**Mission:** To discover, explore and understand all forms of nuclear matter; to understand how the fundamental particles, quarks and gluons, fit together and interact to create different types of matter in the universe, including those no longer found naturally.

**Priorities:**

- To understand how quarks and gluons assemble into the various forms of matter and to search for yet undiscovered forms of matter.
- To understand how protons and neutrons combine to form atomic nuclei and how these nuclei have emerged during the 13.7 billion years since the origin of the cosmos.
- To understand the fundamental properties of the neutron and develop a better understanding of the neutrino.
- To conceive, plan, design, construct, and operate national scientific user facilities; to develop new detector and accelerator technologies.
- To provide stewardship of isotope production and technologies to advance important applications, research and tools for the nation.
- To foster integration of the research with the work of other organizations in DOE.
DOE/SC is the largest supporter of nuclear physics in the US and operates large National User Facilities

**Responsible for Strategic Planning and Funding**
- Identify the scientific opportunities for discoveries and advancements
- Build and operate forefront facilities to address these opportunities
- Develop and support a research community that delivers significant outcomes
- Work with other agencies/countries to optimize use of U.S. resources

**Goals are:**
- World-class facility research capabilities (to make significant discoveries/advancements)
- A strong, sustainable research community (to deliver significant outcomes)
- Forefront advanced technologies capabilities (for next-generation capabilities)
- A well-managed & staffed, strategic sustainable program (that ensures leadership/optimize resources)

**Deliverables are:**
- New insights and advancements in the fundamental nature of matter and energy
- New and accumulated knowledge, developed and cutting-edge technologies, and a highly-trained next-generation workforce that will underpin the Department’s missions and the Nation’s nuclear-related endeavors
- Isotopes for basic and applied sciences
Nuclear Physics Program in the U.S.

**National User Facilities**
- RHIC (BNL)
- CEBAF (TJNAF)
- ATLAS (ANL)
- HRIBF (ORNL)

**Research Groups**
- 9 National Laboratories
- 85 Universities

**NP Workforce**
- ~720 Faculty & Lab Res Staff
- ~400 Post-docs
- ~500 Graduate Students
- ~100 Undergraduate Students

**Other Lab. Facility**
- 88-Inch Cyclotron (LBNL)
- 200 MeV BLIP (BNL)
- 100 MeV IPF (LANL)
- Hot Cell Facilities at BNL, LANL, ORNL

**Centers of Excellence**
- CENPA (U. of Wash)
- INT (U. of Wash.)
- TAMU (Texas A&M)
- TUNL (Duke)
- REC (MIT)
- WNSL (Yale)
FY 2011 Congressional Request Nuclear Physics by Major Function

65% of the NP budget supports operations or construction of facilities & instrumentation

- Facility Operations: 54%
- Research: 35%
- Major Projects (12 GeV, FRIB): 8%
- Major Items of Equipment: 2%
- All Other (GPE): 1%

FY 2011 Congressional Request
Total = $562.0M
NP Operates Four National User Facilities

Users of NP Facilities

- Relativistic Heavy Ion Collider
- Continuous Electron Beam Accelerator Facility
- Holifield Radioactive Ion Beam Facility
- Argonne Tandem Linac Accelerator System

Users:
- RHIC/BNL
- CEBAF/TJNAF
- HRIBF/ORNL
- ATLAS/ANL
At the NP National User Facilities the Research Spans a Range of Microscopic Scales:

**From Quarks and Gluons**

- Relativistic Heavy Ion Collider

**To Protons and Neutrons**

- Continuous Electron Beam Accelerator Facility

**To Nuclei**

- Holifield Radioactive Ion Beam Facility
- Argonne Tandem Linac Accelerator System
NP has Five Subprograms

- **Medium Energy**
  - Primarily explores the frontier of quantum chromodynamics
  - Spin structure of the proton
  - Parity violating processes relevant to the New Standard Model

- **Heavy Ion**
  - Investigates the frontier of quantum chromodynamics via studies of hot, dense nuclear matter

- **Low Energy**
  - Studies nuclear structure and nuclear astrophysics
  - Investigates the properties of neutrinos, and uses cold neutrons and nuclei to test the Standard Model

- **Theory**
  - Explores all three frontiers of nuclear physics
  - Encompasses the Nuclear Data Program

- **Isotope Production and Applications**
  - Produces, prepares and distributes isotopes for commercial applications and research
  - Research and development relevant to isotope production
CEBAF at JLab provides polarized 6 GeV electron beams

World’s Premier Facility for studies of:
- Quark structure of matter
- Nuclear structure and weak interactions with polarized electrons

Premier NP User Facility
- User community of ~1350
- Outstanding science

Core Competencies utilized by others
- SRF cavities for SNS
- Improvements in cryogenics (efficiencies)
- FEL and ERL for USN/USAF
- SRF cavities for FRIB
- SRF cavities for ILC R&D
- Technology transfer

Accelerator Core Competencies

SNS SC RF cavities at JLAB

Developed most powerful FEL

Single crystal Niobium gives promise for high gradients for acceleration (ILC)

CEBAF Jefferson Laboratory

Technology Transfer

Dillon Gamma Camera used in scanning for breast cancer

Dillon Gamma Camera used in scanning for breast cancer
Unique, world-class facility and scientific program
- Doubling the accelerator beam energy
- New experimental Hall and associated beamline
- Upgrades to the existing three experimental Halls

TPC: $310 Million
Funds redirected from CEBAF Operations
Successful CD-2, CD-3 in FY 2008
Operations anticipated in FY 2015

Recovery Act funding advances project
funding by $65 Million and reduces cost and schedule risk

High Resolution Spectrometer (HRS) Pair, and specialized large installation experiments
CLAS upgraded to higher \(10^{35}\) luminosity and coverage

Super High Momentum Spectrometer (SHMS) at high luminosity and forward angles
9 GeV tagged polarized photons and a 4\(\pi\) hermetic detector
Implementing the Recommendations of the Long Range Plan: Construction of Hall D

Pouring the foundation for the Hall D complex.
RHIC at BNL - Heavy Ion Beams and High Energy Polarized Protons

**Capabilities used by others**

- BLIP (DOE IPA)
- NSRL (NASA)

**World’s Premier Facility for studies of:**

- Hot, dense nuclear matter
- Structure of the proton

**Unique Capabilities utilized by Others**

- NASA (NSRL)
- DOE NE (BLIP)
- NASA, others (SEU, commercial)

**Core Competencies utilized by others**

- Synchrotron for SNS
- Magnets/Tier I Center for LHC
- USN work for ERL
- Technology transfer

**Premier NP User Facility**

- User community of ~1200
- Outstanding Science

**Accelerator Core Competencies**

- Synchrotron and component for SNS
- Magnets for LHC
- ERL for USN
- Designs for medical synchrotrons

**Instrumentation Core Competency**

- World-class Instrumentation Group
- Awake Animal Imaging
- Micro-electronics/detectors for PET
- etc.

**RHIC Brookhaven National Laboratory**

**Fast kicker system designed and built for the SNS**

**Awake animal imaging**
ATLAS and HRIBF Provide Stable and Radioactive Beams

**Capabilities:**
- ATLAS: stable beams (1<A<238) with energies > 8 MeV/u
- HRIBF: >175 radioactive ion beams with energies above the Coulomb barrier for Sn

**Programs:**
- ATLAS: NS at the proton drip line, N=Z and heavy nuclei; CNO cycle breakout and cosmogenic gamma-ray emitters; precision mass measurements
- HRIBF: delayed proton decay, NS at the proton drip line, closed-shell neutron rich nuclei; CNO cycle breakout, rp - and r-processes

**New Capabilities:**
- ATLAS: CARIBU source of complementary RIBs; HELIOS spectrometer for reaction studies with RIBs in reverse kinematics; Canadian Penning Trap for precision mass measurements
- HRIBF: High Power Target Laboratory and Injector for Radioactive Ion Species 2; new endstation for study of rare isotopes including beta-delayed neutron decay; ORRUBA spectrometer for proton reactions with rare isotope beams (in collaboration with Rutgers/NNSA)

**User Community:**
- ~700 users including international and NSF-supported researchers

**Core Capabilities:**
- ATLAS: Superconducting Radiofrequency technology for heavy ion accelerators; gas cell heavy ion catchers
- HRIBF: development of ISOL technology for radioactive ion beams

**HRIBF**
Re-accelerates
Rare Isotope Beams
NP plays a key role in the studies of neutrinos including understanding their oscillation properties, assessing their particle/anti-particle nature, and determining their masses.

- NP researchers collaborate on three neutrino experiments and one R&D project:
  - Upgraded KamLAND to measure low energy solar neutrinos
  - CUORE to search for neutrino-less double beta decay
  - KATRIN to determine the neutrino mass (down to ~300 meV) by measuring the shape of the tritium beta decay spectrum
  - Majorana Demonstrator R&D to determine the feasibility of a germanium-based neutrino-less double beta decay experiment (Majorana is a candidate to be sited at DUSEL)

A DUSEL Joint Oversight Group organized by NSF, HEP, and NP coordinates activities related to the research program at the facility.
The Facility for Rare Isotope Beams

Lehman review of readiness for CD1 July 27-29, 2010

ESAAB August 31, 2010

Project receives CD-1

- Physically compact layout
- Minimize higher-cost subterranean structures
- Single tunnel for all linac segments
Theory Subprogram

- **Addresses all three of the field’s scientific frontiers**
  - Quantum chromodynamics
  - Nuclei and Nuclear Astrophysics
  - Fundamental Symmetries and Neutrinos

- **The Nuclear Data Program activities are within this subprogram**
  - Compilation, evaluation, and dissemination of nuclear structure and reaction data
  - Coordination with international nuclear data activities

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**Three body forces required to calculate the masses of heavy Helium nuclei**

- *Ab initio* calculations of Helium masses carried out as part of SciDAC-2 show a systematic deviation compared to those measured
- Deviation attributed to three-body forces missing in these calculations
- Coupled cluster calculations are being carried out for medium mass nuclei with up to 40 and 48 protons and neutrons
Components of the IDPRA Subprogram

- **Research groups supported at national laboratories and universities**
  - Limited research and development provides improved isotope production and processing
  - The 2009 Appropriation re-established a research and development effort and the production of research isotopes
  - Reduces dependence on foreign supplies, affordable isotopes for research, meet present and future researchers’ needs for isotopes

- **Operations for isotope production**
  - Stewardship of Brookhaven Linear Isotope Producer (BLIP) at BNL
  - Stewardship of Isotope Production Facility (IPF) at LANL
  - Isotope production at reactors at ORNL and INL
  - Hot cell facilities at BNL, ORNL, LANL, others
  - National Isotope Data Center (NIDC)—management information center for all national laboratories and universities in the subprograms portfolio of processing and production of isotopes

- **Technical activities**
  - Production, processing, packaging and transportation of radioisotopes
  - R&D includes target fabrication, enhance processing techniques, radiochemistry, material conversions, new production techniques
  - Sales of and services for stable isotopes from stockpile