Nuclear Physics
Funding Profile by Subprogram and Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Medium Energy Nuclear Physics			
Research	37,922	37,296	35,374
Operations	82,563	77,372	80,651
SBIR/STTR and Other	1,648[a]	17,909	19,235
Total, Medium Energy Nuclear Physics	122,133	132,577	135,260
Heavy Ion Nuclear Physics			
Research	40,203	39,977	38,630
Operations	161,391	160,617	158,571
Total, Heavy Ion Nuclear Physics	201,594	200,594	197,201
Low Energy Nuclear Physics			
Research	57,310	52,194	48,946
Operations	38,114	31,533	27,072
Facility for Rare Isotope Beams	10,000	22,000	22,000
Total, Low Energy Nuclear Physics	105,424	105,727	98,018
Nuclear Theory			
Theory Research	34,776	32,047	30,246
Nuclear Data Activities	8,159	7,360	6,933
Total, Nuclear Theory	42,935	39,407	37,179
Isotope Development and Production for Research and Applications			
Research	4,060	4,827	4,453
Operations	15,610	14,255	14,255
Total, Isotopes	19,670	19,082	18,708
Subtotal, Nuclear Physics	491,756	497,387	486,366
Construction			
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	35,928	50,000	40,572
Total, Nuclear Physics	527,684[a]	547,387[b]	526,938

[a] Total is reduced by $12,430,000: $11,098,000 of which was transferred to the Small Business Innovation and Research (SBIR) program and $1,332,000 of which was transferred to the Small Business Technology Transfer (STTR) program.
[b] The FY 2012 appropriation is reduced by $2,613,000 for the Nuclear Physics share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

Public Law Authorizations

Public Law 95-91, "Department of Energy Organization Act", 1977
Public Law 101-101, "1989 Energy and Water Development Appropriations Act," establishing the Isotope Production and Distribution Program Fund)
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 Act of 2010"

Program Overview and Benefits

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 is still largely unknown. It is one of the enduring mysteries of the universe: What, really, is matter? What are the units that matter is made of, and how do they fit together to give matter the properties we observe?

The quest to understand matter takes place through theory and experiment, with both being necessary to develop a full understanding of the properties and behavior of matter. In the theoretical approach, scientists have developed a precise mathematical description of how the quarks and gluons in nuclear matter interact, referred to as Quantum Chromodynamics (QCD). However, to solve the equations of QCD is a formidable task; approximate solutions are being developed and improved with the help of today's most advanced computer systems. On the experimental side, scientists accumulate a large amount of diverse 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 spanning acres. These particle accelerators slam bits of matter into each other, and scientists observe the results. The careful integration and comparison of experimental measurements 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 has come to focus on three broad, yet tightly interrelated, areas of inquiry. 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 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 interaction that was first indirectly detected in nuclear beta decay.

At the heart of the NP program are groups of highly trained scientists who conceive, plan, execute, and interpret the numerous experiments carried out at various 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. Approximately 80 Ph.D. degrees are granted annually to students for research supported by the program. Research at nine national laboratories is guided by the DOE mission and priorities and underpins strategic core competencies needed to achieve the goals of the NP program. The national laboratory scientists work and collaborate with academic scientists, other national laboratory experimental researchers, and those carrying out theoretical investigations. The national laboratory scientists collect and analyze data as well as support and maintain the detectors and facilities used in these experiments. The national laboratories also provide state-of-the-art resources for detector and accelerator R&D for future upgrades and new facilities.

NP supports facilities that complement one another and provide a variety of approaches to producing and collecting data about matter at the level of the nucleus, as well as the sub-nuclear level. The necessary facilities and equipment are large and complex, and they account for a significant portion of the program's budget—approximately 50 percent. NP currently supports three national user facilities, each with capabilities found nowhere else in the world: the Relativistic Heavy Ion Collider (RHIC) at BNL; the Continuous Electron Beam Accelerator Facility (CEBAF) at TJNAF; and the Argonne Tandem Linac Accelerator System (ATLAS) at ANL. These major scientific facilities provide research beams for a user community of approximately 3,000 scientists from all over the world. Approximately 35 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 and Nuclear Energy), Federal Agencies (NSF, NASA, and Department of Defense), and industries use the NP user facilities to carry out their own research programs.

The development and construction of NP facilities, advanced instrumentation, and the development of accelerator technology and computational techniques are essential for workforce development and are helping to transition the character of the U.S. workforce by creating technologies which will require high tech jobs. A recent example is superconducting radio frequency (SRF) particle acceleration, which has advanced the technology for accelerator driven sub-critical (ADS) reactors, a potential innovation for nuclear power generation and waste transmutation. Particle beams from accelerators are used in an increasingly broad range of applications including materials research, cancer therapy, food safety, bio-threat mitigation, waste treatment, and commercial fabrication. Another example is using Accelerator Mass Spectroscopy (AMS) technology to understand how to design fuel for future nuclear reactors that burns more completely, is proliferation resistant, and has reduced long-lived waste products. Enhancements in isotope production and processing techniques are leading to innovative new uses for isotopes, including neutron detectors to combat terrorism, explosives detection, oil exploration, industrial radiography, heart and lung imaging, cancer therapy, personnel protection and climate change research. These are just several examples of how stretching beyond the limits of present day science and technology to realize the groundbreaking advances made possible by strategic investments in the basic nuclear science research program helps drive innovation in areas important for a secure energy future, and for the national and economic security of the United States.

Basic and Applied R&D Coordination

The Nuclear Physics program supports an annual competitive program of targeted initiatives in Applications of Nuclear Science and Technology, the primary goal of which is to pursue forefront nuclear science research and development important to the NP mission, but which is also inherently relevant to applications. One of the goals of this initiative is to 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. These initiatives are peer reviewed with participation from the applied sciences community. The integration of the underpinning nuclear science advances that have resulted from innovative basic research with the applied sciences optimizes cross fertilization, cost effectiveness, performance, and technology transfer.

The Isotope Development and Production for Research and Applications subprogram produces commercial and research isotopes that are important for basic research and applications. NP has taken significant steps in aligning the 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 with the National Nuclear Security Administration and other federal agencies, foster interactions between researchers and Isotope Program staff, obtain data from site visits, attend scientific community exhibitions and conferences, and develop strategic plans and priorities with community input. 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/National Institutes of

Health (NIH) federal working group to develop a strategic plan and priorities for medical isotope production; participating in the OSTP Interagency and the Organization for Economic Cooperation and Development (OECD) international working group to address the supply of molybedenum-99; and working with industry to ensure availability of isotopes of strategic and economic importance to the Nation. NP also funds isotope production development at universities to increase the Department's ability to meet researchers' requests by improving product availability and reliability. The Isotope Development and Production for Research and Applications subprogram supports research for the development of alternative production and separation techniques of stable and radioactive isotopes, and the production of research isotopes identified by National Academy reports and the Nuclear Science Advisory Committee (NSAC) as needed for high priority research opportunities across a broad range of scientific disciplines.

Program Accomplishments and Milestones

The nuclear neutron skin. Scientists have obtained first results indicating that, rather than being uniformly interspersed with protons, neutrons form a "neutron skin" in the outer radius of the heavy lead nucleus, Pb-208. This result is central to understanding the structure of heavy nuclei, and for determining the theoretical equations that describe the life cycles of neutron stars. The experiment used high intensity polarized electron beams available at the Thomas Jefferson National Accelerator Facility to determine, in a model independent way, that the neutrons occupy a larger volume than the protons in this heavy nucleus, hence, the neutron skin.

RHIC sheds light on processes that occurred in early universe. New theoretical advances and experimental analyses of nucleus-nucleus collisions at RHIC have shown scientists how to remove the effects of "ordinary" fluctuations from the observed expansion in the fire ball of subatomic particles resulting from the collisions in order to precisely determine fundamental properties of the newly created hot, dense matter. The technique relies on RHIC's ability to accelerate and collide nuclei of different species. New experimental results also indicate that the RHIC energy range spans the region where the transition takes place from hot nuclear matter to the quark-gluon plasma, providing RHIC a unique ability to study matter above and below the transition in order to understand its nature, shedding new light into the processes that formed our universe. The announcement by RHIC in 2011 of the first observation of anti-helium nuclei was recently recognized as one of the top twenty scientific achievements of 2011 by Discover Magazine.

Nuclear physicists study element production in core-collapse super novae. Understanding how nuclei that contain significantly more neutrons than protons are produced and decay in stellar processes is a nuclear physics "grand challenge" since little is known even though such processes create approximately half of the neutron-rich atomic nuclei heavier than iron. It also plays a central role in the late stage evolution of core-collapse super novae. Scientists at the Holifield Radioactive Ion Beam Facility (HRIBF) have studied the exotic zinc and gallium isotopes that are created by nature in such cataclysmic environments, and measured their lifetimes and other decay properties. Theoretical calculations incorporating these results show an appreciable redistribution of isotopic abundances for nuclei created in these extreme environments, yielding new insights on the synthesis and origin of the neutron-rich atomic elements. The capability to study such nuclei will be dramatically increased by the recently commissioned Californium Rare Isotope Breeder Upgrade (CARIBU) at Argonne National Laboratory (ANL), and the future Facility for Rare isotope Beams (FRIB) at Michigan State University (MSU).

Particle "jets" at the Large Hadron Collider. At the Large Hadron Collider (LHC), U.S. scientists have analyzed data from the world's highest energy heavy collisions using lead ion beams. They have observed sprays of very energetic particles called "jets" emanating from the collision. Studies at RHIC and the LHC of how these jets lose energy on their way out of the hot dense matter formed is important for understanding the nature and evolution of the matter in the universe in the first few moments after its creation. U.S. scientists and engineers have recently completed the fabrication of the ALICE (A Large Ion Collider Experiment) Electromagnetic Calorimeter (EMCal) project ahead of schedule and under budget. The EMCal significantly enhances the capabilities of the ALICE experiment by enabling further study of yields and correlations of the "jets."

Producing isotopes for cancer treatment. Isotope research has led scientists to promising strategies for producing isotopes which decay by alpha particle emission for use in cancer treatment. An example is research on accelerator-based production of actinium-225 being conducted by Isotope Program scientists. Actinium-225 is an alpha-emitting isotope identified as a high priority by the National Institutes of Health, which shows potential in the treatment of cancers such as leukemias and lymphomas.

Milestone[a]	Date
Obtain Critical Decision-2/3A for the Facility for Rare Isotope Beams to establish the schedule and cost baselines of this next generation facility for nuclear structure and nuclear astrophysics that is being constructed at MSU.	4th Qtr, FY 2012
Conduct a broad review of national laboratory research efforts in Heavy Ion Physics to ensure productivity and assess the performance of individual groups, which includes efforts at the Relativistic Heavy Ion Collider and experiments at the LHC at CERN.	4th Qtr, FY 2012

Explanation of Changes

The FY 2013 budget request is focused on optimizing, within the resources available, the scientific productivity of the program by ensuring a proper balance of investments in research, facility operations, new tools, and capabilities. It continues support for the two highest priorities in the 2007 Long Range Plan for Nuclear Science: an energy upgrade of the Thomas Jefferson National Accelerator Facility (TJNAF) Continuous Electron Beam Accelerator Facility (CEBAF) and the Facility for Rare Isotope Beams (FRIB). The FY 2013 budget is a decrease of $20,449,000 relative to the enacted FY 2012 appropriation, which includes a $6,928,000 decrease for the 12 GeV CEBAF Upgrade project (TEC and OPC). The NP national user facilities are operated for an estimated 5,360 hours of beam time for research, 38% of optimal utilization for the operating facilities, and a decrease of about 6,800 hours compared with the beam hours planned for FY 2012. The reduction in hours is a result of reduced RHIC and ATLAS operations, and a planned shutdown period at CEBAF associated with the construction of the 12 GeV CEBAF Upgrade. Funding for research across the program is reduced 5.8% relative to FY 2012.

Program Planning and Management

To ensure that funding is allocated as effectively as possible, NP has developed a rigorous and comprehensive process for strategic planning and priority setting that relies heavily on input from groups of outside experts. All activities within the subprograms are peer reviewed and performance is assessed on a regular basis. Priority is given to those research activities which support the most compelling scientific opportunities. NP has also instituted a number of peer review and oversight measures designed to assess productivity and maintain effective communication and coordination among participants in NP activities. On an as-needed basis, the program has taken the initiative to establish interagency working groups to tackle issues of common interest and to enhance communication. NP takes all of this input into account in its budget requests, making decisions to maximize scientific impact, productivity, quality, and cost-effectiveness within available resources.

NP works closely with the National Science Foundation (NSF) to jointly charter the Nuclear Science Advisory Committee (NSAC) for advice regarding compelling opportunities and productivity of the national nuclear science program. NP develops its strategic plan for the field with input from the scientific community via long range plans produced by NSAC every five to six years. These plans provide retrospective assessments of major accomplishments, assess and identify scientific opportunities, and set priorities for the next decade. The most recent long range plan for nuclear science, *The Frontiers of Nuclear Science*[b] (2007) addresses the compelling scientific thrusts in three frontiers: Quantum Chromodynamics, Nuclei and Nuclear Astrophysics, and Fundamental Symmetries and Neutrinos. In addition, NSAC completed a strategic plan in 2009 for the Isotope Development and Production for Research and Applications subprogram, *Isotopes for the Nation's Future—A Long Range Plan*[c]. As resource availability, scientific needs, and global capabilities evolve, the Nuclear Physics program needs to review its strategic plans. In FY 2012, NP will seek guidance from NSAC

[a] Subject to results of guidance sought from NSAC regarding opportunities and priorities for the Nuclear Physics program and the implementation of its strategic plan

[b] http://science.energy.gov/np/nsac

[c] http:/science.energy.gov/np/nsac/reports

regarding opportunities and priorities for the Nuclear Physics program and the implementation of its strategic plan.

NSAC provides NP with additional guidance in the form of reviews of subfields, special interest topics, and assessment of the management of the NP program itself. In February 2011, NSAC received two charges: to review and evaluate the current and proposed research program, scientific capabilities, and opportunities for fundamental nuclear physics with neutrons and make recommendations of priorities consistent with projected resources; and to provide a report to the Office of Science describing current policies and practices for disseminating research results in the fields relevant to the Nuclear Physics program. The reports from both charges were transmitted to DOE and NSF in FY 2011. NP strategic plans are also influenced by National Academy reports and Office of Science and Technology Policy (OSTP) and National Security Council (NSC) Interagency Working Group (IWG) efforts, the latter two under the auspices of the White House Executive Office of the President. The National Academies study *Advancing Nuclear Medicine through Innovation*[a] motivated NP to establish a federal working group with the National Institutes of Health (NIH), along with the Office of Science (SC) Biological and Environmental Research program, to better coordinate radioisotope production and to address other issues important to nuclear medicine. The National Academies embarked on a new decadal study of nuclear science in 2009. In order to optimize interagency activities, NP is currently involved in three OSTP or NSC IWG's: Forensic Science, Molybdenum-99 Production, and Helium-3 Shortage.

NP peer reviews all of its activities. Biennial science and technology reviews of the national user facilities and isotope production facilities with panels of international peers assess operations, performance, and scientific productivity. These results influence budget decisions and NP's assessment of laboratory performance as documented in annual 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. In FY 2011, NP conducted a total of 30 reviews with panels of national and international experts. All NP baselined projects are currently on cost and on schedule. Performance of instrumentation projects is also assessed on a monthly and quarterly basis.

One of the most pressing priority-setting issues at the national user facilities is how to allocate available beam time, or time spent doing experiments on a facility's accelerator. Facility directors at the host institution (laboratory or university) seek advice from the facility's Program Advisory Committees to determine the allocation of this valuable scientific resource. The facility Program Advisory Committees review research proposals requesting resources and time at the facilities and then provide advice on the scientific merit, technical feasibility, and personnel requirements of the proposals. University grants are proposal driven. Based on peer review, NP funds the most compelling and internationally competitive ideas submitted in response to grant solicitation notices. Proposals are reviewed by external scientific peers and competitively awarded according to the guidelines published in 10 CFR 605. 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 by external scientific peers, with progress reports required annually, to ensure laboratory research efforts maintain a high level of productivity on compelling, internationally competitive mission driven science. Funding decisions in this budget request are influenced by the results of these periodic peer reviews of the national laboratory research efforts. Laboratory research groups in the Low Energy subprogram were reviewed in August 2011.

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 value of the NP scientific user and isotope production facilities. All construction

[a] http://dels.nas.edu/dels/rpt_briefs/advancing_nuclear_medicine.pdf

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.

Goal Areas by Subprogram

	Research	Facility Operations	Future Facilities	Workforce
Medium Energy	31%	69%	0%	0%
Heavy Ion	17%	81%	2%	0%
Low Energy	50%	28%	22%	0%
Nuclear Theory	100%	0%	0%	0%
Isotopes	24%	76%	0%	0%
Construction	0%	0%	100%	0%
Total, Nuclear Physics	32%	56%	12%	0%

Explanation of Funding and Program Changes

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Medium Energy Nuclear Physics	132,577	135,260	+2,683

The increase is dominated by Other Project Costs for the 12 GeV CEBAF Upgrade project for pre-operations and commissioning according to the project baseline, and also reflects the recently increased legislative set-aside for SBIR/STTR applied to the NP program. Offsetting these increases is decreased funding relative to FY 2012 for research efforts at universities and laboratories which will focus on the implementation of the 12 GeV CEBAF Upgrade project and analysis of data from the recently completed 6 GeV program at TJNAF as well as the RHIC Spin program.

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Heavy Ion Nuclear Physics	200,594	197,201	-3,393

Funding for research efforts at universities and laboratories is reduced relative to FY 2012 and is focused on exploiting the capabilities of RHIC in the near-term and on the ongoing heavy-ion research effort at the Large Hadron Collider. Operations hours at RHIC are reduced by about 50 percent relative to FY 2012; effective operation will be achieved by combining FY 2013–FY 2014 running into a single back-to-back run bridging the two fiscal years. Partially offsetting these decreases is an increase in funding for the STAR Heavy Flavor Tracker MIE according to project plans.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Low Energy Nuclear Physics	105,727	98,018	-7,709
Funding for research efforts at universities and laboratories is reduced relative to FY 2012, including decreases due to the closure of HRIBF in FY 2012; D&D planning continues. Research continues on making a technology choice for a future international double beta decay experiment at a deep underground site. A neutron physics program continues at the Fundamental Neutron Physics Beamline (FNPB) at the Spallation Neutron Source focused on parity violating experiments. A modest R&D effort in support of a potential neutron electric dipole moment experiment in the future continues. Funding is held flat relative to FY 2012 for the next-generation FRIB, which is supported with operating funds through a Cooperative Agreement with MSU. FY 2012 efforts, including engineering and design activities, continue in support of achieving CD-3, "Approve Construction Start." Funding also supports operations of the ATLAS facility.			
Nuclear Theory	39,407	37,179	-2,228
Funding for theoretical activities which underpin the experimental efforts throughout the NP program is reduced relative to FY 2012, as is support to maintain the National Nuclear Data Center. Funding for SciDAC is held flat with the FY 2012 level.			
Isotope Development and Production for Research and Applications	19,082	18,708	-374
Funding is reduced for research efforts on developing new techniques for production of isotopes for research and applications that are in short supply.			
Construction	50,000	40,572	-9,428
Construction (TEC) of the 12 GeV CEBAF Upgrade project continues in FY 2013, supporting the installation of the new cryomodules in the accelerator tunnel; procurement, fabrication, and installation of the Hall D experimental equipment; and upgrades to the Halls B & C experimental equipment.			
Total, Nuclear Physics	547,387	526,938	-20,449

Medium Energy Nuclear Physics
Funding Profile by Activity

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Research	37,922	37,296	35,374
Operations (TJNAF)	82,563	77,372	80,651
SBIR/STTR[a] and Other	1,648	17,909	19,235
Total, Medium Energy Nuclear Physics	122,133	132,577	135,260

[a] FY 2011 total is reduced by $12,430,000: $11,098,000 of which was transferred to the Small Business Innovation and Research (SBIR) program and $1,332,000 of which was transferred to the Small Business Technology Transfer (STTR) program. All required NP funding for SBIR/STTR is included here in FY 2012 and FY 2013.

Overview

The Medium Energy Nuclear Physics subprogram focuses primarily on questions having to do with the first scientific frontier, Quantum Chromodynamics (QCD) and the behavior of quarks inside protons and neutrons, although it touches on all three scientific frontiers. Specific questions that are 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 and nucleons?
- What is the role of gluons and gluon self-interactions in nucleons and nuclei?

One major goal, for example, is to achieve an experimental description of the substructure of the nucleon. In pursuing that goal the Medium Energy subprogram supports different experimental approaches that seek to determine such things as the distribution of up, down, and strange quarks in the nucleons; the roles of the gluons that bind the quarks; the role of the "sea" of virtual quarks and gluons, which makes a significant contribution to the properties of protons and neutrons; 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 measures the excited states of hadrons (composite particles made of quarks, including nucleons) in order to identify which properties of QCD determine the dynamic behavior of the quarks.

The subprogram also supports investigations into a few aspects of the second scientific frontier, Nuclei and Nuclear Astrophysics, such as the question: What is the nature of the nuclear force that binds protons and neutrons into stable nuclei? Finally, this subprogram examines certain aspects of the third scientific frontier, Fundamental Symmetries and Neutrinos, including the questions: Why is there now more visible 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 it evolved?

Funding for this subprogram supports both research and operations of the subprogram's primary research facility, the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF), as well as a component of medium energy research that is carried out at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL). 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 of parity violating processes that can provide information relevant to the development of the New Standard Model. These are capabilities that are unique in the world. The increase in energy supported by construction of the 12 GeV CEBAF Upgrade, opens up compelling new scientific opportunities and secures continued U.S. world leadership in this area of physics. RHIC provides colliding beams of spin-polarized protons to probe the spin structure of the proton, another important aspect of the QCD frontier. Research support at both facilities includes the laboratory and university personnel needed to implement and run experiments and to conduct the data analysis necessary to publish results. Individual experiments which address key scientific questions in the medium energy sub-program are also supported at the High Intensity Gamma Source (HIGS) at Triangle Universities Nuclear Laboratory, at Fermi National Accelerator Laboratory (Fermilab), and at several facilities in Europe. All these facilities produce beams of sufficient energy to see details smaller than the size of a nucleon. In addition, research is supported at the Research and Engineering Center at the Massachusetts Institute of Technology (MIT) which has specialized infrastructure capabilities to develop and fabricate advanced instrumentation and accelerator equipment.

The SBIR/STTR and Other category within this subprogram reflects all of the mandatory set-aside SBIR/STTR funding for the NP program, as well as funding to meet other obligations required of the NP program, including the annual Lawrence Awards and Fermi Awards for honorees selected by DOE for outstanding contributions to science.

Explanation of Funding Changes

Funding is provided for research and operations necessary to be able to implement and then exploit the new capabilities of the 12 GeV CEBAF Upgrade at the TJNAF.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	37,296	35,374	-1,922
Funding for university and laboratory research is reduced 5.8% relative to FY 2012 levels and is focused on preparations for the 12 GeV program overall and analysis of 6 GeV data. Research is also supported at universities and laboratories for efforts with polarized proton beams at RHIC. The decrease is partially offset by a small shift of a lab research effort from the Heavy Ion subprogram.			
Operations	77,372	80,651	+3,279
There are no dedicated beam hours for research in FY 2013 as the 12 GeV CEBAF Upgrade project is implemented and commissioning activities are initiated; important maintenance and improvements of the existing facility continue in preparation for post-construction operations. The majority of the increase is for Other Project Costs for the 12 GeV CEBAF Upgrade project, which is requested according to the project baseline.			
SBIR/STTR and Other	17,909	19,235	+1,326
Funds are provided for NP's mandatory contributions to the SBIR/STTR programs at recent legislatively increased levels, and for other obligations of the NP program, including continued support for annual Fermi and Lawrence Awards. Required contributions to DOE's working capital fund increase in FY 2013. In FY 2011, $11,098,000 and $1,332,000 were transferred to the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, respectively. SBIR/STTR funding is set at 2.95% of non-capital funding in FY 2012 and 3.05% in FY 2013.			
Total, Medium Energy Nuclear Physics	132,577	135,260	+2,683

Research

Overview

Research in the Medium Energy subprogram is supported at universities and national laboratories to study QCD and the behavior of quarks inside protons and neutrons. 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. These state-of-the-art detectors often have relevance to 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. Additionally, a scientific group is being developed for the new experimental Hall D that is 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 the laboratory and bridge positions with regional universities are also supported at TJNAF, which is a cost-effective approach to augmenting scientific expertise at the laboratory and boosting STEM educational 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. The development of this technology at ANL has found practical applications in geological and environmental research, such as, in tracking ground water flows in Egypt. 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 by development and fabrication of advanced instrumentation, as well as data acquisition and analysis efforts. At LANL, scientists and collaborators are also completing the Fermilab MiniBooNE anti-neutrino running and analysis. A present intriguing discrepancy between anti-neutrino and neutrino data needs to be resolved. If these results are confirmed, they could unveil new physics beyond the Standard Model which will drive future research directions in this area. Finally, researchers at MIT are utilizing their unique expertise in the study of high current, polarized electron sources.

Accelerator R&D research proposals from universities and laboratories are evaluated by peer review under a single competition for funding under the Medium Energy and Heavy Ion subprograms. This research is to develop the needed 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, and can lead to technological advances for a variety of applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	High priority research at 5 national laboratories and 40 university grants were supported at levels flat relative to FY 2010. The 6 GeV program at CEBAF in FY 2011 supported 5 experiments in Hall A, including a proton and neutron Double Virtual Compton Scattering experiment; 2 ongoing and 1 new experiment in Hall B, including the HDIce experiment; and a major part of the Qweak experiment in Hall C. In addition, preparation for the future 12 GeV physics program continued.	37,922
2012 Enacted	Funding for research was reduced relative to FY 2011. Efforts are focused on completing the highest priority 6 GeV experiments at CEBAF prior to installation of the 12 GeV Upgrade, and for support of the RHIC spin program.	37,296

Fiscal Year	Activity	Funding ($000)
2013 Request	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.	35,374

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Research	19,191	19,021	17,918
National Laboratory Research			
TJNAF Research	6,495	6,550	6,172
Other National Laboratory Research	11,368	10,845	10,455
Total, National Laboratory Research	17,863	17,395	16,627
Other Research			
Accelerator R&D Research	868	880	829
Total, Research	37,922	37,296	35,374

Operations

Overview

The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF) is a unique facility with unparalleled capabilities using polarized electron beams to study quark structure; there is no other facility in the world like it and its user community has a strong international component.

Accelerator Operations support is provided for the accelerator physicists that operate the facility as well as maintenance, power costs, capital infrastructure investments, and accelerator improvements of the complex. Investments in accelerator improvement projects are aimed at increasing the productivity, cost-effectiveness, and reliability of the facility. Support is also provided to maintain efforts in developing advances in superconducting radiofrequency (SRF) technology. 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 techniques for detection of buried land mines, and carbon nanotube and nano-structure manufacturing techniques for the manufacture of 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 towards instrumentation needed to support the laboratory's core competencies in SRF and cryogenics. TJNAF accelerator physicists are also strongly engaged in educating the next generation of accelerator physicists, including support for the Center for Accelerator Science at Old Dominion University (ODU) where TJNAF scientists teach courses and the laboratory jointly supports the ODU Director position.

Experimental Support is provided for the scientific and technical staff, as well as for materials and services to integrate 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 ($000)
2011 Current	CEBAF operated for 4,661 hours of beam time in support of the highest priority 6 GeV experiments.	82,563
2012 Enacted	FY 2012 funding is reduced by 6.3% relative to FY 2011, which supports running at near the maximum possible given the planned shutdown beginning in the latter half of FY 2012 as part of the 12 GeV CEBAF Upgrade project. Operations are focused on efforts to implement the highest priority experiments before the completion of the current 6 GeV experimental program. Experiments distributed among all three halls are addressing compelling physics including a precision measurement of the weak charge of the proton to help constrain new physics beyond the Standard Model, an important experiment for the laboratory's search for missing excited states of the neutron, and experiments that will help develop the laboratory's research program using the 12 GeV CEBAF Upgrade.	77,372
2013 Request	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.	80,651

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
TJNAF Accelerator Operations	50,163	49,552	50,331
12 GeV Other Project Costs (OPC)	0	0	2,500
TJNAF Experimental Support	32,400	27,820	27,820
Total, Operations (TJNAF)	82,563	77,372	80,651

Heavy Ion Nuclear Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	40,203	39,977	38,630
Operations	161,391	160,617	158,571
Total, Heavy Ion Nuclear Physics	201,594	200,594	197,201

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 that define one of the three frontiers identified by NSAC—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?

A program of research on hot nuclear matter began at the Relativistic Heavy Ion Collider (RHIC) at BNL in 2000 when the first collisions were observed at beam energies ten times higher than those available at any other facility in the world. Since then collisions have been produced at beam energies exceeding the first by a factor of 3 at RHIC and about 40 at the LHC. In the debris of these collisions, 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 accumulate data that offer insights into the creation of the universe and begin to understand how the protons, neutrons, and other bits of normal matter developed from that plasma.

The RHIC facility places heavy ion research at the frontier of nuclear physics. RHIC serves two large-scale international experiments called PHENIX and STAR. In these experiments, scientists are attempting to determine the physical characteristics of the recently discovered perfect liquid of quarks and gluons. U.S. researchers recently discovered the antimatter partner of the helium nucleus: antihelium-4. This new particle, also known as the anti-alpha, is the heaviest antinucleus ever detected, topping a similar discovery of the anti-hypertriton last year. A 10-fold enhancement in the heavy ion beam collision rate and detector upgrades will contribute further scientific results and understanding. Accelerator R&D is conducted at RHIC in a number of advanced areas including cooling of high-energy hadron beams; 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.

Participation in the heavy ion program at the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN) provides U.S. researchers the opportunity to search for 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. The LHC will ultimately provide a center-of-mass energy 30 times that of the highest now available at RHIC. In 2010, U.S. scientists successfully conducted first experiments using the ALICE (A Large Ion Collider Experiment) detector and the CMS (Compact Muon Spectrometer). Results from these experiments suggest that the energy lost by jets of highly energetic particles when penetrating the “perfect liquid” is different from theoretical predictions offering the potential for important scientific advances in understanding of the properties of extremely dense matter. U.S. researchers have also completed the fabrication of a large Electromagnetic Calorimeter (EMCal) detector which was installed in the ALICE experiment. First heavy ion beam operations at the LHC started in late 2010 with new results reported at the Quark Matter conference in 2011.

Explanation of Funding Changes

Funding in FY 2013 supports heavy ion research and operations at the Relativistic Heavy Ion Collider, the continuation of the STAR Heavy Flavor Tracker (HFT) MIE, and experiments at the Large Hadron Collider.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	39,977	38,630	-1,347
Research efforts at university and laboratories decrease by 5.8% relative to FY 2012 and will focus on the highest priority experiments at RHIC, as well as the commitments and experimental fees to allow U.S. researchers to exploit the ALICE EMCal MIE and other detectors at the LHC. Partially offsetting the decrease to university and laboratory research is an increase for continued fabrication of the STAR HFT MIE to detect particles containing charm quarks at RHIC as planned according to the project's performance baseline. In addition, there is a small shift of a lab research effort to the Medium Energy subprogram.			
Operations	160,617	158,571	-2,046
Reduced funding in FY 2013 will support an estimated 1,360 hours of RHIC operations for the highest priority experiments. Relative to FY 2012, this is a decrease of 1,030 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. The impacts of constrained FY 2012 funding, including a voluntary reduction in force at RHIC and one-time cuts to materials and supplies, are still being assessed and may further impact FY 2013 levels of operations. Funding is also reduced for lab-wide General Purpose Equipment (GPE) at BNL.			
Total, Heavy Ion Nuclear Physics	200,594	197,201	-3,393

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 carry out research primarily at RHIC as well as a modest program at the LHC. Some of the new research topics that will be investigated at RHIC in the next several years include determining the speed of sound in the quark-gluon plasma and trying to discover the critical point in the QCD phase diagram. Discovering the speed of sound and the QCD critical point could revolutionize the quantitative understanding of the QCD phase diagram, giving insight to the processes involved in the creation of the early universe.

The university groups provide scientific personnel and graduate students needed for running the RHIC and LHC heavy ion experiments, as well as for data analysis and publishing results, and designing and fabricating the RHIC and LHC heavy ion detector upgrades. The national laboratory scientists provide essential personnel for designing, fabricating, and operating the RHIC detectors; analyzing RHIC data and publishing scientific results; conducting R&D of innovative detector designs; project management and fabrication of MIEs; and planning for future experiments. In addition, BNL and LBNL provide substantial computing infrastructure for terabyte-scale data analysis and state-of-the-art facilities for detector and instrument development. BNL scientists continue to develop and implement new instrumentation needed to effectively utilize the RHIC beam time for research, train junior scientists, and develop the computing infrastructure used by the scientific community. 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), and LLNL computing resources are also made available for LHC data analysis.

Accelerator R&D research proposals from universities and laboratories are evaluated by peer review under a single competition for funding under the Heavy Ion and Medium Energy subprograms. This research to develop the knowledge and technologies to design and build next-generation NP accelerator facilities is also of relevance to machines being developed by other domestic and international programs, and can lead to technological advances for a variety of societal applications.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	High priority research at 5 national laboratories and 29 university grants were supported at levels flat with FY 2010. The fabrication of the EMCal MIE at ALICE at the LHC was completed below budget and ahead of schedule in FY 2011. The PHENIX Silicon Vertex Tracker (VTX) at the RHIC, which received its final funding under the Recovery Act, was also completed in FY 2011.	40,203
2012 Enacted	FY 2012 funding, at reduced levels relative to FY 2011, will maintain heavy ion research efforts and fulfill the NP commitment to the international ALICE and CMS experiments at the LHC. The PHENIX Forward Vertex Detector (FVTX) MIE received its final funding under the Recovery Act 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 by adding two silicon endcaps. The STAR Heavy Flavor Tracker (HFT), an MIE initiated in FY 2010, is an ultra-thin, high-precision tracking detector that will provide direct reconstruction of short-lived particles containing heavy quarks; its schedule and budget baseline were established in October 2011.	39,977

Fiscal Year	Activity	Funding ($000)
2013 Request	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.	38,630

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Research	13,578	13,978	13,168
National Laboratory Research			
BNL RHIC Research	12,032	10,812	11,430
Other National Laboratory Research	13,074	13,582	12,491
Total, National Laboratory Research	25,106	24,394	23,921
Other Research			
Accelerator R&D Research	1,519	1,605	1,541
Total, Research	40,203	39,977	38,630

Operations

Overview

Support is provided for the operations, power costs, capital infrastructure investments, and accelerator improvement projects of the Relativistic Heavy Ion Collider (RHIC) accelerator complex at Brookhaven National Laboratory (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 NASA Space Radiation Laboratory Program, for the study of space radiation effects applicable to human space flight, and the Brookhaven Linac Isotope Producer Facility (BLIP), for the production of research and commercial isotopes critically needed by the Nation. BNL nurtures important core competencies in accelerator physics techniques, which have applications in industry, medicine, homeland security, and other scientific projects outside of NP. The RHIC accelerator physicists continue to lead the effort to address technical feasibility issues of relevance to a possible next-generation collider, including beam cooling techniques and energy recovery linacs. RHIC accelerator physicists also play an important role in the education of next generation accelerator physicists, with support of graduate students and post-doctoral associates. The laboratory supports the Center for Accelerator Science and Education (CASE) in partnership with Stony Brook University. CASE takes advantage of the collaboration with BNL by providing opportunities for students to learn on the state-of-the-art accelerators at BNL and having BNL staff teach courses and advise students.

In addition to the accelerator complex, support is provided for 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. The STAR and PHENIX detectors provide complementary measurements, with some overlap, in order to cross-calibrate the measurements. Instrumentation advances by this community have led to practical applications in medical imaging and homeland security.

Implementation of EBIS along with detector upgrades will allow the RHIC program to make incisive measurements leading to better insights into the discovery of strongly interacting quark gluon matter and to establish whether other phenomena, such as a color glass condensate or chiral symmetry restoration exist in nature.

Finally, NP funds BNL site-wide general purpose equipment (GPE) expenses for minor new fabrications and general laboratory equipment that is essential for maintaining the productivity and usefulness of this DOE-owned facility and for meeting its requirement for safe and reliable operations.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	RHIC operated for 3,114 hours of beam time in support of the highest priority heavy ion experiments. A reduction in support for BNL GPE efforts was the result of the overall funding constraints of the FY 2011 appropriation.	161,391
2012 Enacted	RHIC operations are supported for an estimated 2,390 hour operating schedule (58 percent utilization) in FY 2012, a decrease of more than 20% from the hours achieved in FY 2011 due to overall funding constraints of the enacted FY 2012 appropriation. Operations will be focused on addressing the highest priority scientific opportunities and goals of the heavy ion program, with very modest support included for continued R&D of luminosity enhancement technologies. Operations workforce is decreased compared to the FY 2011 level due to voluntary reductions and retirements of some laboratory staff.	160,617

Fiscal Year	Activity	Funding ($000)
2013 Request	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.	158,571

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
RHIC Operations			
RHIC Accelerator Operations	122,942	122,128	121,282
RHIC Experimental Support	36,443	35,489	35,289
Total, RHIC Operations	159,385	157,617	156,571
Other Operations (BNL GPE)	2,006	3,000	2,000
Total, Operations	161,391	160,617	158,571

Low Energy Nuclear Physics
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	57,310	52,194	48,946
Operations (ATLAS, HRIBF, and other)	38,114	31,533	27,072
Facility for Rare Isotope Beams	10,000	22,000	22,000
Total, Low Energy Nuclear Physics	105,424	105,727	98,018

Overview

The Low Energy Nuclear Physics subprogram is the most diverse within the NP portfolio, supporting research activities aligned with scientific thrusts which focus primarily on answering the overarching questions associated with the second and third frontiers identified by NSAC.

Questions associated with the second frontier, Nuclei and Nuclear Astrophysics, 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?

Major goals of this subprogram are to develop a comprehensive description of nuclei spanning the entire nuclear chart, to utilize rare isotope beams to reveal new nuclear phenomena and structures unlike those gleaned from studies using stable nuclei, and to measure the cross sections of nuclear reactions that power stars and spectacular stellar explosions responsible for the synthesis of the elements.

Questions addressed in the third frontier, Fundamental Symmetries and Neutrinos, 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?

Neutrinos are now known to have small but non-zero masses. The subprogram 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). These neutrino properties are believed to play a role in the evolution of the cosmos. Beams of cold and ultracold neutrons will be used for precision measurements of parity-violating processes and beta-decay parameters, and to investigate the dominance of matter over antimatter in the universe in order to answer fundamental questions in nuclear and particle physics, astrophysics, and cosmology.

Two NP national user facilities have been pivotal in making progress in these frontiers and together serve a national and international community of approximately 700 users. The Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL) is used to study questions of nuclear structure by providing high-quality beams of all the stable elements up to uranium and selected beams of short-lived nuclei for experimental studies of nuclear properties under extreme conditions and reactions of interest to nuclear astrophysics. The Holifield Radioactive Ion Beam Facility (HRIBF) at Oak Ridge National Laboratory (ORNL), which ceases operation in FY 2012, will provide beams of short-lived radioactive nuclei that scientists use to study exotic nuclei that do not normally exist in nature through March 2012. HRIBF has also been used to explore reactions of interest to nuclear astrophysics and isotope production.

Progress in both nuclear structure and nuclear astrophysics studies depends increasingly upon the availability of rare isotope beams. While ATLAS has capabilities for these studies, one of the highest priorities for the NP program is support of a facility with next-generation capabilities for short-lived radioactive beams. The future Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU) is a next-generation machine that will advance the 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 and models of stellar evolution.

Within this subprogram, NP continues to support the LBNL 88-Inch Cyclotron jointly with the National Reconnaissance Office (NRO) and the U.S. Air Force (USAF).

Explanation of Funding Changes

National laboratory and university research supports analysis of data from ATLAS and HRIBF, collecting data at ATLAS, scientific leadership for the construction of FRIB, implementation of scientific instrumentation for neutrino physics, R&D for a next generation double beta decay experiment, conducting experiments at the FNPB, and conducting R&D and developing instrumentation for next-generation neutron experiments. Support for the ATLAS national user facility operations is maintained. Funding for D&D activities associated with the closure of the HRIBF national user facility is provided. The neutron program at the FNPB focuses on the fundamental properties of the neutron through research on parity violating experiments, 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, as recommended by NSAC, following termination of the nEDM MIE in FY 2012. Finally, funding is provided to continue the implementation of FRIB.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	52,194	48,946	-3,248
Funding for national laboratory and university research in nuclear structure, nuclear astrophysics, neutron physics, and neutrino physics is reduced by 5.8% relative to FY 2012. In addition, there is a decrease associated with the reduced research effort at HRIBF, the last year of support for the Majorana Demonstrator R&D in FY 2013, and the final year of funding in FY 2012 for the CUORE MIE for neutrinoless double beta decay. These reductions are partially offset by support for a modest R&D effort on the electric dipole moment of the neutron aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment and by operations support for the KATRIN experiment to put a new limit on the neutrino mass, and the GRETINA MIE for nuclear structure research, both of which were completed in FY 2011.			
Operations	31,533	27,072	-4,461
Support is provided to maintain operations at the ATLAS national user facility. Funding associated with HRIBF in FY 2013 supports D&D-related activities following the end of its operation as a national user facility in FY 2012. The decrease in funding reflects one-time NP support of dewatering and minimal sustenance of operations activities at the Homestake Mine in South Dakota in FY 2012.			

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
	(Dollars in Thousands)		
Facility for Rare Isotope Beams	22,000	22,000	0
Funding is provided for FRIB; an assessment of the total project costs and schedule will be made at the project baseline review planned to take place in FY 2012. The FY 2013 request continues support for the FY 2012 efforts and for activities aimed at achieving final CD-3, "Approve Construction Start."			
Total, Low Energy Nuclear Physics	105,727	98,018	-7,709

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 35 universities. About two-thirds of the supported university scientists have conducted nuclear structure and astrophysics research using specialized instrumentation at the ATLAS and HRIBF national user facilities. 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. This currently includes the Cryogenic Underground Observatory for Rare Events (CUORE) experiment at the Gran Sasso Laboratory in Italy, where the U.S. has a lead role to search for evidence that the neutrino is its own antiparticle and to measure or set a limit on the effective Majorana neutrino mass and the Majorana Demonstrator R&D effort to demonstrate a proof of principle for a neutrino-less double beta decay experiment with germanium detectors. In the future, NP will assess opportunities with next-generation xenon and germanium-based double beta decay experiments. U.S. university scientists participating in the German-lead Karlsruhe Tritium Neutrino (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 in FY 2012, and a modest R&D effort aimed at resolving technical challenges to inform DOE on the feasibility of a future experiment continues, consistent with recent NSAC recommendations.
- Accelerator operations are supported at two university Centers of Excellence with well-defined goals and unique physics programs, the Cyclotron Institute at Texas A&M University (TAMU) and the HIGS facility 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.
- NP continues an in-house research effort at the LBNL 88-Inch Cyclotron whose operations are partially supported by the NRO and the USAF.
- The Applications for Nuclear Science and Technology initiative (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 ($000)
2011 Current	High priority research at 6 national laboratories and 54 university grants were supported at levels flat with FY 2010. The Gamma Ray Energy Tracking In-Beam Nuclear Array (GRETINA) MIE was completed on cost and schedule. It is a segmented germanium detector array with unparalleled position and energy resolution for nuclear structure studies with fast nuclear beams that will rotate among the domestic low-energy nuclear physics facilities.	57,310

Fiscal Year	Activity	Funding ($000)
2012 Enacted	The funding reduction relative to FY 2011 reflects reduced university and laboratory research, the termination of the nEDM MIE, and the ramp down of the CUORE funding profile as planned. In addition, with HRIBF's closure, researchers who conducted research at HRIBF will complete analyses of data obtained in prior years, then will begin to transition to other efforts. The ATLAS research program will achieve the highest priority scientific goals for this field and mitigate some of the impact of the reduced radioactive ion beam hours caused by the closure of HRIBF. Funding supports continuation of the Majorana Demonstrator R&D effort, and transitioning to operations of new instrumentation projects as they come on-line , including GRETINA, experiments at the FNPB, and the international KATRIN experiment.	52,194
2013 Request	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.	48,946

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Research	21,109	19,721	18,645
National Laboratory Research			
National Laboratory User Facility Research	10,960	9,263	7,863
Other National Laboratory Research	25,241	23,210	22,438
Total, National Laboratory Research	36,201	32,473	30,301
Total, Research	57,310	52,194	48,946

Operations

Overview

The ATLAS Facility is the premiere stable beam facility in the world. The ATLAS facility nurtures a core competency in accelerator expertise with superconducting radio frequency cavities for heavy ions that is relevant to the next generation of high-performance proton and heavy-ion linacs, and is important to the Office of Science mission and international stable and radioactive ion beam facilities. ANL accelerator physicists and scientists are working closely with MSU researchers in the development and fabrication of components for FRIB.

ATLAS provides stable and selected radioactive beams coupled to specialized instrumentation for scientists to conduct nuclear structure studies. Capital equipment investments support the fabrication and implementation of small-scale instrumentation at the facility, including HELIOS, which is a novel spectrometer that probes the structure of exotic nuclei. Short-lived and very unstable intermediate nuclei are very important in the synthesis of heavier elements from lighter elements in stellar cores and explosions. To study them requires accelerators capable of producing beams composed of radioactive ions. The Californium Rare Ion Breeder Upgrade (CARIBU) source at ATLAS provides limited capabilities to produce radioactive ion beams, while FRIB will be the world-leading facility for rare ion beams when operational at the end of the decade.

Operation of HRIBF is supported through March 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 have included high power target design and ISOL ion beam production techniques that will have importance for the future Facility for Rare Isotope Beams and other rare isotope beam facilities.

Limited operations of the 88-Inch Cyclotron at the Lawrence Berkeley National Laboratory (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 ($000)
2011 Current	ATLAS, which possesses unique capabilities in an international context and has cutting edge instrumentation, was operated for 5,470 hours of beam time and HRIBF for 5,742 hours of beam time in support of the highest priority nuclear structure and nuclear astrophysics experiments. ATLAS is commissioning CARIBU to enhance the radioactive beam capabilities and productivity of ATLAS. Joint support continued with the NRO and USAF for the 88-Inch Cyclotron. NP prepositioned $500,000 to support minimal, sustaining operations awaiting the final FY 2012 appropriation for DOE-supported activities at the Homestake mine in South Dakota; the funding was used for this purpose after passage of the appropriation.	38,114
2012 Enacted	ATLAS accelerator operations and experimental support funding provides for 5,900 beam hours of operation and continued cost-effective 7 day-a-week operations and maintains support for 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 funding is significantly reduced relative to FY 2011 as it continues limited operations through March 2012 to complete the highest priority experiments prior to its closure; D&D planning activities commence in FY 2012. Support continues at reduced levels for joint operations of the 88-Inch Cyclotron with the NRO and USAF. $4,500,000 is provided to support sustaining operations at the Homestake mine; an additional $9,500,000 is provided from the High Energy Physics program.	31,533

Fiscal Year	Activity	Funding ($000)
2013 Request	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.	27,072

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
User Facility Operations			
ATLAS Operations	16,196	16,048	16,429
HRIBF Operations	17,165	6,821[a]	0
HRIBF D&D Planning	0	0	6,479
Total, User Facility Operations	33,361	22,869	22,908
Other Operations	4,753	8,664	4,164
Total, Operations	38,114	31,533	27,072

[a] A portion of the FY 2012 funding is also being utilized for D&D planning activities as the facility prepares to cease operations in March 2012.

Facility for Rare Isotope Beams

Overview

The Facility for Rare Isotope Beams (FRIB) at Michigan State University (MSU) will enable world-leading research opportunities in nuclear structure, nuclear astrophysics, and fundamental symmetry studies, and complement other rare isotope beam research programs at facilities elsewhere in the world. MSU is undertaking a comprehensive effort to design, construct, and operate FRIB, which includes utilizing core competencies developed by other NP-supported national laboratory groups.

This proposed facility is to provide intense beams of rare isotopes for a wide variety of studies that will advance knowledge of the origin of the elements and the evolution of the cosmos. It offers a laboratory 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. The facility will offer new glimpses into the origin of the elements by leading to a better understanding of key issues by creating exotic nuclei that, until now, have existed only in nature's most spectacular explosion, the supernova. Experiments addressing questions of the fundamental symmetries of nature will similarly 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.

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 proposed facility will have a production area, three-stage fragment separator, three ion stopping stations, and post accelerator capabilities. It is being funded with operating expense dollars through a cooperative agreement with MSU and, therefore, is not a DOE line item construction project or capital asset. Although cooperative agreements are not included under DOE O 413.3B, the management principles of DOE O 413.3B are being followed, including the approval of Critical Decisions. As proposed, FRIB will be operated as a DOE national user facility. Consistent with 10 CFR 600, real property and equipment acquired with Federal funds shall be vested with MSU. However, such items will not be encumbered by MSU for as long as the Federal government retains an interest. When the property and equipment are no longer of interest to the government, MSU will be responsible for decontamination and decommissioning.

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, originally planned in FY 2012.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Funds were used to support engineering and design efforts and R&D efforts.	10,000
2012 Enacted	Funds are provided to continue engineering and design efforts aimed at developing FRIB, and pursue long-lead procurements and possibly a phased construction start that will 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 2012.	22,000
2013 Request	Efforts begun in FY 2012 continue, and engineering and design efforts aimed at achieving CD-3, "Approve Construction Start" are pursued.	22,000

Design and Construction Schedule

This project does not have a performance baseline. Previous dates contained in this table were preliminary estimates. Changes in the planned funding profile in FY 2012 and FY 2013 will be evaluated and reviewed, and the dates for future critical decisions will be updated based on that review.

	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

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 (DOE Only)

This table does not include MSU's cost share which totals approximately $31,700,000 through FY 2012.

(dollars in thousands)

	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013 Request	Outyears	Total
TEC	0	0	10,000	22,000	22,000	TBD	TBD
OPC	7,000	12,000	0	0	0	TBD	TBD
TPC	7,000	12,000	10,000	22,000	22,000	TBD	TBD

Nuclear Theory
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Theory Research	34,776	32,047	30,246
Nuclear Data Activities	8,159	7,360	6,933
Total, Nuclear Theory	42,935	39,407	37,179

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 suggest future experimental investigations. Nuclear Theory addresses all three of nuclear physics' 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 that starts from the fundamental theory of quarks and gluons, 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 (as in 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 High Energy Physics/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 machine has increased the capacity for LQCD research approximately fourfold, and effectively operates currently at sustained 95 teraflops.

Explanation of Funding Changes

The funding for nuclear theory and nuclear data activities is reduced relative to FY 2012.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Theory Research	32,047	30,246	-1,801
Funding for university and national laboratory research is reduced by 5.8% relative to the FY 2012 level, while funding for SciDAC is held flat with the FY 2012 level.			
Nuclear Data Activities	7,360	6,933	-427
Funding is reduced by 5.8% relative to the FY 2012 level for university and national laboratory research.			
Total, Nuclear Theory	39,407	37,179	-2,228

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 the 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. The overall nuclear theory effort addresses the three scientific frontiers of nuclear physics: QCD, nuclear structure and astrophysics, and fundamental symmetries. It is also aligned with the experimental program through the program performance milestones established by NSAC. The need for increased support for nuclear theory activities to provide the effort necessary for the interpretation of experimental results throughout the NP program has been repeatedly stressed in successive NSAC Long Range Plans (LRPs). In FY 2010, NP implemented three new topical collaborations through 5-year awards to bring together theorists nationwide to effectively 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).

The national laboratory theory groups conduct broad research programs in nuclear theory, aligned to the experimental program at that laboratory, where appropriate. The base programs of the laboratory theory groups are evaluated through reviews every four years, which assess the significance of previous research accomplishments and their planned future research program, scientific leadership, creativity, productivity, and overall cost-effectiveness. The next review takes place in FY 2013.

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

SciDAC is a collaborative program promoted by ASCR that partners scientists and computer experts in research teams to address major scientific challenges that require supercomputer facilities at the current technological limits, and is supported within the Nuclear Theory subprogram. 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 -2 ended in FY 2011 and programs throughout SC are being recompeted in FY 2012 as SciDAC-3.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Theoretical research at 7 national laboratories and 81 university grants were supported; 5 scientific computing projects were supported by NP under SciDAC-2 at 7 national laboratories and 2 universities. The NP SciDAC-2 initiative that ended in FY 2011 primarily involved collaborations with ASCR, HEP, and NNSA, and supported five projects on low energy nuclear structure and nuclear reaction theory (UNEDF), lattice quantum chromodynamics (LQCD), nuclear astrophysics (CAC), advanced accelerator design (ComPASS), and grid computing (OSG).	34,776
2012 Enacted	Funding is reduced relative to FY 2011, reflecting a decrease in the NP contribution to the SciDAC initiative, and a reduction in funding for research efforts. Support is continued as planned for the second-generation LQCD project in partnership with the DOE HEP program, and third-year funding is provided for the topical theory collaborations. SciDAC programs throughout SC are being recompeted in FY 2012 as SciDAC-3. NP plans to support up to four computational nuclear theory projects under SciDAC-3 in collaboration with ASCR, HEP, and other DOE offices.	32,047

Fiscal Year	Activity	Funding ($000)
2013 Request	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.	30,246

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Research	16,389	16,361	14,873
National Laboratory Research	15,787	14,686	14,373
SciDAC	2,600	1,000	1,000
Total, Theory Research	34,776	32,047	30,246

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. The NNDC participates in the International Data Committee of the International Atomic Energy Agency and is an important national and international resource.

Independent of the core Nuclear Data activities, funding is also included to support initiatives in Applications of Nuclear Science and Technology, including efforts relevant to nuclear fuel cycle research. This initiative is funded from both the Low Energy subprogram and the Nuclear Data program, and funding is split between the two pending competitive peer review and award.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	The Nuclear Data program continued updating online databases on experimental and evaluated nuclear structure data, nuclear reaction cross sections, and nuclear science literature. Competitive awards for the Applications of Nuclear Science and Technology initiative were made for: nuclear data cross section measurement and evaluation, fission product data, collaborative awards in neutron spectroscopy, and collaborative awards in reactor decay heat.	8,159
2012 Enacted	Funding for ongoing work of the National Nuclear Data Program is reduced relative to FY 2011. In addition, funding for new competitively awarded Applications of Nuclear Science and Technology research is reduced by roughly 25 percent.	7,360
2013 Request	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.	6,933

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

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	4,060	4,827	4,453
Operations	15,610	14,255	14,255
Total, Isotope Development and Production for Research and Applications	19,670	19,082	18,708

Overview

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 that are 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 domestic 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 Isotope Program, which operates under 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. Research isotopes are priced at lower rates to facilitate scientific advances and are now sold at a unit price, as opposed to a batch price. 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 numbers 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 medicine, homeland defense, and energy security; and nickel-63 use as a component in molecular sensing devices and helium-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, the National Institute of Standards and Technology, the Environmental Protection Agency, the Department of Agriculture, the Department of Homeland Security, the National Nuclear Security Administration (NNSA), and other Office of Science programs. NP continues to work in close collaboration with these federal agencies 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 National Institutes of Health (NIH) which identifies the isotopes and projected quantities needed by the medical community in the context of the

Isotope Program capabilities. Moreover, 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 molybedenum-99 (Mo-99) and offering technical and management support. 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. SC is also 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) on Radioisotopes. NP also 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 staff from NNSA, the Department of Homeland Security, the Department of Defense, the Institutes of Health and many other agencies. While the Isotope Program role in helium-3 (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. 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 Oak Ridge National Laboratory.

Explanation of Funding Changes

Support is maintained for the research and development of new isotope production techniques, the mission readiness of the production and processing facilities within the program's portfolio, and for the staffing at the National Isotope Development Center.

(Dollars in Thousands)

	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
Research	4,827	4,453	-374
University and laboratory research is reduced 5.8% relative to FY 2012. In addition, there is a decrease reflecting support in FY 2012 for a one-time R&D effort in support of the development of a californium-252 target for the CARIBU upgrade at ATLAS.			
Operations	14,255	14,255	0
Operations are maintained at the same funding level as FY 2012 for the Isotope Production Facility and Brookhaven Linac Isotope Producer, as well as processing capabilities at ORNL. Funding is maintained for the National Isotope Development Center, a virtual service center which coordinates DOE isotope production across the federal and academic community.			
Total, Isotope Development and Production for Research and Applications	19,082	18,708	-374

Research

Overview

Research is supported to identify, design, and optimize production targets and separation methods. Examples for planned research include the need for positron-emitting radionuclides to support the rapidly growing area of medical imaging using positron emission tomography (PET), development of isotopes that support medical research used to diagnose and treat diseases spread through acts of bioterrorism, development of production methods for alpha-emitting radionuclides that exhibit great potential in disease treatment, development and use of research isotopes for various biomedical applications, development of stable isotope enrichment technologies, and the need for 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 highest priorities is to conduct R&D aimed at re-establishing a domestic capability for stable isotope production in the U.S. All R&D activities are peer reviewed.

Support is provided for scientists at universities, industry, and BNL, LANL, ORNL, INL, PNNL, and ANL to perform peer-reviewed experimental research on targets, separation technology maturation and development of isotope production techniques, and for the production of research isotopes at more affordable rates to the researcher. Research and development also includes target design, enhanced processing techniques, radiochemistry, material conversions, and other related services. Researchers provide unique expertise and facilities for data analysis. R&D activities utilize reactor and accelerator capabilities throughout the DOE complex and at university sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	A Funding Opportunity Announcement (FOA) soliciting competitive R&D proposals for new isotope production techniques resulted in 35 applicants, of which 4 projects were funded in FY 2011 based on peer review.	4,060
2012 Enacted	Based on the FY 2011 FOA, 4 research projects were awarded with FY 2012 funding. Increased funding above FY 2011 reflects modest support to establish laboratory research groups at those sites in which production capabilities exist; some funding is shifted from Operations to Research reflecting this effort. In addition, funding was provided for a one-time R&D effort for the californium-252 target for the CARIBU upgrade at ATLAS.	4,827
2013 Request	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.	4,453

(Dollars in Thousands)

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
National Laboratory Research	1,530	3,677	3,370
University Research	2,530	1,150	1,083
Total, Research	4,060	4,827	4,453

Operations

Overview

This Isotope Program is steward of the Isotope Production Facility (IPF) at Los Alamos National Laboratory (LANL) and the Brookhaven Linac Isotope Producer (BLIP) facility, 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 production of isotopes at the Idaho National Laboratory reactor and processing and packaging strontium-90 at the Pacific Northwest National Laboratory.

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 also supports isotope production capabilities at a few university, other national laboratory, 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 Development Center (NIDC) at ORNL 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 has recently unveiled a new website for the program at www.isotopes.gov. The NIDC has also accepted a coordinating role for all transportation issues within the program and now coordinates these efforts among all of the production sites. The NIDC also coordinates quality control issues across all the production sites.

Funding and Activity Schedule

Fiscal Year	Activity	Funding ($000)
2011 Current	Substantial quantities of radioactive and stable isotopes were produced and distributed to support commercial uses and research applications, most prominently strontium-82, germanium-68, californium-252, actinium-225, nickel-63, and selenium-75.	15,610
2012 Enacted	Mission readiness is maintained, within constrained funding, for isotope production at university and laboratory accelerator and reactor facilities, and the NIDC. Isotopes produced at these facilities will primarily be those produced in FY 2011 with additional commercial isotope production initiated in response to sufficient customer demand (e.g., gadolinium-153, strontium-89, neptunium-236, carbon-14, tin-117m) and high priority isotopes identified by NSAC (e.g., astatine-211, actinium-225, berkelium-249). Some funding is shifted to Research to support R&D activities at the national laboratories.	14,255
2013 Request	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.	14,255

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
University Operations	202	150	150
Isotope Production Facility (IPF) Operations	1,041	941	941
Brookhaven Linear Isotope Producer (BLIP) Operations	520	520	520
National Isotope Data Center (NIDC)	2,162	2,278	2,278
Other National Laboratory Operations	11,685	10,366	10,366
Total, Operations	15,610	14,255	14,255

Construction
Funding Profile by Activity

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	35,928	50,000	40,572

Overview

This subprogram 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 that is being supported is the 12 GeV CEBAF Upgrade at TJNAF (see construction project data sheet at the end of the NP narrative).

Explanation of Funding Changes

In FY 2013, funding is requested to continue construction of the 12 GeV CEBAF Upgrade. The upgrade was identified in the 2007 NSAC Long-Range Plan as the highest priority for the U.S. Nuclear Physics program. The upgrade will enable scientists to address one of the mysteries of modern physics—the mechanism of quark confinement.

The FY 2012 appropriation necessitates a review during FY 2012 to evaluate the impact of the FY 2012 funding level, including possible schedule delays and increased project costs.

	(Dollars in Thousands)		
	FY 2012 Enacted	FY 2013 Request	FY 2013 vs. FY 2012
06-SC-01, 12 GeV CEBAF Upgrade, TJNAF	50,000	40,572	-9,428

In FY 2013, funding is requested according to the approved 12 GeV CEBAF Upgrade project baseline plan, which is a decrease of $9,428,000 (TEC) relative to the FY 2012 appropriation.

Supporting Information

Operating Expenses, Capital Equipment and Construction Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Operating Expenses	456,552	473,154	461,501
Capital Equipment	27,029	18,611	19,243
General Plant Projects	2,891	2,000	2,000
Accelerator Improvement Projects	5,284	3,622	3,622
Construction (12 GeV Upgrade)	35,928	50,000	40,572
Total, Nuclear Physics	527,684	547,387	526,938

Funding Summary

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Research	173,525	170,115	160,182
Scientific User Facilities Operations	275,309	257,858	253,651
Other Facility Operations	20,363	22,919	24,898
Projects			
Major Items of Equipment	8,505	3,586	4,400
Facility for Rare Isotope Beams[a]	10,000	22,000	22,000
Construction Projects (12 GeV Upgrade)	35,928	50,000	40,572
Total Projects	54,433	75,586	66,972
Other	4,054[b]	20,909	21,235
Total Nuclear Physics	527,684[b]	547,387	526,938

[a] FRIB is being funded with operating expense dollars through a Cooperative Agreement with Michigan State University (MSU).

[b] Total reduced by $12,430,000: $11,098,000 of which was transferred to the Small Business Innovation and Research (SBIR) program and $1,332,000 of which was transferred to the Small Business Technology Transfer (STTR) program.

Scientific User Facilities Operations and Research

	(Dollars in Thousands)		
	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
CEBAF (TJNAF)			
Operations[a]	82,563	77,372	80,651
Facility Research/MIEs	11,644	11,404	10,175
Total CEBAF	94,207	88,776	90,826
RHIC (BNL)			
Operations	159,385	157,617	156,571
Facility Research/MIEs	12,032	10,812	11,430
Total RHIC	171,417	168,429	168,001
HRIBF (ORNL)			
Operations[b]	17,165	6,821	0
Facility Research/MIEs	5,620	4,123	0
Total HRIBF	22,785	10,944	0
ATLAS (ANL)			
Operations	16,196	16,048	16,429
Facility Research/MIEs	5,340	5,140	4,669
Total ATLAS	21,536	21,188	21,098
Scientific User Facilities			
Operations	275,309	257,858	253,651
Facility Research/MIEs	34,636	31,479	26,274
Total Scientific User Facilities	309,945	289,337	279,925

[a] CEBAF Operations includes $2,500,000 in 12 GeV Other Project Cost funding in FY 2013.

[b] Operations of HRIBF as a National User Facility will cease in March 2012. Funding in FY 2012 will be used for D&D planning, transitioning staff, and limited operations to complete the highest priority experiments prior to closure.

Total Facility Hours and Users

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
CEBAF (TJNAF)[a]			
Achieved Operating Hours	4,661	N/A	N/A
Planned Operating Hours	4,090	3,870	0
Optimal Hours	4,090	3,940	0
Percent of Optimal Hours	114%	98%	N/A
Unscheduled Downtime	7%	N/A	N/A
Number of Users	1,370	1,390	1,390
RHIC (BNL)			
Achieved Operating Hours	3,114	N/A	N/A
Planned Operating Hours	3,210	2,390	1,360
Optimal Hours	4,100	4,100	4,100
Percent of Optimal Hours	76%	58%	33%
Unscheduled Downtime	24%	N/A	N/A
Number of Users	1,200	1,200	1,200
HRIBF (ORNL)			
Achieved Operating Hours	5,742	N/A	N/A
Planned Operating Hours	5,200	0	0
Optimal Hours	6,100	0	0
Percent of Optimal Hours	94%	N/A	N/A
Unscheduled Downtime	17%	N/A	N/A
Number of Users	300	0	0

[a] The optimal hours for CEBAF in FY 2012 and FY 2013 reflect the maximum possible due to the planned shutdown schedule associated with the 12 GeV CEBAF Upgrade project. The user community will remain involved during the shutdown in FY 2013 with instrumentation and equipment implementation.

	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
ATLAS (ANL)			
Achieved Operating Hours	5,470	N/A	N/A
Planned Operating Hours	5,700	5,900	4,000
Optimal Hours	6,600	6,200	5,000[a]
Percent of Optimal Hours	83%	95%	80%
Unscheduled Downtime	7%	N/A	N/A
Number of Users	410	410	410
Total Facilities			
Achieved Operating Hours	18,987	N/A	N/A
Planned Operating Hours	18,200	12,160	5,360
Optimal Hours	20,890	14,240	9,100
Percent of Optimal Hours (funding weighted)	89%	74%	38%
Unscheduled Downtime	13%	N/A	N/A
Total Number of Users	3,280	3,000	3,000

Major Items of Equipment

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
Heavy Ion Nuclear Physics							
Heavy Ion LHC Experiments, LBNL							
TEC	12,000	1,205	0	0	0	13,205	4Q FY 2011
OPC	295	0	0	0	0	295	
TPC	12,295	1,205	0	0	0	13,500	
STAR Heavy Flavor Tracker, BNL							
TEC	2,400	4,400	3,050	4,400	950	15,200	4Q FY 2015
OPC	280	0	0	0	0	280	
TPC	2,680	4,400	3,050	4,400	950	16,580[b]	

[a] The optimal hours in FY 2013 reflect the maximum hours that ATLAS can operate due to the scheduled installation of upgrades.

[b] This project received CD-2/3 approval in October 2011; the TPC includes $1.1M of support for engineering and technical activities already supported by the RHIC research program.

	(Dollars in Thousands)						
	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
Low Energy Nuclear Physics							
Neutron Electric Dipole Moment (nEDM), ORNL							
TEC	8,547	2,100	0	0	0	N/A	N/A
OPC	933	0	0	0	0	N/A	
TPC	9,480	2,100	0	0	0	N/A[a]	
Cryogenic Underground Observatory for Rare Events (CUORE), LBNL							
TEC	6,600	800	186	0	0	7,586	2Q FY 2015
OPC	764	0	350	0	0	1,114	
TPC	7,364	800	536	0	0	8,700	
Total MIEs							
TEC		8,505	3,236	4,400			
OPC		0	350	0			
TPC		8,505	3,586	4,400			

[a] nEDM is terminated as an MIE in FY 2012.

Heavy Ion Nuclear Physics MIEs

Heavy Ion LHC Experiment (ALICE EMCal), LBNL: This MIE fabricated a large electromagnetic calorimeter (EMCal) for the ALICE experiment at the LHC, and is a joint project with France and Italy. The project received CD-4 approval in September 2011, and was completed on cost and schedule.

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, with an early finish planned in FY 2014.

Low Energy Nuclear Physics MIEs

Neutron Electric Dipole Moment (nEDM), ORNL: This joint DOE/NSF project to fabricate a cryogenic apparatus to measure the neutron electric dipole moment using ultra-cold neutrons from the FNPB is terminated as an MIE in FY 2012.

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 and is scheduled to finish in FY 2015. This is a joint DOE/NSF project with NSF contributing additional funds.

Construction Projects

(Dollars in Thousands)

	Prior Years	FY 2011 Current	FY 2012 Enacted	FY 2013 Request	Outyears	Total	Completion
12 GeV CEBAF Upgrade, TJNAF							
TEC	134,500	35,928	50,000	40,572	26,500	287,500	3Q FY 2015
OPC	10,500	0	0	2,500	9,500	22,500	
TPC[a]	145,000	35,928	50,000	43,072	36,000	310,000	

Scientific Employment[b]

	FY 2011 Current (Actual)	FY 2012 Enacted (estimated)	FY 2013 Request (estimated)
# University Grants	225	215	205
Average Size per year	$315,000	$315,000	$300,000
# Laboratory Projects	34	34	33
# Permanent Ph.D.s	725	715	645
# Postdoctoral Associates	359	350	315
# Graduate Students	538	530	475
# Ph.D.s awarded	86	80	80

[a] The TPC reflects the current baseline and does not reflect impacts of reduced FY 2012 funding.

[b] This table does not include approximately 1,100 engineering, technical, and administrative FTEs that were supported by the NP program in FY 2011. Comparable reductions in the number of supported FTEs are likely among this group as projected for PhDs, postdocs and graduate students in FY 2012 and FY 2013. An additional 27 Ph.D.s, 16 Postdoctoral Associates, and 13 graduate students were supported with Recovery Act funds in FY 2011.

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

1. 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 in 3Q FY 2015.

A Federal Project Director at the appropriate level is assigned to this project.

This Project Data Sheet (PDS) does not include a new start for the budget year.

This PDS is an update of the FY 2012 PDS. A baseline change will be required as a result of the recently enacted FY 2012 Consolidated Appropriations Act which provided $50,000,000 for this project, $16,000,000 less than the baseline profile. Changes in project cost or schedule resulting from the FY 2012 funding have not yet been evaluated and reviewed and are not reflected in this PDS. It is expected that a new baseline will be established by the end of FY 2012. The project continues to manage all identified risks. Risks change from month to month, and include issues with the procurement and installation of components, overall staffing levels and schedule, impacts of continuing resolutions, and claims from subcontractors. For each moderate and high risk a mitigation plan is developed in order to assure successful project completion.

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

(fiscal quarter or date)

	CD-0	CD-1	PED 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[b]	3Q FY 2015[b]	N/A

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
D&D– Demolition & Decontamination (D&D) work

[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-4A and CD-4B dates reflect the original baseline schedule and do not reflect impacts of reduced FY 2012 funding which may require schedule revision.

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[a]

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 to leverage the federal investment of $310,000,000 for an upgrade of the Jefferson Lab’s research facilities. The additional funding reduces project risks associated with cost and schedule and helps ensure timely completion of the project. 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 review that assesses the impacts of reduced FY 2012 funding which may result in a change to the TPC.

CD-4A Key Performance Parameters

Subsystem	Technical Definition of Completion
Accelerator	12 GeV capable 5.5 pass machine installed
Accelerator	11 GeV capable beamline to existing Halls A, B, and C installed
Accelerator	12 GeV capable beamline to new Hall D tagger area installed
Accelerator	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, *Approve Start of Operations or Project Closeout*, are phased around 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 to help ensure that the two high risk and eleven moderate risks will not impact the planned completion dates.

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 the 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	6,752	61,249
FY 2013	40,572	40,572	0	49,000
FY 2014	26,500	26,500	0	23,500
FY 2015	0	0	0	3,059
Total, Construction[b]	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[a]	35,928	35,928	25,889	40,808
FY 2012	50,000	50,000	6,752	61,249
FY 2013	40,572	40,572	0	49,000
FY 2014	26,500	26,500	0	23,500
FY 2015	0	0	0	3,059
Total, TEC[b]	287,500	287,500	65,000	222,500

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

[b] The TEC total reflects the original baseline. The FY 2012 reduction is restored in FY 2014 as a placeholder pending a baseline review and assessment.

	(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	2,500	2,500	0	2,403
FY 2014	7,500	7,500	0	7,000
FY 2015	2,000	2,000	0	2,600
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[a]	35,928	35,928	25,889	40,808
FY 2012	50,000	50,000	6,752	61,249
FY 2013	43,072	43,072	0	51,403
FY 2014	34,000	34,000	0	30,500
FY 2015	2,000	2,000	0	5,659
Total, TPC[b]	310,000	310,000	65,000	245,000

[a] The FY 2011 funding was reduced by $72,000 as a result of the FY 2011 rescission.
[b] The TPC total reflects the original baseline. The FY 2012 reduction is restored in FY 2014 as a placeholder pending a baseline review and assessment.

6. Details of Project Cost Estimate

	(dollars in thousands)		
	Current Total Estimate	Previous Total Estimate	Original Validated Estimate
Total Estimated Cost (TEC)			
Design (PED)			
Design	21,000	21,000	19,200
Contingency	0	0	1,800
Total, PED (PED no. 06-SC-01)	21,000	21,000	21,000
Construction Phase			
Civil Construction	29,507	31,880	27,450
Accelerator/Experimental Equipment/ Management	210,058	191,463	174,150
Contingency	26,935	43,157	64,900
Total, Construction	266,500	266,500	266,500
Total, TEC	287,500	287,500	287,500
Contingency, TEC	26,935	43,157	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	9,394	8,195	7,450
Contingency	2,609	3,808	5,150
Total, OPC	22,500	22,500	22,500
Contingency, OPC	2,609	3,808	5,150
Total, TPC	310,000	310,000	310,000
Total, Contingency	29,544	46,965	71,850

7. Schedule of Appropriation Requests

(dollars in thousands)

Request Year		Prior Years	FY 2009	FY 2009 Recovery Act	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	0	21,000
	OPC	11,000	0	0	0	0	0	0	0	0	11,000
	TPC	30,000	2,000	0	0	0	0	0	0	0	32,000
FY 2008 (PED only)	TEC	21,000	0	0	0	0	0	0	0	0	21,000
	OPC	10,500	0	0	0	0	0	0	0	0	10,500
	TPC	31,500	0	0	0	0	0	0	0	0	31,500
FY 2009[a] (Performance Baseline)	TEC	20,877	28,623	0	59,000	62,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	0	59,000	62,000	66,000	43,000	18,000	2,000	310,000
FY 2010[b]	TEC	20,877	28,623	65,000	22,000	34,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	65,000	22,000	34,000	66,000	43,000	18,000	2,000	310,000
FY 2011	TEC	20,877	28,623	65,000	20,000	36,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	65,000	20,000	36,000	66,000	43,000	18,000	2,000	310,000
FY 2012	TEC	20,877	28,623	65,000	20,000	36,000	66,000	40,500	10,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC	31,377	28,623	65,000	20,000	36,000	66,000	43,000	18,000	2,000	310,000
FY 2013	TEC	20,877	28,623	65,000	20,000	35,928[c]	50,000	40,572	26,500	0	287,500
	OPC	10,500	0	0	0	0	0	2,500	7,500	2,000	22,500
	TPC[d]	31,377	28,623	65,000	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 FY 2011 funding was reduced by $72,000 as a result of the FY 2011 rescission.

[d] The TPC total reflects the original baseline. The FY 2012 reduction is restored in FY 2014 as a placeholder, pending a baseline review and assessment.

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter or date)	3Q FY 2015
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[a]	2,250,000[b]
Maintenance	Included above	Included above	Included above	Included above
Total, Operations & Maintenance	150,000	150,000	2,250,000	2,250,000[b]

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.

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.

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[a] 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.

[b] The FY 2012 request to Congress incorrectly included the $310,000,000 total project cost in this total, and so reported an operations and maintenance total of $2,560,000,000.