

DOE Office of Nuclear Physics Overview

Linda Horton, Paul Mantica, and Sharon Stephenson

Office of Nuclear Physics

April 26, 2024

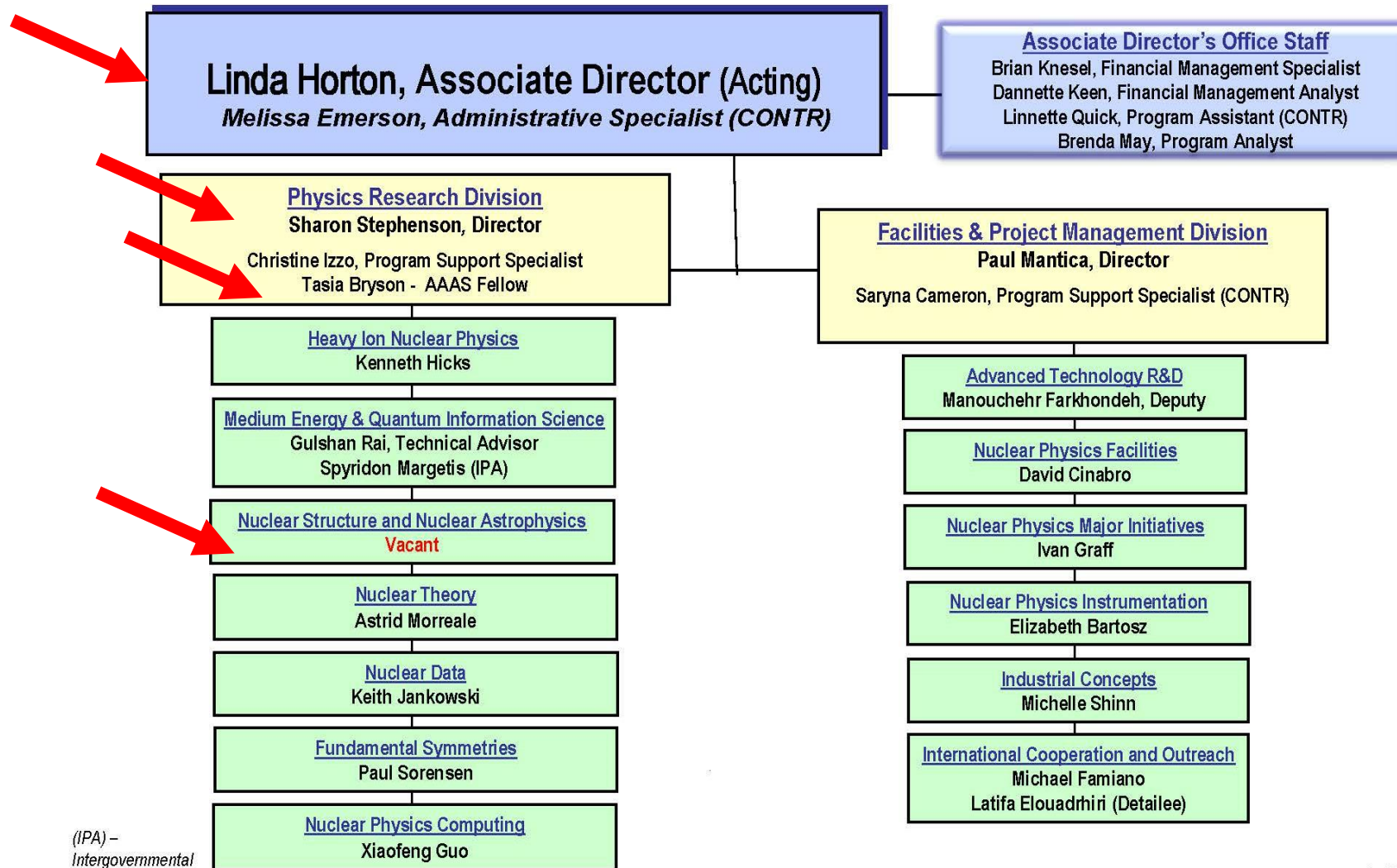


U.S. DEPARTMENT OF
ENERGY

Office of
Science

[Energy.gov/science](https://www.energy.gov/science)

DOE-SC Office of Nuclear Physics



(IPA) –
Intergovernmental
Personnel Act

April 8, 2024

Linda Horton, Associate Deputy Director for Science Programs Acting Associate Director of Science for Nuclear Physics



15 years with DOE – previously Associate Director for Basic Energy Sciences (including acting Division Director for Scientific User Facilities)

29 years at ORNL – materials research; group and division leadership; leading construction, then serving as Director, of the Center for Nanophase Materials Sciences (SC User Facility)

Many service roles, including vice-chair of the BES advisory committee

Education: BS Mathematics and Physics;
MS, PhD Materials Sciences and Engineering

Sharon Stephenson, Physics Research Division Director



- ◆ Stepped into role January 2024
- ◆ DOE-NP Program Manager for Nuclear Structure and Nuclear Astrophysics, 2019 - 2024
- ◆ W.K.T Sahm Professor of Physics & Chair, Gettysburg College 1998 - 2019

Tasia Bryson, Ph.D., AAAS Fellow

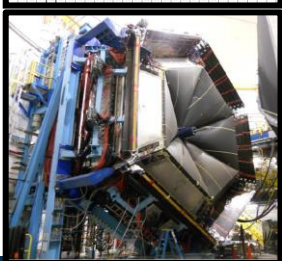
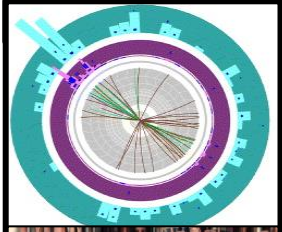
- Joined NP in September 2023 for workforce development scope
- Postdoctoral Research Fellow for the I CAN PERSIST STEM Initiative at the University of Massachusetts Boston, 2021 - 2023
- Western Michigan University-Mallinson Institute for Science Education (Doctorate), 2021



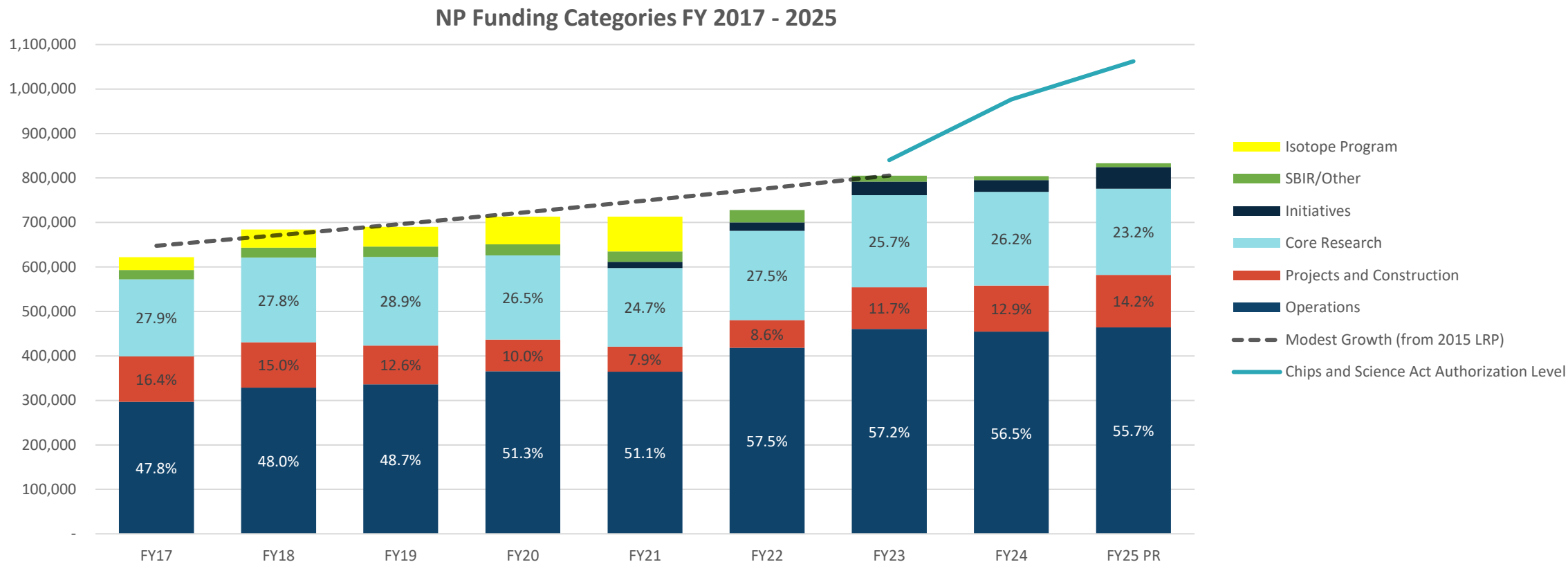
DOE Nuclear Physics Program

Understanding why matter takes on the specific forms observed in nature and how that knowledge can benefit energy, economic, and national security

- ◆ **Quantum Chromodynamics:** Mapping the inside of the proton; Discovering the properties of quark-gluon plasma; and Exploring mechanisms underlying confinement of quarks and gluons
- ◆ **Fundamental Symmetries:** Searching for new exotic particles and violations of nature's symmetries
- ◆ **Nuclei and Nuclear Astrophysics:** Determining the limits of nuclear existence and how heavy elements are made in stars
- ◆ **Neutrino-less Double Beta Decay:** Discovering if the neutrino is its own anti-particle or if the neutron's precise properties point to new physics
- ◆ **Nuclear Theory:** Exploring the strong force in many-body systems
- ◆ **Nuclear Data:** Curation of accurate nuclear data for space, energy, and research



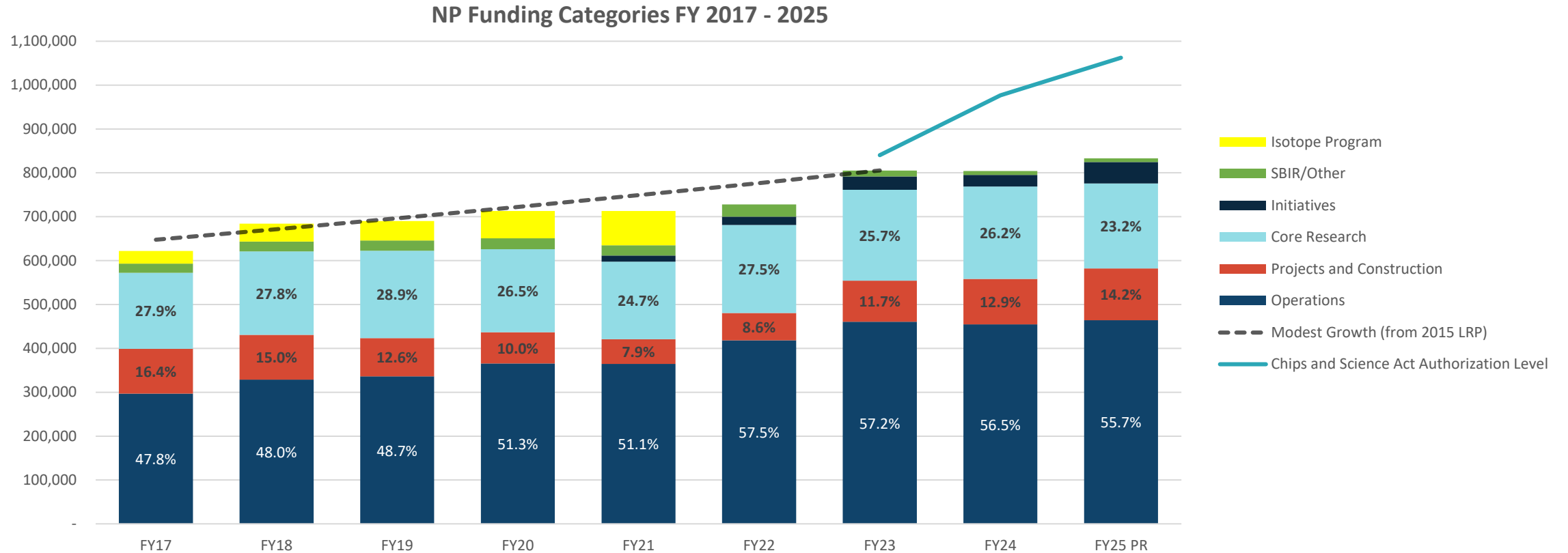
The Trend in DOE-NP Appropriations: FY 2024 appropriation (\$804M) is approximately flat with FY 2023



FY 2024 supports user facility operations at ~90% of the funding level required for full operations. Increased support of construction is focused on EIC. For research, initiative support focuses on QIS, AI/ML, RENEW, FAIR. Core research is up slightly.

Trend in DOE-NP Appropriations

FY 2025 President's Budget Request is ~\$833.1M, ~3.6% above FY 2024

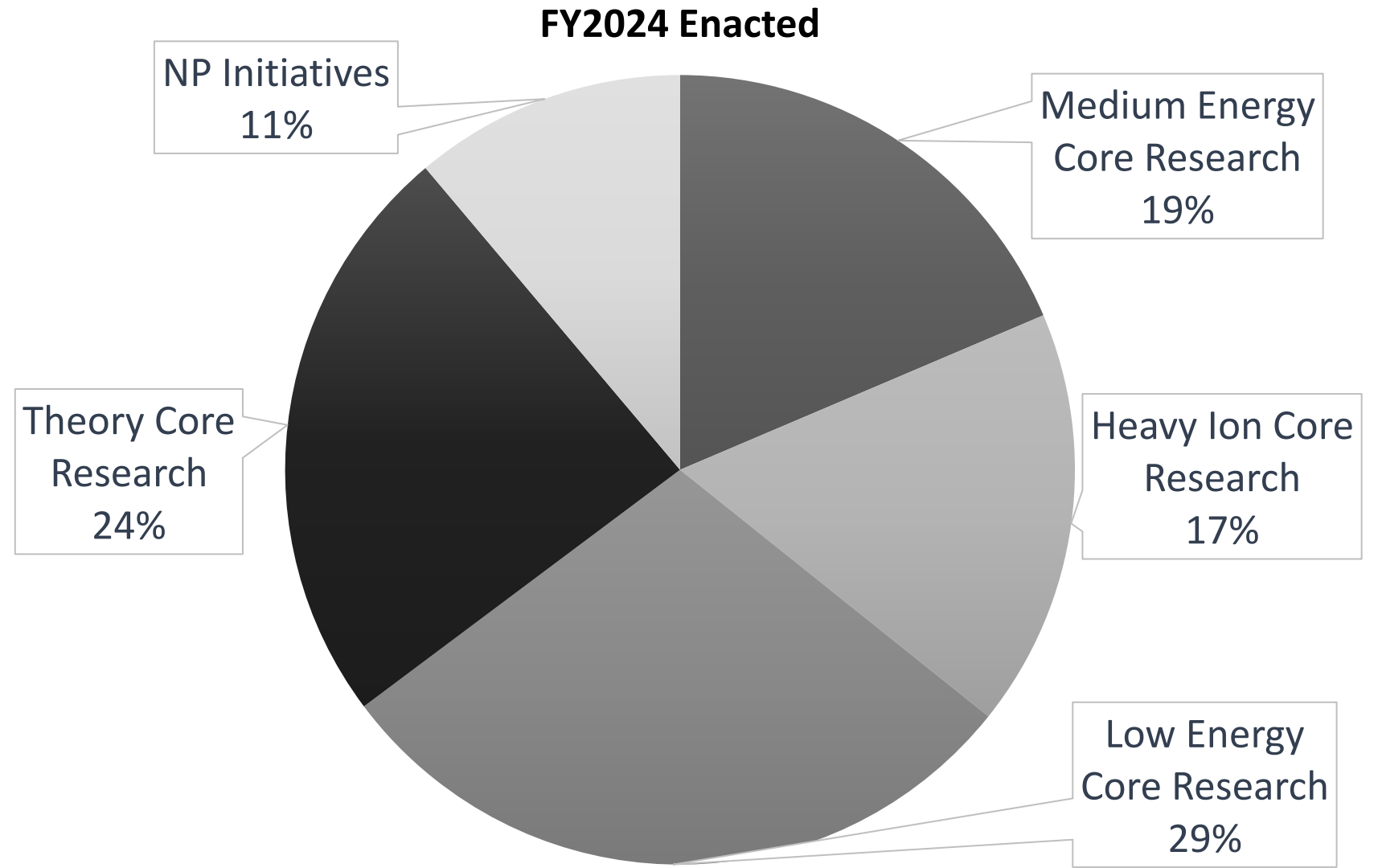


FY 2025 President's Budget Request supports user facility operations at >90% of the funding level required for full operations. Increase support for construction is focused on EIC. For research, increased initiative support (+\$23M) focuses on AI/ML, RENEW, and FAIR; Core research is down by ~\$17M.

FY 2024 NP-RD Appropriations Overview

- \$256M FY2024 Enacted

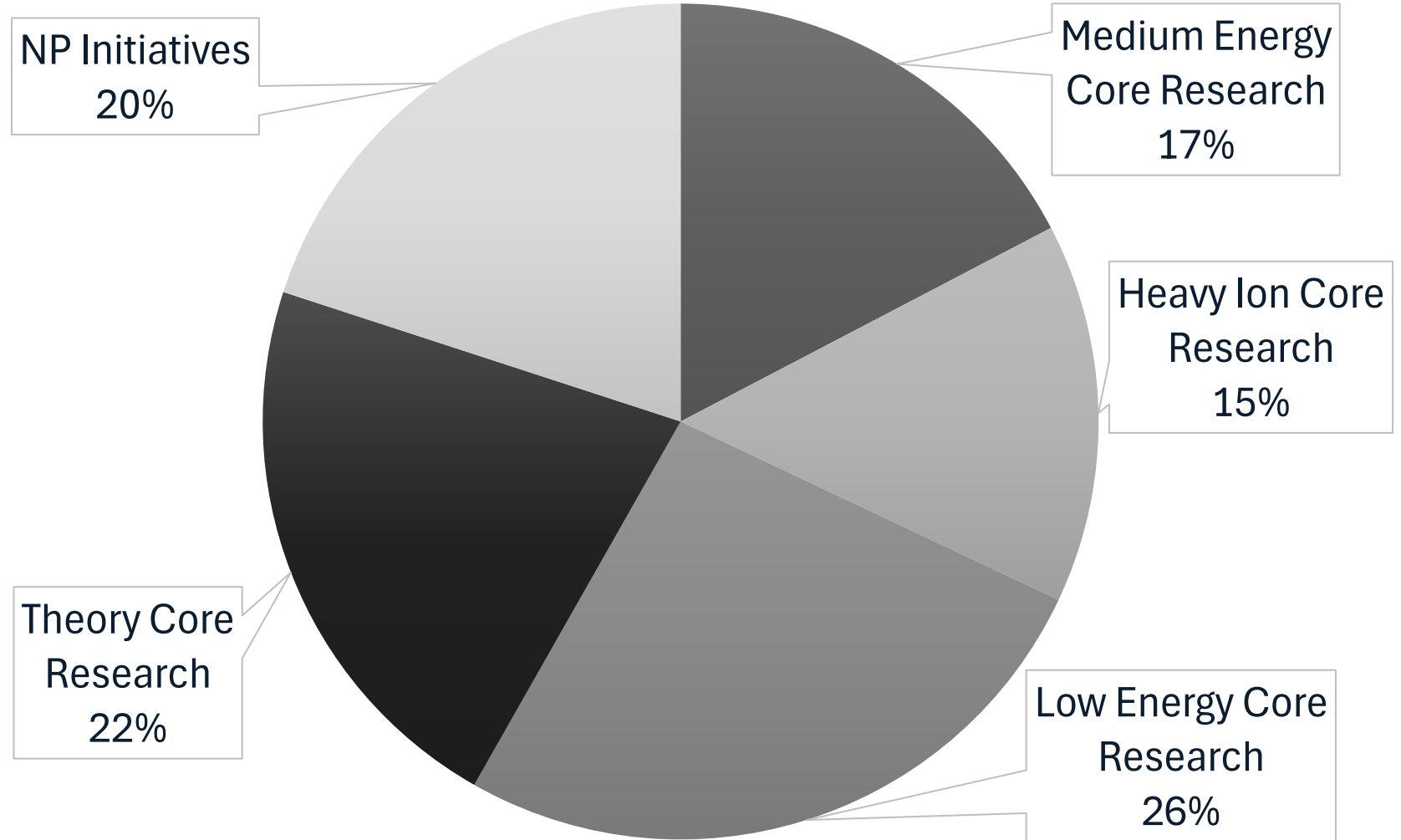
- NP Initiatives:
 - *Microelectronics*
 - *AI/ML*
 - *QIS*
 - *ACCELERATE*
 - *RENEW*
 - *FAIR*



FY 2025 NP-RD President's Budget Request Overview

FY 2025 President's Request

- \$251M FY 2025 President's Request
- Initiative investment increases (~\$23M) focus on AI/ML, RENEW, and FAIR
- Core Research will focus on highest priorities (down ~\$17M from FY 2024 Enacted)



FY 2024 Funding Opportunities/National Lab Calls

| Funding Opportunity Announcement/Lab Call | Title | Release Date | Closing Date | Estimated FY 2024 Funding |
|---|---|-------------------------------|--------------|---------------------------|
| FOA-SC-3176 | Early Career Research Program | 12/15/2023 | 4/25/2024 | ~\$8M (NP) |
| FOA-SC-3201 | EPSCoR State-Lab Grants | 12/08/2023 | 2/28/2024 | ~\$2M+ |
| FOA-3238 | Nuclear Data Interagency Working Group Research Program | 1/04/2024 | 4/04/2024 | ~\$12M (NP+NNSA) |
| FOA-3261 | Research and Development for Next Generation Nuclear Physics Accelerator Facilities | 1/22/2024 | 3/04/2024 | ~\$4M+ ~\$4M (FY 2025) |
| FOA-SC 3207 | Funding for Accelerated, Inclusive Research (FAIR) | 3/12/2024 | 7/16/2024 | ~\$2M |
| FOA-SC 3280 | Reaching a New Energy Sciences Workforce (RENEW) | 3/12/2024 Preapps due 4/30 | 7/23/2024 | ~\$6M |

Research Highlights

- ▲ First high-precision mass measurement for lightest bound Al isotope
- ▲ New mass value factor of 30 more precise than most recent result
- ▲ The result corresponds to the very small proton separation energy of 100.4(8) keV for ^{22}Al – such a small separation energy may allow for halo formation
- ▲ A measurement of the ^{22}Al charge radius now becomes critical to size up the spatial extent of the proton

PHYSICAL REVIEW LETTERS **132**, 152501 (2024)

Precision Mass Measurement of the Proton Dripline Halo Candidate ^{22}Al

S. E. Campbell^{*}, G. Bollen, B. A. Brown, A. Dockery, C. M. Ireland, K. Minamisono, D. Puentes, B. J. Rickey, R. Ringle, and I. T. Yandow

*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824, USA
and Facility for Rare Isotope Beams, East Lansing, Michigan 48824, USA*

K. Fosse

*Department of Physics, Florida State University, Tallahassee, Florida 32306, USA
and Physics Division, Argonne National Laboratory, Lemont, Illinois 60439, USA*

A. Ortiz-Cortes, S. Schwarz, C. S. Sumithrarachchi, and A. C. C. Villari
Facility for Rare Isotope Beams, East Lansing, Michigan 48824, USA



Research Highlights

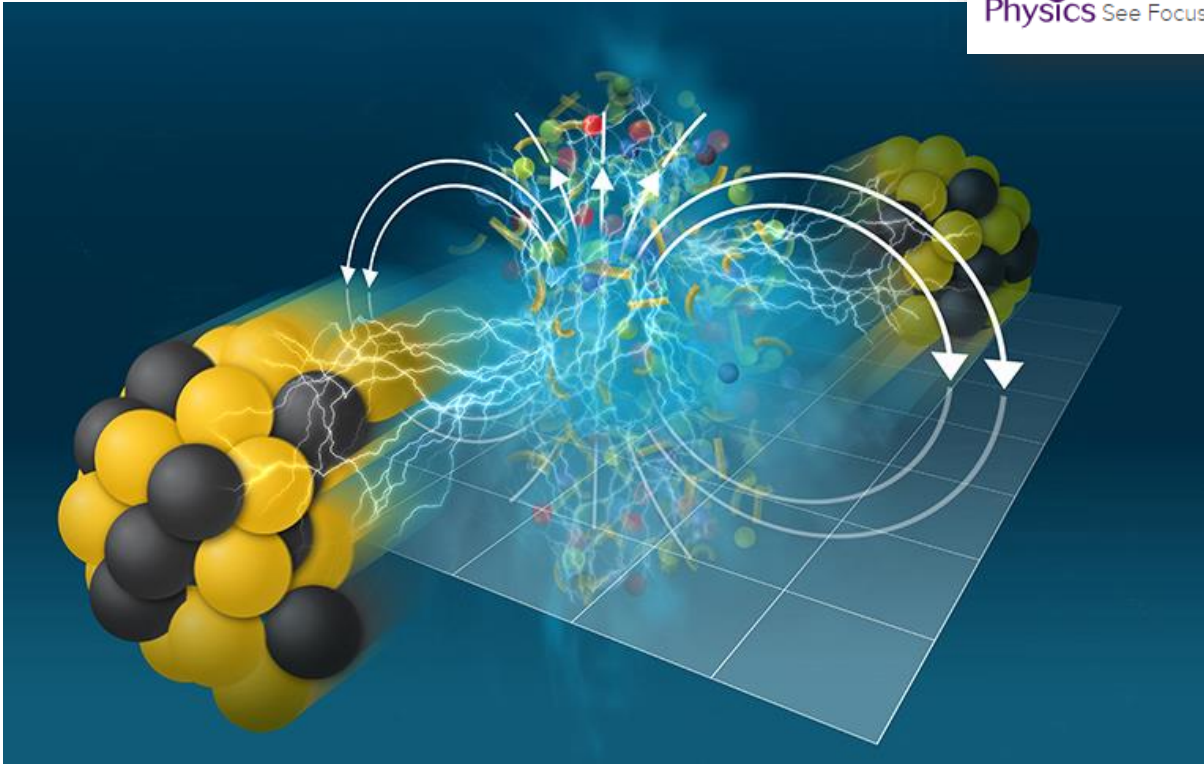
Featured in Physics

Open Access

Observation of the Electromagnetic Field Effect via Charge-Dependent Directed Flow in Heavy-Ion Collisions at the Relativistic Heavy Ion Collider

M. I. Abdulhamid *et al.* (STAR Collaboration)
Phys. Rev. X **14**, 011028 – Published 23 February 2024

PhysICS See Focus story: [Colossal Magnetic Field Detected in Nuclear Matter](#)



- ▲ Results in central collisions can be explained by transported quark effect
- ▲ Results in peripheral collisions reveal the contributions from Faraday induction and Coulomb effect for the first time in heavy-ion collisions

Research Highlights

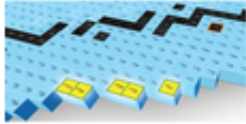
Featured in Physics

Editors' Suggestion

Observation of New Isotopes in the Fragmentation of ^{198}Pt at FRIB

O. B. Tarasov, A. Gade, K. Fukushima, M. Hausmann, E. Kwan, M. Portillo, M. Smith, D. S. Ahn, D. Bazin, R. Chyzh, S. Giraud, K. Haak, T. Kubo, D. J. Morrissey, P. N. Ostroumov, I. Richardson, B. M. Sherrill, A. Stolz, S. Watters, D. Weisshaar, and T. Zhang
Phys. Rev. Lett. **132**, 072501 (2024) – Published 15 February 2024

Physics: Five New Isotopes Is Just the Beginning



Less than a year after its opening, the Facility for Rare Isotope Beams produced five never-before-seen isotopes for observation, a success that researchers say highlights the discovery potential of the facility.

SCIENTIFIC
AMERICAN.

FEBRUARY 27, 2024 | 5 MIN READ

Weird Lab-Made Atoms Hint at Heavy Metals' Cosmic Origins

Researchers have created ultraheavy versions of elements that have never existed before on Earth



Includes researchers from RIKEN in **Japan**, IBS in **South Korea**, and MSU in the **U.S.**

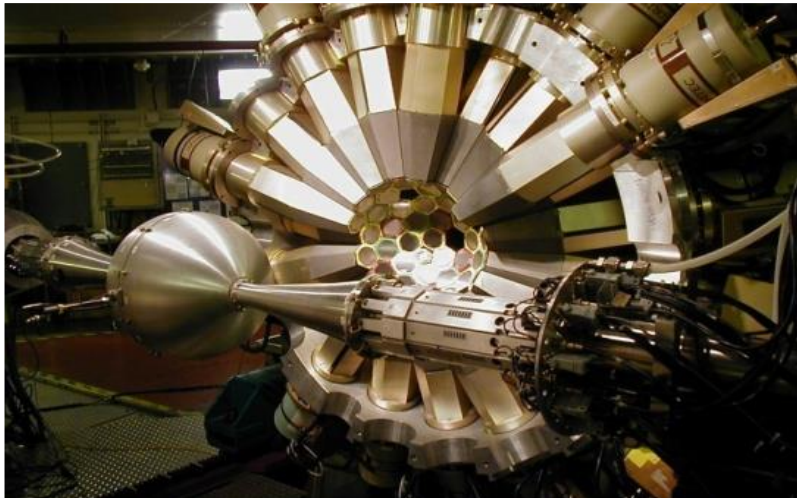
Four World-Leading National User Facilities Driving Advances



Relativistic Heavy Ion Collider



Continuous Electron Beam Accelerator Facility



Argonne Tandem Linac Accelerator System



Facility for Rare Isotope Beams

“Microscopes” with Complementary Resolving Power

NP User Facility Operations Status

| FY 2023 Enacted | FY 2024 Enacted | FY 2025 PR |
|--|--|--|
| <p>All NP user facilities operate at >90% of optimal funding in FY 2023.</p> <ul style="list-style-type: none"> ◆ RHIC operates 25 weeks (96% optimal) ◆ CEBAF operates 33 weeks (96% optimal) ◆ ATLAS operates 40 weeks (96% optimal) ◆ FRIB operates 26 weeks (99% of optimal) | <p>All NP user facilities operate at roughly 90% of optimal funding in FY 2024.</p> <ul style="list-style-type: none"> ◆ RHIC supported for 19 weeks (94% optimal) ◆ CEBAF operates 27 weeks (88% optimal) ◆ ATLAS operates 39 weeks (91% optimal) ◆ FRIB operates 24 weeks (94% optimal) | <p>All NP user facilities operate at roughly 90% of optimal funding in FY 2025.</p> <ul style="list-style-type: none"> ◆ RHIC operates 22 weeks (95% optimal) ◆ CEBAF operates 25 weeks (89% optimal) ◆ ATLAS operates 40 weeks (90% optimal) ◆ FRIB operates 26 weeks (90% of optimal) |

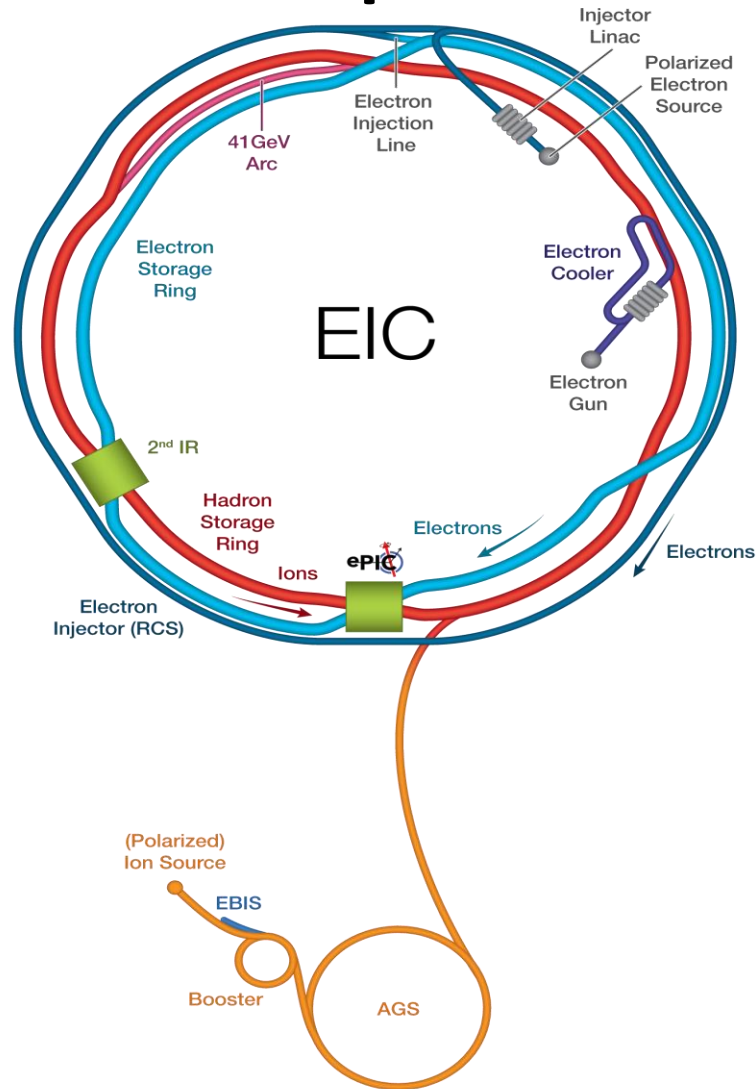
- ◆ RHIC is planning to run 25 weeks (including 6 additional weeks due to early end of Run 23) in FY 2024 focused on p+p data for sPHENIX and STAR
- ◆ CEBAF is planning to run 30 weeks in FY 2024 with the aim to complete experiments scheduled in Hall A; 3 additional weeks were added by replanning several activities in accelerator operations and experimental support
- ◆ ATLAS is planning to run 39 weeks in FY 2024; readying for the arrival of GRETINA and commissioning of the nuCARIBU driver cyclotron
- ◆ FRIB is planning to run 24 weeks in FY 2024, operating at 10 kW

NP Projects Status

| Project | Location | Status | Cost | CD-4 |
|---|----------|--------|---------------------------|---------------|
| Construction Projects | | | | |
| Electron-Ion Collider (EIC) | BNL | CD-3A | \$1.7B to \$2.8B (Est) | Q4 FY33 (Est) |
| Major Items of Equipment | | | | |
| Gamma Ray Energy Tracking Array (GRETA) ^{FF} | LBNL | CD-2/3 | \$58.3M (TPC) | 3/2028 |
| Measurement of Lepton-Lepton Electroweak Reactions (MOLLER) ^{FF} | TJNAF | CD-3A | \$45.8M to \$56.6M (Est) | Q2 FY28 (Est) |
| High Rigidity Spectrometer (HRS) | MSU | CD-1 | \$85.0M to \$111.4M (Est) | Q2 FY29 (Est) |
| Ton Scale Neutrinoless Double Beta Decay (TS-NLDBD) Program | TBD | CD-0 | \$215M to \$250M (Est) | TBD |

| FY 2023 Enacted | FY 2024 Enacted | FY 2025 PR |
|--|---|--|
| EIC at TEC of \$50M and OPC of \$20M GRETA at optimal level, providing the project with the final year of funding (\$15.5M) MOLLER receives the final \$4M of planned TEC funding TS-NLDBD at \$1.44M TEC HRS at \$3M TEC | EIC at TEC of \$95M and OPC of \$2.9M GRETA and MOLLER received full TPC amount in FY23 Request. Progress continues, but no new funding requested in FY24. TS-NLDBD at \$3M TEC HRS at \$3M TEC | EIC at TEC of \$110M and OPC of \$2.9M GRETA and MOLLER received full TPC amount in FY23 Request. Progress continues, but no new funding requested in FY25. TS-NLDBD at \$2M TEC HRS at \$3.3M TEC |

Top Priority for New Facility Construction in the 2023 Long Range Plan: Expedient Completion of the Electron-Ion Collider



The EIC will be the most advanced accelerator in the world and the only new collider built for decades. It will maintain US leadership in accelerator physics.

Status:

- CD-3A approved March 2024
 - ~\$90M in procurements to reduce technical risk
- Project continues to support preliminary engineering & design and execution of long lead procurements
- Pursuing additional long lead procurements (CD-3B) followed by CD-2

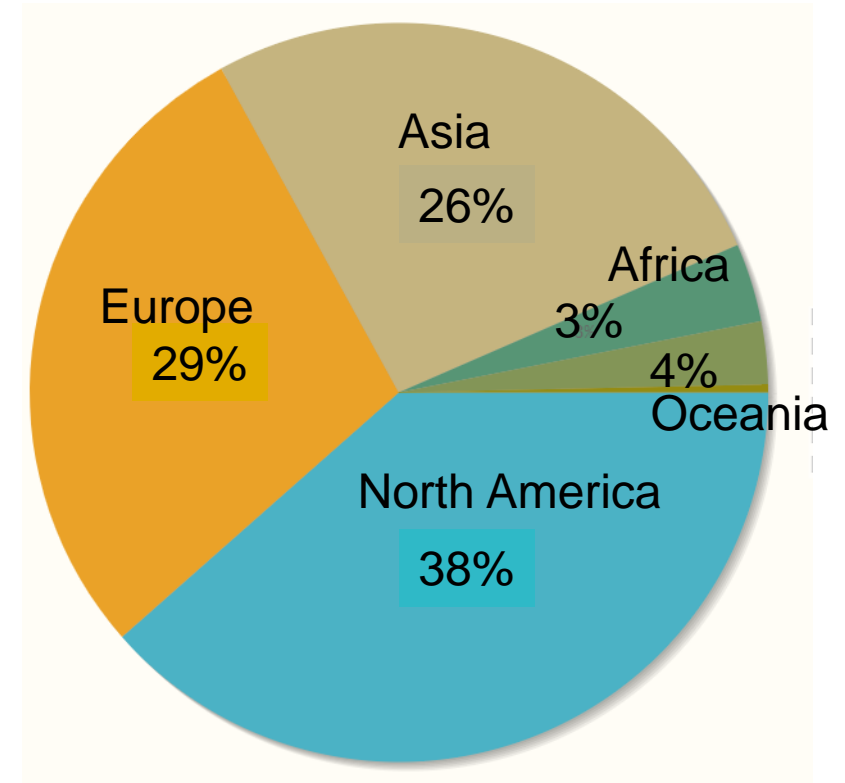
The Electron-Ion Collider is International at its Core

EIC Users Group Formed in 2016

EICUG.ORG

Status April 2024:

- ◆ Collaborators **1491**
- ◆ Institutions **291**
- ◆ Countries **40**



International Contributions to the Electron-Ion Collider

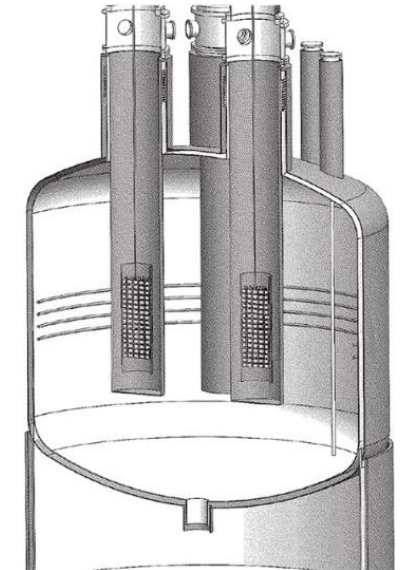
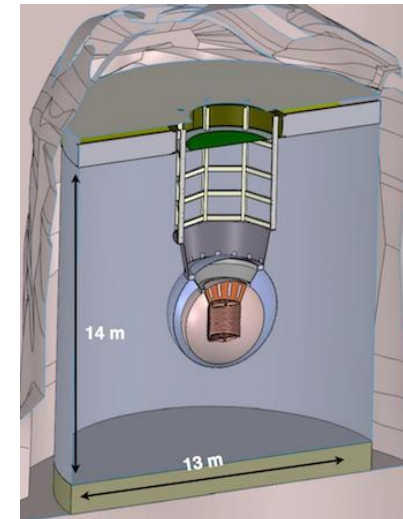
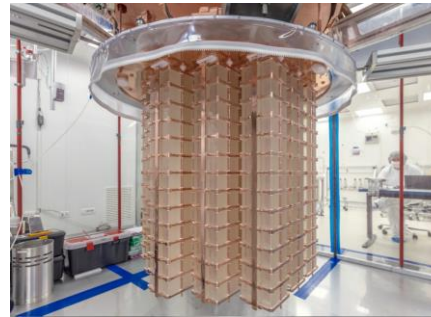
- ◆ The EIC Project is envisioning international contributions to the EIC detector of approximately \$100M, and contributions to the accelerator of approximately \$50M
 - 100% of these contributions have been notionally identified by international partners and interest continues to grow
- ◆ Two entities established to coordinate EIC in-kind contributions
 - EIC Advisory Board – Meets quarterly and provides guidance and advice to the BNL Director on the design and construction of the EIC accelerator facility and on the efforts to establish partnerships with institutions collaborating on the facility
 - EIC Resource Review Board (RRB) – Meets twice per year and provides coordination among the different funding partners during both the detector development and construction phase of the project and during the operations of the experiments that follow

Top Priority for New Experiment Construction in the 2023 Long Range Plan for Nuclear Science: Neutrinoless Double Beta Decay

- ◆ Between IRA funding and NP Program Funding, ~\$20M has been allocated since 2020 to explore three technologies: LEGEND 1000, nEXO, and CUPID; supporting conceptual design and R&D
- ◆ Additional resources provided by international partners
- ◆ Inability to procure isotopes from countries of concern is having a severe impact
- ◆ A 3rd DBD international summit is being planned for spring 2025
- ◆ A working group has been established and charged with defining an organizational framework for a Virtual Global DBD Observatory

Three Proposed Technologies

- ◆ Scintillating bolometry (**CUPID**, ^{100}Mo enriched Li_2Mo_4 crystals)
- ◆ Enriched ^{76}Ge crystals (**LEGEND-1000**, drifted charge, point contact detectors)
- ◆ Liquid Xenon TPC (**nEXO**, light via SiPM, drifted ionization)



Potential Partners:
Italy, Canada, and Germany

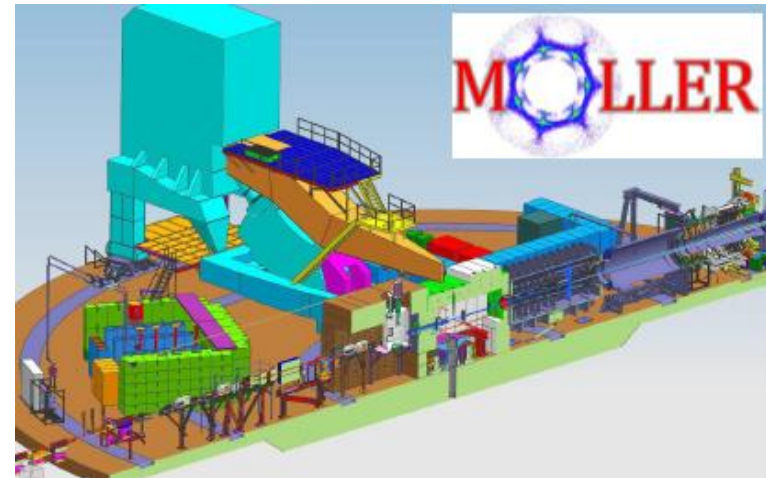
Status of other MIE Projects

Gamma Ray Energy Tracking Array (GRETA)



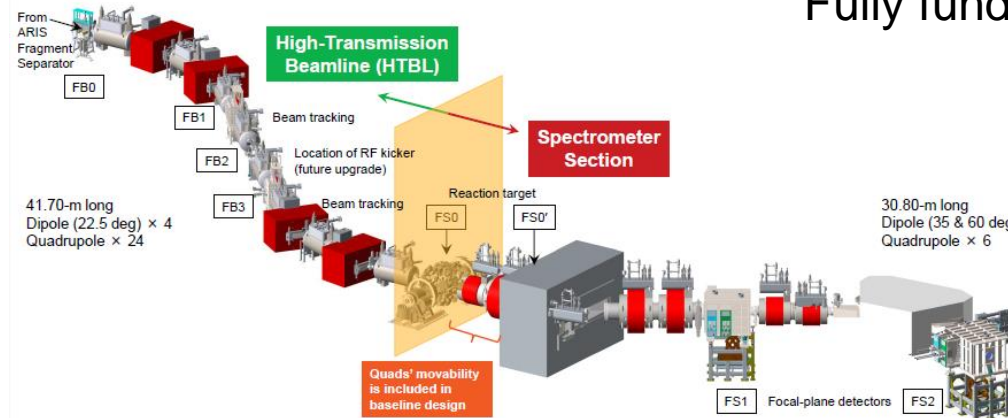
Fully funded; CD-4A forecast: Q3 FY 2025

Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER)



Fully funded; CD-2/3 forecast: Q3 FY 2024

High Rigidity Spectrometer (HRS)



High-Transmission Beamline
CD-2/3 forecast: Q1 FY 2025

International Engagement Activities

◆ Recent Events

- DOE-CEA (France) Statement of Interest on EIC collaboration signed (November 13, 2023)
- Kickoff meeting of the CNRS-MSU International Research Lab (December 11-13, 2023)
- DOE-IN2P3 (France) Statement of Interest on EIC collaboration signed (February 1, 2024)
- NP-MEXT (Japan) science division meeting (February 28, 2024)
- **UKRI announces £58.8M award to support EIC construction (March 27, 2024)**
- NP-CNRS (France) program meeting (April 8, 2024)
- Meeting with Minister of University and Research of the Italian Republic (April 9, 2024)
- NP-INFN (Italy) bilateral meeting (April 11, 2024)
- EIC Advisory Board (April 19, 2024)
- CERN RRB (April 22-24, 2024)

◆ Upcoming Events

- **EIC RRB (May 6-7, 2024)**



CNRS-MSU kickoff meeting attendees

The New NP Long Range Plan: A New Era of Discovery

Capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States. We must draw on the talents of all in the nation to achieve this goal.

We reaffirm the exceptionally high priority of the following two investments in new capabilities for nuclear physics. The Electron–Ion Collider (EIC), ...will elucidate the origin of visible matter in the universe and significantly advance accelerator technology... Neutrinoless double beta decay experiments have the potential to dramatically change our understanding of the physical laws governing the universe.

As the highest priority for new experiment construction..., lead an international consortium that will undertake a neutrinoless double beta decay campaign.

We recommend the expeditious completion of the EIC as the highest priority for facility construction.

Capitalize on the unique ways nuclear physics can advance discovery science and applications for society.



Later Today: NSAC Facilities Charge: Assessment of Science and Readiness for Construction for NP Projects (pre-CD-2, >\$100M)

List of projects provided by NP for consideration by the subcommittee:

- ◆ Electron-Ion Collider (EIC)
- ◆ High Rigidity Spectrometer (HRS)
- ◆ Ton Scale Neutrinoless Double Beta Decay (TS-NLDBD)
 - Large Enriched Germanium Experiment for NLDBD (LEGEND-1000)
 - Next Enriched Xenon Observatory (nEXO)
 - Cryogenic Underground Observatory for Rare Events with Particle Identification (CUPID)
- ◆ Project 8
- ◆ FRIB Energy Upgrade (FRIB400)
- ◆ Solenoid Large Intensity Device (SoLID)
- ◆ EIC Detector II