DEPARTMENT OF ENERGY
FY 1994 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. 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 and radioactive decay data in active support and collaboration with these programs.

However, the major activity and vitality of the field focuses upon continually improving the fundamental understanding of the material and forces of nature. These activities are an essential component 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) has been formulated. 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. Another active area addresses problems of mutual interest to nuclear physics and astrophysics, including measurements or calculations of supernovae, neutron stars, solar neutrinos, composition of 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 possible 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 continuing guidance is provided by the Nuclear Science Advisory Committee (NSAC) based on the 1989 Long Range Plan for Nuclear Science. 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, with the rest being supported by the National Science Foundation (NSF). In FY 1994 it will maintain a research program that focusses on current problems of high scientific and technological interest and points 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 NSF 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. Special emphasis is placed on use of the completed South Hall Ring Experiment at the Massachusetts Institute of Technology and on the Tandem/AGS high energy heavy ion beams at Brookhaven National Laboratory (BNL) using the recently completed booster. Although the Holifield Heavy Ion Research Facility will remain closed for research through FY 1994, the existing accelerators will be reconfigured and upgraded to provide a Radioactive Ion Beam (RIB) Facility at Oak Ridge National Laboratory. In light of this changed mission, the management of RIB will be transferred to the Low Energy program, while operation of other national laboratory facilities at Argonne and Berkeley will be accommodated completely within the Heavy Ion program to more accurately reflect their actual programs.

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 states, and solar neutrino research. An important component is the role of university facilities in attracting young scientists, many of whom perform their research at off-campus user facilities. Detector projects include continuation of the segmented gamma ray detector for nuclear structure physics (Gammasphere) and the Sudbury Neutrino Observatory (SNO) project in joint participation with Canada and the United Kingdom. The Institute for Nuclear Theory, sited in FY 1990 at the University of Washington, will maintain its planned program with scientific research and the provision of theory workshops to enhance effective interaction within the nuclear physics community.

In FY 1994, the largest construction project in the Nuclear Physics program will be the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory with procurement of superconducting magnets as a major activity. Construction funding for CEBAF will be complete in FY 1995; the primary activities on the accelerator components will be final assembly and installation. There will be significant activity in the design and fabrication of experimental detectors for both facilities in FY 1994. These two accelerator projects received the highest priority for support in the NSAC Long Range Plan for Nuclear Science. Already, 325 physicists from 66 institutions have submitted 65 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 250 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 600 scientists from 70 universities and laboratories throughout the world. Two major detectors, STAR and PHENIX, have received tentative approval to begin design and construction, and international teams of scientists are working on each. Two smaller detectors will address specialized scientific questions.

Preparations for decommissioning the LAMPF facility at Los Alamos National Laboratory will begin in FY 1994, and will continue for the Bevalac at Lawrence Berkeley Laboratory which ceased operations in FY 1993. The ORELA facility at Oak Ridge National Laboratory will cease operations in support of the advanced reactor program.

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(Tabular dollars in thousands narrative in whole dollars)

LEAD TABLE

Nuclear Physics

Activity	FY 1992 Adjusted	FY 1993 Appropriation	FY 1993 Adjustment	FY 1994 Request
Operating Expenses				
Medium Energy Nuclear Physics	$100,434	$58,000 f/	-$550	$91,555
Heavy Ion Nuclear Physics	74,357	67,900	-650	67,400
Low Energy Nuclear Physics	26,958	26,100	-250	25,600
Nuclear Theory	13,989	14,800	-150	14,800
Capital Equipment	30,000	31,200 f/	-5,000	29,000
Construction	105,699	111,100	-2,400	93,990
TOTAL	$351,437	$309,100	-$9,000 g/	$322,345
Summary				
Operating Expenses	$215,738 a/c/d/	$166,800 f/	-$1,600	$199,355
Capital Equipment	30,000	31,200 f/	-5,000	29,000
Construction	105,699 c/e/	111,100	-2,400	93,990
Total Program	$351,437 b/	$309,100 f/	-$9,000	$322,345
Staffing (FTEs)	(Reference General Science Program Direction)			

Authorizations:

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

a/ Total has been reduced by $2,807,000 ($1,137,000 Medium Energy, $270,000 Heavy Ion, $1,400,000 Low Energy) reprogrammed to Energy Supply for SBIR.

b/ Reflects transfer of $215,000 to A&O for ES&H activities.

c/ Reflects reprogramming of $6,500,000 from CEBAF operating to CEBAF construction 92-R-13.

d/ Reflects reprogramming of $146,000 operating to Environmental Restoration and Waste Management 92-R-13.

e/ Reflects reprogramming of $1,852,000 from GPP Construction to Ultra High Vacuum Cleaning Facility Construction 92-R-13.

f/ Does not reflect $53,500,000 in Medium Energy operating expenses and $1,000,000 in Capital Equipment appropriated within AEDA for LAMPF operations and managed by ER.

g/ Reflects general reduction for use of prior year balances.

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

SUMMARY OF CHANGES

Nuclear Physics

FY 1993 Appropriation	$ 309,100
- Adjustment - General reduction for use of prior year balances	- 9,000
FY 1993 Adjusted	300,100 *
* Does not include $54,500 appropriated in Atomic Energy Defense Activities for LAMPF operations and managed by Energy Research making $354.6 million available for FY 1993 Nuclear Physics activities	+ 54,500
- Funding required to maintain a constant overall level of program activity	+ 6,062
Medium Energy Nuclear Physics	
- Terminate medium energy physics research and operations at the LAMPF facility and provide planned level of support for the CEBAF and MIT/BATES Laboratories	- 22,058
Heavy Ion Nuclear Physics	
- Conduct heavy ion research and operations at slightly reduced level of activity except for AGS. Complete preparations for decommissioning of Bevalac at LBL	- 1,464
Low Energy Nuclear Physics	
- Continue overall low energy operations and research and nuclear data program at slightly reduced level of activity, provide operations support for the Radioactive Ion Beam (RIB) project at ORNL, and terminate operation of ORELA at ORNL in support of Advanced Reactor Research	- 870

Nuclear Theory

- Maintain overall level of activity with continued support of the Institute of Nuclear Theory	- 201

Capital Equipment

- Increase in Nuclear Physics Instrumentation needed for CLAS Detector at CEBAF, Gammasphere Detector, and Sudbury Neutrino Observatory	+ 1,147

Construction

- Maintain level of effort for AIP and GPP	+ 539
- Continue Continuous Electron Beam Accelerator Facility (CEBAF) construction project at planned level	- 15,410
- Continue Relativistic Heavy Ion Collider (RHIC) construction project	0
FY 1994 Congressional Budget Request	**$ 322,345**

DEPARTMENT OF ENERGY
FY 1994 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 have been 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. Funds are provided to prepare the LAMPF for an orderly shutdown of Nuclear Physics operations in FY 1994. (In FY 1993, $54,500,000 was appropriated in AEDA for LAMPF operations.)

II. A. Summary Table: Medium Energy Nuclear Physics

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Research				
LAMPF-Based Research	$ 11,263	$ 1,266	$ 367	- 71
Bates Based Research	3,616	3,717	3,639	- 2
CEBAF-Based Research	11,725	14,709	16,291	+ 11
Research at Other Sites	11,730	10,888	13,048	+ 20
Subtotal, Research	$ 38,334	$ 30,580	$ 33,345	+ 9
Operations				
LAMPF Operations	$ 41,600	$ 0	$ 15,000	>999
Bates Operations	8,000	9,400	9,400	0
CEBAF Operations	12,200	17,070	33,810	+ 98
Other Operations	300	400	0	-100
Subtotal, Operations	$ 62,100	$ 26,870	$ 58,210	+117
Total, Medium Energy Nuclear Physics	$ 100,434	$ 57,450	$ 91,555	+ 59

II. B. Major Laboratory and Facility Funding

ARGONNE NATIONAL LABORATORY (EAST)	$ 2,811	$ 2,900	$ 3,000	+ 3
BROOKHAVEN NATIONAL LABORATORY	$ 2,100	$ 2,570	$ 2,170	- 16
CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY	$ 23,203	$ 28,070	$ 44,670	+ 59
LOS ALAMOS NATIONAL LABORATORY	$ 48,530	$ 1,600	$ 16,700	+944
PACIFIC NORTHWEST LABORATORY	$ 90	$ 0	$ 0	0
STANFORD LINEAR ACCELERATOR CENTER	$ 300	$ 0	$ 0	0

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

Program Activity	FY 1992	FY 1993	FY 1994
Medium Energy Nuclear Physics			
Research			
LAMPF-Based Research	Make use of the Medium Resolution Spectrometer (MRS) and the Neutron Time of Flight (NTOF) facility with beam from the high intensity polarized proton source. Use the energy spread compressor (scruncher) on the Low Energy Pion Channel (LEP) for experiments. Assemble new Neutral Meson Spectrometer (NMS). Prepare for carrying out and completing highest priority research studies in FY 1993.	Continue and complete planned highest priority research programs. Extract maximum information from the use of new detectors. Prepare for termination of Nuclear Physics operations at the end of fiscal 1993.	No activity.
	Develop new Liquid Scintillation Neutrino Detector (LSND). Plan use for neutrino-proton scattering and higher sensitivity neutrino oscillation studies. Prepare for carrying out and completing highest priority research studies in FY 1993.	Continue and complete planned highest priority research programs. Extract maximum information from the use of new detectors. Prepare for termination of Nuclear Physics operations at the end of fiscal 1993.	No activity.
	Do selected high mass studies of neutron-rich isotopes on the Time-of-Flight Isochronous Spectrometer Facility (TOFI). Investigate ways to improve intrinsic mass resolution to enable mass measurements of fission products. Prepare for carrying out and completing highest priority research studies in FY 1993.	Continue and complete planned highest priority research programs. Extract maximum information from the use of new detectors. Prepare for termination of Nuclear Physics operations at the end of fiscal 1993.	No activity.
	Complete partial detector and take data on the rare muon decay experiment, MEGA. The electron detector arm and two of the three photon detector arms will be complete. Prepare for carrying out and completing highest priority research studies in FY 1993.	Complete the full MEGA detector (electron arm and three photon arms) and continue data taking at maximum sensitivity. Continue and complete planned highest priority research programs. Extract maximum information from the use of new detectors. Prepare for termination of all Nuclear Physics operations at the end of fiscal 1993.	No activity.

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

Program Activity	FY 1992	FY 1993	FY 1994
LAMPF-Based Research (Cont'd)	Continue research program in nuclear structure and nuclear reactions with incident pions and protons. Prepare for carrying out and completing highest priority research studies in FY 1993.	Continue and complete planned highest priority research programs. Extract maximum information from the use of new detectors. Prepare for termination of all Nuclear Physics operations at the end of fiscal 1993.	No activity.
	The total for LAMPF-based research is derived as follows. Of the $6,930 medium energy research budget at LANL, $757 is for research carried out by LANL scientists at locations other than LAMPF, leaving $6,173 for in-house use of LAMPF. To this is added $5,090 of direct medium energy research funds to outside users for their LAMPF research programs.	Because the majority of LAMPF support has been transferred to the AEDA, only $1,266 of direct medium energy research funds are provided to outside users for their LAMPF programs. Additional support of $9,755 is provided by funds appropriated within AEDA and managed by ER.	The total for LAMPF-based research is derived as follows. Of the $1,700 medium energy research budget at LANL, all is for research carried out by LANL scientists at locations other than LAMPF. To this is added $367 of direct medium energy research funds to outside users for analysis of experiments that had been performed at LAMPF.
	$ 11,263	$ 1,266	$ 367
Bates Based Research	Suspend coincidence measurements program with polarized electron beams during installation of the South Hall Ring (SHR). Plan for new experiments to measure spin observables using the new focal plane polarimeter in the One-Hundred-Inch Proton Spectrometer (OHIPS). Begin testing components for future experiments with the SHR Experiment internal targets.	Continue coincidence measurements program with polarized electron beams. Emphasize measurement of spin observables. Begin using new out-of-plane detection techniques, polarized targets, and polarization detection capability. Begin performing experiments with the new SHR.	Continue coincidence measurement program with higher intensity polarized electron beams. Emphasize measurement of spin observables utilizing the new OHIPS focal plane polarimeter. Carry out measurements "out of the scattering plane" with new detector systems (OOPS) jointly developed with the National Science Foundation (NSF) at the University of Illinois. Begin phasing in experiments with the SHR polarized internal targets. An important experiment will be a measurement of the charge form factor of the neutron.

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

Program Activity	FY 1992	FY 1993	FY 1994
Bates Based Research (Cont'd)	Suspend high precision measurements with the Energy Loss Spectrometer System (ELSSY) in the North Hall while completing the South Hall Ring (SHR) installation.	Continue high precision measurements with ELSSY in the North Experimental Hall and increase level of research activities in the South Hall as the SHR Experiment installation is completed.	De-emphasize high precision measurements with ELSSY; experiments will continue on nuclear structure studies with high level densities. Begin full utilization of new SHR internal target capability and cw beam availability in the South Hall to undertake a new program of research studies.
	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.	Design and implement detector components which take advantage of internal targets and cw beam operation which is now available in the South Hall.
	The total for Bates-based research is derived as follows. Of the $3,573 medium energy research budget at MIT, $1,323 is for research carried out by MIT scientists at locations other than Bates, leaving $2,250 for in-house use of Bates. To this is added $1,366 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 $1,127 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 $3,637 medium energy research budget at MIT, $1,091 is for research carried out by MIT scientists at locations other than Bates, leaving $2,546 for in-house use of Bates. To this is added $1,093 of direct medium energy research funds to outside users for their Bates research programs.
	$ 3,616	$ 3,717	$ 3,639
CEBAF-Based Research	Carry out testing of North Linac components, arc magnets, and associated RF, cryogenic, and facility safety systems. Begin commissioning of approximately half of the North Linac.	Carry out testing of North and South Linac components, arc magnets, and associated RF, cryogenic and facility safety systems. Continue commissioning of North Linac and assembly of South Linac. Machine Control Center is staffed around the clock.	Continue final assembly and commissioning of entire accelerator facility and the beam switchyard which channels the electron beam to the three experimental Halls. Bring initial beam into Experimental Hall C for testing of experimental apparatus. Commence the experimental research program.

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

Program Activity	FY 1992	FY 1993	FY 1994
CEBAF-Based Research (Cont'd)	Utilize newly expanded 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 the Local Area Network (LAN). Modify system to handle inputs from all accelerator components leading to automated operation of the facility.	Utilize data acquisition system for testing of components and systems during accelerator assembly. Bring computer systems up to full capability for automated operation and querying of the thousands of inputs monitored for proper operation of the entire facility. Establish the on-line data acquisition capability for automated collection and analysis of data from experiments.
	Assemble and begin the 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 completed as soon as possible thereafter.	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 completed as soon as possible thereafter. In FY 1994, at an intermediate stage in commissioning, beam will be brought into experimental Hall C. At that time, Hall C equipment will be used to commence the CEBAF experimental research program.
	Continue superconducting research activities and strengthen theoretical efforts.	Continue superconducting research activities and strengthen theoretical efforts. Research by CEBAF scientific staff at other laboratories will be curtailed to concentrate on facility completion and preparation for experiments.	Continue superconducting research activities and strengthen theoretical efforts. CEBAF scientific staff is now almost completely involved in preparation for the CEBAF research program. First experiments get underway.

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

Program Activity	FY 1992	FY 1993	FY 1994
CEBAF-Based Research (Cont'd)	The total for CEBAF-based research is derived as follows. Of the $11,003 medium energy research budget at CEBAF, $770 is for research carried out by CEBAF scientists at locations other than CEBAF, leaving $10,233 for in-house use of CEBAF. To this is added $1,492 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 $4,479 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 $10,860 medium energy research budget at CEBAF, $760 is for research carried out by CEBAF scientists at locations other than CEBAF, leaving $10,100 for in-house use of CEBAF. To this is added $6,191 of direct medium energy research funds to outside users for their CEBAF research programs.
	$ 11,725	$ 14,709	$ 16,291
Research at Other Sites	Continue data taking phase and analysis of one of two approved experiments to search for the H-particle using the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL).	Complete data taking phase and continue analysis of the first H-particle search using the AGS at BNL. Begin second phase experiment which examines a different mass region.	Continue analysis of H-particle data from first experiment, take data on the second phase experiment which examines a different mass region.
	Support experiment NE-18 to search for "color transparency." NE-18 uses the Nuclear Physics Injector (NPAS) and End Station A at the Stanford Linear Accelerator Center (SLAC).	Carry out analysis of the NE-18 SLAC experiment. Prepare for experiment E-142 at SLAC to investigate the spin structure function of the neutron. E-142 should help solve the mystery of which of the sub-nuclear structures (quarks and gluons) carry the known spins of the nucleons.	Carry out experiment E-142 at SLAC to investigate the spin structure function of the neutron.
	Begin taking data on the spin structure function experiment using the muon beam at CERN. The 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. Upgrade experimental setup with improved polarized target.	Continue spin structure function experiment at CERN including analysis of data.
	Continue xenon-based double beta decay experiment in the St. Gotthard tunnel (Caltech/Neuchatel/PSI).	Conclude xenon based double beta decay experiment.	Analyze data from double beta decay experiment.

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

Program Activity	FY 1992	FY 1993	FY 1994
Research at Other Sites (Cont'd)	Establish full utilization of the Laser Electron Gamma Source (LEGS) facility at Brookhaven National Laboratory (BNL). Commence measurements of the delta resonance.	Utilize the LEGS facility at BNL. Continue experimental program with emphasis on measurement of the E2/M1 mixing ratio in the delta.	Utilize the LEGS facility at BNL. Continue experimental program and begin studies of hadron polarizabilities, particularly of the proton and the pion.
	Conduct program of selected nuclear physics experiments at other facilities including Fermilab, TRIUMF (Canada), Saclay (France), PSI (Switzerland), and NIKHEF (Netherlands).	Conduct program of selected nuclear physics experiments at other facilities including Fermilab, TRIUMF (Canada), Saclay (France), PSI (Switzerland), and NIKHEF (Netherlands).	Conduct program of selected nuclear physics experiments at other facilities including Fermilab, TRIUMF (Canada), Saclay (France), PSI (Switzerland), and NIKHEF (Netherlands).
	Funding in the amount of $1,137,000 has been transferred to the SBIR program.	Funding in the amount of $1,478,000 has been budgeted for the SBIR program.	Funding in the amount of $375,000 has been budgeted for the SBIR program.
	$ 11,730	$ 10,888	$ 13,048
Subtotal, Research	$ 38,334	$ 30,580	$ 33,345
Operations			
LAMPF Operations	Operate accelerator and facilities about 1900 hours for nuclear physics research with about seven secondary beams operating simultaneously.	Operate accelerator and facilities about 1900 hours for nuclear physics research with about seven secondary beams operating simultaneously, using funds appropriated within AEDA ($53,500,000), and managed by ER.	All Nuclear Physics operations are terminated. Carry out preparations for decommissioning and decontamination (D&D) to be complete in three years or more. Details and schedules of preparations for D&D will be determined in consultation with other elements of the Department of Energy. The planned D&D described here would not foreclose use of the facility for other DOE missions, such as a possible spallation neutron source.
	Provide beams for approximately 33 nuclear physics experiments involving about 270 scientists.	Provide beams for approximately 33 nuclear physics experiments involving about 270 scientists using funding appropriated within AEDA and managed by ER.	All Nuclear Physics operations are terminated.
	Operate with high intensity polarized ion source and polarized targets.	Operate with high intensity polarized ion source and polarized targets.	All Nuclear Physics operations are terminated.

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

Program Activity	FY 1992	FY 1993	FY 1994
LAMPF Operations (Cont'd)	$ 41,600	$ 0	$ 15,000
Bates Operations	Cease accelerator and facilities operations for nuclear physics research during assembly and initial testing of the new South Hall Ring.	Operate accelerator and facilities about 2000 hours for nuclear physics research during commissioning of the South Hall Ring. Experiments will include initial use of the new South Hall Ring.	Operate accelerator and facilities about 2000 hours for nuclear physics research utilizing the new internal target facility on the South Hall Ring, and the new cw electron beam capability.
	Provide no beam.	Provide beam for approximately 10 experiments involving about 100 scientists.	Provide beam for approximately 10 experiments involving about 100 scientists.
	Operate accelerator at 1 GeV for required tasks during selected operating cycles during the year. Inject beam into South Hall Ring.	Operate accelerator at 1 GeV for required experiments during selected operating cycles during the year. Modify electron injector and operate with circulating beam in South Hall Ring.	Operate upgraded accelerator at 1 GeV for required experiments during selected operating cycles during the year. Routinely inject electron beam into South Hall Ring and operate with circulating electron beams in the Ring. Extract external cw electron beams for experiments.
	Continue installation and testing of components for the South Hall Ring Experiment.	Complete installation and testing of components for the South Hall Ring. Complete installation of upgrades to Linac including a high intensity polarized electron gun.	No activity.
	$ 8,000	$ 9,400	$ 9,400
CEBAF Operations	Provides for startup of laboratory operations and accelerator commissioning. Operate and test sections of the full injector and the North Linac along with associated systems.	Provides 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 Helium Refrigerator, RF system, safety systems, beam monitors, and computer controls.	Provides 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 Helium Refrigerator, RF system, safety systems, beam monitors, and computer controls. Begin testing and operation of experimental equipment. Commence initial experimental research operations in Hall C.

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

Program Activity	FY 1992	FY 1993	FY 1994
CEBAF Operations (Cont'd)	$ 12,200	$ 17,070	$ 33,810
Other Operations	Provide low level of operations support of the Nuclear Physics Injector (NPI) at the Stanford Linear Accelerator Center (SLAC), and subsequently suspend operations of NPI.	Continue suspension of operation of NPI at SLAC. Provide operation support to the AGS.	Continue suspension of operation of NPI at SLAC. Terminate other operations support.
	$ 300	$ 400	$ 0
Subtotal, Operations	$ 62,100	$ 26,870	$ 58,210
Medium Energy Nuclear Physics	$ 100,434	$ 57,450	$ 91,555

DEPARTMENT OF ENERGY
FY 1994 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 nuclei and 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.

II. A. Summary Table: Heavy Ion Nuclear Physics

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Research				
LBL Relativistic Heavy Ion Research	$ 6,332	$ 6,490	$ 6,640	+ 2
BNL Tandem/AGS Research	10,060	10,250	9,570	- 7
National Laboratory Research	10,281	10,713	12,105	+ 13
University Research	9,753	11,060	12,425	+ 12
Subtotal, Research	$ 36,426	$ 38,513	$ 40,740	+ 6
Operations				
LBL Bevalac Operations	$ 17,545	$ 9,900	$ 6,000	- 39
BNL Tandem/AGS Operations	8,850	7,600	9,000	+ 18
University Accelerator Operations	2,135	2,267	2,705	+ 19
Other Operations (including ANL, LBL, ORNL)	9,401	8,970	8,955	0
Subtotal, Operations	$ 37,931	$ 28,737	$ 26,660	- 7
Total, Heavy Ion Nuclear Physics	$ 74,357	$ 67,250	$ 67,400	0

II. B. Major Laboratory and Facility Funding

	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
ARGONNE NATIONAL LABORATORY (EAST)	$ 6,902	$ 7,120	$ 9,365	+ 32
BROOKHAVEN NATIONAL LABORATORY	$ 18,910	$ 17,850	$ 18,570	+ 4
LAWRENCE BERKELEY LABORATORY	$ 28,487	$ 21,235	$ 19,005	- 11
LAWRENCE LIVERMORE NATIONAL LABORATORY	$ 230	$ 290	$ 290	0
LOS ALAMOS NATIONAL LABORATORY	$ 960	$ 960	$ 1,160	+ 21
OAK RIDGE NATIONAL LABORATORY	$ 6,980	$ 6,760	$ 3,480	- 49

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

Program Activity	FY 1992	FY 1993	FY 1994
Heavy Ion Nuclear Physics			
Research			
LBL Relativistic Heavy Ion Research	At the Bevalac, begin Time Projection Chamber (TPC) studies of multifragmentation and the nuclear equation of state at high densities and temperatures. With the Dilepton Spectrometer (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 the STAR 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 the STAR experiment at RHIC, including R&D efforts.	Conduct a research program consistent with the FY 1993 phaseout of Bevalac Operations. Work on analysis of Bevalac data, with emphasis on the important data obtained with the TPC and DLS detector systems. Continue intermediate energy studies investigating energy deposition, multifragmentation, and fusion processes at the 88" cyclotron, and elsewhere. Continue involvement in the CERN NA35/NA49 experiment by developing TPC electronics for the FY 1994 Lead (Pb) beam run. Improve support for the core group which provides leadership for the STAR detector at RHIC.
	$ 6,332	$ 6,490	$ 6,640

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

Program Activity	FY 1992	FY 1993	FY 1994
BNL Tandem/AGS Research	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 E878, as well as others. Continue RHIC R&D efforts at a level of about $7,000. 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 $7,200. Continue work directed towards designing, and implementing experiments at RHIC.	Continue relativistic heavy ion program at the BNL/AGS to investigate energy flow, nuclear stopping, strangeness and anti-particle production, and spatial-time evolution of reaction dynamics with Gold (Au) beams. Continue R&D directed at RHIC accelerator and detector projects at the level of $6,000. Increase support for efforts directed towards designing and implementing experiments at RHIC.
	$ 10,060	$ 10,250	$ 9,570
National Laboratory Research	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.	At ANL continue the ATLAS heavy ion program with emphasis on those studies exploiting the unique beam capabilities and instrumentation at that facility, in particular the measurements being performed with the FMA and APEX detector systems. Continue gamma-ray high-spin spectroscopy program both at ATLAS and with Gammasphere at LBL. Continue R&D activities directed at low-frequency superconducting RF cavities.

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

Program Activity	FY 1992	FY 1993	FY 1994
National Laboratory Research (Cont'd)	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.	At LBL continue the experimental program at the 88" cyclotron, including the high spin and transuranic nuclei studies. Continue measurements with the early implementation phase of Gammasphere to address physics questions of high priority. Emphasis will be placed on providing the needed support to assure timely completion of Gammasphere.
	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 ORNL continue the experimental program directed at nuclear structure with emphasis on utilization of large detector arrays, such as Gammasphere and studies with Radioactive Ion Beams (RIB's). Continue reaction mechanism study activities and in particular the measurements of energetic photons from highly excited nuclei. Continue relativistic heavy ion program by participation in the WA98 experiment at CERN using Lead (Pb) beams in FY 1994, and continuing R&D work and planning for the PHENIX detector 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.	At LANL continue involvement in the NA44 experiment at CERN, participating in data taking with Lead (Pb) beams in FY 1994 and in the analysis of previous data taken with sulfur and proton beams. Enhance R&D and planning activities associated with the PHENIX detector for RHIC.

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

Program Activity	FY 1992	FY 1993	FY 1994
National Laboratory Research (Cont'd)	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. Begin effort on nuclear structure studies with Gammasphere.	At LLNL continue participation in the E866 experiment at the BNL/AGS using Gold (Au) beams in FY 1994, and in the efforts on R&D and planning for the PHENIX detector for RHIC. Continue efforts directed at nuclear structure studies with Gammasphere.
	$ 10,281	$ 10,713	$ 12,105
University Research	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.	Continue strengthening university user research at national laboratory facilities where unique instrumentation, such as Gammasphere, and beams, such as relativistic heavy ions at the AGS, exist. At the upgraded university accelerators at Yale, University of Washington, and Texas A&M, the research program will continue to carry out 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 detector systems acquired and on improving the instrumentation available.
	Funding in the amount of $270,000 has been transferred to the SBIR program.	No activity.	Funding in the amount of $1,000,000 has been budgeted for the SBIR program.
	$ 9,753	$ 11,060	$ 12,425
Subtotal, Research	$ 36,426	$ 38,513	$ 40,740

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

Program Activity	FY 1992	FY 1993	FY 1994
Operations			
LBL Bevalac Operations	Continue facility operation for nuclear physics and biomedical research at about 2800 hours. Use full compliment of beamlines for program with Dilepton Spectrometer (DLS), the Equation of State (EOS) Time Projection Chamber (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 to initiate decommissioning activities.	Funds at the level of $4.0 million are provided for activities in preparation of decommissioning of the Bevalac facility. Funds are provided for continued R&D activities in support of the Nuclear Physics program.
	$ 17,545	$ 9,900	$ 6,000
BNL Tandem/AGS Operations	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 4 weeks of 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.	Conduct operations of Tandem/Booster AGS accelerator facility to provide at least 8 weeks of Gold (Au) beams for an experimental program. Provide support for implementation of gold beam experiments. Support RHIC test beam activities.
	$ 8,850	$ 7,600	$ 9,000
University Accelerator Operations	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	At the Yale tandem facility provide light heavy-ion beams for nuclear structure, astrophysics, and fundamental interaction studies. Fully support the Texas A&M superconducting cyclotron, with use of the Electron Cyclotron Resonance (ECR) ion source to produce heavy ion beams at low to intermediate energies for a program focussing on the properties of excited nuclei, fundamental interactions, and astrophysics.

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

Program Activity	FY 1992	FY 1993	FY 1994
University Accelerator Operations (Cont'd)	physics program and install and use new detector systems installed.	research program using newly installed experimental instrumentation.	
	$ 2,135	$ 2,267	$ 2,705
Other Operations (including ANL, LBL, ORNL)	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.	Support the ANL ATLAS facility to provide beams up to uranium in an enhanced running schedule for a research program which includes FMA and APEX measurements. Continue improvements to optimize the performance and reliability of ATLAS for heavy ion acceleration. At the LBL 88" Cyclotron provide beams in an enhanced running schedule of heavy ion beams for a research program which includes Gammasphere measurements. Continue R&D on the Advanced ECR ion source.
	$ 9,401	$ 8,970	$ 8,955
Subtotal, Operations	$ 37,931	$ 28,737	$ 26,660
Heavy Ion Nuclear Physics	$ 74,357	$ 67,250	$ 67,400

DEPARTMENT OF ENERGY
FY 1994 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; 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 primary goal the compilation, evaluation and dissemination of an accurate, complete, and accessible nuclear data information base. A secondary goal is measurement of critical quantities. Nuclear standards are developed having commonality to several nuclear sub-disciplines such as metrology standards related to nuclear waste management, reactor safety, and nuclear medicine. Lastly, neutron cross section measurements are performed that address the needs of the DOE nuclear technologies, which include: nuclear waste management, biomedical and environmental applications of radioactive materials, fusion energy and fundamental nuclear research.

II. A. Summary Table: Low Energy Nuclear Physics

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Research				
Research at University Facilities	$ 3,168	$ 3,290	$ 2,967	- 10
Research at National Laboratory Accelerators	3,337	3,425	2,855	- 17
Research at Reactors	965	1,215	1,070	- 12
Other Research	4,631	5,296	6,433	+ 21
Subtotal, Research	$ 12,101	$ 13,226	$ 13,325	+ 1
Operations				
Accelerator Operations	$ 3,346	$ 3,559	$ 5,060	+ 42
Subtotal, Operations	$ 3,346	$ 3,559	$ 5,060	+ 42
Nuclear Data				
Nuclear Data Measurements	$ 6,821	$ 4,350	$ 2,365	- 46
Nuclear Data Compilation and Evaluation	4,690	4,715	4,850	+ 3
Subtotal, Nuclear Data	$ 11,511	$ 9,065	$ 7,215	- 20
Total, Low Energy Nuclear Physics	$ 26,958	$ 25,850	$ 25,600	- 1

II. B. Major Laboratory and Facility Funding

ARGONNE NATIONAL LABORATORY (EAST)	$ 2,976	$ 2,545	$ 810	- 68
BROOKHAVEN NATIONAL LABORATORY	$ 4,076	$ 3,320	$ 3,420	+ 3
IDAHO NATIONAL ENGINEERING LABORATORY - EG&G	$ 350	$ 360	$ 355	- 1
LAWRENCE BERKELEY LABORATORY	$ 2,723	$ 2,930	$ 2,370	- 19
LAWRENCE LIVERMORE NATIONAL LABORATORY	$ 355	$ 265	$ 300	+ 13
LOS ALAMOS NATIONAL LABORATORY	$ 1,926	$ 1,675	$ 1,705	+ 2
OAK RIDGE NATIONAL LABORATORY	$ 5,670	$ 3,350	$ 4,990	+ 49

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

Program Activity	FY 1992	FY 1993	FY 1994
Low Energy Nuclear Physics			
Research			
Research at University Facilities	At Texas A&M, begin the development of specialized equipment and detectors that focus on properties of excited nuclei; 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, emphasis will be on giant resonance studies using new detectors. 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.	At TUNL, work emphasizes tests of fundamental symmetries. This includes searches for quantum systems which display chaotic behavior, charge symmetry breaking and additional evidence of parity violation in the nucleus. At the University of Washington use the 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 University, support is provided for activities associated with giant resonance studies and nuclear astrophysics.
	$ 3,168	$ 3,290	$ 2,967
Research at National Laboratory Accelerators	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.	Continue low energy research at three of the national laboratories. At ORNL, continue development of the Radioactive Ion Beam facility and associated research. At ANL, research into the structure of nuclei far from stability will continue with the use of the recoil mass separator (RMS); at LBL the main effort will be devoted to the Sudbury Neutrino Observatory (SNO) collaboration (described below under Other Research). At BNL and LBL, developmental efforts will address issues associated with producing and handling beams of unstable nuclei.
	$ 3,337	$ 3,425	$ 2,855

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

Program Activity	FY 1992	FY 1993	FY 1994
Research at Reactors	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.	Continue both the BNL nuclear structure research and the fundamental neutron measurements at the NIST. At BNL, use the TRISTAN on-line isotope separator at the HFBR to study isotopes of interest to nuclear astrophysics problems. Continue studies of isotopes important to safety related issues such as emergency core cooling and reactor decay heat calculations. Access to isotopes important to both of these categories will be improved with the possible upgrade of the TRISTAN on-line isotope separator by locating the ion source nearer to the reactor core and thereby gaining a factor of thirty in intensity of the separated beams. At the NIST cold neutron beam facility, continue studies of time reversal symmetry violation.
	$ 965	$ 1,215	$ 1,070
Other Research	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	Continue support for international collaborations in solar neutrino research, the Sudbury Neutrino Observatory (SNO), the Gallium Experiment (GALLEX) and the Soviet-American Gallium Experiment (SAGE) projects. For the SNO project: the Univ. of Penn. has major responsibility for optimization of the many thousands of photomultipliers and the development and acquisition of photomultiplier tube bases, signal processing electronics, and software organization; LANL has major responsibilities for R&D on the large acrylic vessel for the 1,000 tons of heavy water, and for acquisition of photomultipliers and computer hardware; LBL, for fabrication of a critical radioactive-free photomultiplier support structure. At BNL, the nuclear

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

Program Activity	FY 1992	FY 1993	FY 1994
Other Research (Cont'd)		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, a calibration using a Cr-51 source is completed, and early results are published.	chemistry aspects of GALLEX will be supported by the involvement of their nuclear chemists, including development of a Cr-51 calibration source.
	Funding in the amount of $1,100,000 has been transferred to the SBIR program.	Funding in the amount of $600,000 has been budgeted for the SBIR program.	Funding in the amount of $1,615,000 has been budgeted for the SBIR program.
	$ 4,631	$ 5,296	$ 6,433
Subtotal, Research	$ 12,101	$ 13,226	$ 13,325
Operations			
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 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.	Fully support two university accelerator facilities located at Duke University and the Univ. of Washington. Operations support of the superconducting cyclotrons at Texas A&M will be provided by the heavy ion program. Provide operations support for the Radioactive Ion Beam (RIB) project at ORNL.
	$ 3,346	$ 3,559	$ 5,060
Subtotal, Operations	$ 3,346	$ 3,559	$ 5,060

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

Program Activity	FY 1992	FY 1993	FY 1994
Nuclear Data			
Nuclear Data Measurements	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 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.	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 encourage 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 ANL/Fast Neutron Generator. Introduce other cost saving measures to lower funding profile. At LANL, $195,000 of additional funds appropriated within AEDA and managed by ER are provided for neutron induced reactor measurement at WNR/LAMPF.	Based on priorities set by DOE's Nuclear Advisory Committee's (NSAC's) study of National Nuclear Data Needs in the 1990's (NNDN-90), strengthen high priority components and phase out or consolidate lower priority components. Strengthen the university based measurements of priority cross-sections for higher energy neutrons and charged particles. Address issues important to several segments of the DOE nuclear data user community such as measurements important to the decay heat problem, nuclear reaction cross section measurements important to nuclear astrophysics, and standards used in waste management, and nuclear medicine. Cease activities associated primarily with advanced reactor research. This includes terminating the operation of ORELA at ORNL in support of advanced reactor research.
	Funding in the amount of $300,000 has been transferred to the SBIR program.	No activity.	No activity.
	$ 6,821	$ 4,350	$ 2,365

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

Program Activity	FY 1992	FY 1993	FY 1994
Nuclear Data Compilation and Evaluation	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 prepare for discontinuance of hard copy Nuclear Data Sheets. Support expansion of electronic data bases as vehicles for timely and cost effective compilation and dissemination of assessed nuclear properties. Address assessed cross section code files at LLNL.	Using the results of the NNDN-90's review, the National Academy of Science's Nuclear Data Compilation Panel and the Nuclear Structure Evaluation Working Group, strengthen the structure component of the program that is developing electronic data access and assessment capabilities. This will include revising the compilation and evaluation activities to improve nuclear data libraries, and their accessibility. Support activities with respect to modernization and coordination of the nuclear structure data information system including replacement with more effective electronic data dissemination techniques. 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 the IAEA international Nuclear Data efforts. Address cross section code files and modernization of national data, networking at BNL, LANL, LBL, and LLNL.
	No activity.	Funding in the amount of $100,000 has been budgeted for the SBIR program.	No activity.
	$ 4,690	$ 4,715	$ 4,850
Subtotal, Nuclear Data	$ 11,511	$ 9,065	$ 7,215
Low Energy Nuclear Physics	$ 26,958	$ 25,850	$ 25,600

DEPARTMENT OF ENERGY
FY 1994 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 constituent 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 prerequisite for a description of the material foundations of the universe, including astrophysics phenomena such as the formation of the elements in stars and supernovae. Nuclear theory research at universities and national laboratories entails individual efforts that transcend subcategories of nuclear physics. Much of nuclear theory requires extensive use of supercomputer capabilities.

II. A. Summary Table: Nuclear Theory

Program Activity	FY 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Nuclear Theory	$ 13,989	$ 14,650	$ 14,800	+ 1
Total, Nuclear Theory	$ 13,989	$ 14,650	$ 14,800	+ 1

II. B. Major Laboratory and Facility Funding

ARGONNE NATIONAL LABORATORY (EAST)	$ 1,090	$ 855	$ 950	+ 11
BROOKHAVEN NATIONAL LABORATORY	$ 1,205	$ 1,130	$ 1,130	0
CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY	$ 130	$ 135	$ 135	0
LAWRENCE BERKELEY LABORATORY	$ 1,085	$ 955	$ 1,000	+ 5
LOS ALAMOS NATIONAL LABORATORY	$ 1,105	$ 425	$ 800	+ 88
OAK RIDGE NATIONAL LABORATORY	$ 945	$ 800	$ 815	+ 2

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

Program Activity	FY 1992	FY 1993	FY 1994
Nuclear Theory			
Nuclear Theory	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 further 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, 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 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, 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. $500,000 of additional support for the theory program at LANL is provided by funds appropriated within AEDA and managed by ER.	Operate the Institute for Nuclear Theory at the University of Washington (Seattle) as a focus center for the development of forefront basic research programs in theoretical nuclear physics. Maintain the present level of effort at the institute and continue to support interaction with the nuclear physics community by providing study groups and long-term workshops in critical research areas. Support initiatives which enhance the mutual interaction and stimulation between theory programs at national laboratories and the university programs, (in part in collaboration with the USDOE High Performance Computing and Communications Program). Support those efforts which provide a strong theoretical support to the highest priority programs in Nuclear Physics, including the Continuous Electron Beam Accelerator Facility (CEBAF), the Relativistic Heavy Ion Collider (RHIC), and the GAMMASPHERE multi-detector array. These programs should lead 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. They will require the development of theories that address the description of nuclei in terms of the underlying quark-gluon substructure of nuclear matter, and of phase transitions in nuclear matter.

III. Nuclear Theory (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Nuclear Theory (Cont'd)	No activity.	Funding in the amount of $300,000 has been budgeted for the SBIR program.	No activity.
	$ 13,989	$ 14,650	$ 14,800
Nuclear Theory	$ 13,989	$ 14,650	$ 14,800

DEPARTMENT OF ENERGY
FY 1994 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 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
CEBAF	$ 5,400	$ 9,100	$ 8,300	- 9
BNL	3,075	1,940	1,940	0
LBL	3,320	1,355	1,250	- 8
LANL	4,121	40	1,225	>999
MIT/Bates	1,725	1,450	1,500	+ 3
ANL	1,115	770	1,000	+ 30
ORNL	1,500	992	1,100	+ 11
University Laboratories and User Groups	803	2,000	2,100	+ 5
Sudbury Neutrino Observatory	2,701	3,001	3,362	+ 12
Gammasphere	4,300	3,000	3,900	+ 30
Lawrence Berkeley Laboratory - GPE	1,700	1,870	1,870	0
Other	240	682	1,453	+113
Total, Capital Equipment	$ 30,000	$ 26,200	$ 29,000	+ 11

II. B. Major Laboratory and Facility Funding

ARGONNE NATIONAL LABORATORY (EAST)	$ 1,115	$ 770	$ 1,000	+ 30
BROOKHAVEN NATIONAL LABORATORY	$ 3,075	$ 1,940	$ 1,940	0
CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY	$ 5,400	$ 9,100	$ 8,300	- 9
LAWRENCE BERKELEY LABORATORY	$ 11,520	$ 6,525	$ 7,810	+ 20
LOS ALAMOS NATIONAL LABORATORY	$ 4,421	$ 2,575	$ 3,590	+ 39
OAK RIDGE NATIONAL LABORATORY	$ 1,500	$ 992	$ 1,100	+ 11

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

Program Activity	FY 1992	FY 1993	FY 1994
Capital Equipment			
CEBAF	Continue procurement of components for the High Resolution Hadron Spectrometer in Hall A, including support frame and floor plates. Continue procurement of components for the CEBAF Large Acceptance Spectrometer (CLAS) in Hall B, including the superconducting toroidal magnet, the drift chamber system, and the electromagnetic calorimeter. Procure general use equipment for the CEBAF facility such as equipment for the computer center, laboratories, offices, and shops.	Complete procurement of components for the High Resolution Hadron Spectrometer in Hall A, including parts for the detector system. Continue procurement of components for CLAS in Hall B, including the superconducting toroidal magnet, the drift chamber system, the electromagnetic calorimeter, scintillation detectors, and photon tagging system. Procure general use equipment for the CEBAF facility such as equipment for the computer center, laboratories, offices, and shops.	Continue procurement of components for the CEBAF Large Acceptance Spectrometer (CLAS) in Hall B, at the same level as FY 1993. These include the superconducting toroidal magnet, the drift chamber system, and the electromagnetic calorimeter. This spectrometer will provide data on reactions with multiple particle final states, which would be impossible to obtain with any combination of conventional magnetic spectrometers. Large solid angle coverage is CLAS's most important feature, but its major cost driver. Procure general use equipment for the CEBAF facility such as equipment for the computer center, laboratories, offices, and shops.
	$ 5,400	$ 9,100	$ 8,300
BNL	Continue construction of several AGS heavy ion experiments that will use the gold beam now available from the Booster Synchrotron at the AGS. In particular, experiment E866 utilizes the single-arm magnetic spectrometer system originally built for E802, but requires a second forward spectrometer as well as a new tracking system for the higher rates and multiplicities. Experiments E877, a continuation of E814, has a new silicon multiplicity detector and a new upstream TOF wall. Provide funding for a dedicated test beam line for RHIC detector R&D.	Complete construction of experiments E866, E877 and E878 which are fashioned to utilize the AGS gold beam. Complete construction of the dedicated test beam for RHIC detector R&D. At LEGS, start construction of the NaI array for the XTAL BOX, which is essential for the experiments on the polarizability of the pion.	Continue implementation of experimental systems to take advantage of the unique gold beam from the AGS. Nuclear reactions with the gold beam present very rewarding and exciting physics opportunities, but also present major experimental difficulties. There are about four times as many particles produced (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, finish construction of the NaI array for the experiments on the polarizability of the pion.
	$ 3,075	$ 1,940	$ 1,940

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
LBL	Begin fabrication of innovative read-out electronics for the time projection chamber (TPC) of CERN lead beam experiment NA49. The design and construction of this electronics by LBL serves as a full scale test of the electronics needed for the TPC of the RHIC STAR detector. The NA49 experiment will study the high energy density baryon-rich environment generated by lead beams which are appreciably stopped in nuclear matter. Complete construction of the Equation of State (EOS) experiment at the Bevalac and begin initial experiments. This experiment uses a TPC with LBL-developed read-out electronics for the pad plane.	Continue fabrication of the read-out electronics for the CERN lead beams experiment NA49. Construct a high performance data analysis center for processing data tapes from the EOS TPC at the Bevalac and CERN lead beam experiment NA49. Provide equipment for on-going research needs of internal and external programs, and for operation of the 88-Inch Cyclotron.	Complete fabrication of the read-out electronics for the CERN lead beams experiment NA49. Continue to develop the TPC data analysis center. The analysis center (using high-speed, closely-coupled RISC-based computer processors) must be capable of processing large numbers of events which require expensive pattern recognition and 3-dimensional viewing. Begin construction of auxiliary detector systems for use with Gammasphere, such as particle detectors and a prototype for an inner ball for gamma-ray detection.
	$ 3,320	$ 1,355	$ 1,250
LANL	Complete construction of the Neutral Meson Spectrometer (NMS), providing a factor of ten improvement in energy resolution and a doubling of solid angle over the existing pi-zero spectrometer. Begin commissioning of the NMS and make measurements of pion single charge exchange on the deuteron and proton. Improve LAMPF data analysis system by adding eight millimeter tape storage and high capacity intermediate disk storage in counting houses to avoid network overload. Upgrade the accelerator control system by adding an ethernet-connected work station at the injector for use as a control console.	Construct a calibration experiment for the SAGE solar neutrino observatory at Baksan using a chromium-51 source. An additional amount of $1,000,000 is provided for capital equipment needs at LAMPF by funds appropriated within AEDA and managed by ER.	Begin construction of an additional detector system for the Sudbury Neutrino Observatory that will permit real-time measurement of free neutrons produced by solar neutrinos that interact with the heavy water through the neutral current interaction.
	$ 4,121	$ 40	$ 1,225

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
MIT/Bates	Continue procurement of equipment for the South Hall Ring Experiment (SHRE), including control system hardware, readout electronics packages for x-y monitors, lutes, toroids, and synchrotron light monitors. Procure equipment for polarized and cryogenic targets. Complete construction of the focal-plane polarimeter for OHIPS spectrometer by purchasing the remainder of the wire chamber readout system.	Complete procurement of equipment for the SHRE. Provide jointly with the National Science Foundation funds for construction of the support frame for the Out of Plane Spectrometer (OOPS). OOPS will permit measurement of interference structure functions in coincidence electron scattering experiments.	Provide for upgrade of detectors and associated electronics to utilize the high duty cycle beam available from the SHRE. Complete construction of the OOPS support frame. Provide hardware for upgrading the linear accelerator.
	$ 1,725	$ 1,450	$ 1,500
ANL	Provide equipment for on-going research needs and accelerator operations at ATLAS. Provide for construction by the medium energy group of polarized internal gas targets for electron and proton scattering experiments. Provide equipment for the maintenance of the Fast Neutron Generator used by the nuclear data measurements program.	Provide equipment for on-going research needs and accelerator operations at ATLAS, for construction of polarized internal gas targets used by the medium energy group, and modest improvements to the APEX experiment.	Provide improvements to the APEX and Fragment Mass Analyzer (FMA) detector systems which take advantage of recent technical advancements. APEX is studying positron production in collisions of very heavy nuclei in order to explore the origin of unexplained sharp lines in the observed spectra. Provide double-sided silicon strip focal-plane detector for the FMA. This will permit the FMA to detect recoiling nuclei in extremely weak reaction channels and to perform experiments with high Z elements where fission dominates.
	$ 1,115	$ 770	$ 1,000
ORNL	Procure equipment, including a mass separator system, for development studies on generation of radioactive ion beams (RIB). Construct a highly-integrated electronic readout system for a 10,000-element lead-glass photon detector for CERN experiment WA93. Procure Holifield accelerator and ORELA maintenance items.	In preparation for research using RIB ion beams, procure components for the RMS beam line and the RMS focal plane detector. Continue construction of electronic readout system for lead-glass photon detector for CERN experiment WA93. Procure Holifield and ORELA maintenance items.	In preparation for research using RIB ion beams, procure components for the RMS beam line and the RMS focal plant detector. Provide equipment for the Holifield accelerator operations. Complete construction of electronic readout system for lead-glass photon detector for CERN experiment WA93.
	$ 1,500	$ 992	$ 1,100

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
University Laboratories and User Groups	Continue upgrade of instrumentation at university laboratories. Construct experimental equipment as follows: Texas A&M University (magnetic spectrometer upgrade, computer facility upgrade), TUNL (improvements to atomic beam polarized source, upgrading of magnetic spectrograph, particle detectors), University of Washington (high-capacity RISC workstations for relativistic heavy ion research), and Yale University (upgrades of data acquisition system and beam bunching and pulsing system).	Continue instrumentation initiative at university accelerator laboratories to increase amount of available experimental equipment. Yale University will likely begin construction of experiment E864 which will use the AGS gold beam at BNL. This experiment will search with very high sensitivity for novel forms of matter produced in high energy heavy ion collisions.	Continue upgrade of equipment at university laboratories, providing such items as detectors, data acquisition and analysis systems, ion sources, and accelerator components. Continue at Yale University the probable construction of the strangelet experiment E864 at the BNL AGS. Discovery of strange quark matter systems (strangelets) would have major impact on physics, astrophysics and cosmology.
	$ 803	$ 2,000	$ 2,100
Sudbury Neutrino Observatory	Continue procurement, delivery and testing of the 10,000 photomultiplier tubes (PMT) needed for the Sudbury Neutrino Observatory (SNO). Begin construction of the 55-foot diameter geodesic support frame for the PMTs.	Continue procurement, delivery and testing of the 10,000 photomultiplier tubes. Begin installation of the PMT support frame at the 6800 foot level of the Creighton mine in Sudbury.	Complete installation of PMT support frame in the Creighton mine. Install the 10,000 photomultiplier tubes on the support frame in preparation for start of the heavy water fill in the spring of 1995. 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, in particular neutrino oscillations. The U.S. share of the detector project is $11.9 million in actual year dollars. The entire SNO project has a capital cost estimate of about $50 million and will make use of a valuable store of 1,000 tons of extra pure Canadian heavy water loaned to the project by the Atomic Energy Commission of Canada.
	$ 2,701	$ 3,001	$ 3,362

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Gammasphere	Continue detailed design and construction of Gammasphere. Sign contract for manufacture of the germanium and BGO detector modules. Fabricate the hemispherical support frame and design the specialized electronics.	Continue construction of Gammasphere, receiving delivery of approximately 50 of the 110 planned detector modules. Begin first physics use in March 1993 with about 30 detectors, and temporary electronics and computer system.	Continue construction of Gammasphere, receiving delivery of approximately 30 more detector modules. Complete construction of final data acquisition and computer system. Gammasphere is 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. The system consists of 110 large Compton-suppressed germanium detectors. The instrument can 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 will be sited initially at Lawrence Berkeley Laboratory's 88-Inch Cyclotron facility. Gammasphere has an total estimated cost (TEC) of $17.7 million in actual year dollars.
	$ 4,300	$ 3,000	$ 3,900
Lawrence Berkeley Laboratory - GPE	Provide general purpose equipment at Lawrence Berkeley Laboratory, for which the Nuclear Physics program has landlord responsibility, 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	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	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

III. Capital Equipment (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Lawrence Berkeley Laboratory - GPE (Cont'd)	Engineering Division.	drafting plotters, equipment to develop programmable logic arrays, radioactive waste compactor, solvent recycler, and whole body counter.	drafting plotters, equipment to develop programmable logic arrays, radioactive waste compactor, solvent recycler, and whole body counter.
	$ 1,700	$ 1,870	$ 1,870
Other	Provide equipment for smaller programs at other national laboratories (INEL, LLNL, SLAC) including portions of the nuclear data measurements program.	Provide equipment for some participants of the nuclear data measurements program, more rapid completion of selected experimental systems in the medium energy or heavy ion research program.	Provide equipment for some participants of the nuclear data measurements program, more rapid completion of selected experimental systems in the medium energy or heavy ion research program.
	$ 240	$ 682	$ 1,453
Capital Equipment	$ 30,000	$ 26,200	$ 29,000

DEPARTMENT OF ENERGY
FY 1994 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 1992 Enacted	FY 1993 Enacted	FY 1994 Request	% Change
Continuous Electron Beam Accelerator Facility (CEBAF)	$ 48,300	$ 32,000	$ 16,590	- 48
Relativistic Heavy Ion Collider (RHIC)	49,350	70,000	70,000	0
Ultrahigh Vacuum Cleaning Facility	1,852	0	0	0
Accelerator Improvements and Modifications	4,100	3,200	3,800	+ 19
General Plant Projects	2,097	3,500	3,600	+ 3
Total, Construction	$ 105,699	$ 108,700	$ 93,990	- 14

II. B. Major Laboratory and Facility Funding

ARGONNE NATIONAL LABORATORY (EAST)	$ 400	$ 300	$ 300	0
BROOKHAVEN NATIONAL LABORATORY	$ 50,600	$ 71,300	$ 71,300	0
CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY	$ 48,300	$ 32,000	$ 16,599	- 48
LAWRENCE BERKELEY LABORATORY	$ 4,050	$ 3,655	$ 3,555	- 3
LOS ALAMOS NATIONAL LABORATORY	$ 219	$ 0	$ 0	0
OAK RIDGE NATIONAL LABORATORY	$ 600	$ 800	$ 1,000	+ 25

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

Program Activity	FY 1992	FY 1993	FY 1994
Construction			
Continuous Electron Beam Accelerator Facility (CEBAF)	Install North Linac and begin pre-operational check out. Begin assembly of South Linac. Complete accelerator control software. Complete installation of accelerator and end station cryogenic transfer lines. Complete end station construction and begin installation of experimental equipment.	Continue operational checkout of North linac and assembly of South linac. Complete RF system. Complete installation of beam switchyard magnets and power supplies. Commission cryogenic control system. Continue installation of experimental equipment.	Complete civil construction. Complete accelerator and begin commissioning. Start beam delivery to experimental Hall C and physics operation.
	$ 48,300	$ 32,000	$ 16,590
Relativistic Heavy Ion Collider (RHIC)	Continue construction of RHIC with main emphasis on procurement of superconducting dipole, quadrupole and sextupole magnets for the accelerator arcs. Complete preliminary design of the major detectors.	Continue construction 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. Start conventional construction work. Initiate detailed design of major detectors and begin procurement of long-lead detectors components such as spectrometer magnets.	Continue installation of first sextant of collider ring magnets. Continue construction and installation of superconducting magnets for the accelerator arcs. Continue procurement of components for cryogenic piping and power supplies. Continue conventional construction work. Continue long-lead procurement activities on detector systems.
	$ 49,350	$ 70,000	$ 70,000
Ultrahigh Vacuum Cleaning Facility	Funds were provided to LBL to eliminate an existing plating shop and construct an Ultrahigh Vacuum Cleaning Facility for the Advanced Light Source.	No activity.	No activity.
	$ 1,852	$ 0	$ 0
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.	Lower level of activity resulting from phase out of Bevalac operations.	Increased level of activity due to requirements at the Radioactive Ion Beam facility at ORNL and the MIT/Bates Linear Accelerator Center.

III. Construction (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Accelerator Improvements and Modifications (Cont'd)	$ 4,100	$ 3,200	$ 3,800
General Plant Projects	Essential additions, modifications, and improvement on an annual basis to maintain safety and effectiveness of general laboratory plant and support facilities.	Approximately same level of effort as FY 1992.	Approximately same level of effort as FY 1993.
	$ 2,097	$ 3,500	$ 3,600
Construction	$ 105,699	$ 108,700	$ 93,990

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
(Changes from FY 1993 Congressional Budget Request are denoted with a vertical line in left margin.)

OFFICE OF ENERGY RESEARCH
GENERAL SCIENCE AND RESEARCH
Nuclear Physics
(Tabular dollars in thousands. Narrative material in whole dollars.)

IV. A. Construction Funded Project Summary

Project No.	Project Title	Previous Obligations	FY 1993 Appropriated	FY 1994 Request	Unappropriated Balance	TEC
GPE-300	General Plant Projects, Various Locations	$ ---	$ ---	$ 3,600	$ 0	$ 3,600
94-G-302	Accelerator Improvements and Modifications, Various Locations	---	---	3,800	0	3,800
91-G-300	Relativistic Heavy Ion Collider, BNL	62,850	70,000	70,000	274,400	477,250
87-R-203	Continuous Electron Beam Accelerator Facility, CEBAF	263,610	32,000	16,590	1,000	313,200
Total, Nuclear Physics Construction		$ 326,460	$ 102,000	$ 93,990	$ 275,400	$ 797,850

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project GPE-300, General Plant Projects
Various locations

TEC: $3,600
TPC: $3,600

Start Date: 2nd Qtr. FY 1994 Completion Date: 2nd Qtr. FY 1996

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Obligations	Costs
1994	$ 3,600	$ 3,600	$ 1,300
1995		0	1,800
1996		0	500

3. Narrative: 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.

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.

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 1994 funding for the various locations:

Lawrence Berkeley Laboratory	$ 3,355
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	245
Total Estimated Cost.....	$ 3,600

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994 Request
Construction	XXXX	$2,097	$3,500	$3,600

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project 94-G-302, Accelerator Improvements and Modifications — TEC: $ 3,800
Various locations — TPC: $ 3,800

Start Date: 2nd Qtr. FY 1994 Completion Date: 2nd Qtr. FY 1996

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Obligations	Costs
1994	$ 3,800	$ 3,800	$ 2,400
1995	0	0	1,100
1996	0	0	300

3. Narrative: 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.

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 1994 funding for the various locations:

Argonne National Laboratory	$ 300
Brookhaven National Laboratory (AGS/Tandem)	1,300
Lawrence Berkeley Laboratory	200
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	1,000
Oak Ridge National Laboratory	1,000
Total Estimated Costs.....	$ 3,800

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994 Request
Construction	XXXX	$4,100	$3,200	$3,800

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project 91-G-300, Relativistic Heavy Ion Collider, Brookhaven National Laboratory — TEC: $ 477,250, TPC: $ 597,550

Start Date: 2nd Qtr. FY 1991 — Completion Date: 2nd Qtr. FY 1999

2. Financial Schedule (Federal Funds): a/

Fiscal Year	Appropriation	Adjustments	Obligations	Costs
1991	$ 15,000	- 1,500 b/	$ 13,500	$ 6,000
1992	49,350		49,350	23,265
1993	71,400	- 1,400 c/	70,000	77,000
1994	70,000		70,000	80,000
1995	70,000		70,000	75,000
1996	70,000		70,000	75,000
1997	65,000		65,000	64,000
1998	57,000		57,000	59,000
1999	12,400		12,400	17,985

a/ For consistency with Departmental accounting system, the Appropriations, Obligations, and Costs for fiscal years prior to 1993 have been changed from amounts on the last data sheet.
b/ Reflects the reduction of funds resulting from the FY 1991 sequester and general reduction.
c / Application of a portion of the FY 1993 General Science and Research general reduction of $30,000,000 for use of prior year balances.

3. Narrative: Due to the proposed decrease in FY 1994 funding, the completion date for the project has been delayed from the fourth Quarter of FY 1997 to the second Quarter of FY 1999 resulting in an increase in the TEC and TPC. The TEC has been increased from $406,600,000 to $477,250,000. The TPC has been increased from $509,400,000 to $597,550,000. 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.

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.

Construction of RHIC will proceed in an expeditious manner, consistent with available funds. FY 1994 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. Continue major construction activities on detector systems.

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994 Request	To Complete
Construction	$13,500	$49,350	$70,000	$70,000	$274,400
Capital Equipment	0	0	0	0	0
Operating Expenses	28,064	7,000	7,200	6,000	72,036

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project 87-R-203, Continuous Electron Beam Accelerator Facility, Newport News, Virginia — TEC: $313,200 TPC: $514,946

Start Date: 2nd Qtr. FY 1987 Completion Date: 1st Qtr. FY 1995

2. Financial Schedule (Federal Funds): a/

Fiscal Year	Appropriation	Adjustments	Obligations	Costs
1987	$ 16,200		$ 16,200	$ 7,842
1988	33,500		33,500	41,858
1989	44,500		44,500	29,086
1990	65,000	- 2,389 b/	62,611	53,441
1991	65,000	- 6,501 c/	58,499	53,595
1992	41,800	+ 6,500 d/	48,300	59,469
1993	33,000	- 1,000 e/	32,000	41,300
1994	16,590		16,590	24,700
1995	1,000		1,000	1,909

a/ For consistency with Departmental accounting system, the Appropriations, Obligations, and Costs for fiscal years prior to 1993 have been changed from amounts on the last data sheet.
b/ Reflects the sequester of funds and distribution of general reduction for FY 1990.
c/ Reflects the sequester of funds and distribution of general reduction for FY 1991.
d/ Reflects reprogramming of $6,500,000 from other project costs (operating expenses) relating to this project to the other construction costs. (92-R-13)
e/ Application of a portion of the FY 1993 General Science and Research general reduction of $30,000,000 for use of prior year balances.

3. Narrative: 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.

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.

Construction of CEBAF will continue in an expeditious manner, consistent with available funds. FY 1994 construction funds will be used to complete accelerator and civil construction.

4. Total Project Funding (BA):

	Prior Years	FY 1992	FY 1993	FY 1994 Request	To Complete
Construction	$215,310	$48,300	$32,000	$16,590	$ 1,000
Capital Equipment	5,419	1,600	1,600	1,600	1,600
Operating Expenses	77,480	23,330	28,217	44,800	16,100

DEPARTMENT OF ENERGY
FY 1994 OMB CONGRESSIONAL BUDGET REQUEST
(Changes from FY 1993 Congressional Budget Request are denoted with a vertical line in left margin.)

GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

NUCLEAR PHYSICS

1. Title and Location of Project: General plant projects Various locations	2a. Project No. GPE-300 2b. Construction Funded
3a. Date A-E Work Initiated: 1st Qtr. FY 1994 3b. A-E (Titles I & II) Duration:	5. Previous Cost Estimate: Total Estimated Cost (TEC) -- none Total Project Cost (TPC) -- none
4a. Date Physical Construction Starts: 2nd Qtr. FY 1994 4b. Date Construction Ends: 2nd Qtr. FY 1996	6. Current Cost Estimate: TEC -- $3,600 TPC -- $3,600

7. Financial Schedule:

Fiscal Year	Appropriations	Obligations	Costs
1994	$ 3,600	$ 3,600	$ 1,300
1995	0	0	1,800
1996	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	2a. Project No. GPE-300 2b. Construction Funded

8. Brief Physical Description of Project (Continued)

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

The ranked list of the laboratory's currently needed GPP projects include the following: Upgrade of LCW System - Building 51, Low Voltage Breaker Upgrade - Building 51, Second Level Addition - Building 72, Construct New Microscopy Laboratory - Building 6, Construct New Spectroscopy Laboratory - Building 6, and New Laboratory/User Facility - Building 6.

Massachusetts Institute of Technology
(Bates Linear Accelerator Center)..... $ 245

Upgrade the water cooling system of the South Experimental Hall from a capacity of 922 KW to 2900 KW to meet the requirements of new experimental activities. Two evaporative coolers capable of cooling 800 GPM from 107°F to 85°F will be mounted on the roof of the experimental hall. Increased capacity in both lower temperature capability and water flow will result from the installation of these coolers.

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

The distribution of funds requested for FY 1994 is as follows:

Lawrence Berkeley Laboratory.....	$ 3,355
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	245
Total Estimated Construction Cost.....	$ 3,600

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.

1. Title and location of project:	General plant projects Various locations	2a. Project No. GPE-300 2b. Construction Funded

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 1994 CONGRESSIONAL BUDGET REQUEST
(Changes from FY 1993 Congressional Budget Request are denoted with a vertical line in left margin.)

GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

NUCLEAR PHYSICS

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a. Project No. 94-G-302 2b. Construction funded
3a. Date A-E Work Initiated: 2nd Qtr. FY 1994 3b. A-E Work (titles I & II) Duration: Various	5. Previous Cost Estimate: none Total Estimated Cost (TEC) -- none Total Project Cost (TPC) -- none
4a. Date Physical Construction Starts: 2nd Qtr. FY 1994 4b. Date construction ends: 2nd Qtr. FY 1996	6. Current Cost Estimate: TEC -- $3,800 TPC -- $3,800

7. Financial Schedule:

Fiscal Year	Appropriations	Obligations	Costs
1994	$ 3,800	$ 3,800	$ 2,400
1995	0	0	1,100
1996	0	0	300

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.

Following is a list of the proposed FY 1994 funding for the various locations:

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a. Project No. 94-G-302 2b. Construction funded

8. Brief Physical Description of Project (Continued)

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

The refrigeration capacity of the ATLAS cryogenic system will be improved with the addition of wet engines to all liquid helium refrigerators. Also the upgrade of fast tuners on the ATLAS resonators with ones of improved design will be completed.

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

As part of a general upgrade of the AGS for heavy ion operations, the following modifications are proposed: modernize the controls of the main magnet water cooling system; refurbish the equipment which controls the accelerating cycle to accept pulse-to-pulse modulation, timing and control; increase the sensitivity of the existing beam position monitor system to detect low-intensity heavy ion beams; and increase the sensitivity of the radiation loss monitor system to detect heavy ion beam losses.

Lawrence Berkeley Laboratory (88-Inch Cyclotron)..... $ 200

The radiation interlock protection at the 88-Inch Cyclotron will be improved by adding a second independent interlock chain to the existing protection system. The new chain would converge to a different control point in the RF system and be able to independently disable all beam delivery from the cyclotron. The design of the new system is modular with a chassis located in each interlock area. The modular nature minimizes the interference between installation activities and on-going operation of the cyclotron.

Massachusetts Institute of Technology
(Bates Linear Accelerator Center)..... $ 1,500

The electron linac and recirculator will be upgraded to improve reliability, reproducibility and operability. This includes several upgrade packages: polarized electron injector upgrade, transmitter upgrade, accelerator RF upgrade, and upgrade of recirculator and beam switchyard components.

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a. Project No. 94-G-302 2b. Construction funded

8. Brief Physical Description of Project (Continued)

Oak Ridge National Laboratory (Radioactive Ion Beam Facility)... $ 1,000

This project will construct components that will enable the 25-MV tandem accelerator and the ORIC cyclotron to function as a Radioactive Ion Beam (RIB) Facility. The facility will use light-ion beams from ORIC to 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 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 For, and Scope of Project

Argonne National Laboratory (ATLAS)

The wet engines will increase the output of the helium refrigerators by up to 30% and, hence, will greatly improve the reliability with which the ATLAS accelerator can be operated because of the added margin in helium capacity. At present it is possible to keep the linacs at the fields necessary for uranium beams of 6 MeV/A only under absolutely optimum performance of the cryogenic system. This affects reliability and efficiency of operation because of the higher frequency of repair under such conditions. A side benefit of wet engines is a significant saving in electrical power for the compressors when the maximum refrigeration capacity is not needed. The improved fast tuners allow the accelerating fields to be increased by more than 15%. The new tuner also show a marked reduction in failure rate.

Brookhaven National Laboratory (AGS/Tandem)

A principal aim of the AGS upgrade program is to create a machine that will accelerate heavy ions for fixed target experiments using the Booster as an injector. The existing cooling water control system (fully manual) needs to be placed under computer control to improve operational efficiency. Pulse-to-pulse modulation will permit the interleaving of acceleration cycles of different ion beams without manual set-up or change-over of AGS equipment. For satisfactory heavy ion operation the electronics of the beam position monitor system needs to be upgraded providing, thereby, single orbit information. Increased sensitivity of the radiation loss monitors will permit early detector of beam loss so that corrective tuning measures can be implemented.

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a. Project No. 94-G-302 2b. Construction funded

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

Lawrence Berkeley Laboratory (88-Inch Cyclotron)

Standards for radiation interlock systems at accelerators have changed over the years since the 88-Inch Cyclotron was constructed. This project will upgrade the interlock protection system, bringing it into compliance with the new policies described in the LBL Health and Safety manual.

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 polarized injector upgrade is needed to create the high current polarized electron beams for the South Hall Ring Experiment (SHRE). The RF improvements will sharply increase the timing and phasing characteristics needed for optimum beam recirculation. Components of the recirculator and switchyard need to be replaced to allow high beam currents to be transported predictably and safely around the recirculator and to tailor the beam phase space for SHRE injection.

Oak Ridge National Laboratory

Transformation of the ORIC cyclotron and the 25-MV tandem into a Radioactive Ion Beam (RIB) Facility will provide unique access to a new territory of nuclear physics research. Some of the research 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 build a radioactive ion beam facility in a short time frame.

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a. Project No. 94-G-302 2b. Construction funded

10. Details of Cost Estimate

a. Engineering design inspection, construction, procurement, component assembly, and installation.....	$ 3,800
Total line item cost.....	$ 3,800

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 1994 CONGRESSIONAL BUDGET REQUEST
(Changes from FY 1993 Congressional Budget Request are denoted with a vertical line in left margin.)

GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

NUCLEAR PHYSICS

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

SIGNIFICANT CHANGES

- TEC increased from $406,600,000 to $477,250,000 due to the decrease in proposed FY 1994 funding, and the revised outyear funding profile.
- TPC increased from $509,400,000 to $597,550,000 due to the decrease in proposed FY 1994 funding, and the revised outyear funding profile.
- The major sources of cost increase are additional costs due to renegotiated stretch-out of industrial contracts, continuance of project staff cost for an additional 19 months, cost-of-living on the extended profile and inefficiencies due to the less than optimum profile.
- Completion date of 4th quarter FY 1997 changed to 2nd quarter FY 1999 due to the decrease in proposed FY 1994 funding, and the revised outyear funding profile.

DEPARTMENT OF ENERGY
FY 1994 CONGRESSIONAL BUDGET REQUEST
(Changes from FY 1993 Congressional Budget Request are denoted with a vertical line in left margin.)

GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

NUCLEAR PHYSICS

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

2a. Project No. 91-G-300
2b. Construction Funded

3a. Date A-E Work Initiated: 1st Qtr. FY 1991

3b. A-E Work (Title I & II) Duration: 6 months

5. Previous Cost Estimate:
Total Estimated Cost (TEC) -- $406,600
Total Project Cost (TPC) -- $509,400

4a. Date Physical Construction Starts: 2nd Qtr. FY 1991

4b. Date Construction Ends: 2nd Qtr. FY 1999

6. Current Cost Estimate:
TEC -- $477,250
TPC -- $597,550

7. Financial Schedule (Federal Funds): a/

Fiscal Year	Appropriations	Adjustments	Obligations	Costs
FY 1991	$ 15,000	- 1,500 b/	$ 13,500	$ 6,000
FY 1992	49,350		49,350	23,265
FY 1993	71,400	- 1,400 c/	70,000	77,000
FY 1994	70,000		70,000	80,000
FY 1995	70,000		70,000	75,000
FY 1996	70,000		70,000	75,000
FY 1997	65,000		65,000	64,000
FY 1998	57,000		57,000	59,000
FY 1999	12,400		12,400	17,985

a/ For consistency with Departmental accounting system, the Appropriations, Obligations, and Costs for fiscal years prior to 1993 have been changed from amounts on the last data sheet.
b/ Reflects the reduction of funds resulting from the FY 1991 sequester and general reduction.
c/ Application of a portion of the FY 1993 General Science and Research general reduction of $30,000,000 for use of prior year balances.

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

8. Brief Physical Description of Project

Due to the proposed decrease in FY 1994 funding and the revised outyear funding profile, the completion date for the project has been delayed from the fourth Quarter of FY 1997 to the second Quarter of FY 1999 resulting in an increase in the TEC and TPC. The TEC has been increased from $406,600,000 to $477,250,000. The TPC has been increased from $509,400,000 to $597,550,000. The major sources of cost increase are additional costs due to renegotiated stretch-out of industrial contracts, continuance of project staff cost for an additional 19 months, cost-of-living on the extended profile and inefficiencies due to the less than optimum profile.

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.

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.

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

9. Purpose, Justification of Need For, 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.

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	2a. Project No. 91-G-300 2b. Construction Funded

10. Details of Cost Estimate		Item Cost	Total Cost
a. Engineering design inspection and administration of item b.....			$ 73,350
1. Engineering, design and inspection at 18% of construction costs.....		$ 44,000	
2. Construction management at 12% of construction costs, item b.....		29,350	
b. Construction Costs.....			244,600
1. Conventional Construction.....		7,600	
a. Site Improvement.....	$ 1,800		
b. Tunnels and Buildings.....	3,800		
c. Utilities.....	2,000		
2. Technical Components - Collider.....		237,000	
a. Collider Installation.....	27,950		
b. Magnet System.....	101,820		
c. Magnet Electrical System.....	13,930		
d. Cryogenic System.....	21,020		
e. Vacuum System.....	10,660		
f. Injection System.....	15,260		
g. Beam Dump System.....	8,550		
h. RF System.....	15,440		
i. Beam Instrumentation.....	5,570		
j. Control System.....	16,800		
c. Contingencies on Collider at approximately 20 percent of above costs.....			52,300
Subtotal.....			$370,250
d. Research Detectors (including EDIA and Contingency).....			107,000
Total line item costs.....			$477,250

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

2a. Project No. 91-G-300
2b. Construction Funded

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. Schedule of Project Funding and Other Related Funding Requirements

a. Total project funding	Prior Years	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995
1. Total Facility Cost						
Construction line item.....	$ 0	$ 6,000	$23,265	$77,000	$80,000	$75,000
Total facility cost.....	$ 0	$ 6,000	$23,265	$77,000	$80,000	$75,000
2. Other project costs						
a. R&D necessary to complete construction.....	$21,450	$ 6,614	$ 7,000	$ 7,200	$ 6,000	$ 3,800
b. Start-up and Inventory...	0	0	0	0	0	2,200
Total other project costs....	$21,450	$ 6,614	$ 7,000	$ 7,200	$ 6,000	$ 6,000
Total project cost (TPC).....	$21,450	$12,614	$30,265	$84,200	$86,000	$81,000

a. Total project funding	FY 1996	FY 1997	FY 1998	FY 1999	Total
1. Total Facility Cost					
Construction line item.....	$75,000	$64,000	$59,000	$17,985	$477,250
Total facility cost.....	$75,000	$64,000	$59,000	$17,985	$477,250
2. Other project costs					
a. R&D necessary to complete construction.....	$ 0	$ 0	$ 0	$ 0	$ 52,064
b. Start-up and Inventory...	6,000	11,000	19,000	30,036	68,236
Total other project costs....	$ 6,000	$11,000	$19,000	$30,036	$120,300
Total project cost (TPC).....	$81,000	$75,000	$78,000	$48,021	$597,550

III. Processing of Nuclear Materials (Cont'd):
Fuels (Cont'd):
Separations (Cont'd):

Program Activity	FY 1992	FY 1993	FY 1994
Savannah River (Cont'd)	Included PIP implementation, training activities, building services, support operating computer systems, operating power distribution equipment, Canyon ventilation, process cooling water and other area utilities. Dollars were identified as part of Separations General in FY 1992.	Continue support for all facets of H-Area operations. This includes grounds and roadways; area general capital projects; personnel administration; health protection portable monitoring equipment; ALARA, QA and ORR programs; and training support. Funding will also provide for Environment, Safety, Health and Quality Assurance direct support for preliminary waste identification; data review, analysis, and validation; and other services by the Site Services Quality Department. ($32,358)	Continue FY 1993 activities. Funds requested for acceleration of asbestos removal. ($36,036)
	Activity contained in other work breakdown structures (WBS's) in FY 1992.	Provide for electrical upgrades to the cooling towers located in F and H areas. ($79)	Continue prior year activities. ($79)
	Contained in other WBS's in FY 1992. ($0)	Provide site services to the entire processing areas including repairs, maintennace, configuration management, etc. ($3,418)	Funding included in other WBS's in FY 1994. ($0)
	Separations General included activities supporting Building 247-F and other activities which are not directly attributable to a specific facility within F and H Areas. These included 247-F Vault restart and operating costs, PIP implementation, training activities, building services, support operating computer systems, operating power distribution equipment, Canyon ventilation, process cooling water and other area utilities. Support for nuclear criticality safety and environmental compliance for Separations was provided. ($56,215)	These activities are identified under other WBS's in FY 1993.	These activities are identified under other WBS's in FY 1994.

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

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

b. Start-up and Inventory costs

These funds are needed for operation training of crew, early testing and check-out of various systems, as well as to establish a special process sparing inventory 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.

b. Related annual funding (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 1994 CONGRESSIONAL BUDGET REQUEST
(Changes from FY 1993 Congressional Budget Request are denoted with a vertical line in left margin.)

GENERAL SCIENCE AND RESEARCH - PLANT AND CAPITAL EQUIPMENT
(Tabular dollars in thousands. Narrative material in whole dollars.)

NUCLEAR PHYSICS

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

2a. Project No. 87-R-203
2b. Construction Funded

3a. Date A-E Work Initiated: 2nd Qtr. FY 1985

3b. A-E Work (Titles I & II) Duration:

5. Previous Cost Estimate:
Total Estimated Cost (TEC) -- $313,200
Total Project Cost (TPC) -- $514,946

4a. Date Physical Construction Starts: 2nd Qtr. FY 1987

4b. Date Construction Ends: 1st Qtr. FY 1995

6. Current Cost Estimate:
TEC -- $313,200
TPC -- $514,946

7. Financial Schedule (Federal Funds): a/

Fiscal Year	Appropriations	Adjustments	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	65,000	- 2,389 b/	62,611	53,441
FY 1991	65,000	- 6,501 c/	58,499	53,595
FY 1992	41,800	+ 6,500 d/	48,300	59,469
FY 1993	33,000	- 1,000 e/	32,000	41,300
FY 1994	16,590		16,590	24,700
FY 1995	1,000		1,000	1,909

a/ For consistency with Departmental accounting system, the Appropriations, Obligations, and Costs for fiscal years prior to 1993 have been changed from amounts on the last data sheet.
b/ Reflects the sequester of funds and distribution of general reduction for FY 1990.
c/ Reflects the sequester of funds and distribution of general reduction for FY 1991
d Reflects reprogramming of $6,500,000 from other project costs (operating expenses) relating to this project to the other construction costs. (92-R-13)
e/ Application of a portion of the FY 1993 General Science and Research general reduction of $30,000,000 for use of prior year balances.

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia	2a. Project No. 87-R-203 2b. Construction Funded

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.

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	2a. Project No. 87-R-203 2b. Construction Funded

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 For, 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

2a. Project No. 87-R-203

2b. Construction Funded

10. Details of Cost Estimate

		Item Cost	Total Cost
a. Engineering Design and Inspection, and Administration.....			$ 50,000
1. Conventional Construction at approximately 17 percent of item b.1		$ 10,000	
2. Technical components at approximately 23 percent 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. Contingencies at approximately 19 percent of above costs.....			15,000
Total line item 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.

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

2a. Project No. 87-R-203

2b. Construction Funded

12. Schedule of Project Funding and Other Related Funding Requirements

	Prior Years	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.....	$ 7,842	$41,858	$29,086	$53,441	$53,595	$59,469	$41,300	$24,700	$ 1,909	$313,200a/
b. PE&D.....	967	0	0	0	0	0	0	0	0	967
Total facility cost.....	$ 8,809	$41,858	$29,086	$53,441	$53,595	$59,469	$41,300	$24,700	$ 1,909	$314,167
2. Other project costs										
a. R&D necessary to complete construction...	$15,668	$ 6,250	$ 6,000	$ 2,900	$ 1,629	$ 0	$ 0	$ 0	$ 0	$ 32,447
b. Operations	800	2,970	4,467	13,124	19,205	20,730	28,217	44,800	16,100	150,413
c. Spares.....	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.....	$16,968	$10,220	$11,467	$18,603	$24,674	$24,930	$29,817	$46,400	$17,700	$200,779
Total project cost.....	$25,777	$52,078	$40,553	$72,044	$78,269	$84,399	$71,117	$71,100	$19,609	$514,946

a/ Site provided at no cost to DOE.

b. Other related funding requirements (FY 1995 dollars)

1. Annual facility operating costs..... $ 55,000
2. Annual plant and capital equipment costs related to facility operations..... $ 4,000

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia	2a. Project No. 87-R-203 2b. Construction Funded

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

a. Total project funding
   1. Total facility costs
      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
      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.

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