Nuclear Physics
Funding Profile by Subprogram and Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR*	FY 2014 Request
Medium Energy Nuclear Physics			
Research	35,216	—	36,304
Operations	78,222	—	95,344
SBIR/STTR and Other	2,084	—	18,214
Total, Medium Energy Nuclear Physics	115,522	—	149,862
Heavy Ion Nuclear Physics			
Research	39,259	—	35,386
Operations	163,158	—	165,224
Total, Heavy Ion Nuclear Physics	202,417	—	200,610
Low Energy Nuclear Physics			
Research	52,752	—	49,590
Operations	31,537	—	28,023
Facility for Rare Isotope Beams	22,000	—	55,000
Total, Low Energy Nuclear Physics	106,289	—	132,613
Nuclear Theory			
Theory Research	34,547	—	34,109
Nuclear Data Activities	6,785	—	7,713
Total, Nuclear Theory	41,332	—	41,822
Isotope Development and Production for Research and Applications			
Research	4,827	—	4,648
Operations	14,255	—	14,883
Total, Isotopes	19,082	—	19,531
Subtotal, Nuclear Physics	484,642	500,431	544,438
Construction			
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	50,000	50,306	25,500
Total, Nuclear Physics[a]	534,642	550,737[b]	569,938

*FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

[a] SBIR/STTR funding:
- FY 2012 Appropriation: SBIR $11,233,092 and STTR $1,512,147 (transferred out of NP in FY 2012 Current column)
- FY 2014 Request: SBIR $12,530,000 and STTR $1,787,000

[b] FY 2013 amounts shown reflect the P.L. 112-175 continuing resolution level annualized to a full year. These amounts are shown only at the "congressional control" level and above; below that level a dash (—) is shown.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act," 1977
Public Law 101-101, "1990 Energy and Water Development Appropriations Act," establishing the Isotope Production and Distribution Program Fund
Public Law 102-468, "Energy Policy Act of 1992"
Public Law 103-316, "1995 Energy and Water Development Appropriations Act," amending the Isotope Production and Distribution Program Fund to provide flexibility in pricing without regard to full-cost recovery
Public Law 109-58, "Energy Policy Act of 2005"
Public Law 110-69, "America COMPETES Act of 2007"
Public Law 111-358, "America COMPETES Reauthorization Act of 2010"

Overview

One of the enduring mysteries of the universe asks the question, "What, really is matter?" or more precisely, "What are the units that matter is made of, and how do they fit together to give matter the properties we observe?". Primarily, the mass of the matter we are familiar with comes from the nuclei of atoms. The mission of the Nuclear Physics (NP) program is to discover, explore, and understand all forms of nuclear matter. The fundamental particles that compose nuclear matter—quarks and gluons—are relatively well understood, but exactly how they fit together and interact to create different types of matter in the universe, familiar and unfamiliar, is still largely unknown.

The quest to understand the properties and behavior of matter requires both theoretical and experimental examination. In the theoretical approach, the interaction of quarks and gluons in nuclear matter, described by a theory referred to as Quantum Chromodynamics (QCD), is examined by scientists using today's most advanced computers to develop approximate solutions to the precise mathematical description of this interaction. On the experimental side, scientists accumulate experimental data about the behavior of quarks and gluons as well as protons, neutrons, and nuclei in a variety of settings. Most of the experiments today require large accelerator facilities that slam bits of matter into each other at speeds approaching the speed of light. The careful integration and comparison of the observed experimental results with theoretical calculations provides both insight into the behavior of matter and the information needed to test the validity of theoretical models. Nuclear physics seeks to understand matter in all of its manifestations—not just the familiar forms of matter we see around us, but also such exotic forms as the matter that existed in the first moments after the creation of the universe and the matter that exists today inside neutron stars—and to understand why matter takes on the particular forms that it does.

Nuclear physics focuses on three broad, yet tightly interrelated frontiers: Quantum Chromodynamics, Nuclei and Nuclear Astrophysics, and Fundamental Symmetries and Neutrinos. Quantum Chromodynamics seeks to develop a complete understanding of how quarks and gluons assemble themselves into protons and neutrons and how the resulting quark structure of protons and neutrons is modified in the interior of light and heavy nuclei. Nuclei and Nuclear Astrophysics seeks to understand how protons and neutrons combine to form atomic nuclei, including some now being observed for the first time, and how these nuclei have arisen during the 13.7 billion years since the birth of the cosmos. Fundamental Symmetries and Neutrinos seeks to develop a better understanding of the fundamental properties of the neutron and of the neutrino—the nearly undetectable fundamental particle produced by the weak force interactions that was first indirectly observed in nuclear beta decay experiments.

At the heart of the NP program are groups of highly trained scientists who conceive, plan, execute, and interpret transformative experiments carried out at nuclear physics facilities. NP supports scientists at both universities and national laboratories and is involved in a variety of international collaborations. The program provides more than 90 percent of the nuclear science research funding in the U.S. with approximately 80 Ph.D. degrees granted annually to students for research supported by the program. NP research at national laboratories is guided by DOE's mission and priorities and helps develop the core expertise needed to achieve the goals of the NP program. National laboratory scientists work and collaborate with academic scientists and other national laboratory experimental and theoretical researchers to collect and analyze data and to construct, support, and maintain the detectors and facilities used in experiments. The national laboratories also provide state-of-the-art resources for detector and accelerator R&D for future upgrades and new facilities. This research develops knowledge, technologies, and trained scientists to design and build next-generation NP accelerator facilities and is also of relevance to machines being developed by other domestic and international programs.

The complementary user facilities and equipment necessary to advance the U.S. nuclear science supported by NP are large and complex, and they account for about 50 percent of the NP budget. Three national user facilities are currently supported, each with unique capabilities: the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL); the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility (TJNAF); and the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL). These major scientific facilities provide particle beams for a user community of more than 3,000 research scientists world-wide. Approximately 38 percent of the users are from institutions outside of the U.S.; these institutions provide very significant benefits to the U.S. program through contributed capital, human capital, experimental equipment, and intellectual exchange. A number of other SC programs, DOE offices (National Nuclear Security Administration [NNSA] and Nuclear Energy), Federal agencies (National Science Foundation [NSF], National Aeronautics and Space Administration [NASA], and Department of Defense), and industries also use NP user facilities to carry out their own research programs.

Involving students in the development and construction of NP facilities and advanced instrumentation, along with the development of accelerator technology and computational techniques, supports workforce development. These facilities and techniques also provide collateral benefits such as the creation of new technologies with applications in industry. For example, superconducting radio frequency (SRF) particle acceleration has provided technological advances for an increasingly broad range of applications including materials research, cancer therapy, food safety, bio-threat mitigation, waste treatment, and commercial fabrication.

Basic and Applied R&D Coordination

The Isotope Development and Production for Research and Applications subprogram (Isotope Program) produces commercial and research isotopes that are important for basic research and applications and supports research for the development of new or improved production and separation techniques of stable and radioactive isotopes. NP has taken significant steps in aligning the federal, industrial, and research stakeholders of the Isotope Program with each other and with the nuclear science research community. To ascertain current and future demands of the research community, NP continues to develop working groups and relationships with NNSA and other Federal agencies and offices (e.g., National Institutes of Health [NIH], Office of Science and Technology Policy [OSTP], NASA, and National Security Council [NSC]), to foster interactions between researchers and Isotope Program staff; to obtain information from visits to DOE, NNSA, and international isotope production sites; to attend scientific community exhibitions and conferences; and to develop strategic plans and priorities with community input. Program priorities are also guided by National Academy studies and assessments by the Nuclear Science Advisory Committee (NSAC). Examples include conducting a Federal workshop to identify isotope demand and supply across a broad range of Federal agencies in support of research and applications within their areas of responsibility, playing a lead role in an interagency working group for prioritizing requested allocations of helium-3 and seeking alternative supplies, leading the joint DOE/NIH federal working group to develop a strategic plan and priorities for medical isotope production, participating in the OSTP interagency working group and the Organization for Economic Cooperation and Development (OECD) international working group to address the supply of molybdenum-99, and working with industry to ensure availability of isotopes of strategic and economic importance to the Nation.

NP also supports a competitive program of targeted awards in Applications of Nuclear Science and Technology. While the primary goal of these efforts is to pursue forefront nuclear science research and development important to the NP mission, they are also inherently cross-cutting and relevant to applications and help bridge the gap between basic research and applied science. Projects include nuclear physics research relevant to the development of advanced fuel cycles for next generation nuclear power reactors; advanced cost-effective accelerator technology and particle detection techniques for medical diagnostics and treatment; and research in developing neutron, gamma, and particle beam sources with applications in cargo screening and nuclear forensics. The proposals are peer reviewed with participation from the applied sciences community, including other DOE offices as appropriate.

Program Accomplishments and Milestones

TJNAF discovers missing particles, narrowing explanations of the nature of nuclear matter. Recently the CEBAF Large Angle Spectrometer (CLAS) experiment at TJNAF discovered five unstable particles, known as N* baryon resonances. These composite particles, which are dominantly composed of three quarks, are predicted to exist by Lattice Quantum Chromodynamics (QCD) calculations on some of today's most advanced computers. Lattice QCD is a mathematical technique for determining approximate predictions of QCD, a theory which describes nuclear matter and its behavior. Since these missing resonances had long eluded discovery, doubt was cast on earlier models leading to a conjecture that di-quarks—a hypothetical strong pairing of two of the three quarks known to inhabit the interior of baryons—might prevent some specific N* baryon resonances from existing. The advanced experimental capability provided by the CLAS experiment resolved the issue by finding some of these previously missing N* resonances, which eliminated the di-quark conjecture. The new particles discovered by CLAS have now been included in the Particle Data Group 2012 Review of Particle Properties.

RHIC probes the perfect liquid. Following the discovery of a new state of matter, a perfect quark-gluon liquid at the Relativistic Heavy Ion Collider (RHIC), a key question has been, "How perfect is the perfect liquid at RHIC?" NP researchers have achieved major scientific and technological advances toward answering this question. Scientists were able to disentangle the effects of fluctuations in the geometrical overlap of two colliding nuclei by studying collisions of gold and copper, two nuclei very different in size. Researchers also successfully used an advanced device called EBIS (Electron Beam Ion Source) to inject uranium nuclei for collisions in RHIC. Uranium nuclei are naturally football shaped, and the difference in observed experimental data when uranium nuclei collide tip-to-tip versus middle-to-middle can tell scientists whether their understanding of how nuclear matter flows during nucleus-nucleus collisions is correct. First-ever results on high energy uranium-uranium collisions were reported at the Quark Matter 2012 Conference showing conclusively that geometrical effects in uranium-uranium collisions can be detected. These results and technical advances provide scientists a powerful new tool to probe the liquid that is thought to have existed shortly after the birth of the universe and to understand its perfection.

Magic numbers provide insight toward a comprehensive theory of nuclear structure: Magic numbers refer to specific numbers of protons or neutrons that provide additional stability to nuclei and provide unique benchmarks for nuclear theory. A nucleus with a magic number of protons or neutrons behaves like a closed core which is not modified when single protons or neutrons are added. Nuclear theory makes very detailed predictions of the energies and properties of such single-particle excited states associated with an extra nucleon beyond the magic numbers. A very important set of nuclear benchmarks involves the excited states of ^{133}Sn (tin), which adds one neutron to the double-magic nucleus ^{132}Sn (magic in both neutron and proton number). Using a beam of radioactive ^{132}Sn, researchers at Oak Ridge National Laboratory (ORNL) recently produced and measured, with high precision, the energies of the complete set of the expected single-particle states in ^{133}Sn for the very first time. Particularly important is a newly identified state that lies above the energy where neutrons typically boil off the nucleus if it becomes excited. The position of this newly observed state indicates the strength of the spin-orbit force in nuclei, a key input to theoretical models which attempt to predict how nuclei configure themselves as protons and neutrons are added. These long-awaited data provide a stringent test and constraint for any comprehensive theory of nuclear structure.

New horizons on the nuclear landscape. There are 288 stable or nearly stable nuclei that occur in nature, comprising 99.9 percent of the matter in the visible world around us. Some 3,000 more have been synthesized in laboratories. These nuclear species have been mapped onto a chart of nuclides—the periodic table of the nuclear physics world. Until recently, the boundaries marking the edge of where nuclei can exist in this nuclear landscape—where the addition of one more proton or one more neutron will cause the nucleus to fall apart—has been highly uncertain, especially for heavier elements. Research using a technique known as nuclear density functional theory carried out at the University of Tennessee and ORNL using one of the world's most powerful supercomputers now predicts that the number of bound nuclides with atomic numbers between 2 and 120 is around 7,000. These findings represent a major advance in our understanding of nuclear stability and the ultimate limits of nuclear existence. Understanding the stability of nuclides is important to many applications and to natural phenomena such as the stellar processes that create the matter around us.

Further progress on producing isotopes for cancer treatment. Actinium-225 is an alpha-emitting isotope identified as a high priority by the National Institutes of Health that shows significant potential in the treatment of cancers such as leukemias and lymphomas, but inhibiting the realization of this potential has been the inadequate availability of actinium-225. The Isotope Program-sponsored research on accelerator-based production of actinium-225 that showed it is technically possible to produce more than ten times the current annual supply of actinium-225 in the matter of a few days. These quantities are sufficient to support the essential clinical trials and ultimately the clinical applications of this isotope.

Higher efficiency atom trapping allows world-wide analysis of water aquifers and ice cores. The Atom Trap Trace Analysis (ATTA) technique developed at ANL to search for new physics beyond the Standard Model has been adapted to date samples of ground water as old as a million years. Laser trapping of single atoms has been enabling new studies in geophysics, water resource management, and ocean science. Krypton-81 is an extremely rare and long lived isotope present in the atmosphere. When water loses contact with air, the concentration of the krypton-81 isotope in water begins to decline. New technological advances allow the trapping of single atoms of krypton-81 in a sample, and therefore the ability to determine its concentration and so the age of the sample. This approach enables its potential use in a comprehensive world-wide analysis of water aquifers and ice cores for geological studies; recently analyzed samples are from Yellowstone National Park, the Great Artesian Basin in Australia, and the Guarani aquifer in Brazil. This new capability, developed as a by-product of NP supported research, has created a new community of interdisciplinary researchers with complementary expertise supported by NSF, the U.S. Geological Survey, and the International Atomic Energy Agency (IAEA). ANL hosted an international workshop on Tracer Applications of Noble Gas Radionuclides in 2012 to advance new opportunities and foster research partnerships.

Milestone	Date
Obtain Critical Decision-2/3A for the Facility for Rare Isotope Beams (FRIB) to establish the technical, schedule, and cost baselines of this next generation facility for nuclear structure and nuclear astrophysics that is being constructed at MSU, and initiate civil construction.	3rd Qtr, FY 2013
Conduct a broad review of university and national laboratory research efforts within the Nuclear Physics program and assess the performance of individual groups.	4th Qtr, FY 2013
Complete a Committee of Visitor's review of the Nuclear Physics program.	2nd Qtr, FY 2013

The first two milestones are partially carried over from FY 2012.

Program Planning and Management

To ensure that funding is allocated optimally, NP has developed a rigorous and comprehensive process for strategic planning and priority setting that relies heavily on input from groups of outside experts. At a high level, NP works closely with the NSF to jointly charge the Nuclear Science Advisory Committee (NSAC) to provide recommendations regarding the highest priority scientific opportunities. NP develops strategic plans for the field with input from the scientific community via long range plans produced by NSAC every five to six years. In April 2012, DOE and NSF charged NSAC to review the implementation of the priorities and recommendations of the 2007 Long Range Plan in light of projected budgetary constraints; NSAC's report in response to this charge was issued in January 2013[a].

At the program execution level, all activities within the subprograms are peer reviewed by external scientific experts, and performance and productivity are assessed on a regular basis. Priority is given to research activities supporting the most exciting and internationally competitive scientific opportunities.

University grants are proposal driven in response to grant solicitation notices. Funding is competitively awarded according to Federal guidelines, and the quality and productivity of university grants are peer reviewed on a three-year basis with progress reports required annually.

Laboratory research groups are reviewed on a four-year basis, with progress reports required annually to ensure laboratory research efforts maintain a high level of productivity on competitive mission-driven science. As part of NP's peer review process, biennial science and technology reviews of the national user facilities and isotope production facilities are conducted to assess operations, performance, and scientific productivity. These results influence budget decisions and NP's assessment of laboratory performance in the annual Office of Science (SC) laboratory appraisals. The institutions are held accountable for responding to the peer review recommendations. Annual reviews of instrumentation projects focus on scientific merit, technical status and feasibility, cost and schedule, and effectiveness of management approach. Performance of instrumentation projects is also assessed on a monthly and quarterly basis.

NP strategic plans are also influenced by National Academies' reports and White House OSTP and NSC Interagency Working Group (IWG) efforts. NP participates in a federal working group with the NIH, along with the SC Biological and Environmental Research program, to better coordinate radioisotope production and to address other issues important to nuclear medicine. The National Academies new decadal study of nuclear science was released in June 2012;[b] the report re-iterated the importance of a strong nuclear science program to the Nation and endorsed the recommendations of the 2007 NSAC Long Range Plan. In order to optimize interagency activities, on an as-needed basis, the program establishes interagency working groups to tackle issues of common interest and to enhance communication. NP is currently involved in four OSTP or NSC IWGs: Forensic Science, Critical Materials, Molybdenum-99 Production, and Helium-3.

NP takes this input into account in its budget requests, making decisions to maximize scientific impact, productivity, quality, and cost-effectiveness within available resources. Funding decisions in this budget request are influenced by the results of these periodic peer reviews of the university and national laboratory research efforts, and facility and project performance.

Program Goals and Funding

Office of Science performance expectations (and therefore funding requests) are focused on four areas:

- *Research*: Support fundamental research to discover, explore, and understand all forms of nuclear matter.
- *Facility Operations*: Maximize the reliability, dependability, and availability of the NP scientific user and isotope production facilities.
- *Future Facilities*: Build future facilities or upgrades to existing facilities and experimental capabilities to ensure the continuing productivity of the NP scientific user and isotope production facilities. All construction projects and MIEs are within 10% of their specified cost and schedule baselines.
- *Scientific Workforce*: Contribute to the effort aimed at ensuring that DOE and the Nation have a sustained pipeline of highly skilled and diverse science, technology, engineering, and mathematics (STEM) workers which is knowledgeable in nuclear science.

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[a] http://science.energy.gov/~/media/np/nsac/pdf/20130201/2013_NSAC_Implementing_the_2007_Long_Range_Plan.pdf
[b] http://www8.nationalacademies.org/onpinews/newsitem.aspx?recordid=13438

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Medium Energy	28%	72%	0%	0%
Heavy Ion	17%	82%	1%	0%
Low Energy	37%	21%	42%	0%
Nuclear Theory	100%	0%	0%	0%
Isotopes	24%	76%	0%	0%
Construction	0%	0%	100%	0%
Total, Nuclear Physics	32%	55%	13%	0%

Performance Measures

Performance Goal (Measure)	**NP Facility Operations**—Average achieved operation time of NP user facilities as a percentage of total scheduled annual operation time.		
Fiscal Year	**2012**	**2013**[a]	**2014**
Target	≥ 80%	≥ 80%	≥ 80%
Result	Met		
Endpoint Target	Many of the research projects that are undertaken at the Office of Science's scientific user facilities take a great deal of time, money, and effort to prepare and regularly have a very short window of opportunity to run. If the facility is not operating as expected the experiment could be ruined or critically setback. In addition, taxpayers have invested millions or even hundreds of millions of dollars in these facilities. The greater the period of reliable operations, the greater the return on the taxpayers' investment.		

Performance Goal (Measure)	**NP Nuclear Structure**—Investigate new regions of nuclear structure, study interactions in nuclear matter like those occurring in neutron stars, and determine the reactions that created the nuclei of atomic elements inside stars and supernovae.		
Fiscal Year	**2012**	**2013**c	**2014**
Target	N/A	Complete initial measurements with high resolving power tracking array, GRETINA, for sensitive studies of structural evolution and production of superheavy elements.	Perform mass measurements and nuclear reaction studies to infer weak interaction rates in nuclei in order to constrain models of supernovae and stellar evolution.
Result	N/A		
Endpoint Target	Increase the understanding of the existence and properties of nuclear matter under extreme conditions, including that which existed at the beginning of the universe.		

[a] 2013 targets reflect DOE's FY 2013 Budget Request to Congress. FY 2013 target updates can be found in the upcoming FY 2012-2014 Annual Performance Plan & Report.

Explanation of Funding and Program Changes

The FY 2014 requested increase of $35,296,000 over FY 2012 is dominated by an increase to continue construction of FRIB at Michigan State University (MSU). The request also supports continued operations of the NP user facilities—RHIC and ATLAS—as well as the initiation of beam development and commissioning activities at CEBAF. Partially offsetting the increases is a decrease for the 12 GeV CEBAF Upgrade as construction ramps down.

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Medium Energy Nuclear Physics	115,522	149,862	+34,340
$14,317,000 of the increase from FY 2012 is for the required NP contribution to the SBIR/STTR programs; the FY 2012 SBIR/STTR funds have already been transferred out of the amount shown in the FY 2012 Current column. The balance of the increase primarily reflects the transition of key staff from the 12 GeV CEBAF Upgrade project back to CEBAF operations funding to support early operations and commissioning of the facility as the project nears completion. The temporary movement of staff from operations to the project allowed more cost-effective implementation of the project, and it is critical that these personnel transition back to operations to commission and operate the upgraded facility. In addition, power and cryogen usage will increase when pre-operations and commissioning begin, Other Project Costs for the 12 GeV Upgrade project increase as planned, and funding is requested for fabrication of Instrumentation for the 12 GeV scientific program. Research groups at universities and laboratories are focused on the implementation of the 12 GeV CEBAF Upgrade project, completion of the analysis of data on the quark structure of nucleons and nuclei from the recently completed 6 GeV program at TJNAF, and the program at RHIC to determine the origin of the proton spin.			
Heavy Ion Nuclear Physics	202,417	200,610	-1,807
Funding supports 2,770 hours of operations at RHIC, which is the minimum needed for a 2-species run and is made possible partially by a leaner operations staff. Core research at universities and laboratories decreases and is focused on the highest priority efforts at RHIC and LHC to determine the properties of the quark-gluon plasma. Support for the STAR Heavy Flavor Tracker MIE decreases as planned, as the project is completed.			
Low Energy Nuclear Physics	106,289	132,613	+26,324
The increase is dominated by the ramp-up of the FRIB project profile to support construction activities and maintain project performance. Core research efforts at universities and laboratories to advance knowledge of the structure of nuclei and operations of ATLAS decrease and are focused on the highest priority activities. Support for R&D of a neutrinoless double beta decay experiment prototype ramps down as planned.			

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Nuclear Theory	41,332	41,822	+490
Theoretical activities underpinning experimental efforts throughout the NP program are focused on high priority activities. Support for the Nuclear Data stewardship program and the Scientific Discovery through Advanced Computing (SciDAC-3) awards are maintained.			
Isotope Development and Production for Research and Applications	19,082	19,531	+449
Support is provided to maintain research efforts, university production capabilities, and mission readiness of the Isotope production and processing facilities at Brookhaven, Oak Ridge, and Los Alamos National Laboratories.			
Construction	50,000	25,500	-24,500
FY 2014 construction funding decreases for the 12 GeV CEBAF Upgrade project based on the current planned profile, which is revised as a result of the reduced FY 2012 appropriation. A full re-assessment of the project baseline will be conducted in FY 2013.			
Total, Nuclear Physics	534,642	569,938	+35,296

Medium Energy Nuclear Physics
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	35,216	—	36,304
Operations (TJNAF)	78,222	—	95,344
SBIR/STTR and Other[a]	2,084	—	18,214
Total, Medium Energy Nuclear Physics	115,522	—	149,862

[a] SBIR/STTR funding (covers the entire NP program):
- FY 2012 Transferred: SBIR $11,233,092 and STTR $1,512,147 (transferred out of NP in FY 2012 Current column)
- FY 2014 Request: SBIR $12,530,000 and STTR $1,787,000

Overview

The Medium Energy Nuclear Physics subprogram focuses primarily on experimental tests of the mathematical description of how quarks and gluons in nuclear matter interact, referred to as Quantum Chromodynamics (QCD), with an emphasis on the behavior of quarks inside protons and neutrons. Specific questions addressed include:

- What is the internal landscape of the protons and neutrons (collectively known as nucleons)?
- What does QCD predict for the properties of strongly interacting matter?
- What governs the transition of quarks and gluons into pions (hadronic subatomic particle) and nucleons?
- What is the role of gluons and gluon self-interactions in nucleons and nuclei?

Various experimental approaches are pursued to determine the distribution of up, down, and strange quarks and their antiquarks in nucleons as well as the roles of the gluons that bind the quarks; the effects of the quark and gluon spins within the nucleon; and the effect of the nuclear environment on the quarks and gluons. The subprogram also produces and studies higher-mass “excited states” of hadrons (composite particles, including nucleons, made of quarks, antiquarks, and gluons) predicted by QCD in order to determine how the theory leads to the observed properties of these strongly interacting particles.

Funding supports both research and operations of the subprogram’s primary research facility, CEBAF at TJNAF, as well as medium energy research that is carried out at RHIC. CEBAF provides high quality beams of polarized electrons that allow scientists to extract information on the quark and gluon structure of protons and neutrons; it also uses polarized electrons to make precision measurements to search for processes that violate a fundamental symmetry of nature, called parity, in order to reveal physics beyond what is currently known within the Standard Model. These are capabilities that are unique in the world. The increase in beam energy provided by the 12 GeV CEBAF Upgrade opens up exciting new scientific opportunities, and will secure continued U.S. world leadership in this area of physics. Additional research is carried out at RHIC, which provides colliding beams of spin-polarized protons, a capability unique to RHIC, to understand the origin of the spin of the proton, another important QCD frontier. Research support for both facilities includes laboratory and university personnel needed to implement and execute experiments and to conduct the data analysis necessary to extract the physics results. Compelling, special focus experiments that require different capabilities are supported at the High Intensity Gamma Source (HIGS) at Triangle Universities Nuclear Laboratory, Fermi National Accelerator Laboratory (Fermilab), and specific facilities in Europe. Efforts are supported at the Research and Engineering Center at the Massachusetts Institute of Technology (MIT), which has specialized infrastructure capabilities used to develop and fabricate advanced instrumentation and accelerator equipment.

The SBIR/STTR and Other category within this subprogram includes all of the mandated SBIR/STTR funding for the NP program, as well as funding to meet other NP obligations, such as the annual Lawrence Awards and Fermi Awards for honorees selected by DOE for outstanding contributions to science.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	35,216	36,304	+1,088
The FY 2014 Request maintains the highest priority research preparations for the 12 GeV program, as well as continued analysis of 6 GeV data and data from polarized proton beam runs at RHIC.			
Operations	78,222	95,344	+17,122
The increase supports critical operations staff as they transition from the 12 GeV Upgrade project back to the base operations budget. These staff are essential for the operations of CEBAF. Increased funding is provided for Other Project Costs as planned as part of the 12 GeV CEBAF Upgrade project profile to support the increased power and cryogen costs associated with the initiation of commissioning and beam development activities in FY 2014. Increased funding is also requested for scientific instrumentation that is needed for the 12 GeV research program.			
SBIR/STTR and Other	2,084	18,214	+16,130
The increase represents NP's required FY 2014 contributions to the SBIR/STTR programs. The SBIR/STTR funding set-aside of 2.95% in FY 2012 increases to 3.05% in FY 2013 and 3.2% in FY 2014. FY 2012 SBIR/STTR funding has already been transferred to the SBIR/STTR program.			
Total, Medium Energy Nuclear Physics	115,522	149,862	+34,340

Research

Overview

Research groups at TJNAF, BNL, ANL, LBNL, and LANL, and about 160 scientists and 125 graduate students at 32 universities carry out research and conduct experiments at CEBAF, RHIC, and elsewhere, and participate in the development and fabrication of advanced instrumentation, including state-of-the-art detectors that also have applications in medical imaging instrumentation and homeland security. TJNAF staff research efforts include developing experiments, acquiring data, and performing data analysis in the three existing CEBAF experimental Halls A, B, and C. Additionally, a scientific group is being developed to utilize the new experimental capabilities of Hall D being constructed as part of the 12 GeV CEBAF Upgrade project. Scientists also are conducting research to identify and develop the scientific opportunities and goals for next generation facilities. An active visiting scientist program at TJNAF and bridge positions with regional universities are also supported as a cost-effective approach to augmenting scientific expertise at the laboratory and boosting research experience opportunities.

ANL scientists continue targeted experiments at TJNAF and are leading an experiment at Fermilab to distinguish the different quark contributions to the structure of the proton. ANL scientists are also using their unique laser atom-trapping technique to make a precision measurement of the atomic electric dipole moment in order to research possible explanations for the excess of matter over antimatter in the universe. Research groups at BNL, LBNL, ANL, and LANL with important responsibilities in the RHIC program are supported within this subprogram to play lead roles in determining the spin structure of the proton through development and fabrication of advanced instrumentation as well as data acquisition and analysis efforts. At LANL, scientists and collaborators are also completing analysis of data from the MiniBooNE experiment at Fermilab, which has shown an intriguing discrepancy between anti-neutrino and neutrino data and may unveil new physics beyond the Standard Model. Researchers at MIT are developing high current, polarized electron sources.

Accelerator R&D research proposals from universities and laboratories are evaluated by peer review through a single competition for funding under the Medium Energy and Heavy Ion subprograms.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Efforts focused on completing the highest priority 6 GeV experiments at CEBAF prior to installation of the 12 GeV Upgrade and on support of the RHIC spin program.	35,216
FY 2013	The FY 2013 Request proposed $35,524,000. Research funding in FY 2013 is reduced overall by 5.8% relative to FY 2012; the decrease is partially offset by a small shift of a lab research effort from the Heavy Ion subprogram. Efforts are focused on analysis of 6 GeV experiments, the implementation of instrumentation needed for the 12 GeV experimental program at TJNAF, the formation of a research group for the new experimental hall in the 12 GeV CEBAF project, and on collecting experimental data at RHIC with polarized proton beams. Support for accelerator R&D is reduced by 5.8% relative to FY 2012 and addresses high priority technological advances in superconducting radiofrequency technology, cryogenics, and other areas of importance to next-generation NP facilities.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Efforts will focus on the new 12 GeV experimental program at TJNAF such as the implementation of instrumentation and development of the Hall D experimental group, as well as continued analysis of 6 GeV experimental data and RHIC polarized proton beam data. Support for short and mid-term accelerator R&D continues.	36,304

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Research	16,941	—	18,368
National Laboratory Research			
TJNAF Research	7,050	—	6,852
Other National Laboratory Research	10,390	—	10,255
Total, National Laboratory Research	17,440	—	17,107
Other Research			
Accelerator R&D Research	835	—	829
Total, Research	35,216	—	36,304

Operations

Overview

CEBAF is a unique scientific user facility with unparalleled capabilities using polarized electron beams to study the contributions of quarks and gluons to the properties of hadrons, and a user community with a strong international component.

Accelerator Operations support is provided for the accelerator physicists that operate the facility as well as for maintenance, power costs, capital infrastructure investments, and accelerator improvements. Investments in accelerator improvement projects are aimed at increasing the productivity, cost-effectiveness, and reliability of the facility. Support is provided to maintain efforts in developing advances in superconducting radiofrequency (SRF) technology relevant to improving the operations of the existing machine. The core competency in SRF technology plays a crucial role in many DOE projects and facilities outside of nuclear physics and has broad applications in medicine and homeland security. For example, SRF research and development at TJNAF has led to improved land-mine detection techniques and carbon nanotube and nano-structure manufacturing techniques for constructing super-lightweight composites such as aircraft fuselages. TJNAF also has a core competency in cryogenics and has developed award-winning techniques that have led to more cost-effective operations at TJNAF and several other Office of Science facilities. Accelerator capital equipment investment is targeted toward instrumentation needed to support the laboratory's core competencies in SRF and cryogenics. TJNAF accelerator physicists help train the next generation of accelerator physicists, enabled in part by a close partnership with the NP-supported Center for Accelerator Science at Old Dominion University (ODU). Experimental Support is provided for the scientific and technical staff as well as for materials and services for integration, assembly, modification, and disassembly of large and complex CEBAF experiments. Capital equipment investments for experimental support at TJNAF provide scientific instrumentation for the major experiments, including data acquisition computing and supporting infrastructure.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	CEBAF ran near the optimal level at 6 GeV until the planned shutdown in May 2012 as part of the 12 GeV CEBAF Upgrade project plan. Operations focused on efforts to implement the highest priority experiments before the completion of the current 6 GeV experimental program, including a precision measurement of the weak charge of the proton to help constrain new physics beyond the Standard Model, an important experiment to search for missing excited states of the neutron, and experiments that are helping to develop the laboratory's research program using the 12 GeV CEBAF Upgrade.	78,222
FY 2013	The FY 2013 Request proposed $80,271,000. FY 2013 funding supports maintenance and improvements in the existing facility in preparation for post-construction operations, beam study activities, instrumentation implementation, and installation of the 12 GeV project. The growth in operations funding relative to FY 2012 is dominated by the initiation of pre-operations funding for the 12 GeV CEBAF Upgrade project, which is part of the baselined Total Project Cost.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	FY 2014 funding increases significantly as staff are transitioned from the construction project back to base operations support in order to start commissioning and operating the upgraded CEBAF machine and equipment. Increased support is needed for power and cryogens as the facility turns on and begins pre-operations, beam study activities, and commissioning. Other project costs increase in support of the 12 GeV CEBAF project in accordance with the planned project profile. Support is provided to continue the implementation of instrumentation for the planned scientific research program.	95,344

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
TJNAF Accelerator Operations	50,052	—	58,394
12 GeV Other Project Costs (OPC)	0	—	4,500
TJNAF Experimental Support	28,170	—	32,450
Total, Operations (TJNAF)	78,222	—	95,344

Heavy Ion Nuclear Physics
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	39,259	—	35,386
Operations	163,158	—	165,224
Total, Heavy Ion Nuclear Physics	202,417	—	200,610

Overview

The Heavy Ion Nuclear Physics subprogram focuses on studies of nuclear matter at extremely high densities and temperatures that are directed primarily at answering the overarching questions defining one of the three nuclear physics frontiers—Quantum Chromodynamics (QCD). The fundamental questions addressed include:

- What are the phases of strongly interacting matter, and what roles do they play in the cosmos?
- What governs the transition of quarks and gluons into pions and nucleons?
- What determines the key features of QCD, and what is their relation to the nature of gravity and space-time?

At the Relativistic Heavy Ion Collider (RHIC) facility, scientists continue to pioneer the laboratory study of condensed quark-gluon matter at the extreme temperatures characteristic of the infant universe. The intellectual goal is to explore and understand unique manifestations of QCD in this many-body environment and their influence on the universe's evolution. Complementary research capability is also provided at the Large Hadron Collider (LHC) at CERN. In the debris of collisions at RHIC and at the LHC, researchers have seen signs of the same quark-gluon plasma that is believed to have existed shortly after the Big Bang. With careful measurements, scientists are accumulating data which offers insights into the processes early in the creation of the universe, and how protons, neutrons, and other bits of normal matter developed from that plasma. Important avenues of investigation are directed at learning more about the physical characteristics of the quark-gluon plasma including exploring the energy loss mechanism for quarks and gluons traversing the plasma, determining the speed of sound in the plasma and locating the critical point for the transition between the plasma and normal matter.

The RHIC facility places heavy ion research at the frontier of nuclear physics. RHIC serves two large-scale international experiments called PHENIX and STAR. Operation of RHIC in FY 2014 will take advantage of at least a 10-fold enhancement in the heavy ion beam collision rate using the recently completed stochastic cooling systems and the Electron Beam Ion Source (EBIS). New and ongoing detector upgrades coupled with the enhanced collision rate will contribute further scientific results and understanding. The RHIC facility is uniquely flexible, providing a full range of colliding nuclei at variable energies spanning the transition to the new state of matter discovered at RHIC. Short and mid-term accelerator R&D is conducted at RHIC in a number of areas including the cooling of high-energy hadron beams based on a new concept called Coherent Electron Cooling; high intensity polarized electron sources; and high-energy, high-current energy recovery linear (ERL) accelerators. The RHIC facility is used by about 1,200 DOE, NSF, and foreign agency-supported researchers annually.

Participation in the heavy ion program at the LHC at CERN provides U.S. researchers the opportunity to investigate new states of matter under substantially different initial conditions than those provided by RHIC, providing complementary information regarding the matter that existed during the infant universe. U.S. scientists, in collaboration with international scientists, successfully conducted the first heavy ion experiments in 2010 and 2011 using the ALICE, CMS, and ATLAS detectors, confirming that the same quark-gluon plasma is seen at the higher energy. In addition to playing a lead role in the fabrication of a large electromagnetic calorimeter detector installed in FY 2010 in the ALICE experiment, U.S. researchers are making important scientific contributions to the emerging results from all three LHC experiments.

Explanation of Funding Changes

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	39,259	35,386	-3,873
The decrease reflects the planned ramp-down and final year of funding for the fabrication of the STAR HFT MIE at RHIC to detect particles containing charm quarks, a measurement essential to determine the properties of the quark-gluon plasma discovered at RHIC. Core research activities are decreased and focused on the highest priority efforts at RHIC and the LHC.			
Operations	163,158	165,224	+2,066
The increase provides 2,770 hours of RHIC operations, an increase of 970 hours over the FY 2013 planned run. Direct support for General Purpose Equipment at BNL is eliminated.			
Total, Heavy Ion Nuclear Physics	202,417	200,610	-1,807

Research

Overview

Heavy ion research groups at BNL, LBNL, LANL, ORNL, and LLNL, and about 120 scientists and 100 graduate students at 28 universities are supported to analyze data from RHIC and participate in a modest program at the LHC.

The university and national laboratory research groups provide the scientific personnel and graduate students needed for running the RHIC and LHC heavy ion experiments; analyzing data; publishing results; conducting R&D of next-generation detectors; planning for future experiments; and designing, fabricating, and operating the RHIC and LHC heavy ion detectors. BNL also provides project management oversight for the fabrication of the STAR HFT MIE. BNL and LBNL provide computing infrastructure for terabyte-scale data analysis and state-of-the-art facilities for detector and instrument development. At LBNL, the large scale computational system, Parallel Distributed Systems Facility (PDSF), is a major resource used for the analysis of RHIC and LHC data in alliance with the National Energy Research Scientific Computing Center (NERSC), which is supported by the SC's Advanced Scientific Computing Research program. LLNL computing resources are also made available for LHC data analysis.

Accelerator R&D research proposals for short and mid-term accelerator R&D from universities and laboratories are evaluated by peer review through a single competition for funding under the Heavy Ion and Medium Energy subprograms.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Heavy ion research efforts were maintained and the NP commitment to the international ALICE and CMS experiments at the LHC were fulfilled. The PHENIX Forward Vertex Detector (FVTX) MIE received its final funding under the Recovery Act in FY 2009 and was completed in December 2011. Important for both the heavy ion and spin programs, this detector will provide new vertex tracking capabilities to PHENIX. The STAR Heavy Flavor Tracker (HFT), an MIE initiated in FY 2010, will provide direct reconstruction of short-lived particles containing heavy quarks; its schedule and budget baseline were established and fabrication began in October 2011.	39,259
FY 2013	The FY 2013 Request proposed $38,178,000. The FY 2013 request reduces support for heavy ion research efforts at universities and national laboratories by 5.8% relative to FY 2012. Researchers will participate at RHIC and the LHC in the collection and analysis of data, operations of newly completed scientific instrumentation, and scientific leadership essential for the implementation of the STAR HFT MIE. NP commitments for required management and operating costs to the international ALICE and CMS experiments are met. Offsetting the decrease is an increase in funding relative to FY 2012 for fabrication of the STAR HFT consistent with the approved baseline. Funding is reduced for Accelerator R&D focused on high priority activities targeted towards developing technological advances for improving the operations of current facilities and the development of next-generation facilities.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Researchers participate in the collection and analysis of data from RHIC with newly completed scientific instrumentation and in the conduct of R&D for innovative detector designs and planning for future experiments. NP provides scientific leadership to the international ALICE, CMS, and ATLAS experiments and commitments for required management and operating costs are met. The final year of funding is provided for the fabrication of the STAR HFT as it nears completion and a transition to operations is initiated. Mid- and short-term accelerator R&D continues at the FY 2013 level.	35,386

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Research	14,279	—	13,468
National Laboratory Research			
BNL RHIC Research	11,638	—	7,530
Other National Laboratory Research	11,192	—	12,847
Total, National Laboratory Research	22,830	—	20,377
Other Research			
Accelerator R&D Research	2,150	—	1,541
Total, Research	39,259	—	35,386

Operations

Overview

Support is provided for the operations, power costs, capital infrastructure investments, and accelerator improvement projects of the RHIC accelerator complex at BNL. This includes the Electron Beam Ion Source (EBIS), the Booster, and AGS accelerators that together serve as the injector for RHIC. RHIC operations allow for parallel and cost-effective operations of the Brookhaven Linac Isotope Producer Facility (BLIP), supported by NP for the production of research and commercial isotopes critically needed by the Nation, and for the NASA Space Radiation Laboratory Program for the study of space radiation effects applicable to human space flight. Through operations of the RHIC complex, important core competencies are nurtured in accelerator physics techniques to improve RHIC performance and support the NP mission; these core competencies also provide collateral benefits to applications in industry, medicine, homeland security, and other scientific projects outside of NP. RHIC accelerator physicists are leading the effort to address technical feasibility issues of relevance to a next-generation collider, including beam cooling techniques and energy recovery linacs. These physicists also play an important role in the training of next generation of accelerator physicists, with support of graduate students and post-doctoral associates.

In addition to the accelerator complex, the operation, maintenance, improvement, and enhancement of the RHIC experimental complex, including the STAR and PHENIX detectors, the experimental halls, and the RHIC Computing Facility are included in this activity. Instrumentation advances by this community have led to practical applications in medical imaging and homeland security.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	RHIC operated for 3,072 hours (75 percent utilization), an increase above planned operations due to the highest ever reliability of the machine and lower power costs than had been anticipated. Operations focused on the highest priority scientific opportunities and goals of the heavy ion program, with very modest support provided for continued R&D of luminosity enhancement technologies. Operations workforce decreased compared to FY 2011 due to voluntary reductions and retirements of some laboratory staff, and one-time reductions in materials and supplies which allowed the maximum running possible within available funding.	163,158
FY 2013	The FY 2013 Request proposed $158,571,000. RHIC operations are supported for an estimated 1,360 hour operating schedule (33 percent utilization) in FY 2013, a decrease of 1,030 hours from that planned in FY 2012. Increases required to restore one-time cuts made in FY 2012 and for projected staff salary and benefits increases contribute to the reduction in operating hours. Effective operation will be achieved by combining FY 2013–FY 2014 running into a single back-to-back run bridging the two fiscal years. Minimal support is continued for accelerator R&D activities focused on maintaining and improving the current operations of the facility. Support for lab-wide GPE is reduced to the FY 2011 level.	—
FY 2014	RHIC operations provide for 2,770 beam hours (68 percent utilization) in support of the planned RHIC research program, which is partially made possible due to reductions in operations staff. Efforts continue to increase the heavy ion and proton-proton beam luminosity for enhanced scientific productivity. Newly completed electron lenses should improve polarized proton luminosity. General purpose equipment at the laboratory is no longer directly supported by NP.	165,224

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
RHIC Operations			
RHIC Accelerator Operations	124,669	—	128,777
RHIC Experimental Support	35,489	—	36,447
Total, RHIC Operations	160,158	—	165,224
Other Operations (BNL GPE)	3,000	—	0
Total, Operations	163,158	—	165,224

Low Energy Nuclear Physics
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	52,752	—	49,590
Operations (ATLAS, HRIBF, and other)	31,537	—	28,023
Facility for Rare Isotope Beams	22,000	—	55,000
Total, Low Energy Nuclear Physics	106,289	—	132,613

Overview

The Low Energy Nuclear Physics subprogram is the most diverse within the NP portfolio, supporting research activities aligned with scientific thrusts focusing primarily on answering the overarching questions associated with two science areas: Nuclei and Nuclear Astrophysics, and Fundamental Symmetries and Neutrinos.

Questions associated with the Nuclei and Nuclear Astrophysics frontier include:

- What is the nature of the nuclear force that binds protons and neutrons into stable nuclei and rare isotopes?
- What is the origin of simple patterns in complex nuclei?
- What is the nature of neutron stars and dense nuclear matter?
- What is the origin of the elements in the cosmos?
- What are the nuclear reactions that drive stars and stellar explosions?

Questions addressed in the Fundamental Symmetries and Neutrinos frontier, which uses neutrinos and neutrons as primary probes, include:

- What is the nature of the neutrinos, what are their masses, and how have they shaped the evolution of the universe?
- Why is there now more matter than antimatter in the universe?
- What are the unseen forces that were present at the dawn of the universe but disappeared from view as the universe evolved?

One major goal of this subprogram is to develop a comprehensive description of nuclei using beams of stable and rare isotopes to yield new insights and reveal new nuclear phenomena. A second is to measure the cross sections of the nuclear reactions powering stars and leading to spectacular stellar explosions responsible for the synthesis of the elements.

This subprogram also seeks to measure or set a limit on the neutrino mass and to determine if the neutrino is its own anti-particle (a Majorana particle). Neutrino properties are believed to play an important role in the evolution of the cosmos. Beams of cold and ultracold neutrons are used for precision measurements of parity-violating processes and beta-decay parameters and to investigate the dominance of matter over antimatter in the universe, addressing fundamental questions in nuclear and particle physics, astrophysics, and cosmology.

Two NP national scientific user facilities have been pivotal in making progress on these scientific frontiers, serving a combined international community of approximately 700 scientists. ATLAS is used to study questions of nuclear structure by providing high-quality beams of all the stable elements up to uranium as well as selected beams of short-lived nuclei for experimental studies of nuclear properties under extreme conditions and reactions of interest to nuclear astrophysics. HRIBF, which ceased operations April 15, 2012, provided beams of short-lived radioactive nuclei used to study exotic nuclei that do not normally exist in nature. HRIBF was also used to explore reactions of interest to nuclear astrophysics and isotope production.

Progress in nuclear structure and nuclear astrophysics depends increasingly upon the availability of rare isotope beams. While ATLAS has some capabilities for these studies, one of the highest priorities for the NP program is support for the construction of a facility with world-leading capabilities for short-lived radioactive beams, the Facility for Rare isotope Beams (FRIB). FRIB is a next-generation machine that will advance understanding of rare nuclear isotopes and the evolution of the cosmos by providing beams of rare isotopes with neutron and proton numbers far from those of stable nuclei in order to test the limits of nuclear existence.

NP supports the LBNL 88-Inch Cyclotron jointly with the National Reconnaissance Office (NRO) and the U.S. Air Force (USAF).

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	52,752	49,590	-3,162
The decrease reflects the last year of support for the fabrication of the Majorana Demonstrator prototype; commissioning of the prototype begins in FY 2014. Offsetting this decrease is support provided to contribute to the operation of the recently completed Karlsruhe Tritium Neutrino (KATRIN) experiment to measure the mass of the neutrino in tritium beta decay, and to maintain, operate, and enhance the newly completed GRETINA detector. Funding for core research in nuclear structure, nuclear astrophysics, neutron physics, and neutrino physics maintains the highest priority efforts. Research for the final analysis of HRIBF data is completed at the end of FY 2013 and scientific staff transition to other nuclear structure/astrophysics research efforts.			
Operations	31,537	28,023	-3,514
The decrease reflects the transfer of NP dewatering activities at the Homestake mine to the DOE High Energy Physics (HEP) program; HEP provides support for dewatering activities in FY 2014. A modest increase is provided to maintain critical staff and operations at the ATLAS national user facility.			
Facility for Rare Isotope Beams	22,000	55,000	+33,000
Federal funding ramps up for the continued execution of FRIB construction. The request supports continued construction activities of the facility at the MSU according to project plans. The FRIB project will be baselined in FY 2013.			
Total, Low Energy Nuclear Physics	106,289	132,613	+26,324

Research

Overview

Low Energy research groups are supported at ANL, BNL, LBNL, LANL, LLNL, and ORNL and university grants support about 125 scientists and 100 graduate students at 41 universities. About two-thirds of the supported university scientists conduct nuclear structure and astrophysics research primarily using specialized instrumentation at the ATLAS national user facility (and previously, HRIBF), as well as smaller accelerator facilities at two university-based Centers of Excellence. The subprogram also supports a number of other targeted areas of research, and DOE-supported scientists have a lead role in developing important accelerator- and non-accelerator-based projects:

- NP is the steward for double beta decay experiments within the Office of Science. These experiments will search for evidence that the neutrino is its own antiparticle and aim at measuring or setting a limit on the effective Majorana neutrino mass. This includes the CUORE experiment at the Gran Sasso Laboratory in Italy, where the U.S. has a major role, and the Majorana Demonstrator R&D effort to demonstrate feasibility of a future ton-scale neutrino-less double beta decay experiment with germanium detectors. In the future, NP will assess opportunities with next-generation double beta decay experiments. U.S. university scientists participating in the German-led KATRIN experiment aim to achieve a direct determination of the mass of the electron neutrino by measuring the beta decay spectrum of tritium.
- The Fundamental Neutron Physics Beamline (FNPB) at the Spallation Neutron Source will deliver cold and ultra-cold neutrons at the highest (pulsed) intensities in the world for studying the fundamental properties of the neutron, providing experimental tests of the Standard Model.
- The neutron Electric Dipole Moment Experiment (nEDM) MIE, an R&D intensive and technically challenging discovery experiment, was terminated indefinitely in FY 2012. A modest R&D effort aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment, consistent with recent NSAC recommendations, continues.

Accelerator operations are supported at two university Centers of Excellence with specific goals and unique physics programs: the Cyclotron Institute at Texas A&M University (TAMU) and accelerator facilities at the Triangle Universities Nuclear Laboratory (TUNL) at Duke University. At the University of Washington, infrastructure is supported to develop scientific instrumentation projects and provide technical and engineering training opportunities.

Applications for Nuclear Science and Technology, which is also funded under the Nuclear Theory subprogram, supports competitively awarded basic nuclear physics research that also has practical applications to other fields, including medicine, next-generation nuclear reactors, and homeland security.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	HRIBF researchers worked on completing analyses of data obtained through FY 2012, and began transitioning to other efforts. The ATLAS research program achieved its highest priority scientific goals. The nEDM MIE was terminated, and the CUORE MIE funding profile ramped down as planned for its final year of funding. Funding supported continuation of the Majorana Demonstrator R&D effort and transitioning to operations of new instrumentation projects as they came on-line, including GRETINA, experiments at the Fundamental Neutron Physics Beamline (FNPB), and the international KATRIN experiment.	52,752

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2013	The FY 2013 Request proposed $50,354,000. University and laboratory research efforts, including support for the nuclear structure and nuclear astrophysics community to conduct research at ATLAS and support the development of FRIB, is reduced by 5.8% relative to FY 2012. In addition, the closure of HRIBF results in reduced research funding, the final year of funding for the CUORE MIE was provided in FY 2012, and the Majorana R&D effort receives its final year of funding, a decrease relative to FY 2012. Partially offsetting these decreases are increases in several areas, including operations and maintenance of the recently completed GRETINA MIE. Modest funding for R&D on the electric dipole moment of the neutron aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment continues, consistent with the recent NSAC review of priorities in the U.S. neutron science portfolio. Funding for Applications of Nuclear Science and Technology is reduced 5.8% relative to FY 2012.	—
FY 2014	University and laboratory nuclear structure and nuclear astrophysics efforts focus on research at ATLAS, university Centers of Excellence, and support for the development of advanced instrumentation to use new scientific capabilities that will be provided by FRIB. Implementation of scientific instrumentation for neutrino physics and R&D for a next generation double beta decay experiment continue with the start of commissioning of the Majorana Demonstrator; and support is provided for operations, maintenance, and enhancement of the GRETINA detector; operations of the KATRIN experiment; and operation costs for the CUORE MIE. The neutron program at the FNPB focuses on the fundamental properties of the neutron, and a modest R&D effort on the feasibility of setting a world leading limit on the electric dipole moment of the neutron (nEDM) continues	49,590

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Research	20,588	—	20,295
National Laboratory Research			
National Laboratory User Facility Research	8,823	—	4,669
Other National Laboratory Research	23,341	—	24,626
Total, National Laboratory Research	32,164	—	29,295
Total, Research	52,752	—	49,590

Operations

Overview

ATLAS provides stable and selected radioactive beams and utilizes specialized instrumentation for scientists to conduct research on nuclear structure and nuclear astrophysics. It is the premiere stable beam facility in the world. The Californium Rare Ion Breeder Upgrade (CARIBU) at ATLAS provides limited capabilities to produce radioactive ion beams until FRIB, the most advanced facility for rare ion beams in the world, becomes operational near the turn of the decade.

The ATLAS facility nurtures a core competency in accelerator science with superconducting radio frequency cavities for heavy ions that are relevant to the next generation of high-performance proton and heavy-ion linacs. This competency is important to the Office of Science mission and international stable and radioactive ion beam facilities. Capital equipment investments support the fabrication and implementation of small-scale instrumentation at the facility. ANL accelerator physicists and research scientists are also working closely with researchers at Michigan State University on developing the scientific program for FRIB.

Operation of HRIBF was supported through April 15, 2012 to provide unique capabilities for the production of intense radioactive beams by the Isotope-Separator-On-Line (ISOL) technique and for reaccelerating medium mass nuclei to the Coulomb barrier. Core competencies developed through this research include high power target design and ISOL ion beam production techniques that will have importance for FRIB and other rare isotope beam facilities. Efforts in 2013 and outyears focus on disposition of equipment at the facility.

Limited operations of the 88-Inch Cyclotron at LBNL are supported in partnership with the NRO and the USAF to meet national security needs and for a small in-house research program.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	ATLAS provided 6,140 beam hours with cost-effective 7 day-a-week operations. Support was provided for the scientific and technical personnel required to operate the facility, and capital and accelerator investments focused on increasing the reliability and efficiency of operations, including helium compressors and cryogenic system upgrades. HRIBF had limited, but very successful, operations to complete the highest priority experiments prior to its closure on April 15, 2012; equipment disposition planning activities commenced in FY 2012. One-time support was provided for sustaining operations at the Homestake Mine in conjunction with the High Energy Physics (HEP) program.	31,537
FY 2013	The FY 2013 Request proposed $27,072,000. ATLAS operations and experimental support funding levels provide 4,000 hours of operations, 80% of the maximum 5,000 hours possible with the scheduled installation of facility upgrades in FY 2013. Accelerator and capital investments support continuation of the energy and efficiency upgrade of ATLAS and the development of an electron beam ion source in order to conduct experiments with more neutron rich nuclei. Most of the increase for ATLAS Operations reflects a one-time FY 2012 transfer to the Isotope subprogram for R&D in support of the development of a californium-252 target for CARIBU. Support is provided for D&D planning activities at HRIBF. Support continues at the same level as FY 2012 for joint operations of the 88-Inch Cyclotron with the NRO and USAF. The overall funding reduction relative to FY 2012 is largely due to one-time NP funding for dewatering and sustaining operations at the Homestake Mine in FY 2012.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	ATLAS provides an estimated 5,500 hours of beam time (89% utilization) at approximately constant level of effort; additional demands will be placed on this national user facility as it attempts to serve some of the user community from HRIBF. Accelerator and capital investments continue the energy and efficiency upgrade and the development of an electron beam ion source. Funding continues for the implementation of equipment disposition activities at HRIBF.	28,023

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
User Facility Operations			
ATLAS Operations	16,048	—	17,255
HRIBF Operations[a]	6,825	—	0
HRIBF Equipment Disposition	0	—	6,479
Total, User Facility Operations	22,873	—	23,734
Other Operations	8,664	—	4,289
Total, Operations	31,537	—	28,023

[a] A portion of the FY 2012 funding was utilized for equipment disposition activities; HRIBF operations ceased April 15, 2012.

Facility for Rare Isotope Beams (FRIB)

Overview

FRIB will provide intense beams of rare isotopes for world-leading research opportunities in nuclear structure, nuclear astrophysics, and fundamental symmetry studies that will advance knowledge of the origin of the elements and the evolution of the cosmos. It offers a facility for exploring the limits of nuclear existence and identifying new phenomena, with the possibility that a broadly applicable theory of the structure of nuclei will emerge. It will offer new glimpses into the origin of the elements by providing a better insight into the structure of exotic nuclei that, until now, have been created only in nature's most spectacular supernova explosions. Experiments on fundamental symmetries will be conducted through the creation and study of certain exotic isotopes. Although motivated by discovery science, the knowledge gained will also develop competencies relevant to national security applications.

The science which underlies the FRIB mission is a core competency of nuclear physics: understanding how protons and neutrons combine to form various nuclear species; understanding how long chains of different nuclear species survive; and understanding how one nuclear species decays into another and what is emitted when that happens. Forefront knowledge and capability in this competency is essential, both for U.S. leadership in this scientific discipline and to provide the knowledge and workforce needed for numerous activities and applications relevant to national security and economic competitiveness.

Michigan State University (MSU) is undertaking a comprehensive effort to design, construct, and operate FRIB, which includes utilizing core competencies developed by several NP-supported national laboratory groups. FRIB is based on a heavy-ion linac with a minimum energy of 200 MeV per nucleon for all ions at beam power of 400 kW. The facility will include a production area, three-stage fragment separator, three ion stopping stations, and post accelerator capabilities.

Critical Decision 1 (CD-1), Approve Alternative Selection and Cost Range, was signed on September 1, 2010. The preliminary total project cost (TPC) range that DOE has been planning is $500,000,000 to $550,000,000, not including the MSU cost share of $94,500,000. The TPC and cost profile are preliminary and will not be finalized until CD-2, Approve Performance Baseline, planned for 3rd Quarter, FY 2013.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funds support continued engineering and design efforts aimed at developing FRIB, and long-lead procurements to reduce project risks. The Total Project Cost and duration will be evaluated in the process of achieving CD-2, Approve Performance Baseline, planned for FY 2013.	22,000
FY 2013	The FY 2013 Request proposed $22,000,000. Efforts begun in FY 2012 continue, and engineering and design efforts aimed at achieving CD-3, "Approve Construction Start" are pursued.	—
FY 2014	Federal funding ramps up to support construction activities and major procurements in FY 2014. CD-3b (Approve Start of All Construction) is planned and will allow construction of technical components as well as civil construction.	55,000

Design and Construction Schedule

The project performance baseline will be obtained in FY 2013. Previous dates contained in this table are preliminary estimates. Changes in the planned funding profile in FY 2012 and FY 2013 have been evaluated and the project will be baselined in FY 2013; the dates for future critical decisions will be updated based on the approved baseline.

	CD-0	CD-1	Design Complete	CD-2 / 3A	CD-3B	CD-4
FY 2011	02/09/2004	4Q FY 2010	TBD	TBD	TBD	FY 2017–2019
FY 2012	02/09/2004	9/1/2010	TBD	4Q FY 2012	TBD	FY 2018–2020
FY 2013	02/09/2004	9/1/2010	TBD	TBD	TBD	TBD
FY 2014	02/09/2004	9/1/2010	TBD	3Q FY 2013	TBD	TBD

CD-0–Approve Mission Need
CD-1–Approve Alternative Selection and Cost Range
CD-2–Approve Performance Baseline
CD-3–Approve Start of Construction
CD-4–Approve Start of Operations or Project Closeout

Funding Profile History (DOE Only)

This table does not include MSU's cost share, which is estimated to total $51,700,000 by the end of FY 2013.

Request Year		(dollars in thousands)							
		FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	Outyears	Total
FY 2011	TEC	0	0	10,000	TBD	TBD	TBD	TBD	TBD
	OPC	7,000	12,000	0	TBD	TBD	TBD	TBD	TBD
	TPC	7,000	12,000	10,000	TBD	TBD	TBD	TBD	TBD
FY 2012	TEC	0	0	10,000	30,000	TBD	TBD	TBD	TBD
	OPC	7,000	12,000	0	0	TBD	TBD	TBD	TBD
	TPC	7,000	12,000	10,000	30,000	TBD	TBD	TBD	TBD
FY 2013	TEC	0	0	10,000	22,000	22,000	TBD	TBD	TBD
	OPC	7,000	12,000	0	0	0	TBD	TBD	TBD
	TPC	7,000	12,000	10,000	22,000	22,000	TBD	TBD	TBD
FY 2014	TEC	0	0	10,000	22,000	—	55,000	TBD	TBD
	OPC	7,000	12,000	0	0	—	0	TBD	TBD
	TPC	7,000	12,000	10,000	22,000	—	55,000	TBD	TBD

Nuclear Theory
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Theory Research	34,547	—	34,109
Nuclear Data Activities	6,785	—	7,713
Total, Nuclear Theory	41,332	—	41,822

Overview

The Nuclear Theory subprogram provides the theoretical support needed to interpret the wide range of data obtained from the experimental nuclear science subprograms and to advance new ideas and hypotheses that identify potential areas for future experimental investigations. Nuclear Theory addresses all three of NP's scientific frontiers. One major theme of theoretical research is the development of an understanding of the mechanisms and effects of quark confinement and deconfinement. A quantitative description of these phenomena, QCD, is one of this subprogram's greatest intellectual challenges. New theoretical and computational tools are also being developed to describe nuclear many-body phenomena; these approaches will likely also see important applications in condensed matter physics and in other areas of the physical sciences. Another major research area is nuclear astrophysics, which includes efforts to understand the origins of the elements (e.g., via supernovae) and the consequences that neutrino masses have for nuclear astrophysics and for the current Standard Model of elementary particles and forces.

This subprogram supports one of the program's university Centers of Excellence, the Institute for Nuclear Theory (INT) at the University of Washington. Starting in FY 2010, five-year topical collaborations within the university and national laboratory communities were established to address high-priority topics in nuclear theory that merit a concentrated theoretical effort. The Nuclear Theory subprogram also operates the Nuclear Data program through the National Nuclear Data Center (NNDC), which collects, evaluates, and disseminates nuclear physics data for basic nuclear research and for applied nuclear technologies. The extensive nuclear databases maintained and continually updated by the Nuclear Data program are an international resource consisting of carefully organized scientific information gathered from over 100 years of worldwide low-energy nuclear physics experiments.

Much of the research supported by the Nuclear Theory subprogram requires extensive access to leading-edge supercomputers. One area that has a particularly pressing demand for large, dedicated computational resources is lattice quantum chromodynamics (LQCD). LQCD calculations are critical for understanding and interpreting many of the experimental results from RHIC, LHC, and CEBAF. A joint five-year HEP/NP LQCD-ext project, started in FY 2010, follows previous efforts that address the computational requirements of lattice QCD research. The national LQCD computing capability was further augmented by NP Recovery Act funding, which provided a dedicated LQCD computer at TJNAF that made extensive use of graphics processor units (GPUs). This relatively inexpensive GPU-based cluster has greatly increased the U.S. national capacity for LQCD research.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Theory Research	34,547	34,109	-438
Funding maintains the final year of the current theory topical centers, the LQCD-ext project (joint with the Office of High Energy Physics), university and national laboratory research efforts, and third year awards for SciDAC-3 projects.			
Nuclear Data Activities	6,785	7,713	+928
Nuclear Data activities are focused on the highest priority efforts. Increased funding supports awards in Applications of Nuclear Science and Technology, which is also partially supported within the Low Energy Program.			
Total, Nuclear Theory	41,332	41,822	+490

Theory Research

Overview

The Nuclear Theory subprogram supports the research programs of approximately 160 university scientists and 120 graduate students at 45 universities as well as nuclear theory groups at seven national laboratories (ANL, BNL, LANL, LBNL, LLNL, ORNL, and TJNAF). This research has the goals of improving our fundamental understanding of nuclear physics, interpreting the results of experiments carried out under the auspices of the experimental nuclear physics program, and identifying and exploring important new areas of research. It is aligned with the experimental program through the program performance milestones established by NSAC. In FY 2010, NP implemented three new topical collaborations through 5-year awards to bring together theorists to address specific high-priority theoretical challenges: JET (QCD in the heavy-ion environment); NuN (neutrinos and nucleosynthesis in hot and dense matter); and TORUS (low-energy nuclear reactions for unstable isotopes). A midterm review of the three topical collaborations was conducted in September2012.

The research effort supported by the Nuclear Theory subprogram is strengthened by interactions with NSF-supported theory efforts, the HEP program, and other national nuclear theory programs. International collaborations by nuclear theorists are supported by three reciprocal visitor programs: Japan-U.S. (JUSTIPEN), France-U.S. (FUSTIPEN), and Germany-U.S. (GAUSTEQ).

SciDAC is a collaborative program with ASCR that partners scientists and computer experts in research teams to address major scientific challenges that require supercomputer facilities at the current technological limits. The NP SciDAC program operates on a five year cycle, and supports computationally intensive research projects jointly with other SC and DOE offices in areas of mutual interest. SciDAC-3 awards were made for the first year in FY 2012.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Support continued for university and laboratory nuclear theory research efforts, the second-generation LQCD project in partnership with HEP, and the third-year of the topical theory collaborations. SciDAC programs throughout SC were re-competed in FY 2012 as SciDAC-3. NP is supporting three new computational nuclear theory projects under SciDAC-3 in collaboration with ASCR and NNSA.	34,547
FY 2013	The FY 2013 Request proposed $31,770,000. Support for university and laboratory theoretical efforts required for the interpretation of experimental results obtained at NP facilities is reduced by 5.8% relative to FY 2012. A specific focus will be to provide theoretical support for the research program at the upgraded CEBAF 12 GeV facility and the planned FRIB facility in order to fully exploit their physics potentials and to advance theoretical concepts that motivate future experiments at these facilities and elsewhere, including in the relatively new NP area of fundamental symmetries. Funding for SciDAC research under the SciDAC-3 program continues flat with the FY 2012 level. The fourth year for the topical theory collaborations is supported and some funding for these efforts shifts from universities to national laboratories, as planned.	—
FY 2014	Funding supports university and laboratory theoretical efforts required for the interpretation of experimental results obtained at NP facilities. Efforts will continue to focus on the research program at the upgraded CEBAF 12 GeV facility, the research program at the planned FRIB facility, and topics related to fundamental symmetries. Funding supports ongoing research efforts, the SciDAC-3 grants, and the final year of the topical theory collaborations, as planned.	34,109

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Research	16,301	—	15,407
National Laboratory Research	15,836	—	16,702
SciDAC	2,410	—	2,000
Total, Theory Research	34,547	—	34,109

Nuclear Data

Overview

The Nuclear Data effort involves the work of several national laboratories and universities, and is guided by the DOE-managed National Nuclear Data Center (NNDC) at BNL. The NNDC coordinates the work of the U.S. Nuclear Data Network, a group of DOE-supported individual nuclear data professionals located in universities and national laboratories that perform assessments, validate and estimate uncertainties, and develop modern online dissemination capabilities. The databases developed and maintained by the Nuclear Data program cover over 100 years of nuclear science research with between 1,500 and 6,000 nuclear data retrievals on a daily basis. Data retrievals increased to over 9,000 per day following the Japanese earthquake and tsunami. The NNDC participates in the International Data Committee of the IAEA and is an important national and international resource.

Independent of the core Nuclear Data activities, funding is also provided to support efforts in Applications of Nuclear Science and Technology, including efforts relevant to nuclear fuel cycle research. The funding is split between the Low Energy subprogram and the Nuclear Data program pending competitive peer review and award.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Funding for ongoing work of the National Nuclear Data Program continued and NNDC data servers were upgraded.	6,785
FY 2013	The FY 2013 Request proposed $6,933,000. Funding for the Nuclear Data program is reduced 5.8% relative to FY 2012. Efforts will be focused on updating online databases containing experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature. The NNDC plans to hold a major nuclear data conference, ND2013, during FY 2013. Funding for Applications of Nuclear Science and Technology is reduced 5.8% relative to FY 2012.	—
FY 2014	Funding for NNDC efforts increase to support key staff in order to maintain the viability of the program. Efforts focus on updating online databases containing experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature and on maintaining computing infrastructure needed to support important efforts across the NNDC.	7,713

Isotope Development and Production for Research and Applications
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	4,827	—	4,648
Operations	14,255	—	14,883
Total, Isotope Development and Production for Research and Applications	19,082	—	19,531

<u>Overview</u>

The Isotope Development and Production for Research and Applications subprogram (Isotope Program) supports the production, distribution, and development of production techniques for radioactive and stable isotopes in short supply and critical to the Nation. Isotopes are commodities of strategic importance for the Nation that are essential for energy exploration and innovation, medical applications, national security, and basic research. An important goal of the program is to make key isotopes more readily available to meet U.S. needs. To achieve this goal, the program provides facilities and capabilities for the production of research and commercial stable and radioactive isotopes, scientific and technical staff associated with general isotope research and production, and a supply of critical isotopes. The subprogram also supports R&D efforts associated with developing new and more cost-effective and efficient production and processing techniques, and on the production of isotopes needed for research purposes. The R&D activities also provide collateral benefits for training, contributing to workforce development, and helping to ensure a future U.S.-based expertise in the fields of nuclear chemistry and radiochemistry. These disciplines are foundational not only to radioisotope production but to many other critical aspects of basic and applied nuclear science as well.

The Isotope Program, which operates a revolving fund, maintains its financial viability by utilizing a combination of appropriations and revenues from the sale of isotopes and services. These resources are used to maintain the staff, facilities, and capabilities at user-ready levels and to support peer-reviewed research and development activities related to the production of isotopes. Commercial isotopes are priced to provide full cost recovery or the market price (whichever is higher). Investments in new capabilities are made to meet the growing demands of the Nation and foster research in applications that will support national security and the health and welfare of the public.

Isotopes are critical national resources that are used to improve the accuracy and effectiveness of medical diagnoses and therapy, enhance national security, improve the efficiency of industrial processes, and provide precise measurement and investigative tools for materials, biomedical, environmental, archeological, and other research. Some examples are:

- strontium-82 use for cardiac imaging;
- germanium-68 use for calibrating the growing number of positron imaging scanners;
- actinium-225 and bismuth-213 use in cancer and infectious disease therapy research;
- strontium-90 use for cancer therapy;
- selenium-75 use in industrial radiography;
- arsenic-73 use as a tracer for environmental research;
- silicon-32 use in oceanographic studies related to climate modeling;
- californium-252 for well logging, medicine, homeland defense, and energy security; and
- nickel-63 use as a component in molecular sensing devices and helium-3 (He-3) as a component in neutron detectors, both for applications in homeland defense.

Stable and radioactive isotopes are vital to the mission of many Federal agencies including the National Institutes of Health (NIH), the National Institute of Standards and Technology, the Environmental Protection Agency, the Department of Agriculture, the Department of Homeland Security (DHS), NNSA, and DOE Office of Science programs. NP continues to work in close collaboration with these organizations to develop strategic plans for isotope production and to establish effective communication to better forecast isotope needs and leverage resources. For example, a five-year production strategy has been generated with the NIH that identifies the isotopes and projected quantities needed by the medical community in the context of the Isotope Program capabilities. In addition, NP initiated a workshop, attended by representatives of all federal agencies that require stable and radioactive isotopes to support research and applications within their realms of responsibility, to provide a comprehensive assessment of national needs for isotope products and services. Another example is participation in the OSTP working group on molybdenum-99 (Mo-99). While the Isotope Program is not responsible for the production of Mo-99, it recognizes the importance of this isotope for the Nation and is working closely with NNSA, the lead entity responsible for domestic Mo-99 production, and is offering technical and management support. NP is participating in the international High-Level Group on the Security of Supply of Medical Isotopes lead by the Organisation for Economic Co-operation and Development (OECD). NP participates in the Certified Reference Material Working Group which assures material availability for nuclear forensics applications that support national security missions. Finally, NP plays a lead role in a federal working group on the He-3 supply issue involving NNSA, the DHS, the Department of Defense, NIH, and many other agencies. While the Isotope Program role in He-3 is limited to packaging and distribution of the isotope, the program does play a lead role in working with all of the federal agencies in forecasting demand for the gas and its allocation. The objective of the working group is to ensure that the limited supply of He-3 will be distributed to the highest priority applications and basic research.

The National Isotope Development Center (NIDC) is a virtual center that interfaces with the user community and manages the coordination of isotope production across the facilities and business operations involved in the production, sale, and distribution of isotopes. The NIDC includes the Isotope Business Office which is located at ORNL.

Explanation of Funding Changes

(dollars in thousands)

	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
Research	4,827	4,648	-179
Support is provided for competitively awarded university and laboratory research in developing or improving production techniques for critical isotopes.			
Operations	14,255	14,883	+628
Funding maintains constant effort for the Isotope Production Facility, the Brookhaven Linac Isotope Producer, processing capabilities at ORNL, and the NIDC. Funding is provided to support university-based operations in support of isotope production.			
Total, Isotope Development and Production for Research and Applications	19,082	19,531	+449

Research

Overview

Research is supported to develop new or improved production or separation techniques for high priority isotopes in short supply. Examples of isotope needs requiring research to meet national needs include positron-emitting radionuclides to support the rapidly growing area of medical imaging using positron emission tomography (PET), isotopes that support medical research used to diagnose and treat diseases spread through acts of bioterrorism, alpha-emitting radionuclides that exhibit great potential in disease treatment, research isotopes for various biomedical applications, enriched stable isotopes, and alternative isotope supplies for national security applications and advanced power sources. Priorities in research isotope production are informed by guidance from NSAC. One of the high priorities is to conduct R&D aimed at re-establishing a U.S. capability for stable isotope production. Isotope Program research also provides training opportunities for workforce development in the areas of nuclear chemistry and radiochemistry. These disciplines are essential to the long-term health of the fields of radioisotope production and applications. All R&D activities are peer reviewed.

Support is provided for scientists at BNL, LANL, ORNL, INL, PNNL, and ANL and for investigators at universities and in industry to perform peer-reviewed experimental research. The supported work includes research on target design, enhanced processing and separation techniques, radiochemistry, material conversions, and other related services. Researchers provide unique expertise and facilities for data analysis and utilize reactor and accelerator capabilities throughout the DOE complex and at university sites. Isotopes produced by the NP Isotope Program are sold at reduced rates to investigators to make them more affordable for research applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Based on the FY 2011 Funding Opportunity Announcement, 4 projects received FY 2012 funding to support research into new and improved technologies for production of radioisotopes and enriched stable isotopes. Laboratory research groups were established at those sites at which production capabilities exist.	4,827
FY 2013	The FY 2013 Request proposed $4,453,000. Funding for competitively awarded research and development is reduced by 5.8%; support for laboratory research groups at LANL, BNL and ORNL will continue at the same funding level as FY 2012. There is an additional reduction relative to FY 2012 as a result of the one-time R&D project for ATLAS that was funded in FY 2012.	—
FY 2014	Support maintains research and development competitive awards and laboratory research groups at LANL, BNL, and ORNL. Development of production techniques for alpha-emitters is of high priority, as is R&D aimed at re-establishing a domestic capability for research quantities of stable isotopes.	4,648

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
National Laboratory Research	3,677	—	3,415
University Research	1,150	—	1,233
Total, Research	4,827	—	4,648

Operations

Overview

The Isotope Program is steward of the Isotope Production Facility (IPF) at Los Alamos National Laboratory (LANL) and the Brookhaven Linac Isotope Producer (BLIP) facility at BNL and provides support for hot cell facilities for processing and handling irradiated materials and purified products at ORNL, BNL, and LANL. Facilities at other national laboratories are used as needed, such as the Idaho National Laboratory reactor for the production of cobalt-60 and the Pacific Northwest National Laboratory for processing and packaging strontium-90.

Funding is provided for the scientists and engineers needed to support operational readiness of the Isotope Program facilities and includes modest facility maintenance and investments in new facility capabilities. In addition, the program supports isotope production capabilities at a few universities, other national laboratories, and reactor facilities throughout the Nation to promote a reliable supply of domestic isotopes. Facilities at Washington University, the University of California at Davis, the University of Washington, and the Missouri University Research Reactor can provide cost-effective opportunities to partner in order to increase the availability of isotopes. Partnerships with industrial counterparts are pursued to leverage resources.

The National Isotope Data Center (NIDC) interfaces with the user community and manages the coordination of isotope production across the facilities and business operations involved in the production, sale, and distribution of isotopes. The NIDC oversees public outreach for the program and maintains a website for the program at www.isotopes.gov. The NIDC also coordinates all transportation efforts and quality control issues among all of the production sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2012	Support was provided for the infrastructure and maintenance of facilities, core competencies in isotope production and development at university and laboratory accelerator and reactor facilities, and the NIDC. Isotopes produced included commercial isotope production initiated to meet customer demand (e.g., gadolinium-153, strontium-89, neptunium-236, carbon-14, and tin-117m) and high priority isotopes identified by NSAC (e.g., astatine-211, actinium-225, and berkelium-249).	14,255
FY 2013	The FY 2013 Request proposed $14,255,000. Mission readiness for isotope production at university and laboratory accelerator and reactor facilities, and support for the NIDC are maintained within flat funding with FY 2012. The isotopes that will be chosen for production will represent a balance of commercial isotopes that must be produced in order to maintain the program’s livelihood, and high priority research isotopes identified by NSAC and the Federal workshop held in FY 2012.	—

Fiscal Year	Activity	Funding (dollars in thousands)
FY 2014	Support continues at constant effort for infrastructure and maintenance of facilities, core competencies in isotope production and development, and for the NIDC. National Laboratory operations are maintained at constant effort relative to FY 2013 and focused on essential activities required to maintain aging facilities in operational conditions. An increase in university operations is associated with supporting routine production of isotopes that had been developed in prior years through grants awarded by the Isotope Program. The isotopes that will be chosen for production will represent a balance of commercial isotopes, and high priority research isotopes identified by NSAC and the Federal workshop held in FY 2012. Production of actinium-225, a promising alpha-emitter for the treatment of cancer, will be initiated in quantities sufficient to address applications and research important to the Nation.	14,883

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
University Operations	150	—	355
Isotope Production Facility (IPF) Operations	941	—	969
Brookhaven Linear Isotope Producer (BLIP) Operations	520	—	536
National Isotope Data Center (NIDC)	2,278	—	2,346
Other National Laboratory Operations	10,366	—	10,677
Total, Operations	14,255	—	14,883

Construction
Funding Profile by Activity

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	50,000	50,306	25,500

Overview

This funding provides for project engineering and design (PED) and construction needed to meet overall objectives of the Nuclear Physics program. Currently the only line item construction project supported is the 12 GeV CEBAF Upgrade at TJNAF, which was identified in the 2007 NSAC Long-Range Plan as the highest priority for the U.S. Nuclear Physics program to enable scientists to address one of the mysteries of modern physics—the mechanism of quark confinement.

Explanation of Funding Changes

	(dollars in thousands)		
	FY 2012 Current	FY 2014 Request	FY 2014 Request vs. FY 2012 Current
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	50,000	25,500	-24,500

The FY 2014 request reflects the current planned profile. A baseline change will be required as a result of the FY 2012 appropriation, which provided $50,000,000; $16,000,000 less than the baseline profile. A full assessment of the project baseline will be conducted later in FY 2013.

During FY 2014, the new cryomodules will be installed in the accelerator tunnel; the Hall D experimental equipment will be procured, fabricated, and installed; and Halls B and C experimental equipment will be upgraded.

Supporting Information

Capital Operating Expenses

Capital Operating Expenses Summary

(dollars in thousands)

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Capital equipment over $500,000, including major items of equipment (MIE)	13,970	—	19,258
General plant projects (GPP) (under $10 million)	2,000	—	2,000
Accelerator improvement projects (AIP)	3,622	—	5,215
Total, Capital Operating Expenses	19,592	—	26,473

Capital Equipment over $500,000, including MIEs

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Major items of equipment (TEC over $2 million)					
STAR Heavy Flavor Tracker, BNL					
TEC	15,200	6,800	4,050	—	950
OPC	280	280	0	—	0
TPC	15,480[a]	7,080	4,050	—	950
Cryogenic Underground Observatory for Rare Events (CUORE), LBNL					
TEC	7,586	7,400	186	—	0
OPC	1,114	764	350	—	0
TPC	8,700	8,164	536	—	0
Total, MIEs					
TEC			4,236	—	950
OPC			350	—	0
TPC			4,586	—	950
Other capital equipment projects under $2 million TEC			9,734	—	18,308
Total, Capital Equipment (excludes MIE OPC)			13,970	—	19,258

[a] The baselined TPC includes an additional $1,100,000 of support for engineering and technical activities supported by the base RHIC research program, for a total project cost of $16,580,000.

Heavy Ion Nuclear Physics MIEs

STAR Heavy Flavor Tracker (HFT), BNL: This MIE will fabricate a high-precision tracking and vertexing device based on ultra-thin silicon pixel and pad detectors in the STAR detector. It received CD-2/3 approval in October 2011. The project is scheduled for completion in FY 2015.

Low Energy Nuclear Physics MIEs

Cryogenic Underground Observatory for Rare Events (CUORE), LBNL: This MIE fabricates the U.S. contribution to the Italian-led CUORE experiment to measure fundamental neutrino properties. It received CD-2/3 approval in December 2009, final funding in FY 2012, and is scheduled to finish in FY 2015. This is a joint DOE/NSF project with NSF contributing additional funds.

General Plant Projects (TEC under $10 million)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Other general plant projects under $5 million TEC	n/a	n/a	2,000	—	2,000

Accelerator Improvement Projects (AIP)

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
RHIC Low Energy Electron Cooling	8,000	0	0	—	2,300
Other accelerator improvement projects under $5 million TEC	n/a	n/a	3,622	—	2,915
Total, AIP			3,622	—	5,215

Construction Projects Summary

Construction Projects

(dollars in thousands)

	Total	Prior Years	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF					
TEC	287,500	170,428	50,000	50,306	25,500
OPC	22,500	10,500	0	—	4,500
TPC[a]	310,000	180,928	50,000	50,306[b]	30,000

Construction Project Outyears

(dollars in thousands)

	FY 2015 Request	FY 2016 Request	FY 2017 Request	FY 2018 Request	Outyears to Completion
12 GeV CEBAF Upgrade, TJNAF					
TEC	5,000	3,000	0	0	0
OPC	5,000	0	0	0	0
TPC	10,000	3,000	0	0	0

[a] The TPC and the completion date will change as a result of the reduced FY 2012 funding; a full assessment of the project baseline will be conducted later in FY 2013.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. Pending finalization of FY 2013 funding levels, however, the TEC, OPC and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $40,572,000 for TEC, $2,500,000 for OPC, and $43,072,000 for TPC is assumed instead.

Other Supporting Information

Funding Summary

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
Research	168,800	—	166,800
Scientific User Facilities Operations	261,253	—	277,823
Other Facility Operations	22,919	—	25,651
Projects			
Major Items of Equipment	4,586	—	950
Facility for Rare Isotope Beams[a]	22,000	—	55,000
Construction Projects (12 GeV Upgrade TEC)	50,000	—	25,500
Total Projects	76,586	—	81,450
Other[b]	5,084	—	18,214
Total Nuclear Physics	534,642	550,737	569,938

Scientific User Facility Operations and Research

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
CEBAF (TJNAF)			
Operations[c]	78,222	—	95,344
Facility research/MIEs	12,194	—	10,725
Total CEBAF	90,416	—	106,069
RHIC (BNL)			
Operations	160,158	—	165,224
Facility research/MIEs	11,638	—	7,530
Total RHIC	171,796	—	172,754

[a] FRIB is funded with operating expense dollars through a Cooperative Agreement with MSU.
[b] Includes SBIR/STTR funding in FY 2013 and FY 2014.
[c] CEBAF Operations includes $2,500,000 in 12 GeV Other Project Costs in FY 2013, and $4,500,000 in FY 2014.

	(dollars in thousands)		
	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
HRIBF (ORNL)			
Operations[a]	6,825	—	0
Facility research/MIEs	3,673	—	0
Total HRIBF	10,498	—	0
ATLAS (ANL)			
Operations	16,048	—	17,255
Facility research/MIEs	5,150	—	4,669
Total ATLAS	21,198	—	21,924
Scientific User Facilities			
Operations	261,253	—	277,823
Facility research/MIEs	32,655	—	22,924
Total, Scientific User Facility Operations and Research	293,908	—	300,747

Facilities Users and Hours

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
CEBAF (TJNAF)[b]			
Achieved operating hours	3,729	—	N/A
Planned operating hours	3,870	—	0
Optimal hours	3,940	—	0
Percent of optimal hours	95%	—	N/A
Unscheduled downtime	10%	—	N/A
Number of users	1,390	—	1,375

[a] Operations of HRIBF as a National User Facility ceased on April 15, 2012. Funding in FY 2012 was used for equipment disposition planning, transitioning staff, and limited operations to complete the highest priority experiments prior to closure.

[b] Optimal hours for CEBAF reflect the maximum possible due to the shutdown schedule for the 12 GeV CEBAF Upgrade project. During FY 2013 and FY 2014, there will be no research hours while the 12 GeV upgrade is commissioned. In FY 2014, approximately 2,100 hours of operations are supported for beam development and commissioning.

	FY 2012 Current	FY 2013 Annualized CR	FY 2014 Request
RHIC (BNL)			
Achieved operating hours	3,072	—	N/A
Planned operating hours	2,390	—	2,770
Optimal hours	4,100	—	4,100
Percent of optimal hours	75%	—	68%
Unscheduled downtime	15%	—	N/A
Number of users	1,200	—	1,200
ATLAS (ANL)[a]			
Achieved operating hours	6,140	—	N/A
Planned operating hours	5,900	—	5,500
Optimal hours	6,200	—	6,200
Percent of optimal hours	99%	—	89%
Unscheduled downtime	8%	—	N/A
Number of users	395	—	430
Total Facilities			
Achieved operating hours	12,941	—	N/A
Planned operating hours	12,160	—	8,270
Optimal hours	14,240	—	10,300
Percent of optimal hours (funding weighted)	83%	—	70%
Unscheduled downtime	11%	—	N/A
Number of users	2,985	—	3,005

Scientific Employment

	FY 2012 Actual	FY 2013 Estimate	FY 2014 Estimate
Number of university grants	220	—	205
Average size per year	$320,000	—	$340,000
Number of laboratory projects	34	—	33
Number of permanent Ph.D.'s (FTEs)	743	—	710
Number of postdoctoral associates (FTEs)	338	—	300
Number of graduate students (FTEs)	551	—	515
Number of Ph.D.'s awarded	104	—	85

[a] The maximum number of hours ATLAS can operate in FY 2013 is 4,200 hours due to downtime for installation of upgrades.

06-SC-01, 12 GeV CEBAF Upgrade, Thomas Jefferson National Accelerator Facility
Newport News, Virginia
Project Data Sheet is for PED/Construction

1. Summary and Significant Changes

The most recent DOE O 413.3B approved Critical Decision (CD) is CD-3, Approve Start of Construction, which was signed on September 15, 2008, with a Total Project Cost (TPC) of $310,000,000 and a planned CD-4, Approve Project Completion, in the third quarter of FY 2015.

The previous Federal Project Director (FPD) took another position and the Deputy FPD to the 12 GeV project was promoted to the FPD position. He has a training plan and is being mentored as he works toward certification Level 3 from his current certification at Level 1.

This project data sheet (PDS) does not include a new start for the budget year; it is an update of the FY 2013 PDS.

A baseline change will be required as a result of the FY 2012 appropriation, which provided $50,000,000 for this project, $16,000,000 less than the baseline profile. As a result of this directed change, the project will be undergoing a review in FY 2013 to rebaseline the project's cost, schedule, and scope. The directed deviation from the baselined cost profile will increase the TPC, extend the project schedule, and could reduce project scope. The rebaselining effort is also currently planned to reflect any impacts resulting from the final FY 2013 appropriations. The available project contingency shrank in part due to delays and impacts caused by the FY 2012 funding. Risks change from month to month, and include issues with the procurement and installation of components, schedule, and impacts of funding uncertainty. For each moderate and high risk, a mitigation plan is developed in order to optimize successful project completion.

2. Critical Decision (CD) and D&D Schedule

(fiscal quarter or date)

	CD-0	CD-1	Design Complete	CD-2	CD-3	CD-4A	CD-4B	D&D
FY 2007	3/31/2004	1Q FY 2007	4Q FY 2009	4Q FY 2007	4Q FY 2008	N/A	1Q FY 2014	N/A
FY 2008	3/31/2004	2/14/2006[a]	4Q FY 2009	4Q FY 2007	4Q FY 2008	N/A	1Q FY 2015	N/A
FY 2009	3/31/2004	2/14/2006	4Q FY 2009	11/9/2007	4Q FY 2008	N/A	3Q FY 2015	N/A
FY 2010	3/31/2004	2/14/2006	4Q FY 2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2011	3/31/2004	2/14/2006	1Q FY 2010	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2012	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2013	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A
FY 2014[b]	3/31/2004	2/14/2006	12/31/2009	11/9/2007	9/15/2008	1Q FY 2015	3Q FY 2015	N/A

CD-0 – Approve Mission Need
CD-1 – Approve Alternative Selection and Cost Range
CD-2 – Approve Performance Baseline

[a] CD-1 was approved on 2/14/2006. Engineering and design activities started in 4Q FY 2006 after Congress approved the Department of Energy’s request to reprogram $500,000 within the FY 2006 funding for Nuclear Physics, per direction contained in H.Rpt 109–275.
[b] The CD-4B date does not reflect the impact resulting from the reduced FY 2012 funding, which will be assessed at a rebaseline review in FY 2013.

CD-3 – Approve Start of Construction
CD-4 – Approve Start of Operations or Project Closeout
D&D– Demolition & Decontamination (D&D) work

3. Baseline and Validation Status

(dollars in thousands)

	TEC, PED	TEC, Construction	TEC, Total	OPC Except D&D	OPC, D&D	OPC, Total	TPC
FY 2007	21,000	TBD	TBD	11,000	TBD	TBD	TBD
FY 2008	21,000	TBD	TBD	10,500	TBD	TBD	TBD
FY 2009	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2010	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2011	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2012	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2013	21,000	266,500	287,500	22,500	N/A	22,500	310,000
FY 2014[a]	21,000	266,500	287,500	22,500	N/A	22,500	310,000

4. Project Description, Scope, and Justification

Mission Need

The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility is the world-leading facility for the experimental study of the structure of matter governed by the "strong force." An energy upgrade of CEBAF has been identified by the nuclear science community as a compelling scientific opportunity. In particular, the Nuclear Science Advisory Committee (NSAC) stated in the 1996 Long Range Plan that "…the community looks forward to future increases in CEBAF's energy, and to the scientific opportunities that would bring." In the 2007 Long Range Plan, NSAC concluded that completion of the 12 GeV CEBAF Upgrade project was the highest priority for the Nation's nuclear science program.

Scope and Justification for 06-SC-01, 12 GeV CEBAF Upgrade

The 12 GeV CEBAF Upgrade directly supports the Nuclear Physics mission and addresses the objective to measure properties of the proton, neutron, and simple nuclei for comparison with theoretical calculations to provide an improved quantitative understanding of their quark substructure.

The scope of the project includes upgrading the electron energy capability of the main accelerator from 6 GeV to 12 GeV, building a new experimental hall (Hall D) and associated beam-line, and enhancing the capabilities of the existing experimental halls to support the most compelling nuclear physics research.

[a] A Work-for-Others agreement was approved by DOE that provides $9,000,000 appropriated by the Commonwealth of Virginia to leverage the federal investment for an upgrade of the Jefferson Lab's research facilities. The additional funding reduced project risks associated with cost and schedule. Any adjustments to the federal government's share of the TPC as a result of the funding from this Work-for-Others activity will be evaluated by the SC Office of Project Assessment during the rebaseline review in FY 2013 that assesses the impacts of reduced FY 2012 funding. The TPC does not reflect the impact resulting from the reduced FY 2012 funding.

CD-4A Key Performance Parameters

Subsystem	Technical Definition of Completion
Accelerator	12 GeV capable 5.5 pass machine installed
	11 GeV capable beamline to existing Halls A, B, and C installed
	12 GeV capable beamline to new Hall D tagger area installed
	Accelerator commissioned by transporting a ≥ 2 nA electron beam at 2.2 GeV (1pass)
Conventional Facilities	New Experimental Hall D and the Counting House ≥ 10,500 square feet.

CD-4B Key Performance Parameters

Subsystem	Technical Definition of Completion
Hall B	Detector operational: events recorded with a ≥ 2 nA electron beam at > 6 GeV beam energy (3 pass)
Hall C	Detector operational: events recorded with a ≥ 2 nA electron beam at > 6 GeV beam energy (3 pass)
Hall D	Detector operational: events recorded with a ≥ 2 nA electron beam at > 6 GeV beam energy (3 pass)

Key Performance Parameters to achieve CD-4 are phased between the accelerator and conventional facilities (CD-4A) and the experimental equipment in Halls B, C, and D (CD-4B). The deliverables defining completion are identified in the Project Execution Plan and have not changed since CD-2. Mitigation plans exist for identified risks to help ensure successful project completion after a rebaseline due to the directed change.

The project is being conducted in accordance with the project management requirements in DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, and all appropriate project management requirements have been met.

5. Financial Schedule

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Total Estimated Cost (TEC)				
PED				
FY 2006	500	500	0	88
FY 2007	7,000	7,000	0	6,162
FY 2008	13,377[a]	13,377	0	9,108
FY 2009	123[a]	123	0	5,370
FY 2010	0	0	0	265
FY 2011	0	0	0	7
Total, PED	21,000	21,000	0	21,000

[a] The baseline FY 2008 PED funding was reduced by $123,000 as a result of a FY 2008 rescission. This reduction was restored in FY 2009 to maintain the TEC and project scope.

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Construction				
FY 2009	28,500	28,500	0	5,249
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,642
FY 2011[a]	35,928	35,928	25,889	40,801
FY 2012	50,000	50,000	5,203	45,537
FY 2013	50,306[b]	40,572	1,549	48,000
FY 2014	25,500	25,500	0	34,000
FY 2015	1,000	1,000	0	9,271
Total, Construction	266,500	266,500	65,000	201,500
TEC				
FY 2006	500	500	0	88
FY 2007	7,000	7,000	0	6,162
FY 2008	13,377	13,377	0	9,108
FY 2009	28,623	28,623	0	10,619
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,907
FY 2011	35,928	35,928	25,889	40,808
FY 2012	50,000	50,000	5,203	45,537
FY 2013	50,306[b]	40,572	1,549	48,000
FY 2014	25,500	25,500	0	34,000
FY 2015	1,000	1,000	0	9,271
Total, TEC	287,500	287,500	65,000	222,500

[a] The baseline FY 2011 funding was reduced by $72,000 as a result of a FY 2011 rescission.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. Pending finalization of FY 2013 funding levels, however, the TEC total and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 level; the FY 2013 Request level of $40,572,000 for TEC is assumed instead.

(dollars in thousands)

	Appropriations	Obligations	Recovery Act Costs	Costs
Other Project Cost (OPC)				
OPC except D&D				
FY 2004	700	700	0	77
FY 2005	2,300	2,300	0	2,142
FY 2006	4,000	4,000	0	3,508
FY 2007	2,500	2,500	0	2,751
FY 2008	1,000	1,000	0	1,802
FY 2009	0	0	0	155
FY 2010	0	0	0	62
FY 2013	—[a]	2,500	0	1,500
FY 2014	4,500	4,500	0	3,500
FY 2015	5,000	5,000	0	7,003
Total, OPC	22,500	22,500	0	22,500
Total Project Cost				
FY 2004	700	700	0	77
FY 2005	2,300	2,300	0	2,142
FY 2006	4,500	4,500	0	3,596
FY 2007	9,500	9,500	0	8,913
FY 2008	14,377	14,377	0	10,910
FY 2009	28,623	28,623	0	10,774
FY 2009 Recovery Act	65,000	65,000	2,738	0
FY 2010	20,000	20,000	29,621	18,969
FY 2011	35,928	35,928	25,889	40,808
FY 2012	50,000	50,000	5,203	45,537
FY 2013	50,306[a]	43,072	1,549	49,500
FY 2014	30,000	30,000	0	37,500
FY 2015	6,000	6,000	0	16,274
Total, TPC[b]	310,000	310,000	65,000	245,000

[a] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, OPC, and TPC totals and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $40,572,000 for TEC, $2,500,000 for OPC, and $43,072,000 for TPC is assumed instead.

[b] The TPC does not reflect the impact resulting from the reduced FY 2012 funding, which will be assessed at a rebaseline review in FY 2013.

6. Details of Project Cost Estimate

	(dollars in thousands)		
	Current Total Estimate	Previous Total Estimate	Original Validated Estimate
Total Estimated Cost (TEC)			
PED			
Design	21,000	21,000	19,200
Contingency	0	0	1,800
Total, PED	21,000	21,000	21,000
Construction Phase			
Construction	30,306	29,507	27,450
Accelerator/Experimental Equipment/ Management	225,059	210,058	174,150
Contingency	11,135	26,935	64,900
Total, Construction	266,500	266,500	266,500
Total, TEC	287,500	287,500	287,500
Contingency, TEC	11,135	26,935	66,700
Other Project Cost (OPC)			
OPC except D&D			
Conceptual Design	3,445	3,445	3,500
R&D	7,052	7,052	6,400
Start-up	11,836	9,394	7,450
Contingency	167	2,609	5,150
Total, OPC	22,500	22,500	22,500
Contingency, OPC	167	2,609	5,150
Total, TPC[a]	310,000	310,000	310,000
Total, Contingency	11,302	29,544	71,850

[a] The TPC does not reflect the impact resulting from the reduced FY 2012 funding, which will be assessed at a rebaseline review in FY 2013.

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
FY 2007 (PED only)	TEC	19,000	2,000	0	0	0	0	0	0	21,000
	OPC	11,000	0	0	0	0	0	0	0	11,000
	TPC	30,000	2,000	0	0	0	0	0	0	32,000
FY 2008 (PED only)	TEC	21,000	0	0	0	0	0	0	0	21,000
	OPC	10,500	0	0	0	0	0	0	0	10,500
	TPC	31,500	0	0	0	0	0	0	0	31,500
FY 2009[a] (Performance Baseline)	TEC	20,877	28,623	59,000	62,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	59,000	62,000	66,000	43,000	18,000	2,000	310,000
FY 2010[b]	TEC	20,877	93,623	22,000	34,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	93,623	22,000	34,000	66,000	43,000	18,000	2,000	310,000
FY 2011	TEC	20,877	93,623	20,000	36,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	93,623	20,000	36,000	66,000	43,000	18,000	2,000	310,000
FY 2012	TEC	20,877	93,623	20,000	36,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	93,623	20,000	36,000	66,000	43,000	18,000	2,000	310,000
FY 2013	TEC	20,877	93,623	20,000	35,928[c]	50,000	40,572	26,500	0	287,500
	OPC	10,500	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	93,623	20,000	35,928	50,000	43,072	34,000	2,000	310,000

[a] The FY 2009 Congressional Budget was the first project data sheet to reflect the CD-2 Performance Baseline which was approved in November 2007.

[b] The project received $65,000,000 from the American Recovery and Reinvestment Act of 2009 which advanced a portion of the baselined FY 2010 and FY 2011 planned funding. The FY 2010 and FY 2011 amounts reflect a total of $65,000,000 in reductions to the originally planned baselined funding profile to account for the advanced Recovery Act funding.

[c] The baseline FY 2011 funding was reduced by $72,000 as a result of the FY 2011 rescission.

Request Year		Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Total
		(dollars in thousands)								
FY 2014	TEC	20,877	93,623	20,000	35,928	50,000	50,306	25,500	1,000	287,500
	OPC	10,500	0	0	0	0	—	4,500	5,000	22,500
	TPC[a]	31,377	93,623	20,000	35,928	50,000	50,306[b]	30,000	6,000	310,000

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	3Q FY 2016
Expected Useful Life (number of years)	15
Expected Future start of D&D for new construction (fiscal quarter)	N/A

(Related Funding Requirements)

(dollars in thousands)

	Annual Costs		Life cycle costs	
	Current Total Estimate	Previous Total Estimate	Current Total Estimate	Previous Total Estimate
Operations	150,000	150,000	2,250,000[c]	2,250,000
Maintenance	Included above	Included above	Included above	Included above
Total, Operations & Maintenance	150,000	150,000	2,250,000	2,250,000

9. Required D&D Information

	Square Feet
Area of new construction	31,500
Area of existing facility(ies) being replaced	N/A
Area of any additional D&D space to meet the “one-for-one” requirement	31,500

The “one-for-one” requirement is met by offsetting 31,500 square feet of the 80,000 square feet of banked space that was granted to Jefferson Laboratory in a Secretarial waiver.

[a] The TPC does not reflect the estimated impact resulting from the reduced FY 2012 funding, which will be assessed at a rebaseline review in FY 2013.

[b] The FY 2013 amount shown reflects the P.L. 112-175 continuing resolution level annualized to a full year. The TEC, TPC, and outyear appropriation assumptions have not been adjusted to reflect the final FY 2013 funding level; the FY 2013 Request level of $40,572,000 for TEC, $2,500,000 for OPC, and $43,072,000 for TPC is assumed instead.

[c] The total operations and maintenance (O&M) is estimated at an average annual cost of approximately $150,000,000 (including escalation) over 15 years. Almost 90% of the O&M cost would still have been required had the existing accelerator not been upgraded and instead continued operations at 6 GeV.

10. Acquisition Approach

The Acquisition Strategy was approved February 14, 2006 with CD-1 approval. All acquisitions are managed by Jefferson Science Associates with appropriate Department of Energy oversight. Cost, schedule, and technical performance are monitored using an earned-value process that is described in the Jefferson Lab Project Control System Manual and consistent with DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets. The procurement practice uses firm fixed-price purchase orders and subcontracts for supplies, equipment, and services and makes awards through competitive solicitations. Project and design management, inspection, coordination, tie-ins, testing and checkout witnessing, and acceptance are performed by Jefferson Laboratory and Architectural-Engineering subcontractors as appropriate.