DOE/MA-0274
Volume 3 of 4

Congressional Budget Request

General Science and Research
Uranium Enrichment
Geothermal Resources Development Fund
Power Marketing Administrations
Departmental Administration

Volume 3

FY 1988

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

January 1987

FPARTMENT OF ENERGY

FISCAL YEAR 1988 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

URANIUM ENRICHMENT

GEOTHERMAL RESOURCES DEVELOPMENT FUND

POWER MARKETING ADMINISTRATIONS

DEPARTMENTAL ADMINISTRATION

VOLUME 3

TABLE OF CONTENTS

DEPARTMENT OF ENERGY

FISCAL YEAR 1988 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1986 Actual BA	FY 1987 Estimate BA	FY 1988 Request BA
Appropriations Before The Energy and Water Development Subcommittees:			
Energy Supply Research and Development	$ 1,701,351	$ 1,254,131	$ 1,914,710
Uranium Enrichment	1,549,015	1,210,400	1,070,000
General Science and Research	659,059	719,517	814,498
Atomic Energy Defense Activities	7,292,405	7,481,852	8,050,000
Departmental Administration	235,676	139,509	166,133
Alaska Power Administration	3,245	2,881	3,026
Bonneville Power Administration	404,329	327,659	205,800
Southeastern Power Administration	---	19,647	27,400
Southeastern - Continuing Fund	4,028	---	---
Southwestern Power Administration	29,180	25,337	16,648
Western Area Power Administration	195,842	240,309	295,515
Western Area Power Emergency Fund	147	225	---
Federal Energy Regulatory Commission	45,107	-3,465	-900
Nuclear Waste Fund	499,037	499,000	500,000
Geothermal Resources Development Fund	69	72	72
Subtotal, Appropriations Before the Energy and Water Development Subcommittees	$12,618,490	$11,917,074	$13,062,902

DEPARTMENT OF ENERGY

FISCAL YEAR 1988 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

BUDGET AUTHORITY IN THOUSANDS OF DOLLAR

	FY 1986 Actual BA	FY 1987 Estimate BA	FY 1988 Request BA
Appropriations Before Interior and Related Agencies Subcommittees:			
Alternative Fuels Production	$ 2,775	$ ---	$ ---
Clean Coal Technology	---	---	50,000
Fossil Energy Research and Development	309,389	251,402	168,900
Naval Petroleum and Oil Shale Reserves	13,002	122,177	159,700
Energy Conservation	426,187	149,679	86,090
Energy Regulation	23,423	23,400	21,680
Emergency Preparedness	5,750	6,044	6,206
Strategic Petroleum Reserve	107,533	147,433	270,181
Energy Information Activities	57,724	60,301	61,599
Subtotal, Interior and Related Agencies Subcommittees	945,783	760,436	824,356
Subtotal, Energy and Water Development Subcommittees	12,618,490	11,917,074	13,062,902
Subtotal, Department of Energy	13,564,273	12,677,510	13,887,258
Permanent - Indefinite Appropriations:			
Payments to States	629	705	727
Total, Department of Energy	$13,564,902	$12,678,215	$13,887,985

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1986 FTE USAGE	FY1987 -FY86	FY1987 CONGR REQ	FY1988 -FY87	FY1988 CONGR REQ
ENERGY & WATER SUBCOMMITTEE					
HEADQUARTERS	4,663	170	4,833	47	4,880
FIELD	9,393	62	9,455	-4	9,451
SUBCOMMITTEE TOTAL	14,056	232	14,288	43	14,331
INTERIOR SUBCOMMITTEE					
HEADQUARTERS	1,254	-13	1,241	-104	1,137
FIELD	883	5	888	-143	745
SUBCOMMITTEE TOTAL	2,137	-8	2,129	-247	1,882
GRAND TOTAL	16,193	224	16,417	-204	16,213
ADJUSTMENT		-317	-317	54	-263
ADJUSTED TOTAL	16,193	-93	16,100	-150	15,950

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1986 FTE USAGE	FY1987 -FY86	FY1987 CONGR REQ	FY1988 -FY87	FY1988 CONGR REQ
10:ENERGY SUPPLY RESEARCH AND DEV	918	8	926	0	926
HEADQUARTERS	639	4	639	0	639
FIELD	283	4	287	0	287
15:URANIUM ENRICHMENT	65	2	67	0	67
HEADQUARTERS	54	2	56	0	56
FIELD	11	0	11	0	11
20:GENERAL SCIENCE AND RESEARCH	38	1	39	0	39
HEADQUARTERS	38	1	39	0	39
25:ATOMIC ENERGY DEFENSE ACTIVITI	2,710	142	2,860	30	2,890
HEADQUARTERS	491	52	543	19	562
FIELD	2,227	90	2,317	11	2,328
30:DEPARTMENTAL ADMINISTRATION	3,273	77	3,350	20	3,370
HEADQUARTERS	1,693	46	1,739	5	1,744
FIELD	1,580	31	1,611	15	1,626
34:ALASKA POWER ADMINISTRATION	36	2	38	-3	35
FIELD	36	2	38	-3	35
36:BONNEVILLE POWER ADMIN	3,491	-61	3,430	-50	3,380
FIELD	3,491	-61	3,430	-50	3,380
38:SOUTHEASTERN POWER ADMIN	38	2	40	0	40
FIELD	38	2	40	0	40
42:SOUTHWESTERN POWER ADMIN	193	-7	186	0	186
FIELD	193	-7	186	0	186
46:WAPA - POWER MARKETING	1,176	-16	1,160	0	1,160
FIELD	1,176	-16	1,160	0	1,160
50:WAPA - COLORADO RIVER BASIN	219	0	219	0	219
FIELD	219	0	219	0	219
52:FEDERAL ENERGY REGULATORY COMM	1,597	62	1,659	0	1,659
HEADQUARTERS	1,597	62	1,659	0	1,659
54:NUCLEAR WASTE FUND	291	20	311	46	357
HEADQUARTERS	154	3	157	23	180
FIELD	137	17	154	23	177
56:GEOTHERMAL RESOURCES DEV FUND	1	0	1	0	1
HEADQUARTERS	1	0	1	0	1
65:FOSSIL ENERGY RESEARCH AND DEV	706	-3	703	-113	590
HEADQUARTERS	141	-3	138	0	138
FIELD	565	0	565	-113	452
70:NAVAL PETROL & OIL SHALE RES	99	-4	95	0	95
HEADQUARTERS	20	2	22	0	22
FIELD	79	-6	73	0	73
75:ENERGY CONSERVATION	322	30	352	-109	243
HEADQUARTERS	201	26	227	-84	143
FIELD	121	4	125	-25	100
80:EMERGENCY PREPAREDNESS	64	7	71	0	71
HEADQUARTERS	64	7	71	0	71
81:ECONOMIC REGULATION	348	-53	295	-20	275
HEADQUARTERS	348	-53	295	-20	275
85:STRATEGIC PETROLEUM RESERVE	152	-5	147	-5	142
HEADQUARTERS	34	-12	22	0	22
FIELD	118	7	125	-5	120
90:ENERGY INFORMATION ACTIVITIES	446	20	466	0	466
HEADQUARTERS	446	20	466	0	466
94:ADVANCES FOR CO-OP WORK	2	0	2	0	2
FIELD	2	0	2	0	2
GRAND TOTAL	16,193	224	16,417	-204	16,213
ADJUSTMENT		-317	-317	54	-263
ADJUSTED TOTAL	16,193	-93	16,100	-150	15,950

DEPARTMENT OF ENERGY

FISCAL YEAR 1988 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

VOLUME 3

TABLE OF CONTENTS

GENERAL SCIENCE AND RESEARCH ACTIVITIES

For expenses of the Department of Energy, activities including the purchase, construction and acquisition of plant and capital equipment and other expenses incidental thereto necessary for general science and research activities in carrying out the purposes of the Department of Energy Organization Act (Public Law 95-91), including the acquisition or condemnation of any real property or facility or for plant or facilities acquisition, construction, or expansion; purchase of passenger motor vehicles (not to exceed [12] 22, of which 18 are for replacement only); [$708,400,000] $814,498,000 to remain available until expended. (Energy and Water Development Appropriations Act, 1987, as included in Public Laws 99-500 and 99-591, section 101(e).)

DEPARTMENT OF ENERGY

FISCAL YEAR 1988 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

GENERAL SCIENCE AND RESEARCH

BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1986 Actual	FY 1987 Estimate	FY 1988 Request
High Energy Physics	$490,440	$499,679	$566,598
Nuclear Physics	172,527	217,043	245,100
High Energy and Nuclear Physics Program Direction	2,092	2,453	2,800
Subtotal, General Sciences	665,059	719,175	814,498
Less Use of Prior Year Balances and Other Adjustments	-6,000	342	---
Total, General Science and Research.	$659,059	$719,517	$814,498

MENT OF ENERGY

FISCAL YEAR 1988 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

NUCLEAR PHYSICS

GENERAL SCIENCE PROGRAM DIRECTION

VOLUME 3

TABLE OF CONTENTS

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH

OVERVIEW

Nuclear Physics

The central objective of the Nuclear Physics program is the understanding of the interactions, properties, and structures of nuclei and nuclear matter. This knowledge also forms the basis for increasingly important investigations into the fundamental forces of nature as manifested in atomic nuclei. For example, the presence of hot nuclear matter created by the collision of relativistic heavy ions is required to free the quarks confined inside nucleons. The Nuclear Physics program is a vital component in America's long-term investment in science and technology by creating new knowledge, developing trained manpower, and stimulating the invention of advanced instrumentation. The resources available to the Nuclear Physics program include a continuing supply of skilled and motivated research personnel and a mixture of physics facilities and detection equipment upon which the experimental program is based.

The strategy of the program is to address the key scientific questions with new theories, equipment, and facilities while maintaining an effective program mix with appropriate balance among the program elements. The scientific purview covered by the Nuclear Physics program requires activities in the research areas covered by beams of electrons, heavy ions, and protons, including secondary beams of mesons, neutrons and neutrinos. Elements of highest priority are: sustaining the skilled manpower pool; maintaining a vigorous technological R&D effort; upgrading existing research facilities; and building new ones as required. Much can be accomplished using existing facilities with carefully selected upgrades. However, new facilities are required to explore newly identified important aspects of nuclear physics research. Construction of the Continuous Electron Beam Accelerator Facility (CEBAF) will begin in FY 1987.

The strategy for the next few years revolves around the following key factors:

- Nuclear Physics accelerator facilities will operate with an overall utilization of greater than 50 percent in order to accomplish Nuclear Physics program objectives. Funding projections include small upgrade projects to assure the continued scientific vitality of selected existing facilities. Specific projects will be identified as part of the Department's annual budget process for each year in the planning period.

- The Tandem/AGS Heavy Ion Transfer Line (84-R-123; TEC = $10.3 million; $5.0 million in FY 1984 and $5.3 million in FY 1985) became operational in late FY 1986. Beginning in FY 1987, the Tandem/AGS accelerator complex will operate 7-8 weeks per year for high energy heavy ion nuclear research. Provision is also made for university-based users of the AGS-accelerated heavy ion beams, including their participation in the development and construction of detectors.

- Construction of the Continuous Electron Beam Accelerator Facility (CEBAF) was initiated in FY 1987. CEBAF is scheduled to be fully operational in FY 1993. The Total Estimated Cost (TEC) is $255 million, including an initial complement of detectors. Once operational, CEBAF will require an estimated $27 million per year of Operating Expenses for facility operations and in-house research and an estimated total of $4 million per year of Capital Equipment, AIP, and GPP funds.

- Work will continue at Brookhaven National Laboratory (BNL) for the purpose of providing a solid scientific and technical basis for the Relativistic Heavy Ion Collider (RHIC). The R&D necessary to optimize the RHIC project is currently being conducted. A Nuclear Sciences Advisory Committee (NSAC) review has confirmed the high scientific merit of the research to be performed at RHIC. Recent recognition of the extremely high magnetic fields created in the collision process identifies exciting new areas of research unrelated to the core program of quark-gluon plasma investigations.

- In order to address the most important scientific questions and to utilize nuclear physics facilities most effectively, major new detectors are required at selected existing facilities. These equipment projects will be cooperative ventures between university users and national laboratories. Under consideration are a neutrino detector at LAMPF, a total coverage charged particle detector at the Bevalac, a multiparticle calorimeter at the Tandem/AGS, and a recoil mass spectrometer to be located at either ANL or ORNL.

- The budget for the Nuclear Data program will be moved from the Basic Energy Sciences program to the Nuclear Physics program in FY 1988. This move will lead to more efficient program direction since technical management of the program has been provided by the Nuclear Physics program since the inception of the Nuclear Data activity. The reorganization is in accord with the major role played by nuclear physicists in both the measurement and evaluation parts of the Nuclear Data activity.

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

LEAD TABLE

Nuclear Physics

	FY 1986 Actual	FY 1987 Appropriation	FY 1988 Base	FY 1988 Request	% Change from FY 1987 Approp.
Medium Energy Nuclear Physics	$ 73,146	$ 80,975	$ 80,975	$ 83,950	+4
Heavy Ion Nuclear Physics....	48,817	60,675	60,675	65,280	+8
Low Energy Nuclear Physics...	20,883	25,418	25,418	26,195	+3
Nuclear Theory.....	8,999	10,000	10,000	10,500	+5
Capital Equipment.....	13,980	15,875	15,875	17,675	+11
Construction.....	6,702	24,100	24,100	41,500	+72
Total.....	172,527a/b/c/	217,043a/	217,043a/	245,100a/	+13
Operating Expenses.....	(151,845)	(177,068)	(177,068)	(185,925)	+5
Capital Equipment.....	(13,980)	(15,875)	(15,875)	(17,675)	+11
Construction.....	(6,702)	(24,100)	(24,100)	(41,500)	+72
Total Program.....	($172,527)a/b/c/	($217,043)a/	($217,043)a/	($245,100)a/	+13
Staffing (FTEs).....	(Reference General Science Program Direction)				

Authorization: Section 209, Public Law 95-91.

a/ Total has been increased by $9,750,000 in FY 1986, $11,117,000 in FY 1987, and includes $11,698,000 in FY 1988 as a result of the transfer of the Nuclear Data Measurements Compilation and Evaluation activities from the Basic Energy Sciences program to the Nuclear Physics program.
b/ Total has been reduced by $1,795,000 for SBIR.
c/ Total reduced by $7,328,000 in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

SUMMARY OF CHANGES

Nuclear Physics

FY 1987 Appropriation enacted	$217,043
Medium Energy Nuclear Physics	
- Continue research and operations at LAMPF, Bates, and SLAC at the same level of activity	+2,610
- Reduce level of activity at other sites	-635
- Increase level of R&D activity at CEBAF	+1,000
Heavy Ion Nuclear Physics	
- Continue AGS operations and research at the same level of activity	+470
- Increase R&D on new accelerator concepts at RHIC	+2,900
- Support for other heavy ion accelerators is provided at the same level of activity	+1,235
Low Energy Nuclear Physics	
- Continue operation and research at four national and four university accelerators at slightly less than FY 1987 level	+196
- Continue Nuclear Data program at FY 1987 level of activity	+581

Nuclear Theory

- Continue program at the FY 1987 level of activity	$ +500

Capital Equipment

- Provide for start of laboratory-university collaborative neutrino detector project at LAMPF and provide for general purpose equipment to meet laboratory-wide needs of Lawrence Berkeley Laboratory and CEBAF	+1,800

Construction

- Conduct AIP & GPP activities at about constant level of effort	+100
- Continue Continuous Electron Beam Accelerator Facility (CEBAF) project	+17,300
FY 1988 Congressional Budget Request	$245,100

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

NUCLEAR PHYSICS

I. Preface: Medium Energy Nuclear Physics

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

II. A. Summary Table

Program Activity	FY 1986	FY 1987	FY 1988	% Change
Research	$27,962	$31,875	$32,650	+ 2
Operations	45,184	49,100	51,300	+ 4
Total, Medium Energy Nuclear Physics	$73,146	$80,975	$83,950	+ 4

II. B. Major Laboratory and Facility Funding

Los Alamos National Laboratory	$44,431	$46,880	$48,800	+ 4
Massachusetts Inst. of Technology	7,753	8,900	9,400	+ 6
Continuous Electron Beam Accelerator Facility	4,918	7,250	8,250	+14
Other National Laboratories	6,285	6,400	6,855	+ 7
Total	$63,397	$69,430	$73,305	+ 6

III. Activity Descriptions

Program Activity	FY 1986	FY 1987	FY 1988
RESEARCH			
LAMPF-Based Research	Carry out broad research program at this proton facility including the following specific activities:	Carry out broad research program at this proton facility including the following specific activities:	Carry out broad research program at this proton facility including the following specific activities:
	o Start experimental use of Clamshell Spectrometer for elastic, inelastic, and double-charge-exchange pion scattering.	o Continue use of Clamshell Spectrometer and start experiments using new neutron facility.	o Continue use of Clamshell Spectrometer and neutron facility, and initiate research program using medium resolution spectrometer.
	o Complete data taking for neutrino-nucleus scattering experiment and start data taking for first major LAMPF neutrino oscillation experiment.	o Continue data taking phase of neutrino oscillation experiment.	o Complete data taking phase of neutrino oscillation experiment and begin fabrication by broad-based university-laboratory collaboration of Large Cherenkov Detector (LCD) for neutrino experiments.
	o Determine precisely masses of light-mass, neutron-rich isotopes using the new Time-of-Flight Isochronous (TOFI) spectrometer.	o Expand use of TOFI spectrometer by adding outside users.	o Continue use of TOFI facility for nuclear spectroscopy.
	o Begin preliminary activities in ten-institution collaboration to prepare detection facility for highly-sensitive search for the rare decay of the muon into a positron and a gamma ray (MEGA).	o Expand preparation activities for MEGA experiment.	o Complete MEGA preparations and start taking data.
	($9,970)	($10,580)	($10,700)
Bates-Based Research	Carry out comprehensive research program at this electron facility including the following specific activities:	Carry out comprehensive research program at this electron facility including the following specific activities:	Carry out comprehensive research program at this electron facility including the following specific activities:
	o Do preliminary studies for use of polarized electrons.	o Use new polarized electron capability for studies of parity violation.	o Complete data taking phase of parity experiment and start next round of experiments requiring polarized electrons.
	o Utilize new large-acceptance spectrometer (Big Bite) for coincidence experiments capable of accepting the low duty beam.	o Carry out coincidence experiments at higher energies permitted by accelerator improvements.	o Continue program of coincidence experiments not requiring continuous beams

III. Medium Energy Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
Bates-Based Research (Cont'd)	o Use enhanced South Hall capabilities to carry out comparison of the electromagnetic structure of helium-3 and hydrogen-3 (tritium) nuclei. o Study use of pulse stretcher rings to enhance duty factor. ($2,915)	o Do high energy experiments using South Hall spectrometers as well as the high precision energy loss spectrometer. o Initiate R&D program on pulse stretcher ring systems including operation with polarized beams. ($3,210)	o Emphasize high momentum transfer experiments in South Hall. o Continue R&D program on pulse stretcher rings including operation with internal targets. ($3,500)
Research at Other Sites	Carry out experiments at facilities supported by other DOE programs or at other unique U.S. or foreign facilities, including activities as follow: o Continue hypernuclear experiments using kaons produced at the BNL AGS. o Continue electron scattering experiments using the nuclear physics injector (NPI) and elaborate existing spectrometer capability at SLAC. o Complete first round of experiments using the Low Energy Antiproton Ring (LEAR) facility at CERN. o Continue preparations for a double beta decay experiment in the St. Gotthard Tunnel in the Alps. o Continue preparations for the installation of the Laser Electron Gamma Source (LEGS) on the National Synchrotron Light Source at BNL. ($10,159)	Carry out experiments at facilities supported by other DOE programs or at other unique U.S. or foreign facilities, including activities as follow: o Continue preparations for rare kaon decay experiments at the AGS. o Begin deuteron photodisintegration experiment in the Nuclear Physics at SLAC (NPAS) program. o Complete preparations for experiments using the upgraded LEAR facility. o Start data taking phase of the St. Gotthard double beta decay experiment. o Complete installation and begin tests of LEGS facility. ($10,835)	Carry out experiments at facilities supported by other DOE programs or at other unique U.S. or foreign facilities, including activities as follow: o Start data taking phase of rare kaon decay experiment. o Carry out deep inelastic scattering experiments in the NPAS program. o Utilize upgraded LEAR facility for high intensity antiproton experiments. o Continue data taking phase of the St. Gotthard double beta decay experiment. o Start first round of experiments on the LEGS facility. ($10,200)
CEBAF R&D	o Conduct research and development activities on the new superconducting accelerator cavity and prototypes. o Specify the beam transport system magnets.	o Carry out tests on four industrial cryostats. o Establish the instrumentation and control system architecture for the accelerator.	o Complete a computer model for the accelerator. o Complete a cryomodule, the basic unit of accelerator structure which can be cooled to superconducting temperatures.

III. Medium Energy Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
CEBAF R&D (Cont'd)	o Ascertain through computer calculations, the accelerator beam characteristics. o Choose the appropriate RF separator technology. ($4,918)	o Complete cryogenics systems designs. o Emphasize activities for most effective design of experimental equipment including some research at currently operating facilities. ($7,250)	o Develop and test other accelerator components. o Complete design of the large experimental spectrometer and continue some research activities. ($8,250)
OPERATIONS			
LAMPF Operations	o Operate high intensity 800 MeV proton accelerator and experimental facilities 2900 hours for nuclear physics research with an average of seven simultaneous secondary beams of pions, muons, protons, and neutrinos for nuclear physics and other scientific research. o Provide beam for 50 nuclear physics experiments involving 275 scientists. o Complete replacement of accelerator control computer and pulse timing system. ($37,385)	o Operate accelerator and facilities 3000 hours for nuclear physics research, and continue to operate seven secondary beams for research. o Provide beam for approximately 75 nuclear physics experiments involving about 300 scientists. o Operate neutron time-of-flight facility and continue support for installation of a polarized ion source with much higher intensity than the present polarized source. ($40,600)	o Operate accelerator and facilities about 3000 hours for nuclear physics research with about seven secondary beams. o Provide beam for approximately 60 nuclear physics experiments involving about 290 scientists. o Commission medium resolution spectrometer and begin beam line for neutrino research facility including a Large Cherenkov Detector being fabricated by a consortium of university and national laboratory scientists. ($42,400)
Bates Operations	o Operate 850 MeV electron accelerator and experimental facilities 2500 hours for nuclear physics research. o Provide beam for 20 experiments involving 128 scientists from 45 universities and laboratories. o Finish installation of polarized electron source. ($5,332)	o Operate accelerator and facilities 3000 hours for nuclear physics research. o Provide beam for 40 experiments involving 140 scientists from 40 institutions. o Install improved accelerator components to help increase the maximum beam energy to more than 1 GeV. ($5,950)	o Operate accelerator and facilities about 3000 hours for nuclear physics research. o Provide beam for approximately 35 experiments involving about 135 scientists. o Provide beam energies above 1 GeV for experiments requiring the highest energies. ($6,100)

III. Medium Energy Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
Other Operations	o Operate the nuclear physics injector (NPI) and End Station A spectrometers at SLAC for 928 hours. Provide beams of three to four GeV electrons for four experiments involving 40 scientists from 14 institutions.	o Operate the NPI and facilities at SLAC for 1000 hours. Provide beams of six GeV electrons for four experiments involving 50 scientists from 18 institutions.	o Operate NPI and facilities at SLAC for 1000 hours. Provide beams of six GeV electrons for four experiments involving about 50 scientists.
	o Provide operations funds for the LBL Bevalac to support the medium energy research activities (350 hours).	o Provide operations support for the Bevalac medium energy research activities.	o Continue operations support for the Bevalac medium energy research activities.
	($2,467)	($2,550)	($2,800)

I. Preface: Heavy Ion Nuclear Physics

The Heavy Ion Research subprogram is aimed at understanding the behavior of nuclear matter over an ever increasing range of excitation energy, nuclear density, angular momentum, and deformation. These conditions are created in collisions between nuclear targets and nuclear beams. The heavy ion beams are produced by highly sophisticated accelerators located at three large universities and four national laboratories. Studies include the high spin behavior of cold nuclear matter causing severe deformation and eventually fission. At low bombarding energies, nuclear orbiting phenomena are studied. Especially intriguing are close encounters of the heaviest nuclei which lead to unexplained spontaneous positron production. The nuclear dynamics of complex phenomena including deep-inelastic scattering and projectile fragmentation are studied at medium bombarding energies. At higher energies, exploration is made of the nuclear matter equation of state for hot dense nuclear matter. At ultra-relativistic energies, a search is being made for the new state of matter known as the quark-gluon plasma.

II. A. Summary Table

Program Activity	FY 1986	FY 1987	FY 1988	% Change
Research	$20,511	$26,205	$29,080	+11
Operations	28,306	34,470	36,200	+ 5
Total, Heavy Ion Nuclear Physics	$48,817	$60,675	$65,280	+ 8

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory	$ 5,032	$ 5,300	$ 5,480	+ 3
Brookhaven National Laboratory	4,811	11,615	15,025	+29
Lawrence Berkeley Laboratory	24,126	25,710	26,720	+ 4
Los Alamos National Laboratory	168	860	880	+ 2
Oak Ridge National Laboratory	7,756	8,040	8,290	+ 3
Total	$41,893	$51,525	$56,395	+ 9

III. Activity Descriptions

Program Activity	FY 1986	FY 1987	FY 1988
RESEARCH			
LBL Bevalac Research	Conduct research at the Bevalac using relativistic heavy ion beams to study the dynamics of high energy heavy ion collisions. Investigate the properties of nuclei under extreme conditions of temperature and density to understand the nuclear matter equation of state.	Continue the experimental programs on collision dynamics and the understanding of hot dense nuclear matter. Investigate production of K-mesons in heavy ion collisions.	Continue experiments to explore high energy dynamics to understand the earliest stages of nuclear collisions and the production of strange particles.
	Support the construction of the dilepton spectrometer.	Commission the dilepton spectrometer and initiate program to study dilepton production in relativistic heavy ion collisions.	Continue program of study of direct dilepton production using upgraded detector systems.
	Design and supervise the fabrication and installation of three CERN experiments consisting of large collaborations of U.S. and European scientists studying ultra-relativistic heavy ion collisions.	Commission CERN experiments, collect data during two 17 day runs, and begin data analysis.	Continue analyses of CERN experiments concentrating on study of fluctuations in strange baryon production, and particle momentum distributions and multiplicities in order to find evidence of nuclear matter phase changes.
	($4,508)	($4,580)	($4,714)
BNL/Tandem/AGS Research	Bring into operation the single-arm magnetic spectrometer experiment E-802 to measure particle yields and spectra from relativistic oxygen and sulfur beams on sulfur and lead targets.	Collect data on experiment E-802 from the initial operation of the completed Tandem/AGS transfer line and begin data analysis.	Initiate second round of experiments for the improved E-802 and complete data analysis of the initial data.
	Begin testing of equipment for experiment E-810. This experiment uses an existing large magnet system and a TPC tracking chamber to search for fluctuations in particle production from hot dense nuclear matter.	Commission and bring into operation experiment E-810 and begin experimental program.	Continue data taking on experiment E-810 and start data analysis for particle yields and particle energy spectra to search for results to characterize very hot dense nuclear matter.
	No activity.	Begin Relativistic Heavy Ion Collider (RHIC) R&D at a $3M level.	Provide R&D towards a Relativistic Heavy Ion Collider (RHIC) at $5.9M.
	($1,618)	($4,635)	($7,575)
ANL, LBL 88", ORNL, Research	At ANL, conduct experimental program with light and medium mass heavy ion beams from ATLAS in the 5-25 million electron volt per nucleon range. Emphasize the study of the basic modes of nuclear	Continue the experimental program at ATLAS using the upgraded full solid angle gamma-ray detector system. Investigate fusion and transfer reactions with heavy ions.	Continue the experimental program at ATLAS with emphasis on the heavier ion beams available with the new low velocity injector.

III. Heavy Ion Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
ANL, LBL 88", ORNL, Research (Cont'd)	excitation, the dynamics of peripheral and central collisions, and the behavior of nuclei at high spin and high excitation energy.		
	At the LBL 88", Cyclotron, conduct experimental program with light and medium mass heavy ion beams in the 5-25 million electron volt per nucleon range. Emphasize the study of the basic modes of nuclear excitation, and the behavior of nuclei at high spin and high excitation energy.	Continue the experimental program at the 88" Cyclotron using the upgraded full solid angle gamma-ray detector system. Utilize the new ECR source in a series of experiments to study the sub-barrier fusion of calcium isotopes from mass 40 to mass 48 with a lead nucleus.	Continue the experimental program at the 88" Cyclotron with fully implemented full solid angle gamma-ray multiplicity detectors, which should allow these studies to extend to high spins and to higher excitation energies.
	At the ORNL Holifield facility, conduct experimental program with light and medium mass heavy ion beams in the 5-25 million electron volt per nucleon range. Emphasize the study of the dynamics of peripheral and central collisions and the behavior of nuclei at high spin and high excitation energy. Complete design and construction of calorimeters for CERN experiment (WA-80). ($8,480)	Continue the experimental program using the new spectrometer focal plane detector systems. Start study of breakup reactions using reverse kinematics with new HILI detector. Operate calorimeters in data runs for CERN experiment WA-80. ($8,605)	Continue the experimental program with emphasis on providing beams to the improved UNISOR isotope separator. Reduce and analyze calorimeter data from CERN experiment WA-80. ($8,821)
University Research	Carry out independent and collaborative user-group research programs at the LBL Bevalac, LBL 88" Cyclotron, ANL ATLAS, ORNL HHIRF accelerators and at other accelerators in the U.S. and Europe. About 30 university user groups participate in the heavy ion physics experiments at these facilities. ($5,905)	Operate the Tandem and the newly constructed Tandem/AGS transfer line to produce 1000 hours of 14 GeV/A oxygen and sulfur beams for the relativistic heavy ion approved experiments. Begin to phase out the operation of the Tandem for low energy nuclear physics experiments. ($8,385)	Continue university user-group research programs. Continue the studies of interaction symmetries at the Yale Tandem facility. Continue the studies of giant resonance excitation and decay using the higher energy beam capabilities of the upgraded University of Washington accelerator system. ($7,970)
OPERATIONS			
LBL Bevalac Operations	Provide beams of heavy ions through uranium with energies of 1.8 billion electron volts per nucleon for a broad-based research program in heavy ion nuclear physics, nuclear chemistry,	Continue to provide beam for the research program.	Continue to provide beam for the research program.

III. Heavy Ion Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
LBL Bevalac Operations (Cont'd)	atomic physics, and astrophysics. One third of the beam time is provided for a Biomedical research program.		
	Provide 2900 hours of beam time to over 150 university and national laboratory users. ($15,606)	Provide 3000 hours of research time to nuclear physics, biomedical and atomic physics experiments. ($16,975)	Provide 3000 hours of research time to nuclear physics, biomedical and atomic physics experiments. ($17,755)
BNL/Tandem/AGS Operations	Provide 1000 hours of Tandem heavy ion beams for a reduced program in low energy heavy ion nuclear and atomic physics.	Reduce operation of the Tandem for low energy nuclear physics to 100 hours.	No activity.
	Provide 100 hours of test beams for commissioning of the Tandem/AGS accelerator system and the newly constructed Tandem/AGS transfer line.	Operate the combined Tandem/AGS accelerator system to produce 700 hours of oxygen and sulfur beams for relativistic heavy ion experiments.	Operate Tandem/AGS accelerator system to produce 800 hours of oxygen and sulfur, beams for relativistic heavy ion experiments.
	($3,193)	($6,980)	($7,450)
ANL, LBL 88", ORNL Operations	Begin first full year of operation of the ATLAS accelerator. Provide 2800 hours of light to medium mass heavy ions for a broad-based nuclear physics program.	Provide 4000 hours of ATLAS operation for nuclear physics experiments. Increase the acceleration capability to ATLAS by installation of a third helium refrigerator.	Provide 4000 hours of ATLAS operation for nuclear physics experiments. Begin to operate with a dual beam capability and make initial test runs with the new 3-MV positive ion injector.
	At the LBL 88" Cyclotron provide 4000 hours of operation with light to medium mass beams for a broad-based nuclear physics program.	Provide 3300 hours of operation for the nuclear physics program and develop ECR source capability for ions in the 40-100 mass range.	Provide 3300 hours of operation for the nuclear physics program and continue development of the ECR ion source for heavier mass ions.
	At the ORNL Tandem, provide 4100 hours beam time for the nuclear physics and atomic physics research program.	Provide 3700 hours of operation for the nuclear physics and atomic physics research program. Complete installation and testing of reconfigured accelerator tubes on 1/3 of the tandem and complete installation of the new beam pulsing system.	Provide 3700 hours of beam for nuclear physics and atomic physics research program.
	($8,320)	($8,890)	($9,200)
University Accelerator Operations	Complete preparations for utilization of upgraded tandem accelerator at Yale University.	Commission upgraded tandem accelerator at Yale University and begin experimental programs with higher energy and heavier mass beams.	Provide light heavy ion beams for experiments using the upgraded facilities at Yale University.

III. Heavy Ion Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
University Accelerator Operations (Cont'd)	Provide beams of light heavy ions with energies in the range 5-15 MeV/A for in-house experimental programs at the University of Washington.	Begin tests of the superconducting linac booster accelerator at the University of Washington.	Begin experimental program using the superconducting linac booster at the University of Washington.
	Provide beams of light heavy ions with energies in the range 5-20 MeV/A for in-house experimental programs at Texas A&M University.	Provide light heavy ion beams for experiments at Texas A&M and begin activity to incorporate the non-DOE funded superconducting cyclotron booster into the program.	Provide light heavy ion beams at Texas A&M University and continue preparations for implementing higher energy beams from the superconducting booster cyclotron.
	($1,187)	($1,625)	($1,795)

I. Preface: Low Energy Nuclear Physics

This subprogram emphasizes experimental investigations of nuclear structure, decay parameters of radionuclides, and low energy nuclear reaction mechanisms. These studies also include general tests of fundamental theories and symmetries, as well as more specific and detailed studies of reactions involved in stellar and cosmological processes. University-based research is an important feature of the Low Energy program. The facilities required are relatively small and appropriate for siting on university campuses. The university-based programs permit excellent hands-on training of nuclear experimentalists, many of whom contribute after obtaining Ph.D.s to nuclear technology development of interest to the DOE. In addition, low energy research is carried out at a number of national laboratory accelerators in conjunction with heavy ion research. The BNL High Flux Beam Reactor (HFBR) makes available two beam ports for neutron nuclear physics experiments. One provides monoenergetic filtered neutron beams for resonance capture experiments for nuclear structure studies. The other provides intense neutron beams to the state-of-the-art ion sources of the TRISTAN on-line separator. The resulting separated beams of neutron-rich nuclides include some species which have never before been studied. Data from these two types of neutron based experiments are used to test nuclear structure theories, such as the interacting boson model. Additional low energy nuclear physics research is carried out by small university and national laboratory groups. Additional activity is in the area of measurement, evaluation, and compilation of cross section data for the national nuclear data base.

II. A. Summary Table

Program Activity	FY 1986	FY 1987	FY 1988	% Change
University Accelerators.....	$ 4,194	$ 4,585	$ 4,690	+2
National Lab. Accelerators.....	6,262	6,215	6,429	+3
Nuclear Data.....	9,173	10,442	11,023	+6
Other.....	1,254	4,176	4,053	-3
Total, Low Energy Nuclear Physics.....	$20,883	$25,418	$26,195	+3

II. B. Major Laboratory and Facility Funding

Ames National Laboratory.....	$ 206	$ 200	$ 205	+2
Argonne National Laboratory.....	2,735	2,820	2,955	+5
Brookhaven National Laboratory...	3,885	4,295	4,470	+4
Idaho Nat. Engineering Laboratory	284	310	335	+8
Lawrence Berkeley Laboratory.....	1,988	1,945	2,050	+5
Lawrence Livermore Nat. Lab.....	250	210	225	+7
Los Alamos National Laboratory...	1,042	1,210	1,265	+5
Oak Ridge National Laboratory....	4,185	4,475	4,820	+8
Total.....	$14,575	$15,465	$16,325	+6

III. Activity Descriptions

Program Activity	FY 1986	FY 1987	FY 1988
University Accelerators	Operate facility with light ion beams and conduct low energy nuclear physics research at Triangle Universities Nuclear Laboratory (Duke University, University of North Carolina, and North Carolina State University).	Continue facility operations and research at Triangle Universities Nuclear Laboratory and support construction of a new polarized ion source.	Initiate new research programs that exploit upgraded accelerator facilities at Triangle Universities Nuclear Laboratory, with high intensity polarized neutron beams made available by the new intense polarized ion source.
	Operate facility with light ion beams and conduct low energy nuclear physics research at Texas A&M University and support construction of a new superconducting cyclotron booster being built with State and Private funds.	Continue facility operations and research at Texas A&M University and continue support of cyclotron booster project. Support installation of State funded ECR ion source. Begin construction of a magnetic spectrometer to exploit the new beams.	Initiate new research programs that exploit upgraded accelerator facilities at Texas A&M University, where higher energy heavy ions and deuterons will be available. From higher energy polarized deuteron beams, higher energy secondary beams of polarized neutrons will become available, opening an important new area for study.
	Operate facility with light ion beams and conduct low energy nuclear physics research at the University of Washington, support construction of a superconducting LINAC booster upgrade, and complete installation of a polarized ion source.	Continue facility operations and research at the University of Washington using the new polarized ion source and continue support of the LINAC upgrade project.	Initiate new research programs that exploit upgraded accelerator facilities at the University of Washington, where the upgrade has been designed to provide higher energy light ions. Extend studies of highly excited nuclei by capture reactions and, together with a new polarized ion source, make more powerful tests of fundamental symmetries.
	Operate facility with light ion beams and conduct low energy nuclear physics research at Yale University and support	Initiate new research programs that exploit upgraded accelerator facilities at Yale University, where higher energy	Operate the new extended Tandem Accelerator for research at Yale University. Use the extended capability

III. Low Energy Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
University Accelerators (Cont'd)	installation of an extended Tandem Van de Graaf accelerator as part of a facility upgrade project. ($4,194)	heavy ions from the completed upgrade project will extend current reaction studies. ($4,585)	for new research areas in higher energy and heavier mass heavy ion collisions. ($4,690)
National Laboratory Accelerators	Operate facility with low energy light ions and conduct low energy nuclear physics research at the Argonne National Laboratory ATLAS accelerator.	Continue facility operations and low energy research at the Argonne National Laboratory to study the emission of electron positron pairs from the bombardment of gold targets with 4 MeV protons.	Continue facility operations and low energy research at the Argonne National Laboratory. Begin preparations for replacing the tandem injector with a newly developed low velocity superconducting injection LINAC.
	Operate Double Tandem accelerator facility with low energy light ions and conduct low energy nuclear physics research at the Brookhaven National Laboratory.	Continue facility operations and low energy research at a reduced level at the Brookhaven National Laboratory using light ion beams to identify single-particle degrees of freedom to complement information obtained from heavy ion experiments.	Phase out Tandem facility operations for low energy research at the Brookhaven National Laboratory at a reduced level.
	Operate facility with low energy light ions and conduct low energy nuclear physics research at the Oak Ridge National Laboratory HHIRF folded Tandem and coupled cyclotron accelerators.	Continue facility operations and low energy research at the Oak Ridge National Laboratory to investigate the structure of nuclei via the excitation of "giant resonances."	Continue facility operations and low energy research at the Oak Ridge National Laboratory.
	Operate facility with low energy light ions and conduct low energy nuclear physics research at the Lawrence Berkeley Laboratory 88-inch Cyclotron, where the on-line mass analysis system (RAMA) has been used to identify the first nuclide with isospin equal to -5/2, Ca-35. ($4,546)	Continue facility operations and low energy research at the Lawrence Berkeley Laboratory, where the decay of proton-rich nuclei very far from stability will be studied, with emphasis on the search for the as yet unobserved phenomenon of direct two-proton radioactivity. ($4,295)	Continue facility operations and low energy research at the Lawrence Berkeley Laboratory, where gamma-ray production cross sections form proton- and alpha-particle-induced reactions on C, N, O, Ne, Mg, Al, Si, and Fe will be measured for interpretation of spectra obtained from gamma-ray observatories in space. ($4,450)
Neutron Research	Conduct nuclear structure research at the BNL High Flux Beam Reactor. Use of the TRISTAN facility permitted identification and characterization of two extremely neutron-rich nuclides: Zn-80 and Cd-130,	Continue nuclear structure research at the HFBR as a BNL activity; the former members of the disbanded university TRISTAN user group will complete data analysis and publish results.	Continue nuclear structure studies at the BNL HFBR. The very-neutron-rich nuclides provided by TRISTAN will provide information needed to test the new MpxNn model developed at BNL for predicting

III. Low Energy Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
Neutron Research (Cont'd)	that are important participants in the galactic synthesis of the heavy elements. ($1,005)	($1,040)	nuclear level structure over a wide range of nuclides. ($1,070)
Other	At the Los Alamos National Laboratory continue experiment to detect solar neutrinos in deeply buried molybdenum ore. Obtain first full-scale collection of the technetium product from the mine concentrate.	At the Los Alamos National Laboratory obtain preliminary estimates of the time-averaged solar neutrino flux from the molybdenum experiment.	At the Los Alamos National Laboratory, complete measurements of time-averaged neutrino flux.
	At the Lawrence Livermore National Laboratory, complete measurement of the halflife of Re-187, which will permit a better determination of the mean age of the elements and hence the age of our galaxy.	At the Oak Ridge National Laboratory conduct a nuclear structure research program at the University Isotope Separator - Oak Ridge (UNISOR).	At the Oak Ridge National Laboratory continue nuclear structure research at UNISOR, with first results expected from the Nuclear Orientation experiments.
	No activity.	At the Brookhaven National Laboratory initiate collaboration with the Europeans (German, Italian, French) on solar neutrino measurements using gallium (GALLEX).	At the Brookhaven National Laboratory, continue collaboration on GALLEX experiment.
	No activity.	At the University of Pennsylvania and the Los Alamos National Laboratory support a U.S./USSR Solar Neutrino Cooperative Program involving a gallium metal detector in an underground laboratory in the Caucasus. Evaluate other solar neutrino experiments designed to obtain a measurement of the spectrum of neutrino flux at low energies.	Continue support of U.S./USSR cooperative research and evaluation of new concepts in neutrino detection.
	At the University of Wisconsin develop new concepts for polarized ion sources and polarized gas targets. ($1,965)	At the University of Wisconsin complete polarized source and target development. ($5,056)	No activity. ($4,962)
Nuclear Data Measurements	Conduct a coordinated program of measurements devoted to the improvement of the Evaluated Nuclear Data File (ENDF) with emphasis on the neutron cross sections used as standards.	Continue program of measurements at current level of effort. Emphasis on measurements of cross sections needed to improve ENDF file.	Continue program of measurements.

III. Low Energy Nuclear Physics (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
Nuclear Data Measurements (Cont'd)	Begin phase-in of support for ANL Fast Neutron Generator (FNG) which has been transferred from NE.	Continue support of ANL FNG. Emphasis on neutron cross sections of interest to fusion power technology.	Continue support of ANL FNG for neutron cross section measurement program at current level.
	Operate Oak Ridge Electron Linear Accelerator (ORELA) for neutron cross section measurements by pulsed beam time-of-flight.	Continue operation of ORELA at current level of effort. Complete construction of a large-solid-angle photon multiplicity detector to be used at ORELA for measurement of neutron capture cross sections.	Continue ORELA operation and research at current level of effort. Begin use of detector completed in FY 1987.
	($5,448)	($6,352)	($6,713)
Nuclear Data Compilation & Evaluation	Continue the coordinated program of compilation and evaluation devoted to the production of the next version of the ENDF database-(ENDF-6) for use by nuclear technologists.	Continue evaluation effort coordinated by the BNL National Nuclear Data Center NNDC. Complete first "global" analysis-including correlations-of the neutron cross sections used as the reference standards for the ENDF-6 data library.	Continue evaluation effort with goal of completing ENDF-6 by 1989.
	Continue the internationally coordinated effort to update the Evaluated Nuclear Structure and Decay File (ENSDF), from which the Nuclear Data Sheets are produced. Publication (by John Wiley) of the first edition of the "Table of Radioactive Isotopes", designed for use by applied users, and based on the data included in the ENDSF.	Continue effort to reduce "cycle-time" for update of ENSDF. Develop uniform system for on-line access.	Continue evaluation of A-chains. Begin acquisition of new computer to replace 10 year old system at NNDC.
	($3,725)	($4,090)	($4,310)

I. Preface: Nuclear Theory

The purpose of research in theoretical nuclear physics is to obtain a unified description of atomic nuclei and relate this description to elementary constituent particles and the fundamental forces connecting them. Long-range objectives of nuclear theory are to obtain comprehensive understanding of the foundations of nuclear matter at the most fundamental level, in terms of the properties of the constituent quarks and gluons. The objectives of nuclear theory are approached by interpreting results from nuclear physics experiments, and by predicting phenomena and relationships to test this description. The understanding of nuclear phenomena is prerequisite for a description of the material foundations of the universe, including astrophysics phenomena such as formation of the elements in stars and supernovae. Much of nuclear theory requires extensive use of supercomputer capabilities.

II. A. Summary Table

Program Activity	FY 1986	FY 1987	FY 1988	% Change
Nuclear Theory.....	$ 8,999	$10,000	$10,500	+5

II. B. Major Laboratory and Facility Funding

Argonne National Laboratory.....	$ 847	$ 895	$ 930	+4
Brookhaven National Laboratory...	766	940	975	+4
Lawrence Berkeley Laboratory.....	766	815	855	+4
Los Alamos National Laboratory...	938	990	1,030	+5
Oak Ridge National Laboratory....	790	825	860	+4
Total.....	$ 4,107	$ 4,465	$ 4,650	+5

III. Activity Descriptions

Program Activity	FY 1986	FY 1987	FY 1988
Nuclear Theory	Key research activities aim to: (1) Calculate the properties of atomic nuclei and the reactions between colliding nuclei from the basic nuclear forces. (2) Relate the nuclear forces to the more fundamental description based on interactions between constitutent quarks and gluons. (3) Develop equations to describe phase transitions for nuclear matter disintegrating into a plasma of quarks and gluons. ($8,999)	Improve calculations of nuclear structure and reactions and develop connections between the models developed by different theorists. Continue the development of the description of nuclei in terms of their constituent quarks and gluons. Develop improved equations for relativistic heavy-ion collisions and astrophysics. Increase emphasis on electron scattering theory to guide experimental program of CEBAF. ($10,000)	Increase attention to the role of spin in nuclear forces to describe the results of experiments using new polarized beams at DOE-supported facilities. Provide a deeper understanding of the equations describing nuclear matter. Concentrate theory of nuclear phase transitions on the formation of quark-gluon plasmas as related to experiments planned for the relativistic heavy ion collider. ($10,500)

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 maintenance of general purpose plant and equipment at Lawrence Berkeley Laboratory.

II. A. Summary Table

Program Activity	FY 1986	FY 1987	FY 1988	% Change
Capital Equipment.....	$13,980	$15,875	$17,675	+ 11

II. B. Major Laboratory and Facility Funding

Brookhaven National Laboratory...	$ 3,399	$ 3,650	$ 4,500	+ 23
Lawrence Berkeley Laboratory.....	2,725	2,805	2,800	+ 0
Los Alamos National Laboratory...	2,408	2,450	2,800	+ 14
Argonne National Laboratory.....	1,604	1,530	1,080	- 29
Mass. Inst. of Tech/Bates.....	914	1,145	1,200	+ 0
Oak Ridge National Laboratory....	1,137	945	700	- 26
Continuous Electron Beam Accelerator Facility.....	0	500	1,000	+100
TUNL/Duke U.....	287	500	0	-100
Lawrence Berkeley Laboratory GPE.	766	1,170	1,300	+ 11
All Other.....	740	1,180	2,295	+ 94
Total.....	$13,980	$15,875	$17,675	+ 11

III. Activity Descriptions

Program Activity	FY 1986	FY 1987	FY 1988
BNL	Construct large single-arm magnetic spectrometer with high-multiplicity tracking chambers and particle identification detectors for Experiment 802 in preparation for the first round of experiments with the new heavy ion beam from the Tandem/AGS accelerator facility. Procure electronics needed for joint use in Experiment 810 and CERN strange baryon production experiment. Modify beam lines at the AGS for heavy ion running. At the laser electron gamma source facility (LEGS), construct tagging spectrometer. ($3,399)	Make additions to Experiment 802 in the form of hybrid chambers with drift wires and pads with the aim of enhancing tracking abilities at higher particle multiplicities. Construct read-out electronics for Time Projection Chamber (TPC) on Experiment 810. Fabricate new detectors for Experiment 814 including calorimeter modules and 1200 Sodium Iodide crystals. Construct new beam line for Experiment 814. At LEGS, begin construction of the charged-particle spectrometer. ($3,650)	For Experiment 802, add tracking counters in the magnetic field and ring imaging Cherenkov counters in order to search for rare events such as strange baryons. Complete rebuilding of the beam line for Experiment 814 and add dedicated computer for on-line data processing capability. At LEGS, complete construction of the charged-particle spectrometer and tagging spectrometer. Initiate construction of high-intensity kaon beam line for the hyperon physics program. ($4,500)
	Expt. 802 $1,540 Expt. 810/CERN NA 36 490 AGS Beam Lines 384 LEGS 399 Smaller Projects 586 $3,399	Expt. 802 $ 150 Expt. 810 600 Expt. 814 1,100 AGS Beam Lines 860 LEGS 400 Smaller Projects 540 $3,650	Expt. 802 $ 300 Expt. 810 800 Expt. 814 1,150 AGS Beam lines 1,500 LEGS 200 Smaller Projects 550 $4,500
LBL	Complete construction of dilepton spectrometer for the Bevalac, build TPC for strange baryon production experiment at CERN, add large-area drift chambers to	Start construction of heavy ion TPC detector at the Bevalac for study of the nuclear equation of state and build improved time-of-flight (TOF) and	Continue construction of heavy ion TPC detector and acquire electronic equipment for an event filter system for ultra-high-speed data analysis. Begin

III. Capital Equipment (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
LBL (Cont'd)	the HISS spectrometer at the Bevalac. Add central BGO ball to full-solid-angle gamma-ray spectrometer at the 88-Inch Cyclotron. ($2,725)	fragment charge measurement system for the HISS spectrometer. Construct inverse kinematics detector system for use with short half-life secondary beams. Add a multiplicity array to the dilepton spectrometer. ($2,805)	construction of a calorimetry-based collaborative experiment at the BNL Tandem/AGS complex ($2,800)
	Dilepton Spectrometer $ 300 CERN Strange Baryon Expt. 300 HISS drift chambers 220 Central BGO ball 210 Smaller Projects 1,695 $2,725	Heavy ion TPC for Bevalac $ 800 HISS TOF system 150 Inverse kinematics detector 150 Dilepton spectrometer 100 Smaller Projects 1,605 $2,805	Heavy ion TPC for Bevalac $ 950 Event filter system 300 Equipment for AGS experiment 500 Smaller Projects 1,050 $2,800
LANL	As part of the LAMPF polarized beam upgrade program and upgrade of associated experimental equipment, initiate construction of the medium resolution spectrometer, and beam line, target and detector system for the neutron TOF facility. ($2,408)	Complete construction of the medium resolution spectrometer and neutron TOF facility, and initiate construction of the joint LANL-University muon decay to electron gamma experiment (MEGA) for very sensitive detection of rare muon decay events. ($2,450)	Continue major activities on MEGA such as installation of the superconducting solenoid magnet and testing of drift chamber prototypes. Among other smaller projects, develop BGO detector system for coincidence measurements in pion and proton spectrometer experiments. ($2,800)
	Medium resolution spectrometer $ 500 Neutron TOF facility 350 Smaller Projects 1,558 $2,408	Medium resolution spectrometer $ 600 Neutron TOF facility 350 MEGA detector 475 Smaller Projects 1,025 $2,450	MEGA detector $1,100 Smaller Projects 1,700 $2,800
ANL, MIT/Bates and ORNL	Carry out various projects such as construction of ECR ion source, rebuilding klystron and switchtube inventory and constructing part of a heavy-ion/light-ion detector system for kinematic inverse reactions. ($3,655)	Provide additional beam lines, complete the addition of germanium detectors and bismuth germinate sum-energy counters to gamma-ray facilities, and make improvements to polarized electron source. ($3,620)	Procure new quadrupole and focal-plane detectors for an electron spectrometer, start construction of magnetic spectrometer designed for the study of extreme rare events in heavy-ion experiments, and implement the second half of the heavy-ion/light-ion detector system. ($2,980)
CEBAF	No activity.	Procure RF and cryogenic testing equipment for evaluating superconducting RF cavities. ($500)	Procure equipment for the RF cryogenics laboratory, such as long-distance microscope, purification furnace,

III. Capital Equipment (Cont'd)

Program Activity	FY 1986	FY 1987	FY 1988
CEBAF (Cont'd)			radiation mapping instruments and an additional RF cryogenic test stand. ($1,000)
TUNL at Duke University	Initiate construction of a high-intensity polarized ion source to enable an expanded program of study of spin-dependent interactions. ($287)	Complete construction of the high-intensity polarized ion source. ($500)	No activity.
LBL	Provide general purpose equipment at Lawrence Berkeley Laboratory, for which the Nuclear Physics program has landlord responsibility, such as laser printer systems, an integrated site-wide communications system, a modular semiconductor clean room facility, and numerically-controlled machining and metal fabrication equipment. ($766)	Provide general purpose equipment such as spectrum analyzers and corona detectors for the electronics engineering group, film thickness measuring instruments for the mechanical shops, radiation detection equipment for LBL's environmental health and safety groups, and a UNIX work station for the informational services group. ($1,170)	Provide general purpose equipment such as data processing equipment used in administrative functions, equipment for the Computing Division, computer aided design and engineering (CAD/CAM) work stations, a chest x-ray machine, and an emergency power plant. ($1,300)
Other	Provide equipment for the Nuclear Data program, which includes the Nuclear Data subprogram and the Nuclear Data Compilation and Evaluation subprogram. Also provide equipment for the Nuclear Physics Injector program at SLAC and for the Oak Ridge Associated Universities on-line isotope separator (UNISOR) project. ($740)	Provide equipment for the Nuclear Data program, the Nuclear Physics Injector program at SLAC and for UNISOR. ($1,180)	Provide equipment for the Nuclear Data program, for UNISOR, and for a heavy-ion fragment mass analyzer system. ($2,295)
TOTAL CAPITAL EQUIPMENT	$13,980	$15,875	$17,675

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY SUMMARY

CONSTRUCTION PROJECTS

Nuclear Physics

IV. A. Construction Project Summary

Project No.	Project Title	Total Prior Year Obligations	FY 1987 Appropriated	FY 1988 Request	Remaining Balance	TEC
GP-E-300	General Plant Projects	$ 0	$ 0	$ 3,600	$ 0	$ 3,600
88-R-201	Accelerator Improvements and Modifications	0	0	4,400	0	4,400
87-R-203	Continuous Electron Beam Accelerator Facility (CEBAF)	0	16,200	33,500	205,300	255,000
Total, Nuclear Physics Construction		$ 0	$ 16,200	$ 41,500	$205,300	$263,000

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Nuclear Physics

IV. B. Plant Funded Construction Project

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

Project TEC: $ 3,600
Start Date: 2nd Qtr. FY 1988
Completion Date: 2nd Qtr. FY 1990

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1988	$ 3,600	$ 3,600	$ 900
1989	0	0	1,800
1990	0	0	900

3. Narrative:

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

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

(c) A description and listing of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheet. Some of these may be located on non-Government owned property. Following is a listing of the FY 1988 funding proposed for the various locations.

Lawrence Berkeley Laboratory	$ 2,400
Los Alamos National Laboratory (Clinton P. Anderson Meson Physics Facility)	950
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	250
Total Estimated Cost.....	$ 3,600

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Nuclear Physics

IV. B. Plant Funded Construction Project

1. Project title and location: 88-R-201 Accelerator Improvements and Modifications
Various locations

Project TEC: $ 4,400
Start Date: 2nd Qtr. FY 1988
Completion Date: 2nd Qtr. FY 1990

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1988	$ 4,400	$ 4,400	$ 3,000
1989	0	0	1,100
1990	0	0	300

3. Narrative:

(a) Accelerator Improvement Projects provide 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 nuclear physics research programs.

(b) These projects are essential on an annual basis to maintain the operating efficiency and reliability, and the research flexibility of the nuclear physics research accelerators and ancillary experimental facilities. The requested accelerator improvements and modifications will provide greater flexibility for experimental setups, increased performance levels, and increased serviceability, thereby decreasing facility downtime, improving the productivity, scientific effectiveness and cost effectiveness of the program.

(c) A description and listing of the major items of work to be performed at the various locations is contained in the Construction Project Data Sheet. Some of these may be located on non-Government owned property. Following is a listing of the FY 1988 funding proposed for the various locations:

Argonne National Laboratory (ATLAS)	$ 1,500
Brookhaven National Laboratory (AGS/Tandem)	750
Lawrence Berkeley Laboratory	900
Los Alamos National Laboratory (Clinton P. Anderson Meson Physics Facility)	500
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	750
Total Estimated Costs.....	$ 4,400

DEPARTMENT OF ENERGY
FY 1988 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
(dollars in thousands)

KEY ACTIVITY CONSTRUCTION PROJECT SUMMARY

Nuclear Physics

IV. B. Plant Funded Construction Project

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

Project TEC: $255,000
Start Date: 2nd Qtr. FY 1987
Completion Date: 2nd Qtr. FY 1993

2. Financial schedule:

Fiscal Year	Appropriated	Obligations	Costs
1987	$ 16,200	$ 16,200	$ 7,000
1988	33,500	33,500	24,000
1989	65,000	65,000	55,000
1990	65,000	65,000	67,000
1991	55,000	55,000	51,000
1992	20,300	20,300	41,000
1993	0	0	10,000

3. Narrative:

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

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

(c) Continue construction of CEBAF in an expeditious manner and consistent with available funds. Begin procurement of accelerator cavities and klystrons and commence cavity testing. Begin acquisition of cryogenic systems. Beam enclosure construction would begin toward end of fiscal year.

DOE/MA-0274

Congressional Budget Request

Construction Project Data Sheets:
Energy Supply Research and Development
General Science
Uranium Enrichment
Naval Petroleum & Oil Shale Reserves

FY 1988

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

January 1987

DEPARTMENT OF ENERGY
1988 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
NUCLEAR PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

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

2. Project No. GP-E-300

3. Date A-E work initiated: 1st Qtr. FY 1988

3a. Date physical construction starts: 2nd Qtr. FY 1988

4. Date construction ends: 2nd Qtr. FY 1990

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

6. Current cost estimate: $3,600
Less amount for PE&D: 0
Net cost estimate: $3,600
Date: May 1986

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1988	$ 3,600	$ 3,600	$ 3,600	$ 900
1989	0	0	0	1,800
1990	0	0	0	900

8. Brief Physical Description of Project

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

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

2. Project No. GP-E-300

8. Brief Physical Description of Project (continued)

Lawrence Berkeley Laboratory..... $ 2,400

Requirements include: Seismic rehabilitation of Building 10, rehabilitation of laboratories in Building 50/70 complex, mitigation of environmental and safety hazards in plating replacement shop, correction of utility deficiencies in Building 50, second floor addition to Building 50E, roof replacement on several buildings, and seismic bracing for the 184-Inch Cyclotron Magnet.

Los Alamos National Laboratory (LAMPF)..... $ 950

To provide suitable facilities for the next generation of neutrino experiments at LAMPF, a new neutrino research facility is needed. This facility will exploit the unique short beam pulses available from the Proton Storage Ring and make possible a major test of the standard model of electroweak unification. Physical construction includes a 50 m beam tunnel, radiation shielding, and associated utilities.

Massachusetts Institute of Technology
(Bates Linear Accelerator Center)..... $ 250

Recently completed accelerator improvement projects have resulted in linac operation at higher electrical power levels. The water flow capacity of the present primary cooling system will be increased by installing an additional 2000 gpm pump and expanding the piping system. This will also provide some backup protection should the main primary pump fail.

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

Projects at the Lawrence Berkeley Laboratory, the LAMPF facility at Los Alamos National Laboratory, and the Bates Linear Accelerator Center at the Massachusetts Institute of Technology are needed to improve efficiency and productivity of these installations and to assure continuation of safe and reliable operations for both personnel and instrumentation.

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

2. Project No. GP-E-300

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

The distribution of funds requested for FY 1988 is as follows:

Lawrence Berkeley Laboratory	$ 2,400
Los Alamos National Laboratory (Anderson Meson Physics Facility)	950
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	250
Total Estimated Cost	$ 3,600

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

10. Details of Cost Estimate

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

11. Method of Performance

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

DEPARTMENT OF ENERGY
1988 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
NUCLEAR PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

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

2. Project No. 88-R-201

3. Date A-E work initiated: 1st Qtr. FY 1988

3a. Date physical construction starts: 2nd Qtr. FY 1988

4. Date construction ends: 2nd Qtr. FY 1990

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

6. Current cost estimate: $4,400
Less amount for PE&D: 0
Net cost estimate: $4,400
Date: May 1986

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1988	$ 4,400	$ 4,400	$ 4,400	$ 3,000
1989	0	0	0	1,100
1990	0	0	0	300

8. Brief Physical Description of Project

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

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

2. Project No. 88-R-201

8. Brief Physical Description of Project (continued)

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

Argonne National Laboratory (ATLAS)..... $ 1,500

The accelerating voltage of the positive-ion linac injector for ATLAS will be increased from 3 to 8 million volts (MV). This will be accomplished by adding to the existing superconducting injector linac, seven very-low-beta resonators in two cryostats.

Brookhaven National Laboratory (AGS/Tandem)..... $ 750

Beam monitors in the Alternating Gradient Synchrotron (AGS) which measure current, position and radiation loss will be upgraded to make them able to sense very low-intensity beams of heavy ions. The new monitors will also conform to the more stringent vacuum requirements in the AGS which are needed for heavy ion operation.

The vacuum chambers of AGS sections with extraction septums and with special diagnostic equipment will be replaced by ones of ultra-high vacuum design and equipped with cryopumps. This is part of a program to achieve a ring vacuum of 10^{-9} Torr needed for acceleration of the heaviest ion species.

Lawrence Berkeley Laboratory (Bevalac)..... $ 900

The accelerator control system of the Bevatron and SuperHILAC will be modernized by adding high-performance computer work stations and sophisticated software. These work stations will be connected to a high-bandwidth network to allow communications between them and to the existing Modcomp control computers. Present hardware will be utilized in low-level control functions. High level modeling, "smart knob" programming, and advanced graphics will now be possible with the new control system. This $1,300,000 project will be accomplished in two phases: the first phase ($900,000) will be to develope the design and software, and provide for the acquistion of most of the work stations and interface hardware. The second phase ($400,000), under consideration for FY 1989, will provide for the rest of the hardware.

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

2. Project No. 88-R-201

8. Brief Physical Description of Project (continued)

Los Alamos National Laboratory (LAMPF)..... $ 500

A new beam line will be built to deliver beam from the Proton Storage Ring (PSR) to the neutrino production target cell at the new neutrino research facility. Needed are magnets, power supplies, computer control systems, diagnostics, and vacuum and safety systems. The current funding will provide most of the quadrupole magnets needed for this $1,200,000 beam line.

Massachusetts Institute of Technology
(Bates Linear Accelerator Center)..... $ 750

This project provides an Energy Compression System which will improve the energy resolution of the Bates linac beam by more than a factor of 10. Dipole and quadrupole magnets, vacuum system, accelerating waveguide and an RF drive system will be procured and installed.

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

Argonne National Laboratory (ATLAS)

The upgrading of the ATLAS positive ion injector to 8 MV will permit the system to accelerate ion beams to energies greater than 5 MeV/A for ion masses up to 200 atomic mass units, thus approximately doubling the useful mass range of projectiles from ATLAS. This will open up a wide range of unexplored nuclear reactions for investigation with ion beams of unmatched quality and high intensity.

Brookhaven National Laboratory (AGS/Tandem)

The heavy ion beams that are accelerated in the AGS have typically much lower intensity than the proton beam normally accelerated. Hence new AGS ring instrumentation is needed to monitor the beam during the acceleration cycle. This is especially true for the highest mass beams, which are of the greatest scientific interest.

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

2. Project No. 88-R-201

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

When accelerating the heaviest heavy ions in the AGS, a vacuum in the 10^{-9} Torr range is needed to keep the beam from getting lost. Replacement of critical portions of the original 26 year old vacuum chambers and pumps, which were designed for a 10^{-6} Torr vacuum, with ones of modern ultra-high vacuum design is a major step toward improvement of the AGS ring vacuum.

Lawrence Berkeley Laboratory (Bevalac)

The principal goal of this project is to improve operational efficiency. This will manifest itself in two major ways: (1) reduction in tuning time by simplifying tuneup procedures and improving setup reproducibility, and (2) addition of many more monitoring endpoints to the control system. The latter will reduce the burden on maintenance personnel by allowing rapid fault detection and self-diagnosis of components. This project is expected to provide more research hours at lower operating cost. The benefits of the work will be immediate since some of the upgrade of the computer control system is already underway with funding from an In-House-Energy-Management project. Several workstations and the appropriate interface hardware have already been procured.

Los Alamos National Laboratory (LAMPF)

The new beam line will service a new neutrino research facility, which will provide the capability of unique neutrino measurements by exploiting the short beam pulses available from the PSR. It will now be possible to conduct a major test of the validity of the Standard Model of electroweak unification by making a high-accuracy measurement of the Weinberg angle by means of neutrino-electron elastic scattering.

Massachusetts Institute of Technology (Bates Linear Accelerator Center)

The greatly improved energy resolution of the linac beam will be very important both for photoreaction studies and for coincidence experiments. Both the MEPS and OHIPS magnetic spectrometers have the ability to take advantage of the improved resolution. A major additional benefit will be improved beam stability on target.

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

1. Title and location of project: Accelerator improvements and modifications, various locations	2. Project No. 88-R-201

10. Details of Cost Estimate

a. Engineering, design, inspection, construction, procurement, component assembly, and installation	$ 4,400
Total Estimated Cost	$ 4,400

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

11. Method of Performance

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

DEPARTMENT OF ENERGY
1988 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
NUCLEAR PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

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

2. Project No. 87-R-203

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

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

4. Date construction ends: 2nd Qtr. FY 1993

5. Previous cost estimate: $236,300
Less amount for PE&D: 300
Net cost estimate: $236,000
Date: 12/85

6. Current cost estimate: $255,967
Less amount for PE&D: 967
Net cost estimate: $255,000
Date: 8/86

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Cost
FY 1987	$ 16,200	$ 16,200	$ 16,200	$ 7,000
FY 1988	33,500	33,500	33,500	24,000
FY 1989	65,000	65,000	65,000	55,000
FY 1990	65,000	65,000	65,000	67,000
FY 1991	55,000	55,000	55,000	51,000
FY 1992	20,300	20,300	20,300	41,000
FY 1993	0	0	0	10,000

8. Brief Physical Description of Project

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

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

2. Project No. 87-R-203

8. Brief Physical Description of Project (continued)

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

a) Improvements to Land and Conventional Construction

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

b) Accelerator System

The central research tool of CEBAF will be an electron linear accelerator. It will consist of a 1 GeV superconducting linear accelerator split into two segments. The segments will be connected by a recirculator system to transport the electron beams from one segment of the linac to the other. Four complete passes of acceleration through the linac will provide an energy of 4 GeV. The accelerator complex will also include a beam extraction system to extract three continuous beams from the linac; a beam transport system to take the three beams to three experimental halls; a cryogenic system including helium refrigerator, liquid helium storage vessels, and distribution lines; and instrumentation and control systems for the accelerator complex.

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

2. Project No. 87-R-203

8. Brief Physical Description of Project (continued)

c) Research Equipment

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

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

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

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No. 87-R-203

10. Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, Design, Inspection, and Administration.....			$ 43,200
1. Conventional Construction at approximately 17% of item b.1		$ 8,600	
2. Technical components at approximately 29% of item b.2 ...		34,600	
b. Construction Costs.....			169,400
1. Conventional Construction.....		50,400	
a. Accelerator facilities.....	$17,000		
b. Experimental facilities.....	22,600		
c. Support facilities.....	10,800		
2. Technical components.....		119,000	
a. Accelerator components.....	89,800		
b. Research equipment.....	29,200		
c. Standard Equipment.....			1,900
			214,500
d. Contingency at approximately 19% of above costs.....			40,500
Total Estimated Cost.....			$255,000

CONSTRUCTION PROJECT DATA SHEETS

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

2. Project No. 87-R-203

11. Method of Performance

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

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

	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	FY 1993	Total
a. Total project cost										
1. Total facility cost										
a. Construction line item.....	$ 0	$ 0	$ 7,000	$24,000	$55,000	$67,000	$51,000	$41,000	$10,000	$255,000
b. PE&D.....	300	667	0	0	0	0	0	0	0	$ 967
Total facility cost.....	$ 300	$ 667	$ 7,000	$24,000	$55,000	$67,000	$51,000	$41,000	$10,000	$255,967
2. Other project costs										
R&D necessary to complete construction...	$ 4,500	$ 4,918	$ 6,250	$ 6,250	$ 6,000	$ 2,900	$ 1,629	$ 0	$ 0	$ 32,447
Spares.....	0	0	0	0	0	1,100	2,400	2,600	0	6,100
Total other project costs..	$ 4,500	$ 4,918	$ 6,250	$ 6,250	$ 6,000	$ 4,000	$ 4,029	$ 2,600	$ 0	$ 38,547
Total project cost.....	$ 4,800	$ 5,585	$13,250	$30,250	$61,000	$71,000	$55,029	$43,600	$10,000	$294,514

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

2. Project No. 87-R-203

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

b. Other related funding requirements (FY 1986 dollars)

1. Annual facility operating costs including in-house research	$ 27,000
2. Annual plant and capital equipment costs not related to construction but related to the programmatic effort in the facility	4,000
Total other related annual funding requirements	$ 31,000

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

a. Total project cost

1. Total facility cost

Explained in items 8, 9, and 10

2. Other projects costs

R&D necessary to complete construction

The CEBAF linac will use superconducting radiofrequency accelerating cavity technology to generate high energy continuous electron beams. The R&D funds will be used to design, evaluate, and construct prototypes of the technical components which are essential for meeting the design goals for the facility.

b. Other related funding requirements

1. Annual facility operating costs upon completion of construction

This item includes the cost of all personnel employed by the facility for its operation, maintenance, and in-house research, together with electric power and materials and services costs. Approximately 230 man-years of effort annually will be required.

2. Annual plant and capital equipment costs upon completion of construction

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