temperature and density at which this matter loses its identity as a collection of neutrons and protons and is predicted to undergo a phase transition to a plasma of quarks and gluons. This state of matter has not yet been observed. Its existence and properties are predicted by the theory of Quantum Chromodynamics (QCD), the theory of the strong interaction which has been developed over the past two decades of progress and discovery in high energy and nuclear physics.

At present the highest energy man-made heavy ion collisions are achieved with nuclear beams impinging on stationary targets, utilizing the Brookhaven AGS and CERN Super Proton Synchrotron accelerators. Recent experiments at these facilities have confirmed expectations that very energetic collisions produce increased densities and temperatures in nuclear matter. These experiments support the predictions that at much higher energies, which can be achieved only with the colliding beams of heavy ions at the RHIC facility, the most extreme temperatures and energy densities are produced in bursts of particles formed purely from the energy in the collision. These are the sought-for thermodynamic conditions which can be directly compared with QCD calculations, and which approximate the conditions that existed before the universe condensed from a plasma of quarks and gluons to a gas of hadrons.

RHIC is designed to meet the requirements for carrying out a wide-ranging program of experiments which will open up the heretofore unexplored physics of hot dense nuclear matter and to isolate and study the new states of matter thus created. These requirements are not met by any other existing or proposed high energy colliding beams facility, all of which are designed for the acceleration of light, singly-charged particles such as protons, antiprotons, or electrons.

1. Title and location of project: Relativistic Heavy Ion Collider
Brookhaven National Laboratory, Upton, New York

2. Project No. 91-G-300

10. Details of Cost Estimate

| | | Item Cost | Total Cost |
|---|---|---|---|
| a. Engineering, Design, Inspection and Administration of item b.... | | | $ 58,900 |
| 1. Conventional construction at approximately 19% of item b.1.. | | $ 1,100 | |
| 2. Technical components (accelerator system) at approximately 30% of item b.2.......... | | 57,800 | |
| b. Construction Costs.......... | | | 196,200 |
| 1. Conventional Construction.......... | | 5,900 | |
| a. Site Improvement.......... | $ 1,400 | | |
| b. Tunnels and Buildings.......... | 3,000 | | |
| c. Utilities.......... | 1,500 | | |
| 2. Technical Components - Collider.......... | | 190,300 | |
| a. Collider Installation.......... | 22,500 | | |
| b. Magnet System.......... | 81,700 | | |
| c. Magnet Electrical System.......... | 11,200 | | |
| d. Cryogenic System.......... | 16,800 | | |
| e. Vacuum System.......... | 8,500 | | |
| f. Injection System.......... | 12,300 | | |
| g. Beam Dump System.......... | 6,900 | | |
| h. RF System.......... | 12,400 | | |
| i. Beam Instrumentation.......... | 4,500 | | |
| j. Control System.......... | 13,500 | | |
| c. Contingency on Collider at approximately 20% of above costs..... | | | 52,200 |
| Subtotal Estimated Cost.......... | | | $307,300 |
| d. Research Detectors (including EDIA and Contingency).......... | | | 99,300 |
| Total Estimated Cost.......... | | | $406,600 |

1. Title and location of project: Relativistic Heavy Ion Collider
Brookhaven National Laboratory, Upton, New York

2. Project No. 91-G-300

11. Method of Performance

This type of construction project is a unique facility and therefore the design, assembly and testing will be done by the staff of the Brookhaven National Laboratory (with the assistance of an architectural-engineering (A-E) firm). Component parts, wherever possible, will be fabricated by industry under fixed-priced, competitively obtained, procurement actions. Some components may be fabricated in the existing shops at BNL. Building design will be on the basis of a negotiated A-E contract, and its construction will be by a competitively obtained lump-sum contract.

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

| a. Total Project Cost (TPC) | Prior Years | FY 1991 | FY 1992 | FY 1993 | FY 1994 | FY 1995 | FY 1996 | FY 1997 | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1. Total Facility Cost | | | | | | | | | |
| Construction line item. | $ 0 | $ 6,000 | $41,400 | $63,000 | $ 88,100 | $ 90,900 | $ 78,000 | $39,200 | $406,600 |
| Total Facility Cost.... | $ 0 | $ 6,000 | $41,400 | $63,000 | $ 88,100 | $ 90,900 | $ 78,000 | $39,200 | $406,600 |
| 2. Other Project Costs | | | | | | | | | |
| a. R&D necessary to complete construction......... | $21,450 | $ 6,614 | $ 7,000 | $ 7,200 | $ 6,000 | $ 3,836 | $ 0 | $ 0 | $ 52,100 |
| b. Start-up.............. | 0 | 0 | 0 | 0 | 0 | 9,000 | 13,000 | 28,700 | $ 50,700 |
| Total Other Project Costs.. | $21,450 | $ 6,614 | $ 7,000 | $ 7,200 | $ 6,000 | $ 12,836 | $ 13,000 | $28,700 | $102,800 |
| Total Project Cost......... | $21,450 | $12,614 | $48,400 | $70,200 | $ 94,100 | $103,736 | $ 91,000 | $67,900 | $509,400 |

| | | | |
|---|---|---|---|
| 1. Title and location of project: | Relativistic Heavy Ion Collider<br>Brookhaven National Laboratory, Upton, New York | 2. Project No. | 91-G-300 |

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

b. Other Related Estimated Funding Requirements (FY 1997 dollars)

| | |
|---|---|
| 1. Annual RHIC Facility Operating Costs | $47,300 |
| 2. Annual Injector Operating Costs | |
| AGS | 18,400 |
| Booster | 3,100 |
| Tandem | 2,200 |
| Total Facility Operating Costs | $71,000 |
| 3. Annual plant and capital equipment costs related to facility operations | 4,500 |
| Total Other Related Annual Funding Requirements* | $75,500 |

* Not all of these costs are incremental

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

a. Total Project Cost

1. Total facility cost

   Explained in items 8, 9 and 10.

2. Other Project Costs

   a. R&D necessary to complete construction

   This includes supporting R&D work on critical accelerator components before and during the construction phase. The funds cover the development of full-length (9.7 m) dipole magnets, quadrupole magnets, insertion magnets, and trim/correction spool pieces.

1. Title and location of project: Relativistic Heavy Ion Collider
Brookhaven National Laboratory, Upton, New York

2. Project No. 91-G-300

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

This also includes R&D necessary for research detectors. Needed are tests to determine detailed parameters required for large-scale detectors for the heavy-ion experimental facilities, and a continuing effort to develop new techniques of detection and read-out for improved utilization of the collider facility.

b. Start-up costs

These funds are needed for operation training of crew, and early testing and check-out of various systems as their construction is completed. It is anticipated that portions of the cryogenic system and the beam injection system would reach operational status in FY 1995. These funds will also provide spare components for the Collider.

b. Other Related Funding Requirements (Estimated life of the facility: 20 years)

1. RHIC facility operating costs assume 38 weeks of operation with appropriate manpower, material, and support services associated with the research program. For this estimate, four experimental areas are assumed in use.

2. Injector operating costs assume that the Tandem/AGS injector complex is not being used for any function other than as the RHIC injector.

3. This item includes plant and capital equipment needed to maintain the research capability of the facility to evolving research requirements as well as funds for accelerator improvement projects and minor general plant projects required to ensure its continued high performance.

DEPARTMENT OF ENERGY
FY 1993 CONGRESSIONAL BUDGET REQUEST
PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
NUCLEAR PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

3a. Date A-E work initiated: 2nd Qtr. FY 1985

4a. Date physical construction starts: 2nd Qtr. FY 1987

4b. Date construction ends: 1st Qtr. FY 1995

5. Previous Const. cost estimate: $270,967
Total Estimated Cost: 270,000
Total Project Cost: $309,514

6. Current Const. cost estimate:* $314,167
TECC: 313,200
TPC: $514,946

7. Financial Schedule:

| Fiscal Year | Appropriations | Obligations | Costs |
|---|---|---|---|
| FY 1987 | $ 16,200 | $ 16,200 | $ 7,842 |
| FY 1988 | 33,500 | 33,500 | 41,858 |
| FY 1989 | 44,500 | 44,500 | 29,086 |
| FY 1990 | 62,611 | 62,611 | 53,441 |
| FY 1991 | 58,499 | 58,499 | 62,000 |
| FY 1992 | 48,300* | 48,300* | 61,100 |
| FY 1993 | 33,000 | 33,000 | 37,500 |
| FY 1994 | 16,590 | 16,590 | 20,373 |

8. Brief Physical Description of Project

The Continuous Electron Beam Accelerator Facility (CEBAF) is a single purpose, basic nuclear research facility to be located in Newport News, Virginia on a site which includes the land and buildings once occupied by the Space Radiation Effects Laboratory (SREL). Southeastern Universities Research Association (SURA) is expected to remain operating contractor during design, construction, and later operations phases of this project. The site for this facility is Federally owned.

* These data sheets reflect a rebaselining of the project and a proposed reprogramming of $6.5M from CEBAF operations to CEBAF construction in FY 1992.

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

8. Brief Physical Description of Project (continued)

The accelerator facility will include: a 4 billion electron volt (GeV), high intensity, recirculated continuous beam electron linear accelerator (linac); experimental areas and equipment to conduct basic nuclear research; and buildings to house the accelerator complex and its operations and maintenance activities. The facility will possess a complement of equipment for initial experiments and supporting facilities to exploit the capabilities of the accelerator.

a) Improvements to Land and Conventional Construction

Improvements to the site will include such items as drainage, roadways, and the extension of utilities. Support facilities for the accelerator complex will be housed in both new and existing structures. The Virginia Associated Research Center (VARC), an existing single-story structure located on an adjacent site owned by the Commonwealth of Virginia, will provide research and administrative offices. Title to VARC will remain with the Commonwealth of Virginia, which by agreement has made it available to SURA indefinitely for CEBAF use. The Space Radiation Effects Laboratory building will be renovated to provide shop areas, component test and assembly areas, laboratories, and office space. Support structures include: (1) housing for the linac, recirculator magnets, and beam lines and (2) buildings for the end stations, refrigerator, accelerator service functions, and an office and computer center.

b) Accelerator System

The central research tool of CEBAF will be an electron linear accelerator. It will consist of a 0.8 GeV superconducting linear accelerator split into two segments. The segments will be connected by a recirculator system to transport the electron beams from one segment of the linac to the other. Five complete passes of acceleration through the linac will provide an energy of 4 GeV. The accelerator complex will also include a beam extraction system to extract three continuous beams from the linac; a beam transport system to take the three beams to three experimental halls; a cryogenic system including helium refrigerator, liquid helium storage vessels, and distribution lines; and instrumentation and control systems for the accelerator complex.

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

8. Brief Physical Description of Project (continued)

The accelerator will service three independent experimental areas. Research equipment will include an initial complement of experimental instrumentation and other support facilities necessary to perform scientific research using CEBAF's high quality electron beams and secondary photon beams.

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

CEBAF will be the only facility in the world capable of producing electron beams which simultaneously meet the criteria of high energy, continuous beams, and high intensity necessary to advance the frontiers of electromagnetic nuclear physics. CEBAF has been identified as the highest priority new accelerator for the U.S. nuclear physics program. The unique combination of beam parameters available at CEBAF will make it a facility of unparalleled capability, and the research at CEBAF will enable the U.S. to maintain its preeminence in this important area of nuclear science. CEBAF's electron linac, with its capability of providing intense continuous beams at any energy in the range of 0.5 to 4.0 GeV, is designed to study the largely unexplored transition between the nucleon-meson and the quark-gluon descriptions of nuclear matter. In particular, it will study the extent to which individual nucleons change their size, shape, and quark structure in the nuclear medium, study how nucleons cluster in the nuclear medium, and study the force which binds quarks into nucleons and nuclei at distances where this force is strong and the quark confinement mechanism is important. CEBAF's continuous beam will make it possible to observe one or more of the reaction products in coincidence with the scattered electron, ensuring that these studies can be carried out accurately. The broad spectrum of physics accessible at CEBAF ensures that it will become and remain one of the important scientific centers in the world.

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

10. Details of Cost Estimate*

| | | Item Cost | Total Cost |
|---|---|---|---|
| a. Engineering, Design, Inspection, and Administration.......... | | | $ 50,000 |
| 1. Conventional Construction at approximately 17% of item b.1 ...................... | | $ 10,000 | |
| 2. Technical components at approximately 23% of item b.2 ... | | 40,000 | |
| b. Construction Costs............................................ | | | 234,500 |
| 1. Conventional Construction................................ | | 60,000 | |
| a. Accelerator facilities............................ | $ 24,000 | | |
| b. Experimental facilities.......................... | 21,000 | | |
| c. Support facilities................................ | 15,000 | | |
| 2. Technical components.................................... | | 174,500 | |
| a. Accelerator components............................ | 133,000 | | |
| b. Research equipment................................ | 41,500 | | |
| c. Project Management............................................ | | | 13,700 |
| d. Contingency at approximately 19% of above costs.............. | | | 15,000 |
| Total Estimated Cost........... | | | $313,200 |

11. Method of Performance

Design, construction, and inspection of the facility will be done by the Operating Contractor, subcontracting with an A/E contractor for design and a general contractor for construction of the conventional facilities. To the extent feasible, construction, procurement, and installation will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bidding.

PROJECT DATA SHEETS

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

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

| | Prior Years | FY 1987 | FY 1988 | FY 1989 | FY 1990 | FY 1991 | FY 1992 | FY 1993 | FY 1994 | FY 1995 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a. Total project cost | | | | | | | | | | | |
| 1. Total facility cost | | | | | | | | | | | |
| a. Construction line item..... | $ 0 | $ 7,842 | $41,858 | $29,086 | $53,441 | $62,000 | $61,100 | $37,500 | $20,373 | 0 | $313,200a/ |
| b. PE&D........... | 967 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 967 |
| Total facility cost......... | $ 967 | $ 7,842 | $41,858 | $29,086 | $53,441 | $62,000 | $61,100 | $37,500 | $20,373 | $0 | $314,167 |
| 2. Other project costs | | | | | | | | | | | |
| a. R&D necessary to complete construction... | $ 9,418 | $ 6,250 | $ 6,250 | $ 6,000 | $ 2,900 | $ 1,629 | $ 0 | $ 0 | $ 0 | $ 0 | 32,447 |
| b. Operations | 0 | 800 | 2,970 | 4,467 | 13,124 | 19,205 | 20,730 | 28,217 | 44,800 | 16,100 | 150,413 |
| c. Spares.......... | 0 | 0 | 0 | 0 | 1,100 | 2,400 | 2,600 | 0 | 0 | 0 | 6,100 |
| d. Capital Equipment | | 500 | 1,000 | 1,000 | 1,479 | 1,440 | 1,600 | 1,600 | 1,600 | 1,600 | 11,819 |
| Total other project costs.. | $ 9,418 | $ 7,550 | $10,220 | $11,467 | $18,603 | $24,674 | $24,930 | $29,817 | $46,400 | $17,700 | $200,779 |
| Total project cost........... | $10,385 | $15,392 | $52,078 | $40,553 | $72,044 | $86,674 | $86,030 | $67,317 | $66,773 | $17,200 | $514,946 |

a/ Site provided at no cost to DOE.

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

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

b. Other related funding requirements (FY 1995 dollars)
 1. Annual facility operating costs including in-house research.................... $ 45,000

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

a. Total project cost
 1. Total facility cost
 Explained in items 8, 9, and 10
 2. Other projects costs

The CEBAF linac will use superconducting radiofrequency accelerating cavity technology to generate high energy continuous electron beams. The R&D funds will be used to design, evaluate, and construct prototypes of the technical components which are essential for meeting the design goals for the facility. Funding required for support functions of this Federally Funded Research and Development Center (FFRDC) has been included.

b. Other related funding requirements

 1. Annual facility operating costs upon completion of construction

This item includes the cost of all personnel employed by the facility for its operation, maintenance, and in-house research, together with electric power and materials and services costs. Approximately 300 man-years of effort annually will be required. Additional AIP, GPP, or Capital Equipment funding will be provided as needed in an amount to be determined.