DEPARTMENT OF ENERGY
FY 1996 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 fundamental research activities under the mandate provided in Public Law 95-91 which established the Department. The programs intent is to be closely aligned with the Administration's science policies as put forward in "Science in the National Interest" and in the May 6, 1994, Gibbons and Panetta memo on FY 1996 R&D priorities. Specific new initiatives have been taken in the areas of intensified peer review, increased educational and diversity activities, strengthened international conduct of the science program, and support of additional areas for transfer of knowledge and technology to support the nation's economic base. The primary goal of the program is the conduct of fundamental research in order to understand the structure of atomic nuclei and the fundamental forces required to hold their constituents in place.

Science Facilities Utilization Enhancement: The Nuclear Physics request includes $25,000,000 to enhance the utilization of the Department's fundamental science and user facilities. This investment will significantly increase research time available to thousands of scientists in universities, Federal agencies, and U.S. companies. It will also leverage both Federally and privately sponsored research, consistent with the Administration's strategy for enhancing the U.S. National science investment.

The purpose of this targeted science initiative is to increase Nuclear Physics facility operations, instrumentation, and user support as part of a $100 million science initiative to increase the utilization of the Department's large state-of-the-art science facilities. The proposed funding increase for facilities will allow the Department to significantly increase the utilization and efficiency of operations of nearly all of its Nuclear Physics facilities. Approximately 20 percent of the additional funds will be administered directly to users through competitive grants.

The vitality of Nuclear Physics is dependent on continuous advancement of the fundamental understanding of the material and forces of nature. 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 high energy physics. However, the Nuclear Physics program uniquely approaches problems by testing the theoretical predictions in the medium of extended nuclear matter provided by nuclei composed of many nucleons. Another subfield of Nuclear Physics addresses problems of mutual interest to nuclear physics and astrophysics, including measurements of supernovae, neutron stars, solar neutrinos, composition of cosmic rays, and stellar nuclear abundances. Of special current interest are measurements of the solar neutrino flux which permits the measurement of possible small neutrino masses. Relativistic heavy ion collisions create a quark-gluon plasma, which simulates a stage of evolution of the universe that ended ten millionths of a second after the initial "big bang", and will play an increasing role in the program.

Nuclear Physics activities are an essential component of the nation's scientific and technological base. Nuclear processes are responsible for the nature and abundances of all matter, which, in turn determines the essential physical characteristics of our universe. The science of nuclear physics has spawned many a variety of 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 fundamental research program. Nevertheless, vital interactions still occur between 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 have generated many of the radioisotopes used for medical diagnoses and support several cooperative programs in biomedical research, space electronics testing, and atomic physics. They provide the framework for the training of Health Physicists who are dedicated to the maintenance of a radiation-free environment. Over one-half of the approximately 100 new PH.D. graduates produced each year in the DOE Nuclear Physics program will find careers in these areas. In addition, the Nuclear Data program within Nuclear Physics generates, evaluates, and disseminates information such as neutron cross-sections and radioactive decay data to support these programs.

The DOE Nuclear Physics program supports over 85 percent of the U.S. basic research program with the rest being supported by the National Science Foundation (NSF). Essential continuing guidance is provided to both agencies by the Nuclear Science Advisory Committee (NSAC) based on the 1989 Long Range Plan for Nuclear Science, and updated in 1994 by the report "Nuclear Science in DOE: Assessment and Promise". Through their joint support of NSAC, mutual interaction with the Division of Nuclear Physics of the American Physical Society, common sponsorship of workshops and conferences, and similar use of the peer review process, the DOE and NSF programs are mutually supportive and complementary. Although the NSF university program is almost as large as that of the DOE, the DOE program uniquely has the resources and managerial expertise to construct the large facilities and detectors available to the entire community. The university component of the DOE and NSF programs form the central core of the facility user activity. At CEBAF and MIT Bates, for example, roughly half of the experimental leaders are NSF supported, and the NSF has contributed substantially to major equipment at both laboratories.

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. Nuclear theory, design and fabrication of sophisticated detectors and the development and training of creative and skilled personnel are necessary for proper conduct of this research. High priority will be placed on new scientific areas in physics using electron beams, relativistic heavy ion research, studies of high spin states, experiments on quark interactions with nuclear matter, and solar neutrino research. Use of the Tandem/AGS high energy heavy ion beams at Brookhaven National Laboratory (BNL) using the recently completed booster for beams of gold ions and use of the new South Hall Ring experiment at the MIT Bates electron accelerator will be continued. In the Low Energy program, the Holifield Heavy Ion Research Facility will conduct a research program based on the existing accelerators which were reconfigured and upgraded to provide a Radioactive Ion Beam (RIB) Facility at Oak Ridge National Laboratory. Operation of national laboratory facilities at Argonne and Berkeley will continue within the Heavy Ion program. Detector projects include completion of the segmented gamma ray detector for nuclear structure physics (Gammasphere) at Berkeley and initial operation of the Sudbury Neutrino Observatory (SNO) project in cooperation with Canada and the United Kingdom. Permanent staffing at the National Institute for Nuclear Theory is completed, and a full program of basic research and study sessions on forefront topics in nuclear physics will be offered. Scientists supported by the Nuclear Physics program also carry out experiments and conduct research at NSF and High Energy Physics supported facilities and at foreign accelerator facilities . 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 the smaller facilities located at national laboratories. However, newly emerging fundamental problems in nuclear science require large modern facilities that are designed for the research use of the entire nuclear community. The Continuous Electron Beam Accelerator Facility (CEBAF) construction project will be complete in FY 1995, with the completion of the CLAS detector in Hall B in FY 1996, the full research program can begin. Already, 325 physicists from 66 institutions have submitted 65 research proposals to the CEBAF. As the facility begins operation, physicists from 105 institutions, including 125 scientists from 17 foreign countries, will carry out experiments in FY 1996 approved by the peer review process. About 250 scientists from outside of CEBAF are actively participating in the design of experiments to be carried out in the three experimental halls. In FY 1995, the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory will enter its sixth year of construction, with procurement and installation of superconducting magnets as a major activity. The present research focus is on the involvement of the user community in equipment fabrication. The effort to design and fabricate detectors represents about 600 scientist and students from 70 universities and laboratories throughout the world. Two major detectors, STAR and PHENIX, have received approval from both scientific and technical review panels to begin design and construction, and international teams of scientists are working on each. Significant components of the detectors are being provided by collaborators from 12 foreign countries. Two smaller detectors are planned to address specialized scientific questions.

Current performance measures of program outputs for basic research include such metrics as the number of scientists supported, the number of students earning advanced degrees, the number of scientific publications in peer-reviewed journals, the number of awards from professional organizations, and the number of citations in scientific publications. Metrics for the transfer of new knowledge to a technology application include the number of cooperative agreements with industry, the number of projects attaining support from a DOE Energy Technology program, the number of invention records and patents, and the number of industry users at scientific user facilities and the number of smell business innovative research projects (SBIR) initiated. For construction projects, metrics can include cost and schedule milestones completed against approved project beamline. These performance measures are easily tabulated, commonly used, and begin to provide a framework for evaluating program efficiency. However, meaningful performance measures in basic science are more useful when described in qualitative, rather than quantitative terms. For example, in order to measure outcomes, or program effectiveness, the impact of the research outputs must be assessed in terms of the quality and impact of the new knowledge gained, its usefulness to technology development, and its longer-term benefit to society. Although there are limited and expensive methods for evaluating the quality of science through peer-review metrics, no metric exists that can accurately measure science's impact on technology and society.

To augment its normal peer review process, the Nuclear Physics program conducted a broad panel merit review of its entire research program including all National Laboratories and university research grants. Individual panelists on each of the five topically oriented panels evaluated each of the presentations made to the panel; followed a fixed format. A synthesis of these evaluations was made by a DOE official, checked for accuracy, and distributed to the presenter and appropriate program manager to be included in funding decisions. A report of the panel review discussing detailed procedures, statistical results, and programmatic overviews is available.

Performance Indicators for the Nuclear Physics program include the discovery of new scientific knowledge, number of scientists supported, accelerator beam hours available for research and percentage completion (cost and schedule milestones) against the approved project plans for CEBAF and RHIC. In FY 1994, the number of Ph.D.-level scientists supported by the program was 1051 plus 451 graduate students. In FY 1995 and FY 1996, the level is projected to be 1028 Ph.D.s, and 450 graduate students. Expected beam hours for research at accelerator user facilities is 16,700 hours in FY 1995, and 22,700 hours in FY 1996, including initial research capability at CEBAF and RIB. CEBAF construction will be complete in the 1st quarter of FY 1995 and operation for commissioning will begin. At the end of FY 1996, the RHIC project will be 66% complete.

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(Tabular dollars in thousands, narrative in whole dollars)

LEAD TABLE

Nuclear Physics

Activity	FY 1994 Adjusted	FY 1995 Appropriation	FY 1995 Adjustment	FY 1995 Adjusted	FY 1998 Request
Operating Expenses					
Medium Energy Nuclear Physics.........	$108,289	$127,588	-$2,604	$124,982	$103,918
Heavy Ion Nuclear Physics..................	64,839	61,560	-388	61,174	66,800
Low Energy Nuclear Physics...............	23,541	24,760	-164	24,598	27,100
Nuclear Theory..................................	14,648	14,735	-85	14,650	15,500
Capital Equipment..............................	32,000	28,000	0	28,000	28,000
Construction.......................................	101,990	78,100	0	78,100	79,760
TOTAL..	$345,287	$334,741	-$3,239	$331,502	$321,078
Summary					
Operating Expenses...........................	$211,297	$228,641	-$3,239	$225,402	$213,318
Capital Equipment..............................	32,000	28,000	0	28,000	28,000
Construction.......................................	101,990	78,100	0	78,100	79,780
Total Program....................................	$345,287 a/	$334,741	-$3,239 b/	$331,502	$321,078

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

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

a/ Excludes $3,221,000 for the SBIR program and $107,000 for the STTR program which has been reprogrammed to Energy Supply R&D.
b/ Amount of General Reduction and Procurement Reform in Operating.

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(Tabular dollars in thousands, narrative in whole dollars)

SUMMARY OF CHANGES

Nuclear Physics

FY 1995 Appropriation..	$ 334,741
- Adjustment..	- 3,239
FY 1995 Adjusted..	$ 331,502
Medium Energy Nuclear Physics	
- Initial full operation of CEBAF facility is supported as well as continued operation of Bates facility at MIT. Funds for operation of LAMPF are terminated with the transfer of operations to Defense Programs. High priority Nuclear Physics research continues.......	- 21,064
Heavy Ion Nuclear Physics	
- Conduct heavy ion research and operations with increase in operations for RHIC start-up activities and AGS operations..	+ 5,626
Low Energy Nuclear Physics	
- Continue overall low energy operations and research and nuclear data program increase operations support for the Radioactive Ion Beam (RIB) project at ORNL	+ 2,504
Nuclear Theory	
- Concentrate effort in highest priority areas of nuclear physics with continued support of the Institute of Nuclear Theory..	+ 850

Capital Equipment

- Provide Nuclear Physics Instrumentation needed to complete the CLAS Detector at CEBAF, and experimental systems at ANL, BNL, LBL and ORNL..	-	0

Construction

- Increase level of effort for AIP..	+	1,775
- Increased level of effort for GPP high priority ES&H activities..........................	+	885
- Completion of the Continuous Electron Beam Accelerator Facility (CEBAF) construction project funding in FY 1995..	-	1,000
- Continue Relativistic Heavy Ion Collider (RHIC) construction project...................		0
FY 1996 OMB Budget Request..		$ 321,078

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(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 academic fundamental research, and 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 research at accelerators operated by other DOE programs (e.g., High Energy Physics and Basic Energy Sciences) and at other unique domestic or foreign facilities. Two national accelerator facilities are now operated entirely under the Medium Energy subprogram - the Continuous Electron Beam Accelerator Facility (CEBAF) in Newport News, Virginia, operated by the Southeastern Universities Research Association, and the Bates Linear Accelerator Center in Middleton Massachusetts, operated by the Massachusetts Institute of Technology. These accelerator facilities serve a nationwide community of DOE- and NSF-supported scientists from over 100 American institutions, of which over 90% are universities. Both facilities provide major contributions to American education at all levels, and provide a wealth of new technical and innovative discoveries which result in important Technology Transfer and services to American industry and medicine. At the MIT/Bates laboratory, the NSF has made a major contribution to new experimental apparatus. A significant number of foreign scientists collaborate in the research programs of both facilities. The planned research program at the new CEBAF Laboratory, for example, involves 125 scientists from 17 foreign countries; 61 of these scientists are from CERN member states. At CEBAF, foreign collaborators have also made major investments in experimental equipment. The research programs supported at these facilities are ultimately aimed at achieving an understanding of the structure of the atomic nucleus in terms of its quark and gluon sub-structure, and of the "strong force" which holds the nucleus of the atom together. Research efforts include studies of the role of excited states of nucleons in nuclear structure, investigations of the role of specific quarks in nucleon structure, studies of parity violation, investigations of how the properties of a nucleon changes when imbedded in the nuclear medium, measurements of polarized particles and use of polarized beams to determine unique "structure factors" which pin down particular choices for nuclear structure, studies of short-distance correlations between nucleons in nuclei, and high resolution studies of the electric and magnetic structure of nuclei.

Due to a major restructuring of the Los Alamos National Laboratory (LANL) in FY 1994, all LANL FY 1996 Medium Energy Nuclear Physics funding is provided to P Division under the Research Program activity. In FY 1996, primary operation of the Clinton P. Anderson Meson Physics Facility (LAMPF) will be supported by Defense Programs. On this basis, Nuclear Physics funding permits selected high priority Nuclear Physics experiments at LAMPF.

II. A. Summary Table: Medium Energy Nuclear Physics

Program Activity	FY 1994 Adjusted	FY 1995 Adjusted	FY 1996 Request	$ Change
Research				
CEBAF	$ 10,330	$ 8,466	$ 9,000	$ 534
MIT/Bates	3,766	3,450	3,918	468
National Laboratories	15,216	19,942	16,924	-3,018
Universities	11,867	11,420	12,676	1,256
Subtotal, Research	$ 41,179	$ 43,278	$ 42,518	$ -760
Operations				
LAMPF	$ 23,640	$ 23,344	$ 0	$ -23,344
Bates	10,400	9,760	10,900	1,140
CEBAF	33,050	48,600	50,500	1,900
Other	0	0	0	0
Subtotal, Operations	$ 67,090	$ 81,704	$ 61,400	$ -20,304
Total, Medium Energy Nuclear Physics	$ 108,269	$ 124,982	$ 103,918	$ -21,064

II. B. Laboratory and Facility Funding Table: Medium Energy Nuclear Physics

Argonne National Lab (East)	$ 2,896	$ 2,660	$ 3,100	$ 440
Brookhaven National Lab	2,090	1,930	2,180	250
Continuous Electron Beam Accelerator Facility	43,380	57,066	59,500	2,434
Los Alamos National Laboratory	33,870	36,154	8,543	-27,611
All Other	26,033	27,172	30,595	3,423
Total, Medium Energy Nuclear Physics	$ 108,269	$ 124,982	$ 103,918	$ -21,064

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1994	FY 1995	FY 1996
Medium Energy Nuclear Physics			
Research			
CEBAF	Utilized data acquisition system for testing of components and systems during accelerator assembly. Brought computer system up to full capability for automated operation and querying of the thousands of inputs monitored for proper operation of the entire facility. Established the on-line data acquisition capability for automated collection and analysis of data from experiments. Hall C data acquisition and slow controls system was completed.	The Hall A data acquisition and slow controls system will be completed. The central data replay resources will be upgraded to match the data output of Hall C and the start-up activities in Hall A. Data reduction analysis software and data bases will be supported.	The Hall A data acquisition and slow controls system are completed. The central data replay resources will be available for HALL C and Hall A activities. Preparation for Hall B data acquisition is underway.
	Assembled and tested experimental equipment components. Emphasis is 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 of commissioning, the beam was brought into Hall C. Hall C equipment will be used to commence the CEBAF experimental research program.	Complete installation of Hall A spectrometer pair and detector packages. Complete installation and testing of beam lines, control systems, data acquisition systems, safety and environmental systems, and other support equipment. Complete final preparations for beginning of physics operations by 4th quarter, FY 1995.	Experimental equipment in Halls C and A is complete. Hall A spectrometer pair will be calibrated and available for experimental research. Hall B detector installation will be completed and calibration activities will be initiated.
	Continued superconducting RF research and technology development activities and strengthened theoretical efforts. CEBAF scientific staff is now almost completely involved in preparation for the CEBAF research program.	Continue superconducting RF research and technology development activities. Theoretical efforts will be supported by the Nuclear Theory Program.	Continue superconducting RF research and technology development activities. Theoretical efforts will be supported by the Nuclear Theory Program.

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

Program Activity	FY 1994	FY 1995	FY 1996
CEBAF (Cont'd)	Participation in outside experiments by CEBAF staff at facilities such as the MIT/Bates Linear Accelerator Center, the Stanford Linear Accelerator Center, and NIKHEF in the Netherlands, was limited due to pressures of completing CEBAF experimental equipment. Plan for CEBAF research program established through Program Advisory Committee composed of peer experts and users group meetings.	Carry out research in Experimental Hall C. In 4th quarter FY 1995, shake-down for initial operation of Experimental Hall A twin spectrometers will begin.	Carry out research program in Experimental Halls C and A. Complete and begin initial operation of Experimental Hall B detector system. Proposed experiments will be evaluated by a peer review panel called the Program Advisory Committee.
	$ 10,330	$ 8,466	$ 9,000
MIT/Bates	In the South Experimental Hall, carried out coincidence measurements with higher intensity polarized electron beams. Began testing the new South Hall Ring (SHR). Emphasized measurement of spin observables utilizing the new OHIPS focal plane polarimeter. Carried out measurements "out of the scattering plane" with new detection systems (OOPS) jointly funded with the National Science Foundation (NSF) through the University of Illinois. An important experiment will be a measurement of the charge form factor of the neutron.	Continue coincidence measurements with higher intensity polarized electron beams. Perform experiments with the new South Hall Ring (SHR). Emphasize measurement of spin observables utilizing the new OHIPS focal plane polarimeter. Carry out measurements "out of the scattering plane" with new detection systems (OOPS) jointly funded with the National Science Foundation (NSF) through the University of Illinois. Begin phasing in experiments with the SHR polarized internal targets.	Continue coincidence measurements with higher intensity polarized electron beams. Perform experiments with the new South Hall Ring (SHR). Emphasize measurement of spin observables utilizing the new OHIPS focal plane polarimeter. Carry out measurements "out of the scattering plane" with new detection systems (OOPS) jointly funded with the National Science Foundation (NSF) through the University of Illinois. Begin phasing in experiments with the SHR polarized internal targets.
	In the North Hall, began to carry out data taking for the SAMPLE experiment to measure parity violation in elastic scattering from the proton. Used high resolution ELSSY spectrometer for measurements of high q magnetic scattering from He-3, and nuclear structure studies of the neon isotopes.	Continue high precision measurements with the ELSSY spectrometer and the SAMPLE experiment in the North Hall.	In the North Hall, continue high precision measurements with the ELSSY spectrometer. Extend the joint DOE/NSF SAMPLE experiment to carry out measurements on deuterium.

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

Program Activity	FY 1994	FY 1995	FY 1996
MIT/Bates (Cont'd)	Continued R&D on behavior of polarized beams in stretcher rings, and on design of detector components for use in the South Hall. Designed a polarimeter capability internal to the SHR. Designed detection capability for use with internal targets and the cw beam available in the South Hall.	Improve internal polarimeter capability and new experimental detection capabilities for use with new internal target and high current cw beam available in the South Hall Pulse Stretcher Ring.	Utilize internal polarimeter capability and new experimental detection capabilities for use with internal target and high current cw beam available in the South Hall Pulse Stretcher Ring.
	Carried out a program of research at other existing facilities including LAMPF, CEBAF, the Paul Scherrer Institute in Switzerland, and HERA in Germany.	Carry out a program of research at other existing facilities including LAMPF, CEBAF, the Paul Scherrer Institute in Switzerland, and HERA in Germany.	Carry out a program of research at other existing facilities including CEBAF, the Paul Scherrer Institute in Switzerland, and HERA in Germany.
	Included $120,000 for a computer lease for the Laboratory for Nuclear Science Computer Facility Upgrade.	Include $120,000 for a computer lease for the Laboratory for Nuclear Science Computer Facility Upgrade.	Include $120,000 for a computer lease for the Laboratory for Nuclear Science Computer Facility Upgrade.
	$ 3,766	$ 3,450	$ 3,918
National Laboratories	At Brookhaven National Laboratory (BNL), continued analysis of H-particle data from first experiment. Began data accumulation on the second phase H-particle experiment which examines a different mass region. Commenced experiment to measure double-lambda hypernuclei. Continued construction and testing of drift chambers for SOS spectrometer at CEBAF.	Continue data accumulation on the second phase H-particle search experiment and the measurement of double-lambda hypernuclei. CEBAF SOS drift chambers are complete and installed. Plan for commencement of strangeness production experiment at CEBAF.	Continue hadron physics program using the AGS at BNL and commence strangeness production experiment at CEBAF.

Program Activity	FY 1994	FY 1995	FY 1996
National Laboratories (Cont'd)	At BNL, utilized the LEGS Facility. Carried out a broad experimental program of polarized photon scattering looking primarily at few-nucleon targets, and concentrating on measurements of the nuclear tensor force, and polarization observables. Continued experimental program, and begin studies of hadron polarizabilities, particularly of the proton and the pion. Planned new experimental efforts using the crystal box spectrometer and End Cap upgrade.	Utilize the LEGS facility. Carry out a broad experimental program of polarized photon scattering looking primarily at few-nucleon targets, and concentrating on measurements of the nuclear tensor force, and polarization observables. Begin new experimental efforts using the crystal box spectrometer and End Cap upgrade. Plan for a new polarized H-D ice target.	Utilize the LEGS facility. Carry out a broad experimental program of polarized photon scattering looking primarily at few-nucleon targets, and concentrating on measurements of the nuclear tensor force, and polarization observables. Carry out experimental efforts using the crystal box spectrometer and End Cap upgrade, and the new polarized ice H-D target in collaboration with other U.S. and Italian scientists.
	At Argonne National Laboratory (ANL), a program of research was carried out concentrating on the interactions of nuclear constituents and the manner in which they are modified in nuclei. Research was carried out at a number of facilities including Fermilab, SLAC, the VEPP-3 electron storage ring in Russia, HERA in Germany, and CEBAF. Construction of the CEBAF SOS spectrometer was completed and components of an initial detector system was installed. Phase three experiment to measure the tensor force in electron deuteron scattering at VEPP-3 is underway. New initial results from the Fermilab muon scattering experiment are available. Initial data using CEBAF Hall C spectrometers have been taken.	Plan for commencement of full program of research at CEBAF. Complete work on a cryogenic He-3 target for use in a number of Hall C experiments at CEBAF. Carry out phase three experiment at VEPP-3. Begin measurements on spin structure function of the nucleon in the HERA electron ring. Prototype new tritium target for use at CEBAF.	Carry out full program of research at CEBAF. Build and use a new tritium target for experiments at CEBAF. Phase three experiment at VEPP-3, at the Russian Novosibirsk laboratory, will be completed. Carry out measurements on spin structure function of the nucleon in the HERA electron ring. Carry out measurements at Fermilab on antiquark distributions in the proton using the Dress-Yan process.

Program Activity	FY 1994	FY 1995	FY 1996
National Laboratories (Cont'd)	At Los Alamos National Laboratory (LANL), a program of research was carried out concentrating on examination of nuclear phenomena at high energies. Work concentrates on achieving an understanding of nuclear behavior at the quark-gluon level. Research is carried out primarily at Fermilab, and concepts are being developed to establish a future research program at the AGS, and using the PHENIX detector to be built at RHIC at Brookhaven National Laboratory. Continued to analyze Fermilab experiment on two prong decays of B and D mesons, and continued to prepare for new Drell-Yan measurements at Fermilab. Continue planning for future use of the PHENIX detector at RHIC for p-N studies.	Prepare for PHENIX detector activities utilizing the proton capability at RHIC, which involve emphasis on the muon subsystem and the overall trigger and data acquisition systems. Begin to carry out Drell-Yan measurements at Fermilab which will yield crucial results on whether the anti-quark asymmetry in the proton is the source of an apparent violation of a sum rule seen in deep inelastic scattering experiments.	Prepare for PHENIX detector activities utilizing the proton capability at RHIC, which involve emphasis on the muon subsystem and the overall trigger and data acquisition systems. Carry out Drell-Yan measurements at Fermilab which will yield crucial results on whether the anti-quark asymmetry in the proton is the source of an apparent violation of a sum rule seen in deep inelastic scattering experiments.
	At LAMPF, high priority experiments were supported such as the rare muon decay search (MEGA), a search for neutrino oscillations using the new LSND detector, and experiments using the new neutral meson spectrometer (NMS).	High priority experiments continue to be supported such as the rare muon decay search (MEGA), a search for neutrino interactions using the new LSND detector, and experiments using the new neutral meson spectrometer (NMS).	The Department is proposing defense uses for LAMPF and is requesting nuclear weapons research and development funds to continue operations of the facility. In this event, activity would be directed to high priority physics research such as the program of parity and time reversal violation studies using epithermal neutron scattering at the LANSCE facility. Highest priority experiments, such as MEGA, LSND, use of the NMS, will continue to completion as feasible. Continue analysis of completed LAMPF experiments. Ensure integrity of valuable and reusable government equipment as research emphasis shifts from LAMPF to other facilities.

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

Program Activity	FY 1994	FY 1995	FY 1996
National Laboratories (Cont'd)	Funding in the amount of $614,000 and $107,000 has been transferred to the SBIR program and the STTR program, respectively.	Funding in the amount of $1,833,000 and $225,000 has been budgeted for the SBIR program and the STTR program, respectively.	Funding in the amount of $2,100,000 and $320,000 has been budgeted for the SBIR program and the STTR program, respectively.
	$ 15,216	$ 19,942	$ 16,924
Universities	Supported a broad program of university research in Nuclear Physics utilizing not only accelerator facilities supported under the Medium Energy Program, but also using other U.S. and international accelerator laboratories. Also supported non-accelerator based research at a number of international sites where major detector systems have been assembled to examine fundamental physical laws such as searches for neutrino oscillations and double beta decay. Identified and supported high quality nuclear physics research efforts at minority institutions, such as Hampton University and Norfolk State University.	Support a broad program of university research in Nuclear Physics utilizing not only accelerator facilities supported under the Medium Energy Program, but also using other U.S.and international accelerator laboratories. Also support non-accelerator based research at a number of international sites where major detector systems have been assembled to examine fundamental physical laws such as searches for neutrino oscillations and double beta decay. Identify and support high quality nuclear physics research efforts at minority institutions, such as Hampton University and Norfolk State University.	Support a broad program of university research in Nuclear Physics utilizing not only accelerator facilities supported under the Medium Energy Program, but also using other U.S.and international accelerator laboratories. Also support non-accelerator based research at a number of international sites where major detector systems have been assembled to examine fundamental physical laws such as searches for neutrino oscillations and double beta decay. Identify and support high quality nuclear physics research efforts at minority institutions, such as Hampton University and Norfolk State University.
	Conducted program of selected nuclear physics experiments at other facilities including Fermilab, SLAC, TRIUMF (Canada), Saclay (France), PSI (Switzerland), VEPP-3 (Russia), and NIKHEF (Netherlands).	Conduct program of selected nuclear physics experiments at other facilities including Fermilab, SLAC, TRIUMF (Canada), Saclay (France), PSI (Switzerland), VEPP-3 (Russia), and NIKHEF (Netherlands).	Conduct program of selected nuclear physics experiments at other facilities including Fermilab, SLAC, TRIUMF (Canada), Saclay (France), PSI (Switzerland), VEPP-3 (Russia), and NIKHEF (Netherlands).
	$ 11,867	$ 11,420	$ 12,676
Subtotal, Research	$ 41,179	$ 43,278	$ 42,518

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

Program Activity	FY 1994	FY 1995	FY 1996
Operations			
LAMPF	Operated accelerator and facilities about 1900 hours for nuclear physics research with about seven secondary beams operating simultaneously. Provided beam for approximately 20 nuclear physics experiments involving about 180 scientists.	Operate accelerator and facilities about 2200 hours for nuclear physics research with a reduced number of secondary beams operating simultaneously. Provide beam for approximately 20 nuclear physics experiments involving about 180 scientists. The request also provides for preparation for decontamination and decommissioning of selected beam lines.	No activity.
	$ 23,640	$ 23,344	$ 0
Bates	Operated accelerator and facilities about 2000 hours for nuclear physics research. Began testing the new cw internal target facility on South Hall Ring, and developed extracted electron beam capability.	Operate accelerator and facilities about 2000 hours for nuclear physics research. Utilize the new internal target facility in the South Hall Ring and the cw extracted beams for the experimental nuclear physics program.	Operate accelerator and facilities for about 3000 hours for nuclear physics research. Utilize the new internal target facility in the South Hall Ring and the cw extracted beams for the experimental nuclear physics program.
	Provided beam for approximately 10 experiments involving about 100 scientists.	Provide beam for approximately 10 experiments involving about 100 scientists.	Provide beam for approximately 15 experiments involving about 150 scientists.
	Operated accelerator at 1 GeV for required experiments during selected operating cycles during the year. Routinely injected electron beam into the SHR and operate with circulating electron beams.	Operate accelerator at 1 GeV for required experiments during selected operating cycles during the year. Routinely inject electron beam into the SHR and operate with circulating electron beams. Extract external cw electron beams for experiments. Operate SHR with internal polarimeter capability.	Operate accelerator at 1 GeV for required experiments during selected operating cycles during the year. Routinely inject electron beam into the SHR and operate with circulating electron beams. Extract external cw electron beams for experiments. Operate SHR with internal polarimeter capability.
	Continued commissioning of the SHRE.	Complete commissioning of the SHRE.	No activity.
	$ 10,400	$ 9,760	$ 10,900

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

Program Activity	FY 1994	FY 1995	FY 1996
CEBAF	Continued final assembly and commissioning of entire accelerator facility and the beam switchyard which channels the electron beam to the three experimental halls. Brought initial beam into Hall C for testing of experimental apparatus. North and South Linac commissioning was completed. Central Helium Liquefier commissioning was completed. Beam was delivered at 800 MeV to Hall C for start of experimental equipment commissioning.	Complete final assembly and continue commissioning of entire accelerator facility and the beam switchyard which channels the electron beam to the three experimental halls. Make transition from commissioning to operational stage. Achieve 5-pass beam operation and a beam energy of 4 GeV. Establish capability to deliver beam to the three experimental halls simultaneously.	Facility is complete.
	Provided partial support for startup of laboratory operations and accelerator commissioning. Operated and tested 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. Began testing and operation of experimental equipment. Commenced initial experimental research operations in Hall C.	Commence laboratory operations. Continue initial experimental research tests in Hall C and commence testing for initial research operations in Hall A. Operations funding is provided to support commissioning of the accelerator facility and initiation of experimental research. The facility will operate about 15 weeks for research.	Operate the completed CEBAF accelerator facility for the research program in Halls A and C. Provide commissioning beam to Hall B for calibration of new CLAS detector system. Operate 35 weeks for research.
	$ 33,050	$ 48,600	$ 50,500
Other	$ 0	$ 0	$ 0
Subtotal, Operations	$ 67,090	$ 81,704	$ 61,400
Medium Energy Nuclear Physics	$ 108,269	$ 124,982	$ 103,918

DEPARTMENT OF ENERGY
FY 1996 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Heavy Ion Nuclear Physics

The Heavy Ion Nuclear Physics subprogram supports peer-reviewed research directed at understanding the behavior and properties of atomic nuclei and nuclear matter over an ever increasing range of energy, density and deformation conditions. These conditions are created in nucleus-nucleus collisions induced by beams of heavy ions. Sophisticated accelerators located at a three universities (Texas A&M, Yale, University of Washington) and four national laboratories (Argonne, Brookhaven, Oak Ridge, and Lawrence Berkeley) are supported and improved by the Nuclear Physics Program to provide the heavy ion beams necessary for these studies. The national laboratory facilities are utilized by Department of Energy (DOE), National Science Foundation (NSF), and foreign supported researchers whose experiments undergo peer-review by Program Advisory Committees prior to approval for beam time. Heavy Ion Nuclear Physics supported researchers also use NSF and foreign accelerator facilities for their studies. 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 a quark-gluon plasma.

II. A. Summary Table: Heavy Ion Nuclear Physics

Program Activity	FY 1994 Adjusted	FY 1995 Adjusted	FY 1996 Request	$ Change
Research				
LBL Relativistic Heavy Ion Research...........	$ 4,750	$ 4,755	$ 4,865	$ 110
BNL Relativistic Heavy Ion Research............	9,249	8,610	6,405	-2,205
National Laboratory Research...................	14,055	14,126	14,395	269
University Research............................	11,065	12,528	13,570	1,042
Subtotal, Research	$ 39,119	$ 40,019	$ 39,235	$ -784
Operations				
LBL Accelerator R&D............................	$ 5,850	$ 1,545	$ 1,735	$ 190
BNL Tandem/AGS Operations......................	9,020	8,690	13,775	5,085
University Accelerator Operations..............	2,580	2,560	2,555	-5
Other Operations (including ANL and LBL).......	8,270	8,360	9,500	1,140
Subtotal, Operations	$ 25,720	$ 21,155	$ 27,565	$ 6,410
Total, Heavy Ion Nuclear Physics	$ 64,839	$ 61,174	$ 66,800	$ 5,626

II. B. Laboratory and Facility Funding Table: Heavy Ion Nuclear Physics

	FY 1994 Adjusted	FY 1995 Estimate	FY 1996 Request	$ Change
Argonne National Lab (East)	$ 9,340	$ 9,510	$ 10,425	$ 915
Brookhaven National Lab	18,269	17,300	20,180	2,880
Lawrence Berkeley Lab	18,555	14,405	15,330	925
Lawrence Livermore National Lab	250	229	290	61
Los Alamos National Laboratory	1,040	990	1,090	100
Oak Ridge National Lab	3,510	2,110	2,300	190
All Other	13,875	16,630	17,185	555
Total, Heavy Ion Nuclear Physics	$ 64,839	$ 61,174	$ 66,800	$ 5,626

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1994	FY 1995	FY 1996
Heavy Ion Nuclear Physics			
Research			
LBL Relativistic Heavy Ion Research	Conducted a research program consistent with the FY 1993 phaseout of Bevalac Operations. Worked on analysis of Bevalac data, with emphasis on the important data obtained with the Time Projection Chamber (TPC) and DiLepton Spectrometer (DLS) detector systems. Continued involvement in the CERN NA35/NA49 experiment by developing TPC electronics for the FY 1994 Lead (Pb) beam run. Improved support for the core group which provides leadership for the STAR detector at RHIC.	Continue research program focussed on studying the properties of hot, dense nuclear matter produced in relativistic heavy ion collisions. Analysis of data taken in measurements with the DLS and TPC at the Bevalac will be completed. First data will be obtained from the fully instrumented NA49 experiment at CERN, and participation in experiments at the AGS at BNL will continue. Increased effort will be expended for support of the construction of the STAR detector at RHIC. R&D activities on detector instrumentation will continue to be pursued.	Research program will continue to focus on the study of the properties of hot, dense nuclear matter produced in relativistic heavy ion collisions. Analysis of data taken in CERN Pb beam experiment NA49 will be performed. Continued participation in BNL AGS experiments is anticipated. Effort will continue in providing leadership and management in the construction of the STAR detector for RHIC. Detector R&D activities will continue.
	$ 4,750	$ 4,755	$ 4,865

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

Program Activity	FY 1994	FY 1995	FY 1996
BNL Relativistic Heavy Ion Research	Continued 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. Continued R&D directed at RHIC accelerator and detector projects at the level of $5,880,000. Increased support for efforts directed towards designing and implementing experiments at RHIC.	Continue fundamental research program studying energy flow, nuclear stopping, strangeness and anti-particle production, and spatial-time evolution of reaction dynamics with Gold (Au) beams in experiments E864, E866, E877, and E891 at the AGS/BNL. Continue R&D activities which include RHIC R&D at the level of $3,620,000. Increased effort will be devoted to construction of the PHENIX and STAR detectors for RHIC.	Fundamental research program studying energy flow, nuclear stopping, strangeness and antiparticle production, and spatial-time evolution of reaction dynamics with Au beams in experiments E864, E866, E877, and E891 at BNL will continue. R&D activities directed at RHIC detectors and instrumentation will continue to be pursued. Increased effort will be devoted to construction of the PHENIX, PHOBOS, and STAR detectors for RHIC.
	$ 9,249	$ 8,610	$ 6,405
National Laboratory Research	At ANL, continued 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 Fragment Mass Analyzer (FMA) and ATLAS Positron Experiment (APEX) detector systems. Continued gamma-ray high-spin spectroscopy program both at ATLAS and with Gammasphere at LBL. Continued R&D activities directed at low-frequency superconducting RF cavities.	At ANL, continue fundamental research studies exploiting the unique massive heavy-ion beam capabilities and instrumentation at ATLAS, and 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 on superconducting RF cavities.	At ANL, fundamental research studies exploiting the unique massive heavy-ion beam capabilities and instrumentation at ATLAS will continue, including the measurements performed with the FMA and APEX detector systems. The gamma-ray high-spin spectroscopy program both at ATLAS and with Gammasphere at LBL will continue. R&D activities on superconducting RF cavities will continue. Continue and enhance the educational efforts directed at minority institutions.
	At LBL, continued the experimental program at the 88" cyclotron, including the high spin and transuranic nuclei studies. Continued measurements with the early implementation phase of Gammasphere to address physics questions of high priority. Emphasis was placed on providing the needed support to assure timely completion of Gammasphere. Continued intermediate energy studies of reaction mechanisms.	At LBL, continue research at the 88" cyclotron, including the high spin and transuranic nuclei studies. Particular emphasis will be placed on the studies being performed with the Gammasphere detector array, and on the development of the auxiliary detectors and computer systems needed to exploit this powerful detector for addressing the highest priority physics. Work will continue on studies of reaction mechanisms at intermediate energies.	At LBL, research at the 88" cyclotron, including the high spin and transuranic nuclei studies, will be pursued with particular emphasis on using the Gammasphere detector array to address the highest priority physics. Continued development of auxiliary detectors and the computer system needed to exploit this powerful detector will be supported. Work will continue on studies of reaction mechanisms at intermediate energies.

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

Program Activity	FY 1994	FY 1995	FY 1996
National Laboratory Research (Cont'd)	At ORNL, continued 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). Continued reaction mechanism study activities and in particular the measurements of energetic photons from highly excited nuclei. Continued 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 ORNL, continue the research program which includes: nuclear structure studies with emphasis on use of large detector arrays, such as Gammasphere; reaction mechanism studies, in particular the measurements of energetic photons from excited nuclei, and relativistic heavy ion studies at CERN with Lead (Pb) beams in Experiment WA98. Continue activities directed toward construction of the PHENIX detector for RHIC, which includes significant R&D.	At ORNL, a research program will be pursued which includes: reaction mechanism studies, in particular the measurements of the energetic photons emitted from highly excited nuclei, and relativistic heavy ion studies at CERN with Lead (Pb) beams in Experiment WA98. Activities directed towards construction of the PHENIX detector for RHIC will continue to have high priority.
	At LANL, continued 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. Enhanced R&D and planning activities associated with the PHENIX detector for RHIC.	At LANL, continue fundamental research studies at CERN with Lead (Pb) beams in Experiment NA44, and analyses of previous data taken with Silicon and proton beams. Continue activities associated with R&D and construction of the PHENIX detector for RHIC.	At LANL, fundamental research studies of hot, dense nuclear matter at CERN with Pb beams in Experiment NA44 will continue. Increased effort will be focussed on activities associated with construction of the PHENIX detector for RHIC.
	At LLNL, continued 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. Continued efforts directed at nuclear structure studies with Gammasphere.	At LLNL, continue research studies at the BNL/AGS with Gold (Au) beams in Experiment E866, and in the analysis of data taken in E859. Continue efforts directed towards construction of the PHENIX detector for RHIC. Continue efforts directed at nuclear structure studies with Gammasphere.	At LLNL, involvement at BNL/AGS in measurements with Au beams in Experiment E866, studying the properties of hot, dense nuclear matter, will continue. Efforts directed towards construction of the PHENIX detector for RHIC will continue. The research effort directed at nuclear structure studies with Gammasphere will continue.
	$ 14,055	$ 14,126	$ 14,395

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

Program Activity	FY 1994	FY 1995	FY 1996
University Research	Continued 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 continued to carry out studies which are appropriate for the facility and which exploit the inherent strengths of each facility for research and education. Emphasis continued to be placed on the utilization of detector systems acquired and on improving the instrumentation available.	Continue strengthening university user fundamental 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 and which exploit the inherent strengths of each facility for research and education. Continue emphasis on the utilization of the detector systems acquired and on improving the instrumentation available to address forefront nuclear physics topics. Education of students continues to be of high priority in this activity.	University researchers will continue to utilize national laboratory facilities where unique instrumentation, such as Gammasphere, and beams, such as relativistic heavy ions at the AGS, exist. Researchers at university accelerator facilities will continue to focus on studies appropriate for and which exploit the inherent strengths of each facility for research and education. At Texas A&M, continue project measuring radiation hardness of micro-electronics jointly with McDonnell-Douglas and Prairie View A&M. Continued emphasis will be placed on development and use of novel instrumentation. Education of students continues to be of high priority in this activity.
	Funding in the amount of $1,000,000 has been transferred to the SBIR program.	Funding in the amount of $1,410,000 has been budgeted for the SBIR program.	Funding in the amount of $900,000 has been budgeted for the SBIR program.
	$ 11,065	$ 12,528	$ 13,570
Subtotal, Research	$ 39,119	$ 40,019	$ 39,235

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

Program Activity	FY 1994	FY 1995	FY 1996
Operations			
LBL Accelerator R&D	Funds at the level of $3,920,000 were provided for activities in preparation of decommissioning of the Bevalac facility. Funds were provided for continued R&D activities in support of the Nuclear Physics program.	Funds are provided for activities to complete preparation for decommissioning of the Bevalac facility, and for R&D activities in support of the Nuclear Physics program.	Funds are provided for Bevalac facility closure activities and for accelerator R&D activities in support of the Nuclear Physics program.
	$ 5,850	$ 1,545	$ 1,735
BNL Tandem/AGS Operations	Conducted operations of Tandem/Booster/GAS accelerator facility to provide at least 6 weeks of Gold (Au) beams for an experimental program. Provided support for implementation of gold beam experiments. Supported RHIC test beam activities.	Conduct operations of Tandem/Booster/AGS accelerator facility so as to provide at least 4 weeks of Gold (Au) beams for an experimental program. Provide support for implementation and execution of Au beam experiments. Begin RHIC start-up activities for testing accelerator components at the level of $2,200,000 and support RHIC test beam activities.	The Tandem/Booster/AGS accelerator complex will be operated for 12 weeks of Gold (Au) beams for an experimental program. Support will be provided for implementation and execution of Au beam experiments and for RHIC test beams. Funds at the level of $6,000,000 are provided for RHIC start-up activities, including testing of components, and for the procurement of component spares.
	$ 9,020	$ 8,690	$ 13,775
University Accelerator Operations	At the Yale tandem facility, provided light heavy-ion beams for nuclear structure, astrophysics, and fundamental interaction studies. Fully supported 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.	The Yale tandem facility will provide beams for conduct of nuclear structure, astrophysics, and fundamental interaction studies. At Texas A&M, the superconducting cyclotron will provide heavy ion beams at low to intermediate energies for a fundamental research program studying the properties of excited nuclei, fundamental interaction, and astrophysics.	The Yale tandem facility will provide beams for conduct of nuclear structure, astrophysics, and fundamental interaction studies. At the Texas A&M, the superconducting cyclotron will provide heavy ion beams at low to intermediate energies for a program studying the properties of excited nuclei, fundamental interaction, and astrophysics.
	$ 2,580	$ 2,560	$ 2,555

Program Activity	FY 1994	FY 1995	FY 1998
Other Operations (including ANL and LBL)	Supported 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. Continued 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. Continued R&D on the Advanced ECR ion source.	The ANL ATLAS facility will provide heavy ion beams including uranium in a running schedule which includes FMA and APEX measurements. Continue improvements to optimize the performance and reliability of ATLAS for heavy ion acceleration. The LBL 88" Cyclotron will provide beams in a running schedule which emphasizes Gammasphere measurements. R&D will continue on the Advanced ECR ion source.	The ANL ATLAS facility will provide heavy ion beams including uranium in a running schedule which includes FMA and APEX measurements. Continue improvements to optimize the performance and reliability of ATLAS for heavy ion acceleration. The LBL 88" Cyclotron will provide beams in a running schedule which emphasizes Gammasphere measurements. R&D will continue on the Advanced ECR ion source.
	$ 8,270	$ 8,360	$ 9,500
Subtotal, Operations	$ 25,720	$ 21,155	$ 27,565
Heavy Ion Nuclear Physics	$ 64,839	$ 61,174	$ 66,800

DEPARTMENT OF ENERGY
FY 1996 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: nuclear properties important to astrophysics issues; the behavior of nucleons at the surface of the nucleus as well as the collective behavior of the entire ensemble of nucleons acting collectively; nuclear reaction mechanisms; and experimental tests of fundamental symmetries. The last of these categories can often be accomplished without the use of accelerators, such as in 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 main goal serving the nuclear science community and other nuclear based technical disciplines through the maintenance of a nuclear data information base that is readily accessible and user oriented.

II. A. Summary Table: Low Energy Nuclear Physics

Program Activity	FY 1994 Adjusted	FY 1995 Adjusted	FY 1996 Request	$ Change
Research				
Research at University Facilities..............	$ 3,661	$ 2,980	$ 4,315	$ 1,335
Research at National Laboratory Accelerators...	2,805	3,210	3,050	-160
Research at Reactors...........................	1,064	835	195	-640
Other Research.................................	3,715	5,649	7,140	1,491
Subtotal, Research	$ 11,245	$ 12,674	$ 14,700	$ 2,026
Operations				
Accelerator Operations.........................	$ 5,296	$ 5,936	$ 7,600	$ 1,664
Subtotal, Operations	$ 5,296	$ 5,936	$ 7,600	$ 1,664
Nuclear Data				
Nuclear Data Measurements......................	$ 2,284	$ 1,700	$ 0	$ -1,700
Nuclear Data Compilation and Evaluation........	4,716	4,286	4,800	514
Subtotal, Nuclear Data	$ 7,000	$ 5,986	$ 4,800	$ -1,186
Total, Low Energy Nuclear Physics	$ 23,541	$ 24,596	$ 27,100	$ 2,504

II. B. Laboratory and Facility Funding Table: Low Energy Nuclear Physics

	FY 1994 Adjusted	FY 1995 Estimate	FY 1996 Request	$ Change
Argonne National Lab (East)	840	210	225	15
Brookhaven National Lab	3,506	2,310	3,250	940
Idaho National Engineering Lab	345	0	0	0
Lawrence Berkeley Lab	2,600	1,675	1,900	225
Lawrence Livermore National Lab	360	305	305	0
Los Alamos National Laboratory	1,695	530	1,025	495
Oak Ridge National Lab	5,366	7,210	8,540	1,330
All Other	8,829	12,356	11,855	-501
Total, Low Energy Nuclear Physics	$ 23,541	$ 24,596	$ 27,100	$ 2,504

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1994	FY 1995	FY 1996
Low Energy Nuclear Physics			
Research			
Research at University Facilities	At Triangle Universities Nuclear Laboratory (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.	Research at the University of Washington will address issues relating to challenging fundamental problems in symmetries, giant resonances, nucleus-nucleus reactions, and other areas of nuclear physics. This includes the use of the polarized ion source and booster to study a variety of nuclear structure problems and to provide new understanding of possible violations of fundamental symmetries. At TUNL, the fundamental research goal will be to provide new understanding of nuclear astrophysics and fundamental symmetries. In the latter are included searches for quantum systems which display chaotic behavior, charge symmetry breaking and additional evidence of parity violation in the nucleus.	The research goal at TUNL, will be to provide new understanding of nuclear astrophysics and nuclear structure. Research includes the use of the unique polarized ion source to study a variety of nuclear structure problems and to search for violations of fundamental symmetries. In the latter are included searches for quantum systems which display chaotic behavior, charge symmetry breaking and additional evidence of parity violation in the nucleus. Using the Tandem injector and superconducting LINAC booster at the University of Washington, research will encompass fundamental symmetries, giant resonances, nucleus-nucleus reactions, and other areas of nuclear physics. Also at the University of Washington, solar neutrino research, described in the "Other Research" section, involves joint research with a consortium of

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

Program Activity	FY 1994	FY 1995	FY 1996
Research at University Facilities (Cont'd)			U.S., Canadian and British groups that are developing at the Solar Neutrino Observatory (SNO) located in Sudbury, Canada.
	$ 3,661	$ 2,980	$ 4,315
Research at National Laboratory Accelerators	Continued low energy research at three of the national laboratories. At ORNL, continued development of the Radioactive Ion Beam (RIB) facility and associated research. At ANL, research into the structure of nuclei far from stability continued 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 addressed issues associated with producing and handling beams of unstable nuclei.	At ORNL, the intense beams of radioactive ions from RIB will allow, for the first time, access to combinations of proton and neutron configurations at, and beyond, the limits of proton stability. In addition, such beams also will be used to initiate a new and exciting chapter of nuclear astrophysics in which both the structure and the reaction cross sections of nuclei involved in the CNO cycle process and the rapid proton capture process can be studied. At LBL, the main effort will be devoted to an international collaboration, described below under Other Research, to measure solar neutrino flux rates. Activities at ANL have been transferred to the Heavy Ion program.	At ORNL, intense beams of radioactive ions from RIB will be used to initiate a new and exciting chapter of nuclear astrophysics in which both structure and reaction cross sections of nuclei involved in the CNO cycle and the rapid proton capture process can be studied. These studies will be done along with involvement of British scientists using the $3,500,000 recoil separator that has been contributed to ORNL by the Daresbury Laboratory in England. These efforts will be complimented by occasional use of the Oak Ridge Electron Linear Accelerator (ORELA) which has become part of this sub-program. In addition, RIB will allow, for the first time, production and measurement of atomic nuclei with combinations of proton and neutrons at, and beyond, the limits of proton stability. The nuclear structure research effort at ORNL, transferred from the Heavy Ion Program, will focus on RIB related research. At LBL, the main effort will be devoted to an international collaboration to study solar neutrinos (see "Other Research" described below), and studies aimed at better defining the use and characteristics of ion sources for the production of intense radioactive ion beams. At BNL, the Nuclear Structure Group, which previously used the reactor-based on-line isotope separator

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

Program Activity	FY 1994	FY 1995	FY 1996
Research at National Laboratory Accelerators (Cont'd)			TRISTAN, primarily will focus on the investigation of nuclei having abnormal isospin using off-site facilities such as the ORNL RIB Facility.
	$ 2,805	$ 3,210	$ 3,050
Research at Reactors	Continued both the BNL nuclear structure research and the fundamental neutron measurements at the NIST. At BNL, used the TRISTAN on-line isotope separator at the HFBR to study isotopes of interest to nuclear astrophysics problems. Continued 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, continued studies of time reversal symmetry violation.	The goal of the measurements at NIST, which has the only cold neutron facility in the United States, will use their unique polarized beams to provide an understanding of the fundamental properties of the neutron. These measurements also lead to fundamental answers about the weak interaction and provide insight into the origin of parity violations. Using the High Flux Beam Reactor at BNL, investigations of nuclei with abnormal proton-neutron ratios and development of techniques to identify abnormal nuclear properties will complement experiments using radioactive beams that will initially be available at the ORNL RIB facility. At BNL, discontinue studies of isotopes related to reactor decay heat calculations.	Measurements at the NIST reactor, which has the only cold neutron facility with polarized beams in the United States, have as their goal an understanding of the basic properties of the neutron such as lifetimes and dipole moments. These measurements probe fundamental bases of the weak interaction and provide insight into the origin of parity violations. At BNL, the on-line Isotope Separator TRISTAN will cease to operate.
	$ 1,064	$ 835	$ 195

Program Activity	FY 1994	FY 1995	FY 1996
Other Research	Continued 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 chemistry aspects of GALLEX were supported by the involvement of their nuclear chemists, including development of a Cr-51 calibration source.	The objective of the solar neutrino research program is to measure the flux of neutrinos from the sun arising from the nuclear processes that drive the sun's energy production. Previous measurements have found neutrino fluxes substantially lower than those predicted by the best current astrophysical models of the sun. The discrepancy between measurements and predictions have two possible explanations; either the solar nuclear processes are not well understood, or the neutrinos themselves, after the initial solar production, are transformed into exotic types which are not detectable by present experiments. If the later case is true, neutrinos would have a small mass and these results provide the first concrete evidence for a change required to the Standard Model of particles and forces which underlies our fundamental understanding of energy and matter. Present experiments use Gallium as the detection material to focus on the primary proton burning process which is not very sensitive to solar models. These international collaborations include a US/European experiment (GALLEX) located in the Gran Sasso tunnel in Italy, the second being a US/Russian (SAGE) experiment located in a deep cavern in the Russian Caucasus mountains. These will be augmented with a new US/Canadian/UK collaborative experiment (SNO) sited in a very deep nickel mine in Sudbury, Ontario. Use of 1000 tons of heavy water, provided the AECL, will uniquely permit detection of the exotic massive neutrinos if they exist. The responsibilities of the U.S.	The objective of the solar neutrino research program is to measure the flux of the neutrinos from the sun arising from the nuclear processes that drives the sun's energy production. Previous measurements have found high energy neutrino fluxes substantially lower than those predicted by the best current astrophysical models of the sun. The discrepancy between measurement and predictions have two possible explanations: either the solar nuclear processes are not well understood; or the neutrinos themselves, after initial solar production, are transformed into exotic types which are not detectable by present experiments. If the later case is true, neutrinos would have a small mass and these results provide the first concrete evidence for a change required in the Standard Model of particle and forces which underlies our fundamental understanding of energy and matter. Present solar neutrino experiments use Gallium as the detection material to focus on the very low energy neutrinos which arise from the primary proton burning process, because it is not very dependent on the details of solar models. These international collaborations include a US/European experiment (GALLEX) located in the Gran Sasso tunnel in Italy and in a second effort, the US/Russian (SAGE) experiment located in a deep cavern in the Russian Caucasus mountains. Results from these detectors independently find that neutrinos are missing from the low energy solar flux as well. These experiments are coming

Program Activity	FY 1994	FY 1995	FY 1996
Other Research (Cont'd)		participants will be: LANL has major responsibilities for R&D on data-acquisition codes, computer hardware, photomultipliers and nuclear chemistry related issues; LBL for fabrication of the background-free photomultiplier support structure; and the University of Pennsylvania for optimization of the photomultipliers.	to natural conclusion upon completion of calibration tests to verify detector efficiencies. Solar neutrinos research will be refocused onto a US/Canada/UK collaborative experiment, the Solar Neutrino Observatory (SNO), sited in a very deep mine in Sudbury, Ontario. Use of 1000 tons of heavy water provided by the Canadian AECL, supplemented by special neutral current detector techniques, will uniquely permit detection of exotic massive neutrinos if they exist. The responsibilities of the U.S. participants are: the University of Washington (described under the previous section entitled: "Research at University Facilities"); and LANL has responsibility for aspects of radiochemistry measurement and analysis; LBL for fabrication of the background-free photomultiplier support structure and nuclear chemistry related issues; and the University of Pennsylvania for optimization of the photomultipliers. Increased on-site involvement of these groups will occur once SNO is operational. The collaboration will focus on various aspects of data acquisition, analysis and interpretation as well as on going functional improvements including development, installation, and operation of neutral current detectors. During the first year of data taking, part of the efforts will concentrate on the analysis of the charged current reaction, which has a relatively large cross section for Boron-8 neutrinos, to correlate results with previous evidence for neutrino oscillations.

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

Program Activity	FY 1994	FY 1995	FY 1996
Other Research (Cont'd)	Funding in the amount of $1,607,000 has been transferred to the SBIR program.	Funding in the amount of $1,265,000 has been budgeted for the SBIR program.	Funding in the amount of $1,266,000 has been budgeted for the SBIR program.
	$ 3,715	$ 5,649	$ 7,140
Subtotal, Research	$ 11,245	$ 12,674	$ 14,700
Operations			
Accelerator Operations	Fully supported two university accelerator facilities located at Duke University and the Univ. of Washington. Operations support of the superconducting cyclotrons at Texas A&M was provided by the heavy ion program. Provided operations support for the Radioactive Ion Beam (RIB) project at ORNL.	The major objective at ORNL is the completion of a world class accelerator for RIB. This facility will couple the existing ORIC cyclotron and Holifield Tandem facilities into a unique and cost effective facility for producing and accelerating short-lived radioactive nuclides. Additionally, support is provided for two university accelerator facilities located at Duke University and the University of Washington, whose operational goals and objectives are presented above under Research at University Facilities.	The major objective at ORNL is the completion and initial operation of a world class accelerator for RIB. This facility couples the existing ORIC cyclotron and Holifield Tandem facilities into a unique and cost effective facility for producing and accelerating short-lived radioactive nuclides. Support is provided for four university accelerator facilities located at Duke University, the University of Washington, Ohio University and the University of Massachusetts-Lowell, whose operational goals and objectives are presented above in the section entitled: "Research at University Facilities."
	$ 5,296	$ 5,936	$ 7,600
Subtotal, Operations	$ 5,296	$ 5,936	$ 7,600

Program Activity	FY 1994	FY 1995	FY 1996
Nuclear Data			
Nuclear Data Measurements	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), strengthened high priority components and phased out or consolidated lower priority components. Strengthened the university based measurements of priority cross-sections for higher energy neutrons and charged particles. Addressed 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. Ceased activities associated primarily with advanced reactor research. This included terminating the operation of ORELA at ORNL in support of advanced reactor research.	The goal of this subprogram is to provide priority measurements coordinated with the testing and improvement of models for use in the prediction of cross sections. These models address critical questions in uses such as nuclear astrophysics. Some of these measurements of reaction cross-sections are for higher energy neutrons, in particular for (n,p) and (n, alpha) reactions, to derive level density information. At INEL, discontinue measurement of radioactive nuclides related to decay heat calculations.	This subprogram has been terminated. Some activities have been transferred to the Low Energy Research Program, the Operations sub-program, or the Nuclear Data Compilation and Evaluation subprogram. Of those transferred, the Oak Ridge Electron Linear Accelerator (ORELA) will become part of the RIB Nuclear Astrophysics effort (see Research: National Laboratory Accelerators) and operate in a diminished capacity in conjunction with nuclear astrophysics measurements at RIB. Additional nuclear data measurements using ORELA will occur as demands and their concomitant external support are received. A majority of the university component has been transferred to the research component of the Low Energy Nuclear Physics Program.
	$ 2,284	$ 1,700	$ 0
Nuclear Data Compilation and Evaluation	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, strengthened the structure component of the program that is developing electronic data access and assessment capabilities. This included revising the compilation and evaluation activities to improve nuclear data libraries, and their accessibility. Supported activities with respect to modernization and coordination of the nuclear structure data information system including replacement with more effective electronic data dissemination	The goal is to provide a nuclear data base to serve the DOE science and technology base through maintenance of nuclear data activities of compilation, storage and dissemination of evaluated nuclear data files. Cost reductions will be brought about by participation in international data activities such as participation in the international nuclear data effort coordinated by the IAEA nuclear data center, the Nuclear Energy Agency (NEA), and the Working Group on International Evaluation Cooperation. A primary objective will be to modernize the nuclear data information system by replacement of hard copy publications with more	The goal is to provide a nuclear data base to serve nuclear physics and other technical users through the nuclear data activities of compilation, storage and dissemination of nuclear data files. Participation in international data activities such as the international nuclear data effort coordinated by the IAEA nuclear data center, the Nuclear Energy Agency (NEA), and the Working Group on International Evaluation Cooperation will provide a cost effective basis for operation. A primary objective will be the continued modernization of the nuclear data information system by phased replacement of hard copy

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

Program Activity	FY 1994	FY 1995	FY 1996
Nuclear Data Compilation and Evaluation (Cont'd)	techniques. Continued participation in the Working Group on International Evaluation Cooperation to maintain the coordination of nuclear data evaluation activities and free exchange of the results. Continued support for the IAEA international Nuclear Data efforts. Addressed cross section code files and modernization of national data, networking at BNL, LANL, LBL, and LLNL.	effective electronic data dissemination techniques. This includes expansion of electronic data bases as vehicles for timely and cost-effective compilation and dissemination of assessed nuclear properties. This will improve the interactive and interrogative user-friendly nature of both computer network and personal computer information platforms. Strategic research at LLNL, in cooperation with industry, will address the integration of nuclear physics cross section data bases into interactive programs to provide predictions of dose distributions in radiation oncology patients.	publications with more effective electronic data dissemination techniques. This includes expansion of electronic data bases as vehicles for timely and cost-effective compilation and dissemination of assessed nuclear properties. High priority will be placed on the improvement of interactive and interrogative user-friendly nature of both computer network and personal computer information platforms.
	$ 4,716	$ 4,286	$ 4,800
Subtotal, Nuclear Data	$ 7,000	$ 5,986	$ 4,800
Low Energy Nuclear Physics	$ 23,541	$ 24,596	$ 27,100

DEPARTMENT OF ENERGY
FY 1996 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Nuclear Theory

Theoretical Nuclear Physics is a program of fundamental science research to provide new insight into the observed behavior of atomic nuclei. The understanding of nuclear phenomena is prerequisite to understanding the material foundations of the world around us and in our universe. The research ranges from relating the description of elementary constituent particles and the fundamental forces connecting them, to accounting for the collective interactions of nuclei as a whole. The selection of the elements of the nuclear theory program is based on the results of anonymous peer reviews by recognized experts in the international nuclear physics community. The long-range objectives of the Nuclear Theory subprogram are to obtain a comprehensive understanding of the character and structure of nuclear matter at the most fundamental level in terms of the properties of the constituent quarks and gluons, and using this knowledge to further define the relationships between the nucleons embedded 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. 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 and the development of innovative algorithms to use this advanced technology. The graduate students and post-docs supported in the Theoretical Nuclear Physics program are highly trained in technical problem solving techniques and have the flexibility to broadly enhance the nation's scientific and technical literacy. The strength of the nuclear theory effort is enhanced by strong interactions with the international nuclear physics community as well as by nuclear theory efforts supported at other agencies, such as the National Science Foundation. This is particularly true at the National Institute for Nuclear Theory in Seattle, increasingly recognized as a center of world leadership in nuclear theory. The National Advisory Committee of the Institute comprises physicists from Europe, Japan, and the United States from both the DOE and NSF programs. In many cases, program directors of short term programs at the Institute come from outside the United States and from NSF programs.

II. A. Summary Table: Nuclear Theory

Program Activity	FY 1994 Adjusted	FY 1995 Adjusted	FY 1996 Request	$ Change
Nuclear Theory	$ 14,648	$ 14,650	$ 15,500	$ 850
Total, Nuclear Theory	$ 14,648	$ 14,650	$ 15,500	$ 850

II. B. Laboratory and Facility Funding Table: Nuclear Theory

Argonne National Lab (East)	$ 925	$ 900	$ 950	$ 50
Brookhaven National Lab	1,100	1,075	1,175	100
Continuous Electron Beam Accelerator Facility	130	490	520	30
Lawrence Berkeley Lab	935	850	950	100
Los Alamos National Laboratory	775	850	920	70
Oak Ridge National Lab	748	590	830	240

II. B. Laboratory and Facility Funding Table: Nuclear Theory

	FY 1994 Adjusted	FY 1995 Estimate	FY 1996 Request	$ Change
All Other	10,035	9,895	10,155	260
Total, Nuclear Theory	$ 14,648	$ 14,650	$ 15,500	$ 850

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1994	FY 1995	FY 1996
Nuclear Theory			
Nuclear Theory	Operated 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. Maintained the present level of effort at the institute and continued to support interaction with the nuclear physics community by providing study groups and long-term workshops in critical research areas. Supported 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). Supported 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	To enhance our understanding of the fundamental structure and governing forces in atomic nuclei, focus highest quality research on top priority areas of nuclear physics research - the physics relevant to the Continuous Electron Beam Accelerator Facility (CEBAF) and the Relativistic Heavy Ion Collider (RHIC), the GAMMASPHERE multi-detector array, and the Radioactive Ion Beam (RIB) programs. Provide full support of the CEBAF theory program from Nuclear Theory as CEBAF changes from construction to operational status. Maintain a balance between university and laboratory programs to develop an appropriate supply of highly trained students and post-docs, and thus providing a highly skilled supply of theoretical physicists for DOE programs. Operate the fully staffed Institute for Nuclear Theory at the University of Washington as a focus center for the development of forefront basic research programs in theoretical nuclear physics. Support interaction between the Institute and the nuclear physics community by providing for study groups and long-term workshops at the Institute in critical research areas,	To expand our understanding of the fundamental structure of atomic nuclei, support and strengthen those most vital programs which are closely coupled to the highest priority nuclear physics research programs-the physics addressed at the Continuous Electron Beam Accelerator Facility (CEBAF),the Relativistic Heavy Ion Collider (RHIC), the Gammasphere multi-detector array, RIB, and the Solar Neutrino Observatory (SNO). To achieve this objective, support for some existing programs will be phased-out in the period from the beginning of FY 1995 to the end of FY 1996. The program reductions will be chosen to be consistent with the following priorities: 1) strongly support university based theory programs where there are particularly good opportunities for training the highly skilled students and post-docs needed for the DOE research effort; 2) ensure the vitality of strong theoretical nuclear physics programs at the national laboratories to meet high priority objectives; and 3) operate the fully staffed Institute for Nuclear Theory at the University of Washington as a focus center for the development of forefront basic research programs in theoretical nuclear physics. Support

III. Nuclear Theory (Cont'd):

Program Activity	FY 1994	FY 1995	FY 1996
Nuclear Theory (Cont'd)	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.	thereby enhancing the transfer of knowledge to the centers across the nation. Support initiatives which enhance the mutual interaction and stimulation between theory programs at national laboratories and the university programs, including collaboration with the USDOE High Performance Computing and Communications Program. These programs should lead to a more fundamental understanding of nuclear phenomena, of the role of the underlying quark-gluon substructure of nuclear matter, and of phase transitions in nuclear matter.	the interaction between the Institute for Nuclear Theory and the nuclear physics community by providing for long-term programs and workshops in critical research areas of nuclear physics and in areas of strong interaction with other physics disciplines. These programs should lead to a more fundamental understanding of nuclear phenomena, of the role of the underlying quark-gluon substructure of nuclear matter, of phase transitions in nuclear matter, and of several current outstanding problems in astrophysics.
	No activity.		
	$ 14,648	$ 14,650	$ 15,500
Nuclear Theory	$ 14,648	$ 14,650	$ 15,500

DEPARTMENT OF ENERGY
FY 1996 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 1994 Adjusted	FY 1995 Adjusted	FY 1996 Request	$ Change
CEBAF	$ 11,300	$ 10,200	$ 8,100	$ -2,100
BNL	1,890	2,530	5,300	2,770
LBL	1,186	996	1,550	554
LANL	289	844	375	-469
MIT/Bates	1,675	2,125	3,795	1,670
ANL	1,105	1,350	1,400	50
ORNL	2,345	1,525	2,225	700
University Laboratories and User Groups	2,165	3,400	1,280	-2,120
Sudbury Neutrino Observatory	3,362	0	0	0
Gammasphere	4,450	1,750	0	-1,750
Lawrence Berkeley Laboratory - GPE	1,870	1,870	2,000	130
Other	363	1,410	1,975	565
Total, Capital Equipment	$ 32,000	$ 28,000	$ 28,000	$ 0

II. B. Laboratory and Facility Funding Table: Capital Equipment

	FY 1994 Adjusted	FY 1995 Adjusted	FY 1996 Request	$ Change
Argonne National Lab (East)	$ 1,105	$ 1,350	$ 1,400	$ 50
Brookhaven National Lab	1,890	2,530	5,300	2,770
Continuous Electron Beam Accelerator Facility	11,300	10,200	8,100	-2,100
Lawrence Berkeley Lab	8,386	4,616	3,550	-1,066
Los Alamos National Laboratory	2,409	844	375	-469
Oak Ridge National Lab	2,345	1,525	2,225	700
All Other	4,565	6,935	7,050	115
Total, Capital Equipment	$ 32,000	$ 28,000	$ 28,000	$ 0

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1994	FY 1995	FY 1996
Capital Equipment			
CEBAF	Continued procurement of components for the CEBAF Large Acceptance Spectrometer (CLAS) in Hall B. (This spectrometer, designed around a superconducting toroidal magnet, a drift chamber system, and a electromagnetic shower calorimeter, will provide an unique and exciting opportunity to study reactions leading to multiple-particle final states.) Erected space frame for the toroidal magnet and installed the tagging magnet. Commenced stringing wires in first Region 3 drift chamber. Began installing scintillator and lead layers in first calorimeter section. Procured general use equipment for the CEBAF facility such as equipment for the computer center, laboratories, offices, and shops.	Continue procurement of components for the CLAS spectrometer. Install and commission superconducting toroidal magnet. Continue construction of drift chambers, scintillation counters, electromagnetic calorimeters, Cerenkov counters. Install some detector sections. 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 CLAS spectrometer. Complete construction and installation of detectors for all sectors and begin commissioning tests. Procure general use equipment for the CEBAF facility such as equipment for the computer center, laboratories, offices, and shops.
	$ 11,300	$ 10,200	$ 6,100
BNL	Improved heavy ion experiments E866, E877, and E878 to take advantage of the unique gold beam from the AGS facility. Initiated fabrication of silicon Vertex Detector (SVD) for the STAR detector at RHIC. At LEGS, procured a helium dilution refrigerator as the initial step in the construction of a polarized H-D frozen spin target to be used in experiments that measure the spin structure of the proton and the neutron. This type of target has an unusually high degree of polarization and a high fraction of polarized species. The LEGS collaboration includes members from the Frascati National Laboratory, Italy and the University of Rome. Provided a tantalum shield for the chromium-51 calibration source for the GALLEX solar	Begin construction of experiment E896, which is designed to search for new states of nuclear matter produced in nucleus-nucleus collisions at the AGS. The study of these nuclear reactions provide information that will be needed to interpret data from the RHIC facility now under construction. Continue SVD, initiate muon detector for PHENIX, and augment Laboratory computing capability as recommended by NSAC. At LEGS, continue constructing the frozen spin target of H-D ice, purchasing a superconducting holding coil.	Complete construction of experiment E896, which is capable of unambiguously identifying the topological signature of unstable particle decays as well as the rigidity of each charged particle produced, thus affording a sensitive search for new metastable states and investigation of the properties of known strange particle states. Continue SVD, muon detector and computer upgrades. At LEGS, construct a large acceptance detector for use with the frozen spin target of H-D ice and begin a program of experiments which are sensitive to the partitioning of total nucleon spin into the intrinsic and orbital components of the nucleon's constituents.

III. Capital Equipment (Cont'd):

Program Activity	FY 1994	FY 1995	FY 1996
BNL (Cont'd)	neutrino detector. The GALLEX collaboration consists of ten institutions in Germany, Italy, France, Israel, and the U.S.		
	$ 1,890	$ 2,530	$ 5,300
LBL	Completed fabrication of read-out electronics for the CERN lead beams experiment NA49. This electronics development effort also provides prototype experience for the design of the TPC system in the STAR experiment at RHIC in which LBL plays a leading role. Continued to develop the analysis center for 3-dimensional TPC data.	Continue to acquire and modernize equipment to design and test integrated circuits for STAR and CERN TPC electronics. The ongoing endeavor to develop integrated circuits (ICs) requires a continuous effort to stay with state-of-the-art design hardware and software. With each new generation of ICs it is necessary to review the possibility of using more recent and more dense processes, thus further reducing the cost of individual ICs. Continue to develop the analysis center for 3-dimensional TPC data.	Provide equipment for relativistic heavy ion research, nuclear structure and reaction studies, and nuclear astrophysics/weak interactions research. Continue to acquire data acquisition and analysis computing power for the rapid analysis and publication of the physics from existing and new detector systems.
	$ 1,186	$ 996	$ 1,550
LANL	Began construction of an additional detector system for the Sudbury Neutrino Observatory that will permit simultaneous, real-time measurement of the neutral-current and the charged-current signals. Discrete helium-3 filled neutron detectors made from material with extremely low radioactivity will be installed within the heavy water volume of the SNO detector.	Complete fabrication of the neutral current detector system for the Sudbury Neutrino Observatory. By adding the neutral current detection capability, the SNO detector can make an accurate determination of whether solar neutrinos change their flavor en route to the earth. Provide improved detection equipment for the SAGE solar neutrino observatory at the Baksan Laboratory in Russia.	Provide equipment for the on-going medium energy and heavy ion programs and for solar neutrino research.
	$ 289	$ 844	$ 375

III. Capital Equipment (Cont'd):

Program Activity	FY 1994	FY 1995	FY 1996
MIT/Bates	Upgraded existing magnetic spectrometers and associated detector systems to utilize the extracted, high-duty-cycle beam from the South Hall Ring Experiment. Made improvement of the Bates electron linac by upgrading RF, vacuum and control system components. Fabricated components for the HERMES experiment, an international collaborative experiment that will measure the spin structure functions of the nucleon in an electron storage ring at the DESY facility in Germany.	Begin fabrication of detector system for internal target experiments with the South Hall Ring. Fabricate gantry support system for the out-of-plane spectrometer system (OOPS), which is being jointly funded by the National Science Foundation. Construct cryogenic and polarized targets for extracted beam experiments. Procure klystron power tubes for 1 GeV operation. Continue improvement of the Bates electron linac by replacing RF and vacuum system components. Continue fabrication of detector components for the HERMES experiment that will measure the spin structure function of the nucleon.	Continue fabrication of detector system for internal target experiments with the South Hall Ring. Fabricate cryogenic and polarized targets for extracted beam experiments. Continue to procure klystron power tubes to enable full energy, high current operation of the linac. Continue improvement of the Bates electron linac by replacing RF and vacuum system components. Complete fabrication of detector components for the HERMES experiment that will measure the spin structure functions of the nucleon.
	$ 1,675	$ 2,125	$ 3,795
ANL	For the Fragment Mass Analyzer (FMA), provided a double-sided silicon detector and associated electronics that will enable the detection of extremely weak processes. Radioactive nuclei are implanted, mass identified, and time and position correlated with their subsequent proton and alpha decays. Fabricated a high-density helium-3 target, operating at 50 atmospheres and 20 degrees Kelvin, for a major program of experiments in CEBAF's Hall C.	For the APEX detector, which is used to study spontaneous positron production in collisions of very heavy nuclei, modify the heavy ion counters to improve the maximum count rate, the limiting factor in APEX's data acquisition rate. Fabricate the Cerenkov counter for the HERMES experiment at the DESY facility which is measuring the spin structure functions of the nucleon.	Fabricate high-stability and low-noise electronics for the double-sided strip detector on the FMA to fully exploit the capabilities of this very powerful detector system for observing nuclei produced with very low cross sections. For experiments at CEBAF fabricate a laser-polarized tritium target for study of the those two- and three-body nuclear systems which can be calculated exactly: deuterium, tritium and helium-3.
	$ 1,105	$ 1,350	$ 1,400

III. Capital Equipment (Cont'd):

Program Activity	FY 1994	FY 1995	FY 1996
ORNL	In preparation for research using the Radioactive Ion Beam (RIB) facility, began installation of the Daresbury recoil mass separator for a program of nuclear astrophysics studies. The RIB facility presents an opportunity long-awaited by nuclear astrophysics to gain further understanding of stellar explosive hydrogen burning. The proton-rich radioactive beams provided by RIB make it ideally suited for these studies. A large collaboration which includes scientists from four British universities is developing an astrophysics research program around the Daresbury recoil separator. Completed construction of highly-integrated, electronic readout system for lead-glass photon detector for CERN experiment WA98. Provided data acquisition equipment, electronics and mounting hardware needed to combine about 150 crystal BaF2 detectors from several laboratories into a single array.	In further preparation for the research program at the RIB facility, construct a beam line to the Recoil Mass Separator (RMS) apparatus and begin procurement of its detector systems. Studies with the RMS are expected to define the proton drip line in medium-weight elements. Provide equipment to handle remotely RIB components activated during accelerator operations, particularly the RIB target/ion source.	Begin acquisition of a gamma-ray detector array to completely surround the RMS target. High efficiency detection is needed to perform spectroscopic studies with the low intensity radioactive beams available from RIB. Fabricate a higher efficiency target/ion source using an ECR plasma for the ionizer. Upgrade obsolete control systems for accelerators and the beam lines.
	$ 2,345	$ 1,525	$ 2,225
University Laboratories and User Groups	Continued upgrade of instrumentation at university laboratories. Constructed the following research equipment: Texas A&M University (beam analysis system for the magnetic spectrometer), TUNL (upgrade of low energy beam accelerator facility, dynamically polarized proton target), Yale University (equipment to search for strange quark matter -- strangelets -- at the BNL AGS accelerator). Constructed and provided electronic instrumentation for various detector components for the HERMES experiment.	Continue instrumentation initiative at university laboratories with construction of particle and gamma-ray detectors, spectrometer systems, and data analysis facilities. Continue to construct and instrument components for the HERMES experiment. Fabricate the neutral current detectors for the Sudbury Neutrino Observatory (SNO). Construct neutrino experiments at the Chooz and San Onofre nuclear reactor sites.	Continue instrumentation initiative at university laboratories with construction of particle and gamma-ray detectors, spectrometer systems, and data analysis facilities. Complete construction of components for the HERMES experiment. Continue to construct the neutrino experiment at the San Onofre nuclear reactor site.

III. Capital Equipment (Cont'd):

Program Activity	FY 1994	FY 1995	FY 1996
University Laboratories and User Groups (Cont'd)	$ 2,165	$ 3,400	$ 1,280
Sudbury Neutrino Observatory	Installed the 55-foot diameter geodesic frame which supports 9,550 photomultiplier tubes for the Sudbury Neutrino Observatory (SNO) detector. The start of the heavy water fill is scheduled for December 1995. SNO is located in a cavity excavated at the 6800 foot level of the Creighton mine in Sudbury, Ontario. This unique world-class facility for neutrino astrophysics, using heavy water as its principal sensitive medium, has a very high potential for fundamental discoveries in solar physics and in the properties of neutrinos, in particular neutrino oscillations. SNO is a collaborative Canadian, U.S. and U.K. project. The U.S. share of construction costs for the SNO project is $11,900,000 in actual year dollars and is provided as Capital Equipment funds. The entire SNO project has a capital cost estimate of about $50,000,000 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.	No activity.	No activity.
	$ 3,362	$ 0	$ 0

III. Capital Equipment (Cont'd):

Program Activity	FY 1994	FY 1995	FY 1996
Gammasphere	Continued very active physics program with Early Implementation configuration: 35 detectors, temporary electronics and temporary support frame. Began procurement of a new, improved style of detectors which are less influenced by Doppler broadening effects. The new detectors have segmented germanium crystals which increase the granularity of the detector array thus doubling the resolving power over that originally planned for Gammasphere. Installed final support frame and began installation of the new data acquisition electronics and computer system.	Complete receiving detectors of the new style and begin full operation. 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. Up to 110 large Compton- suppressed germanium detectors can be mounted around the target on a spherical support frame. 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 $17,700,000 in actual year dollars.	No activity.
	$ 4,450	$ 1,750	$ 0
Lawrence Berkeley Laboratory - GPE	Provided general purpose equipment at Lawrence Berkeley Laboratory, for which the Nuclear Physics program has landlord responsibility. Typical examples of equipment requested by the various LBL support organizations (Administrative Division; Facilities Department; Information and Computing Science Division; Engineering Division; and Environment, Health and Safety Division) are forklifts and trucks, data processing equipment used in administrative functions, computer networking infrastructure, on-line presentation systems (e.g., Mosaic),	Provide general purpose equipment for the needs of these LBL support organizations: Administrative Division; Facilities Department; Information and Computing Science Division; Engineering Division; and Environment, Health and Safety Division.	Provide general purpose equipment for the needs of these LBL support organizations: Administrative Division; Facilities Department; Information and Computing Science Division; Engineering Division; and Environment, Health and Safety Division.

III. Capital Equipment (Cont'd):

Program Activity	FY 1994	FY 1995	FY 1996
Lawrence Berkeley Laboratory - GPE (Cont'd)	UNIX platforms for Library and TID databases, on-line scientific imaging and visualization capability, CAD/CAM workstations, cable testers, fume hoods, and waste water monitoring units.		
	$ 1,870	$ 1,870	$ 2,000
Other	Provided equipment for smaller programs at other national laboratories which conduct portions of the nuclear data program.	Provide equipment for some participants of the nuclear data program, more rapid completion of selected experimental systems in the low energy, medium energy or heavy ion research program.	Provide equipment for some participants of the nuclear data program, more rapid completion of selected experimental systems in the low energy, medium energy or heavy ion research program.
	$ 363	$ 1,410	$ 1,975
Capital Equipment	$ 32,000	$ 28,000	$ 28,000

DEPARTMENT OF ENERGY
FY 1996 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 1994 Adjusted	FY 1995 Adjusted	FY 1996 Request	$ Change
Construction	$ 101,990	$ 78,100	$ 79,760	$ 1,660
Total, Construction	$ 101,990	$ 78,100	$ 79,760	$ 1,660

II. B. Laboratory and Facility Funding Table: Construction

Argonne National Lab (East)	$ 300	$ 500	$ 500	$ 0
Brookhaven National Lab	79,300	71,300	71,300	0
Continuous Electron Beam Accelerator Facility	16,590	1,345	3,445	2,100
Lawrence Berkeley Lab	3,555	3,555	3,700	145
Oak Ridge National Lab	1,000	200	400	200
All Other	1,245	1,200	415	-785
Total, Construction	$ 101,990	$ 78,100	$ 79,760	$ 1,660

III. Activity Descriptions: (Budget Obligations in thousands of dollars)

Program Activity	FY 1994	FY 1995	FY 1996
Construction			
Construction	At the Continuous Electron Beam Accelerator Facility (CEBAF), completed accelerator and civil construction. Began commissioning activities. Started beam delivery to experimental Hall C and physics operation. ($16,590)	Begin multiphase beam operation. Complete construction project. Complete installation of a pair of High Resolution Spectrometers in Hall A and begin physics use. ($1,000)	
	At the Relativistic Heavy Ion Collider (RHIC), continued installation of injection line magnets. Completed installation of collider ring magnet stands and cable trays. Continued production and started installation of collider ring superconducting magnets. Continued procurement of cryogenic equipment, vacuum pumps, and power supplies. Awarded long lead procurements for major detector subsystems. ($78,000)	Conduct injection line beam tests. Complete installation and start cooldown of the first sextant of the collider ring. Continue production and installation of collider ring superconducting magnets. Continue procurement of cryogenic equipment, vacuum pumps, and power supplies. Continue procurement of detector subsystems. Start detector systems assembly. ($70,000)	Continue installation and cooldown of ring sectors. Complete full system demonstration of the first sextant of the collider ring. Begin final phase of superconducting magnet production. Continue procurement of collider ring and detector components. Begin tests of detector subsystems. ($70,000)
	For Accelerator Improvements and Modifications projects, provided essential modifications and upgrades that are required on an annual basis to maintain and improve the reliability and efficiency of accelerators and experimental facilities. ($3,800)	Reduced level of activity due to completion of funding of Radioactive Ion Beam facility at ORNL. ($3,200)	Increased level of activity due to requirements at Continuous Electron Beam Accelerator Facility. ($4,975)
	For General Plant Projects, provided essential additions, modifications, and improvement that are required on an annual basis to maintain safety and effectiveness of general laboratory plant and support facilities. ($3,600)	Increased level of activity due to requirements at Continuous Electron Beam Accelerator Facility. ($3,900)	Increased level of funding due to emphasis on high priority ES&H activities. ($4,785)
	$ 101,990	$ 78,100	$ 79,760

III. Construction (Cont'd):

Program Activity	FY 1994	FY 1995	FY 1996
Construction	$ 101,990	$ 78,100	$ 79,760

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(Changes from FY 1995 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	TEC	Previous Appropriated	FY 1994 Appropriated	FY 1995 Appropriated	FY 1996 Request	Unappropriated Balance
GPE-300	General Plant Projects, Various Locations	$ ---	$ ---	$ 3,600	$ 3,900	$ 4,785	$ ---
96-G-302	Accelerator Improvements and Modifications, Various Locations	4,975	---	---	---	4,975	---
91-G-300	Relativistic Heavy Ion Collider, BNL	475,250	132,850	78,000	70,000	70,000	124,400
87-R-203	Continuous Electron Beam Accelerator Facility, CEBAF	313,200	295,610	16,590	1,000	0	0
Subtotal Line Item Projects		788,450	428,460	94,590	71,000	70,000	124,400
Total, Nuclear Physics Construction		$ ---	$ ---	$ 98,190	$ 74,900	$ 79,760	$ ---

IV. B. Construction Funded Project Descriptive Summary

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

TEC: $4,785
TPC: $4,785

Start Date: 2nd Qtr. FY 1996 Completion Date: 2nd Qtr. FY 1998

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Obligations	Costs
1996	$ 4,785	$ 4,785	$ 1,900
1997		0	2,100
1998		0	785

3. Narrative: General Plant Projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required at the Continuous Electron Beam Accelerator Facility, 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.

The FY 1996 General Plant Project funding will also support high priority ES&H activities identified in the Department's ES&H five-year plan.

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 1996 funding for the various locations:

Contin. Electron Beam Acc. Facility.........	$ 870
Lawrence Berkeley Laboratory................	3,700
Massachusetts Institute of Technology (Bates Linear Accelerator Center)..........	215
Total Estimated Cost....................	$ 4,785

4. Total Project Funding (BA):

	Prior Years	FY 1994	FY 1995 Enacted	FY 1996 Request
Construction	XXXX	$3,600	$3,900	$4,785

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project 96-G-302, Accelerator Improvements and Modifications — Various locations

TEC: $4,975
TPC: $4,975

Start Date: 2nd Qtr. FY 1996 Completion Date: 2nd Qtr. FY 1998

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Obligations	Costs
1996	$ 4,975	$ 4,975	$ 1,800
1997	0	0	2,500
1998	0	0	675

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 1996 funding for the various locations:

Argonne National Laboratory......................	$ 500
Brookhaven National Laboratory (AGS/Tandem).....	1,300
Continuous Electron Beam Accelerator Facility...	2,575
Massachusetts Institute of Technology (Bates Linear Accelerator Center).............	200
Oak Ridge National Laboratory....................	400
Total Estimated Costs.......................	$ 4,975

4. Total Project Funding (BA):

	Prior Years	FY 1994	FY 1995 Enacted	FY 1996 Request
Construction	XXXX	$ 0	$ 0	$ 4,975

IV. B. Construction Funded Project Descriptive Summary

1. Project Title and Location: Project 91-G-300, Relativistic Heavy Ion Collider, Brookhaven National Laboratory — TEC: $ 475,250; TPC: $ 595,250

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

2. Financial Schedule (Federal Funds):

Fiscal Year	Appropriation	Adjustments	Obligations	Costs
1991	$ 15,000	- 1,500 a/	$ 13,500	$ 6,000
1992	49,350		49,350	23,265
1993	71,400	- 1,400 b/	70,000	60,839
1994	78,000		78,000	82,244
1995	70,000		70,000	90,000
1996	70,000		70,000	70,000
1997	65,000		65,000	61,000
1998	59,400		59,400	59,000
1999	0		0	22,902

a/ Reflects the reduction of funds resulting from the FY 1991 sequester and general reduction.
b/ 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 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 1996 construction funds will be used for procurement of collider ring and detector components.

4. Total Project Funding (BA):

	Prior Years	FY 1994	FY 1995	FY 1996 Request	To Complete
Construction	$132,850	$78,000	$70,000	$70,000	$124,400
Capital Equipment	0	0	0	0	0
Operating Expenses	42,264	5,880	5,820	6,000	60,036

DEPARTMENT OF ENERGY
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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 1996

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 1996

4b. Date Construction Ends: 2nd Qtr. FY 1998

6. Current Cost Estimate:
TEC -- $4,785
TPC -- $4,785

7. Financial Schedule:

Fiscal Year	Appropriations	Obligations	Costs
1996	$ 4,785	$ 4,785	$ 1,900
1997	0	0	2,100
1998	0	0	785

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.

The FY 1996 General Plant Project funding will support high priority ES&H activities identified in the Department's ES&H five-year plan.

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)

Continuous Electron Beam Accelerator Facility.............................. $ 870

Replace roof on the Test Laboratory building. The Test Lab houses component test and assembly areas, chemical facilities, clean rooms, laboratories and office space. This building is over 25 years old and the roof has never been replaced. Portions of the roof are spongy and leak constantly. Patchwork repairs are no longer effective, and the building is beginning to suffer structural damage as a result of leaks. Of the requested funds, $185,000 will be used for addressing high priority ES&H needs.

Lawrence Berkeley Laboratory.. $ 3,700

A ranked list of the laboratory's currently needed GPP projects include the following: office/lab addition to Building 72; improvements to Building 64; add LCW piping/replace pump discharge valves in Building 6/37; consolidate subsurface geosciences programs in Building 51; construct childcare facility; upgrade CardKey system; upgrade of sitewide communications/networking conduit; and upgrade local HEPA exhaust systems on Buildings 70/70A/88. Of the requested funds, $500,000 will be used for addressing high priority ES&H needs.

Massachusetts Institute of Technology
(Bates Linear Accelerator Center).. $ 215

The Secondary Water System which cools the linac accelerator will be upgraded. Of the requested funds, $115,000 will be used for addressing high priority ES&H needs.

The distribution of funds requested for FY 1996 is as follows:

Continuous Electron Beam Accelerator Facility..............................	$ 870
Lawrence Berkeley Laboratory..	3,700
Massachusetts Institute of Technology (Bates Linear Accelerator Center)...	215
Total line item costs...	$ 4,785

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 1996 CONGRESSIONAL BUDGET REQUEST
(Changes from FY 1995 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. 96-G-302
2b. Construction funded

3a. Date A-E Work Initiated: 2nd Qtr. FY 1996

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 1996

4b. Date construction ends: 2nd Qtr. FY 1998

6. Current Cost Estimate:
TEC -- $4,975
TPC -- $4,975

7. Financial Schedule:

Fiscal Year	Appropriations	Obligations	Costs
1996	$ 4,975	$ 4,975	$ 1,800
1997	0	0	2,500
1998	0	0	675

8. Brief Physical Description of Project

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

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

1. Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a. Project No. 96-G-302 2b. Construction funded

8. Brief Physical Description of Project (Continued)

Argonne National Laboratory (ATLAS).. $ 500

Install a second electron cyclotron resonance (ECR) ion source at the ATLAS Positive Ion Injector. An analyzing magnet, a beam buncher, beam line components and power supplies will be procured. The new source, which uses significantly higher magnetic fields for electron confinement, will have much higher currents of intermediate charge states and useful currents of extremely high charge state ions. It will also have the ability to provide beams of very rare isotopes directly from feed materials of natural isotopic abundance.

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

As part of a general upgrade of the AGS for heavy ion operation, the following modifications are proposed: overhaul of air conditioning equipment in the AGS utility buildings located inside the ring, an upgrade of the AGS beam Ionization Profile Monitor system with one of modern design, and installation of a computer-controlled emittance measuring system in the Tandem to Booster transfer line.

Continuous Electron Beam Accelerator Facility .... $ 2,575

A redundant cold compressor system for the CEBAF cryogenic plant will be procured. Needed are a complete set of four cold compressors including four sets of bearing controllers and four sets of motor drives. Also needed are components for a redundant cold box: 2K heat exchanger, valves, vacuum shell, electronics and controls.

Massachusetts Institute of Technology
(Bates Linear Accelerator Center)... $ 200

The RF transmitters which power the linac will be upgraded by fabricating six new modulator decks for the dual transmitters, and by replacing the present switchtubes which are needed in pairs with a single tube of new design. Klystron current is controlled through a circuit utilizing a series switchtube design.

Oak Ridge National Laboratory (Radioactive Ion Beam Facility)............. $ 400

The ORIC accelerator provides the primary beams for the Radioactive Ion Beam (RIB) facility. The most urgently needed improvements to assure reliable high-intensity operation include an upgrade of the accelerator control system and replacement of several antiquated power supplies.

1.	Title and Location of Project: Accelerator improvements and modifications, Various Locations	2a.	Project No. 96-G-302
		2b.	Construction funded

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

Argonne National Laboratory (ATLAS)

New physics opportunities will result from the improved beam quality and higher beam intensities at ATLAS made possible by the new ECR ion source. Experiments such as APEX will benefit greatly because the need for stripping foils for heavy beams will be eliminated. From a facility operations viewpoint the second ECR source will (1) increase efficiency since development of new beams can proceed in parallel with physics running with the other ion source, (2) save operating cost through reduced dependence on the FN tandem injector, and (3) increase by about an order of magnitude the beam intensities available for research at ATLAS.

Brookhaven National Laboratory (AGS/Tandem)

A principal aim of the AGS upgrade program is to create a machine that will reliably accelerate heavy ions for AGS heavy ion operations and future RHIC injection. The existing air conditioning systems for the AGS ring utility houses are well over 30 years old and beyond economical repair. The present AGS Ionization Profile Monitor uses a gas jet which create an undesirable bump in the AGS vacuum profile. The new system uses micro-channel plates that will eliminate the need for the gas jet. A computer-controlled emittance measuring system will be installed in the transfer line which will automatically manipulate the slit and collection arrays so that beam emittance can be measured without the time-consuming processing of data collected from multiple HARP locations.

Continuous Electron Beam Accelerator Facility

The redundant cold compressor system will ensure a high availability of the CEBAF cryogenic plant. Cryogenics is a utility and utilities are expected to provide uninterrupted service. Current experience indicates that it takes three to nine months to repair a problem with the cold compressors. A redundant 2K cold box and set of cold compressors will permit 4 GeV operation of the accelerator while the failed units are being repaired by the manufacturer.

Massachusetts Institute of Technology (Bates Linear Accelerator Center)

The new modulator decks for the RF transmitters will have much greater stability and reliability than the decks of original design for which some components are no longer available. Significant operational cost saving will result from the single switchtube design.

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

Oak Ridge National Laboratory

Opportunities for nuclear physics research at the RIB facility, particularly nuclear structure physics, are strongly determined by the intensity of the radioactive beam from the RIB facility. And this in turn is controlled by the power of the extracted beam from the ORIC cyclotron. RIB operations will begin with an ORIC beam power of 0.5 kilowatt. But ORIC is capable of 2.0 kilowatt of extracted proton beam if properly prepared. Major ORIC improvements are required to reliably produce this higher power extracted beam.

10. Details of Cost Estimate

a. Engineering, design, inspection, construction, procurement, component assembly, and installation.............	$ 4,975
Total line item costs....................................	$ 4,975

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.

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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) -- $477,250
Total Project Cost (TPC) -- $597,550

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

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

6. Current Cost Estimate:
TEC -- $475,250
TPC -- $595,250

7. Financial Schedule (Federal Funds):

Fiscal Year	Appropriations	Adjustments	Obligations	Costs
FY 1991	$ 15,000	- 1,500 a/	$ 13,500	$ 6,000
FY 1992	49,350		49,350	23,265
FY 1993	71,400	- 1,400 b/	70,000	60,839
FY 1994	78,000		78,000	82,244
FY 1995	70,000		70,000	90,000
FY 1996	70,000		70,000	70,000
FY 1997	65,000		65,000	61,000
FY 1998	59,400		59,400	59,000
FY 1999	0		0	22,902

a/ Reflects the reduction of funds resulting from the FY 1991 sequester and general reduction.
b/ 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

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.

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

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 (Continued)

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 a/

		Item Cost	Total Cost
a. Engineering design inspection and administration of item b......			$ 77,660
1. Engineering, design and inspection at 18% of construction costs..		$ 46,590	
2. Construction management at 12% of construction costs, item b..		31,070	
b. Construction Costs..			258,860
1. Conventional Construction..................................		9,730	
a. Site Improvement................................	1,170		
b. Tunnels and Buildings..........................	6,320		
c. Utilities..	2,240		
2. Technical Components - Collider..............................		249,130	
a. Collider Installation..........................	25,830		
b. Magnet System..................................	125,060		
c. Magnet Electrical System.......................	11,390		
d. Cryogenic System...............................	20,960		
e. Vacuum System..................................	10,890		
f. Injection System...............................	11,510		
g. Beam Dump System...............................	5,770		
h. RF System......................................	11,870		
i. Beam Instrumentation...........................	10,960		
j. Control System.................................	12,570		
k. Safety System..................................	2,320		
c. Contingencies on Collider at approximately 20 percent of above costs..			26,730
Subtotal..			$363,250
d. Research Detectors (including EDIA and Contingency)............			112,000
Total line item costs..................................			$475,250

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	$60,839	$82,244	$90,000
Total facility cost.......	$ 0	$ 6,000	$23,265	$60,839	$82,244	$90,000
2. Other project costs						
a. R&D necessary to complete construction............	$21,450	$ 6,614	$ 7,000	$ 7,200	$ 5,880	$ 3,620
b. Start-up & inventory......	0	0	0	0	0	2,200
Total other project costs.	$21,450	$ 6,614	$ 7,000	$ 7,200	$ 5,880	$ 5,820
Total project cost........	$21,450	$12,614	$30,265	$68,039	$88,124	$95,820

a. Total project funding	FY 1996	FY 1997	FY 1998	FY 1999	Total
1. Total Facility Cost					
Construction line item.......	$70,000	$61,000	$59,000	$22,902	$475,250
Total facility cost.......	$70,000	$61,000	$59,000	$22,902	$475,250
2. Other project costs					
a. R&D necessary to complete construction............	$ 0	$ 0	$ 0	$ 0	$ 51,764
b. Start-up & inventory......	6,000	11,000	19,000	30,036	68,236
Total other project costs.	6,000	11,000	19,000	30,036	120,000
Total project cost........	$76,000	$72,000	$78,000	$52,938	$595,250

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

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

b. Related annual funding requirements (FY 1999 dollars)

1. Annual RHIC Facility Operating Costs..	$49,400
2. Annual Injector Operating Costs	
AGS..	19,300
Booster..	3,200
Tandem	2,300
Total facility operating costs...	$74,200
3. Annual plant and capital equipment costs related to facility operations...........	4,700
Total related annual funding *...	$78,900

* Not all of these costs are incremental.

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 project costs

a. R&D necessary to complete construction

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

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

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.