High Energy and Nuclear Physics (HENP) 101

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U.S. DEPARTMENT of ENERGY | Office of Science

Energy.gov/science

Office of High Energy Physics at a Glance

FY 2026 Enacted: $1.235B

As the largest funder of particle physics in the U.S. (**~85%**), HEP also supports international experiments in Canada, Chile, Japan, and Switzerland

Funding at **12** DOE National Labs, and **>175** Academic Institutions, Small Businesses, Non-Profits, and Other Federal Agencies

Snowmass 2022

1,003 Ph.D. Scientists and
448 Grad Students Supported

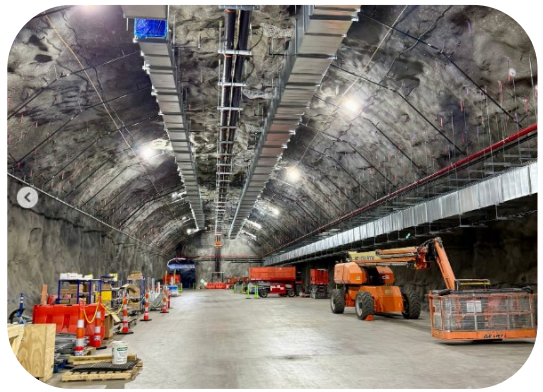
HEP supports **3** SC User Facilities and **2387** Users at BNL, FNAL, and SLAC

~30% of Research to Universities

Research: **35%, $430.6M**

VCR Operations in Chile

Facility Operations: 32**%, $392.1M**



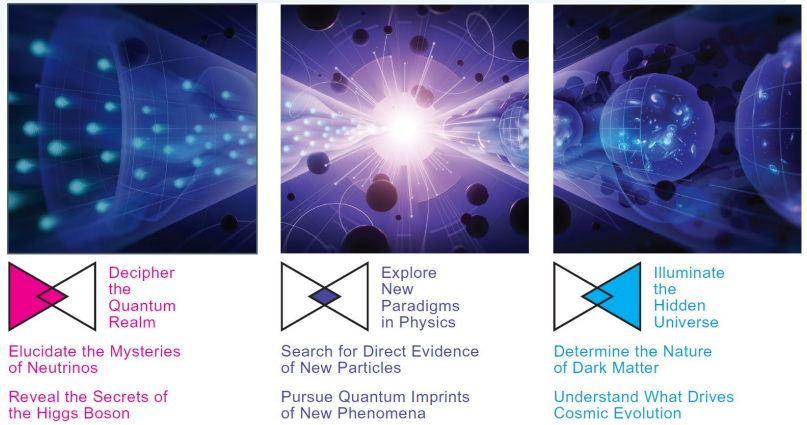
Outfitting of DUNE caverns at SURF for first far detector cryostat

Projects: **33%, $412.4M**

HEP research answers fundamental questions while developing breakthrough technologies

Particle Physics Research

- High Energy Physics explores what the world is made of and how it works at the smallest and largest scales, seeking new discoveries from the tiniest particles to the outer reaches of space.



Accelerator Research and Stewardship

- HEP develops new accelerator, detector, and computational tools to open new doors to discovery science,
- Through Accelerator Stewardship, HEP works to make transformational accelerator technology widely available to science and industry.

Emerging Technology Research

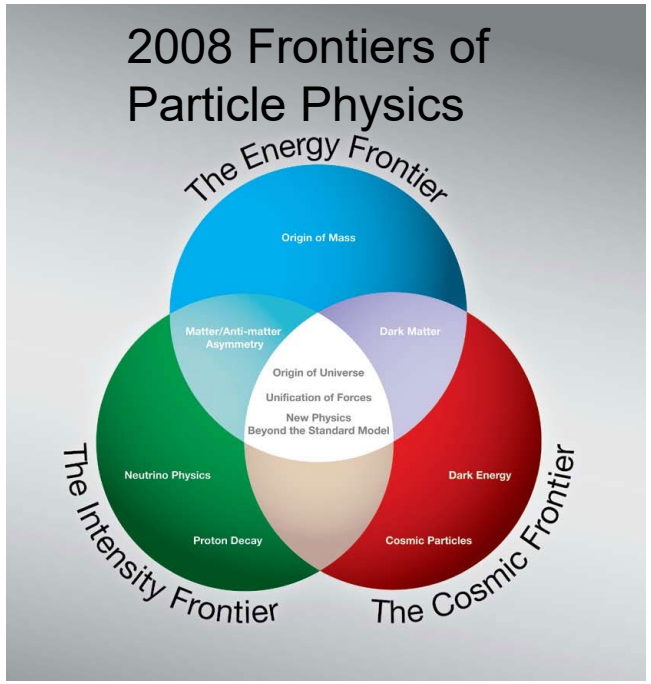
HEP research is inspired by some of the biggest questions about our universe.

- Finding these answers requires development of state of the art detectors using cutting edge technologies

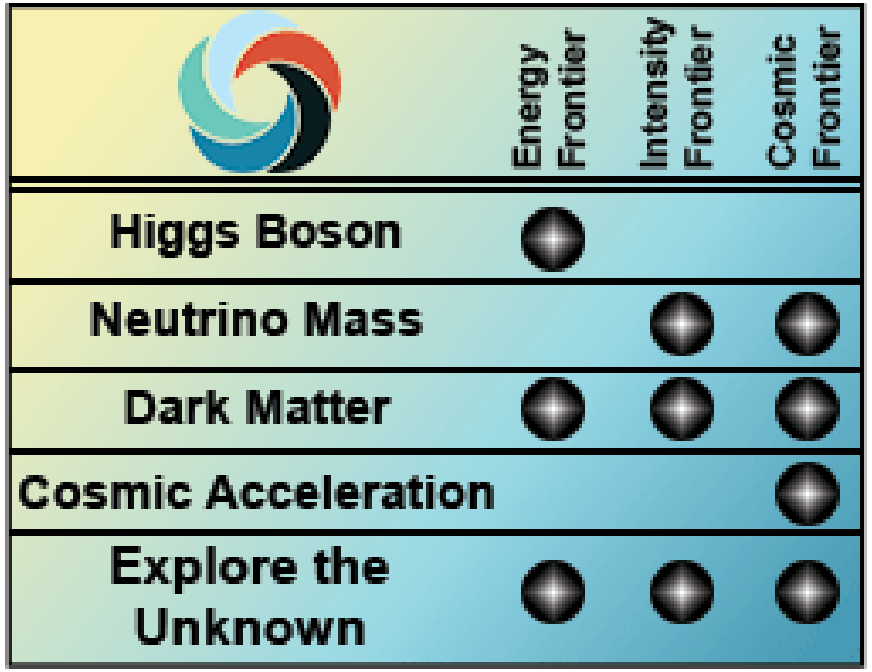
- Technology development inspires young minds, trains an expert workforce, and drives innovation that improves the nation's health, wealth, and security.

U.S. Particle Physics roadmap comes from a Strategic Planning Process

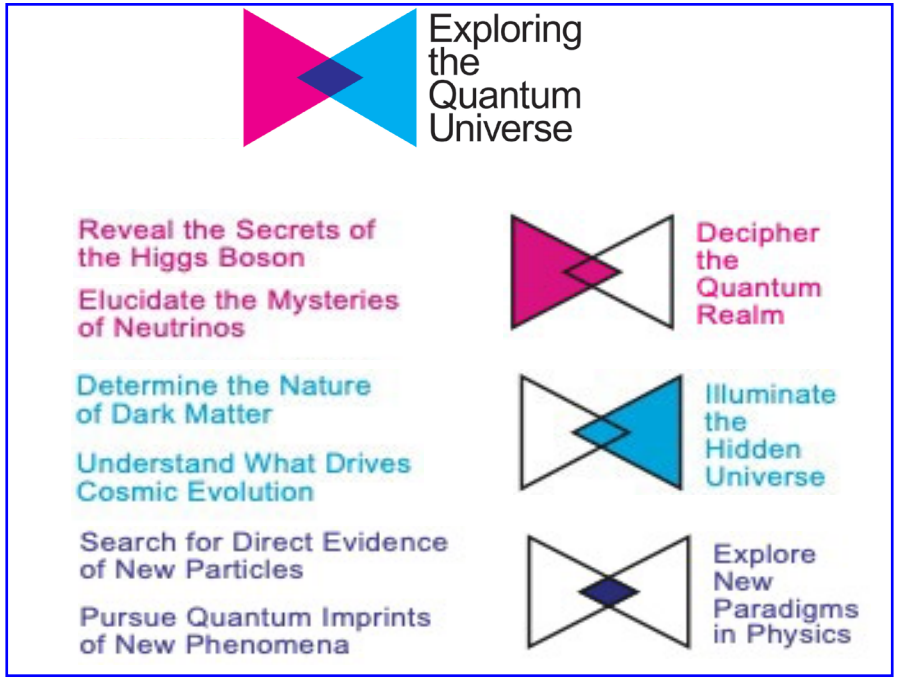
2008 Frontiers



2014 Science Drivers

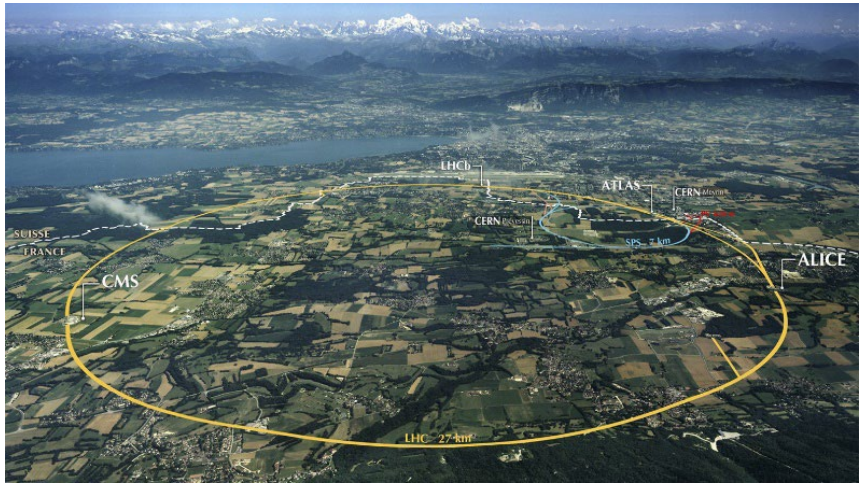


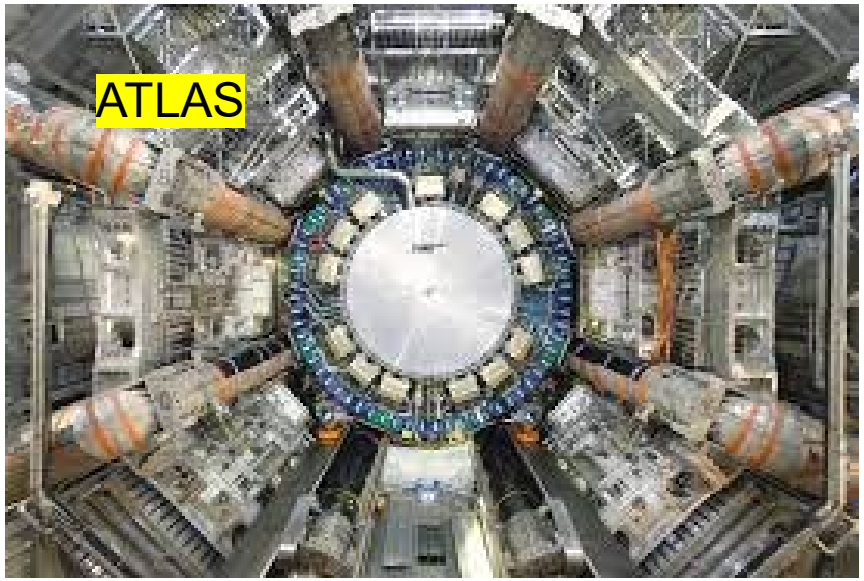
2023 Science Drivers

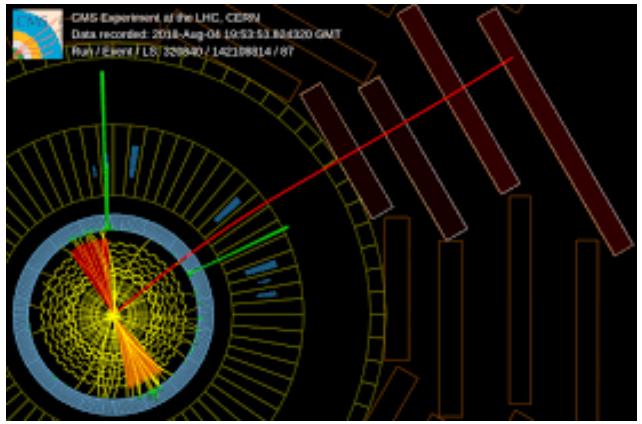


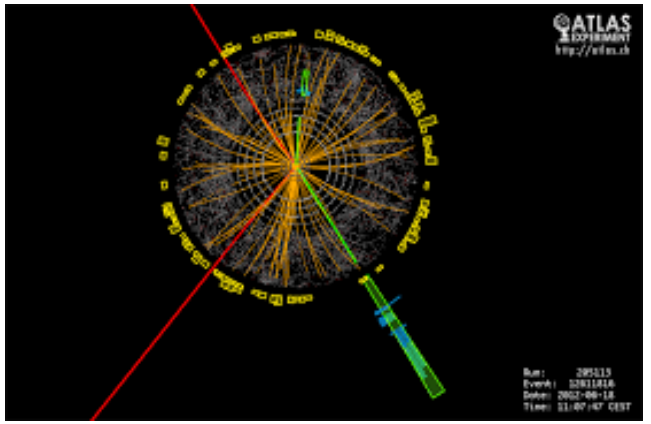
Energy Frontier: Large Hadron Collider experiments

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●



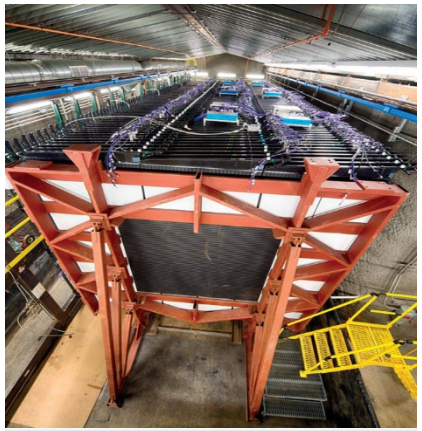






Intensity Frontier Experiments

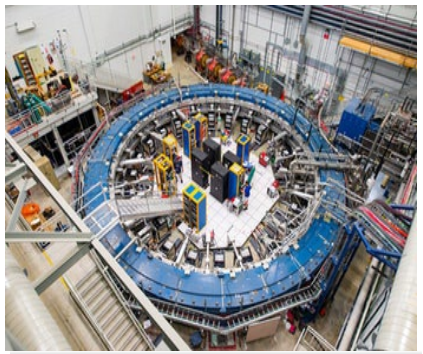
	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●



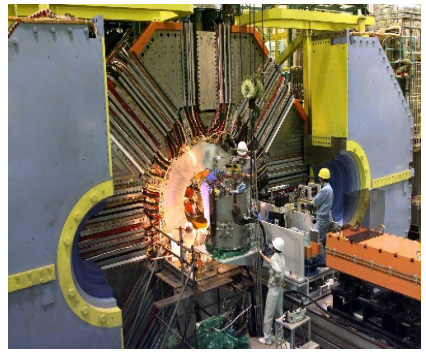
NOvA at Fermilab and Ash

ICARUS at Fermilab

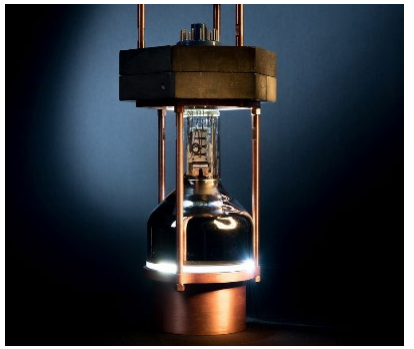
Mu2E at Fermilab



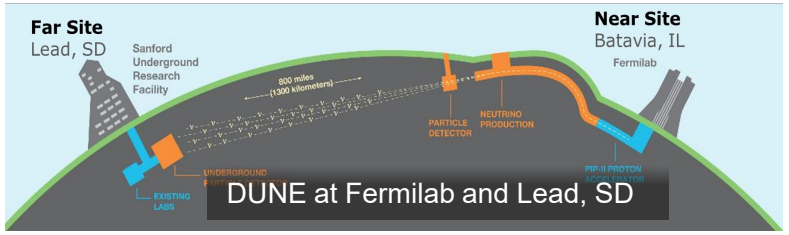
Muon g-2 at Fermilab



Belle II at KEK, Japan



COHERENT at ORNL

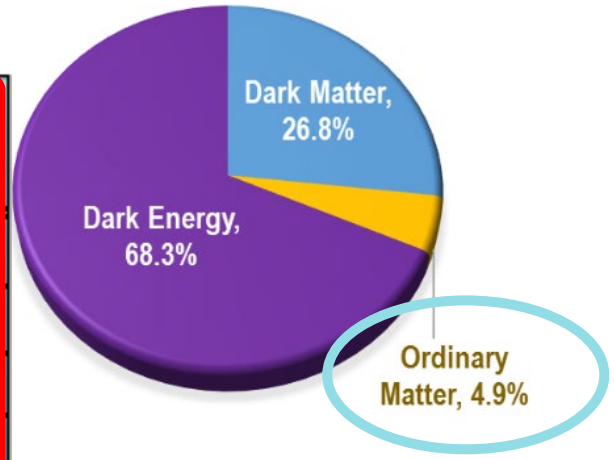


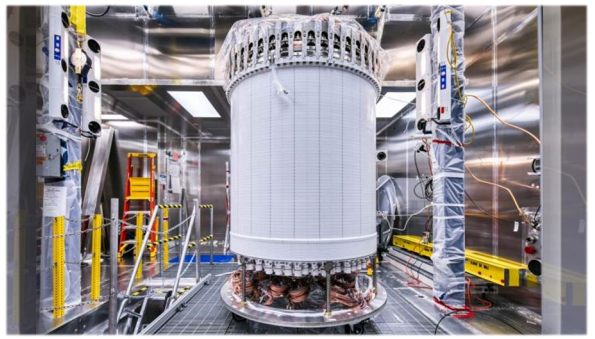
DUNE at Fermilab and Lead, SD

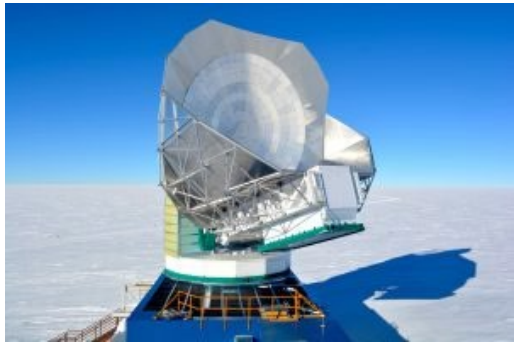
Cosmic Frontier Experiments

Cosmic Frontier experiments address four of five science drivers.
They use naturally occurring sources to determine the fundamental nature of matter, energy, space and time.

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●







Partnerships w/NSF (PHY, AST, OPP) NASA (AST, ISS, CLPS)

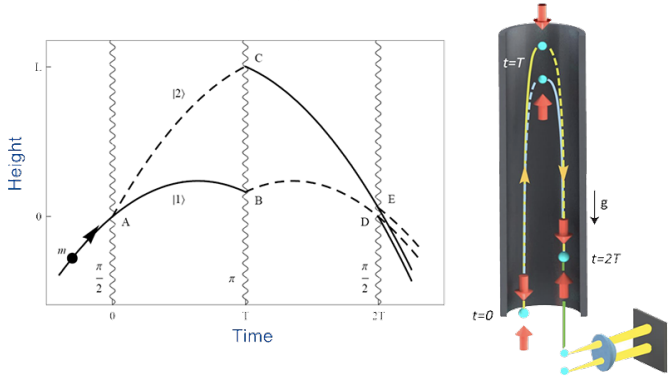
HEP in Quantum Information Science

National QIS Research Centers:

- **SQMS (Fermilab):** Developing superconducting quantum technologies for scalable computing and HEP-specific sensing and computing targets.
- **Q-NEXT (Argonne):** Quantum networking and integration across heterogeneous devices; applying entanglement-enhanced sensing across a range of distances for gravitational physics.

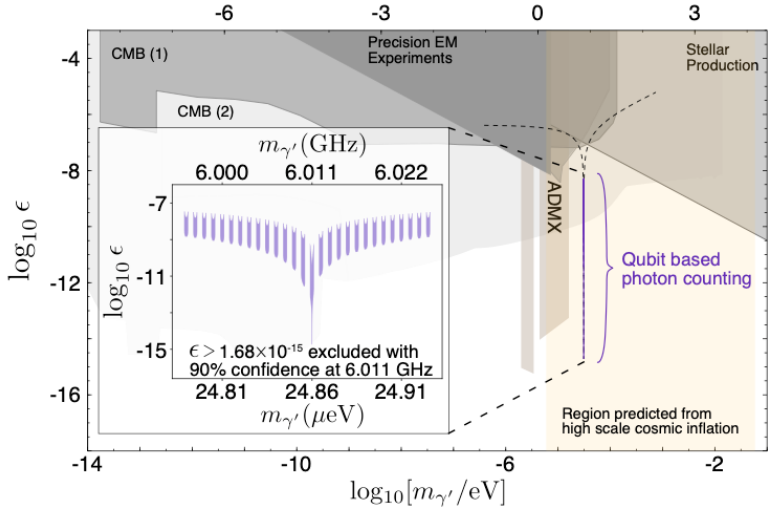
MAGIS-100

Sensing. World record search for dark photon dark matter using qubit readout to reduce noise nearly 16 dB below SQL



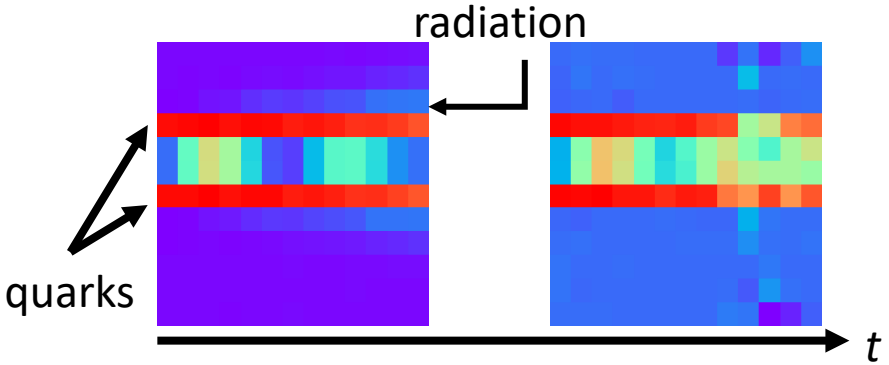
Building and operating a world-record 100m atomic interferometer at Fermilab enabling new dark matter and gravitational wave searches.

Quantum Information Science Enabled Discovery (QuantISED)



A. V. Dixit, et al., Phys.Rev.Lett. 126 (2021) 14, 141302

Computing. Simulation of radiating meson in a 1+1D lattice; new computational methods reducing estimated quantum resources required by as much as 10^{19} (arXiv:2503.11888).

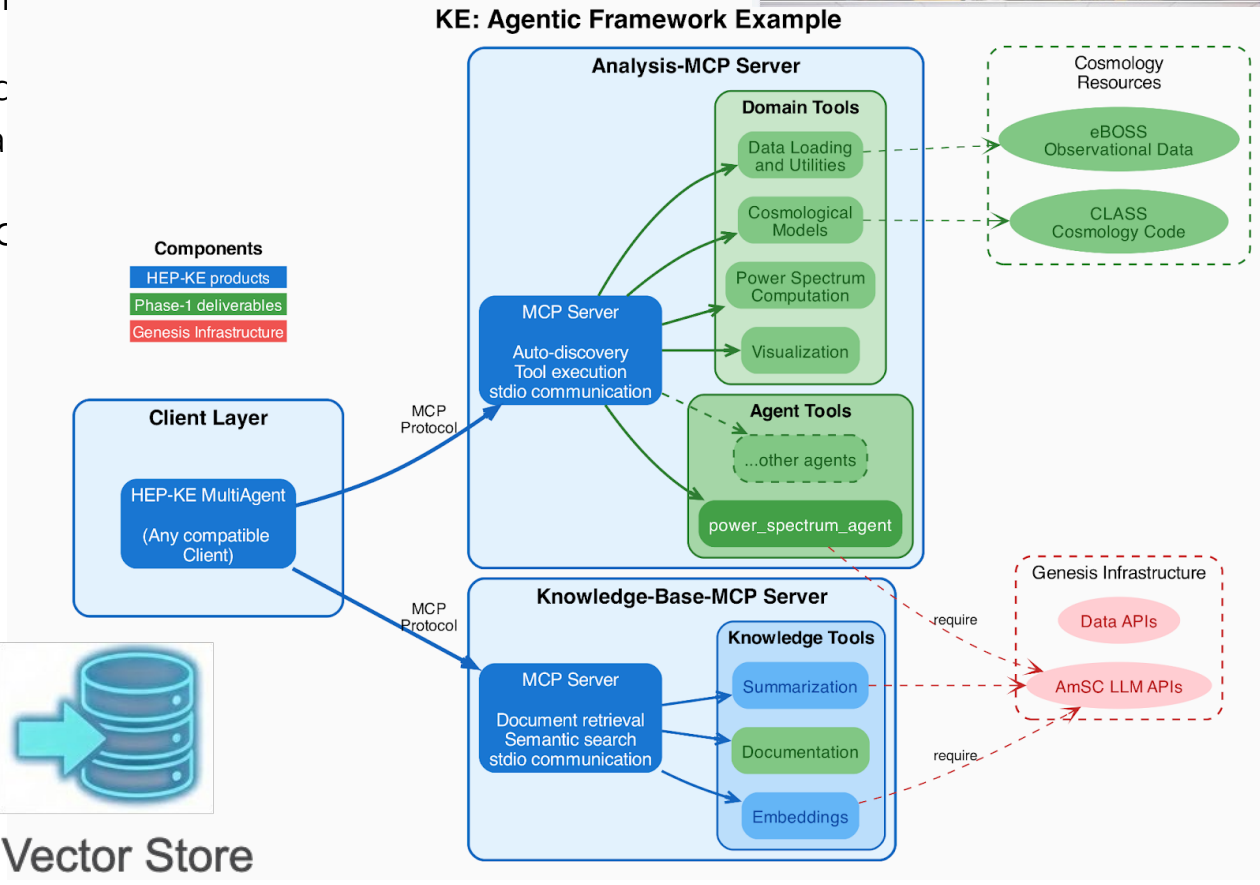


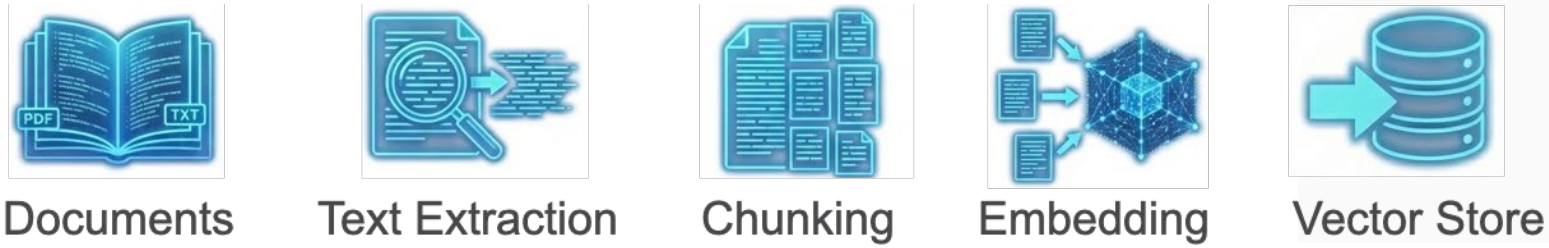
(Left) Classical and (right) quantum [104 qubits, IBM Heron] simulation of a radiating meson in a 1+1D lattice.

Phys. Rev. D 111, 054501

Genesis Mission and High Energy Physics

- HEP's unique expertise plays a key role in the Genesis Mission
  - ***The Genesis Mission Platform:*** integrate cutting edge technologies in experiment's large collaborative efforts and partner to ensure the computing ecosystem can deliver HEP discovery science
    - As Infrastructure Partners use experience to further AI an
      tools along the road to widespread deployment
    - Through Pilot Intelligent Data Activities curate AI-ready c
    - Through Seedling Model Teams develop AI tools that ca
      fundamental constituents of the universe
  - **Genesis Mission National Challenges:** HEP is advanc
    emerging technologies and fundamental science of national interest:
    - Discovering Quantum Algorithms with AI
    - Realizing Quantum Systems for Discovery
    - Recentering Microelectronics in America
    - Enhancing Particle Accelerators for Discovery
    - Unifying Physics from Quarks to the Cosmos





HEP: Facility Operations

Sanford Underground Research Facility

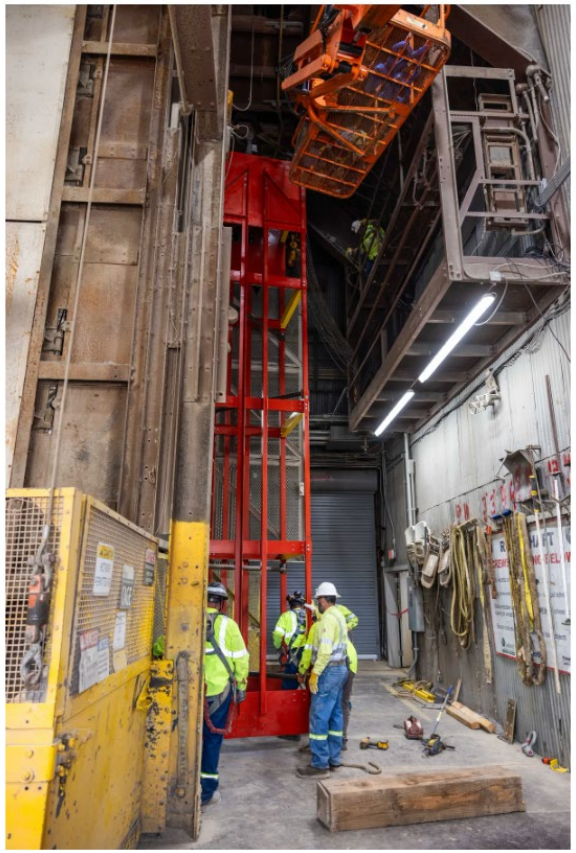
- South Dakota Science and Technology Authority (SDSTA) cooperative agreement which supports basic services and critical infrastructure
- Future home of the DUNE far detectors still under construction, and current location to a variety of underground science including dark matter, geology, and biology.
- Funding will support ongoing modernization efforts.

NSF-DOE Vera C. Rubin Operations

- DOE and NSF jointly operate the Rubin Observatory in Chile, with SLAC managing DOE's responsibilities, including the U.S. Data Facility that processes and serves data to researchers, the world's largest 3.2-gigapixel LSST Camera, and top management roles.
- Rubin is moving towards steady-state operations in its 2nd year. AI/ML will optimize efficiency and discoveries in dark energy research.

U.S. LHC Detector Operations

- Supports the maintenance of U.S.-supplied components of the ATLAS and CMS detectors at CERN, and the U.S.-based computer infrastructure used to analyze LHC data.



A 60-foot-high skip cage was installed at SURF to transport 45-foot steel I-beams 4850 feet underground for the DUNE experiment. These beams form part of DUNE's five-story cryogenic detectors, designed to hold 17,000 metric tons of super-chilled liquid argon, with all components needing to fit the shaft's limited dimensions.

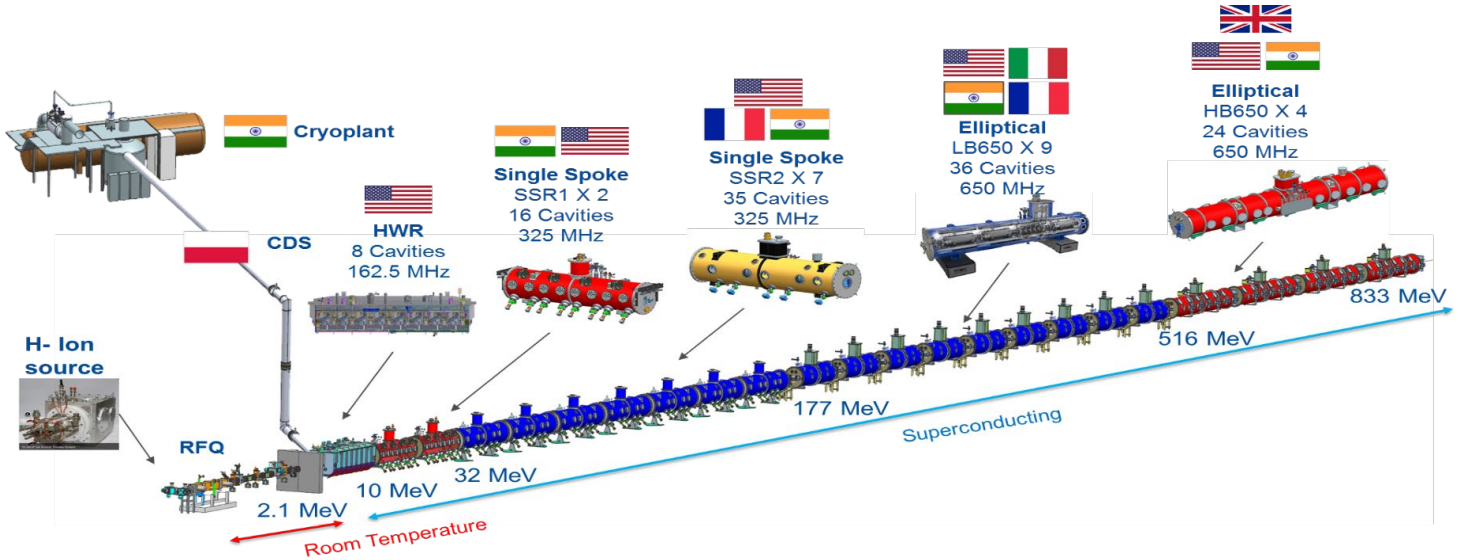
HEP Construction Projects

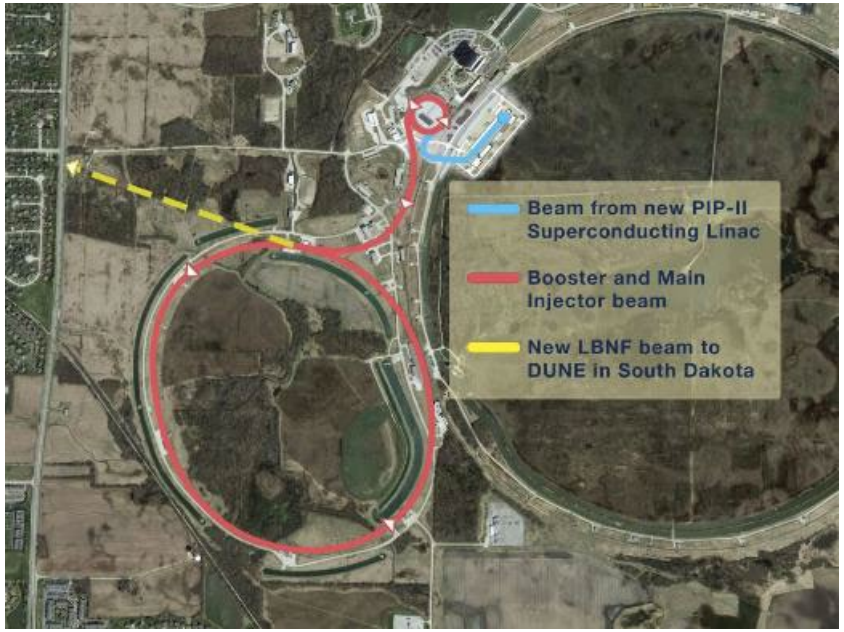
Project	Location	Current CD	Project Cost	Next CD	CD-4 baseline date
Mu2e	**FNAL**	CD-3	$316M	CD-4	Q2FY28
PIP-II	**FNAL**	CD-3	$978M	CD-4 (Q2FY30)	Q1FY33
HL-LHC AUP	**FNAL**	CD-3	$266M	CD-4 (Q1FY28)	Q1FY30
HL-LHC ATLAS	**BNL**	CD-3	$200M	CD-4 (Q3FY29)	Q1FY31
HL-LHC CMS	**FNAL**	CD-3	$200M	CD-4 (Q4FY29)	Q1FY31
LBNF/DUNE: FSCF-EXC	**FNAL**	CD-3	$644M	CD-4	Q4FY26
LBNF/DUNE: FSCF-BSI	**FNAL**	CD-3	$211M	CD-4	Q4FY28
LBNF/DUNE: FDC	**FNAL**	CD-3c	$1119M	CD-2/3 (FY26 Q3)	Q1 FY33
LBNF/DUNE: NSCF +Beam	**FNAL**	CD-3a	$1103M	CD-2/3 (FY27)	Q1 FY32
LBNF/DUNE: ND	**FNAL**	CD-1RR	$200M	CD-2/3 (FY27)	Q1 FY35

5 sub-projects

PIP-II Construction Project

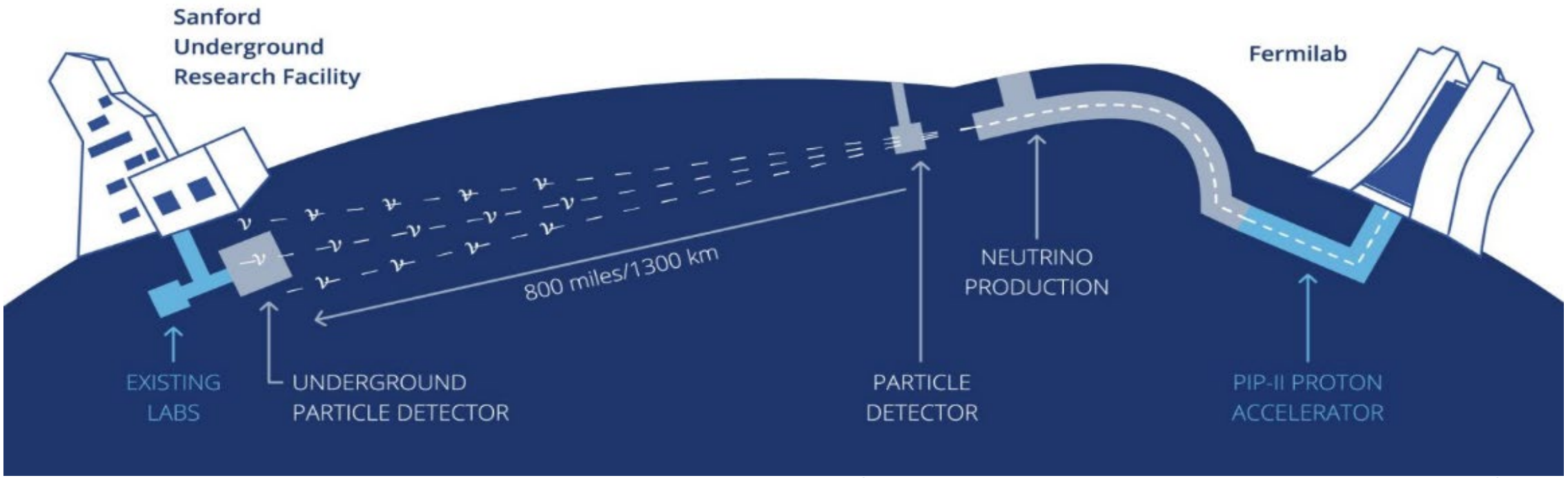
- New Superconducting Linac will replace Fermilab's 50-year-old front-end infrastructure, increasing beam power, energy, reliability, flexibility and upgradability.
- Extends Fermilab's leadership with world's most intense neutrino beam for long baseline experiment and other scientific opportunities.
- DOE Total Project Cost = $978 M
  - CD-3 4/18/2022 Approved Start of Construction
  - CD-4 1Q FY 2033 Forecast for Project Completion





LBNF/DUNE Construction Project

U.S. Project Scope Delivered at Two Sites through Six Subprojects



Three subprojects

- **FSCF-EXC** – Far Site Excavation
- **FSCF-BSI** – Far Site Building & Site Infrastructure
- **FDC** – Far Detectors and Cryogenic Infrastructure

~~Two~~ → Three subprojects

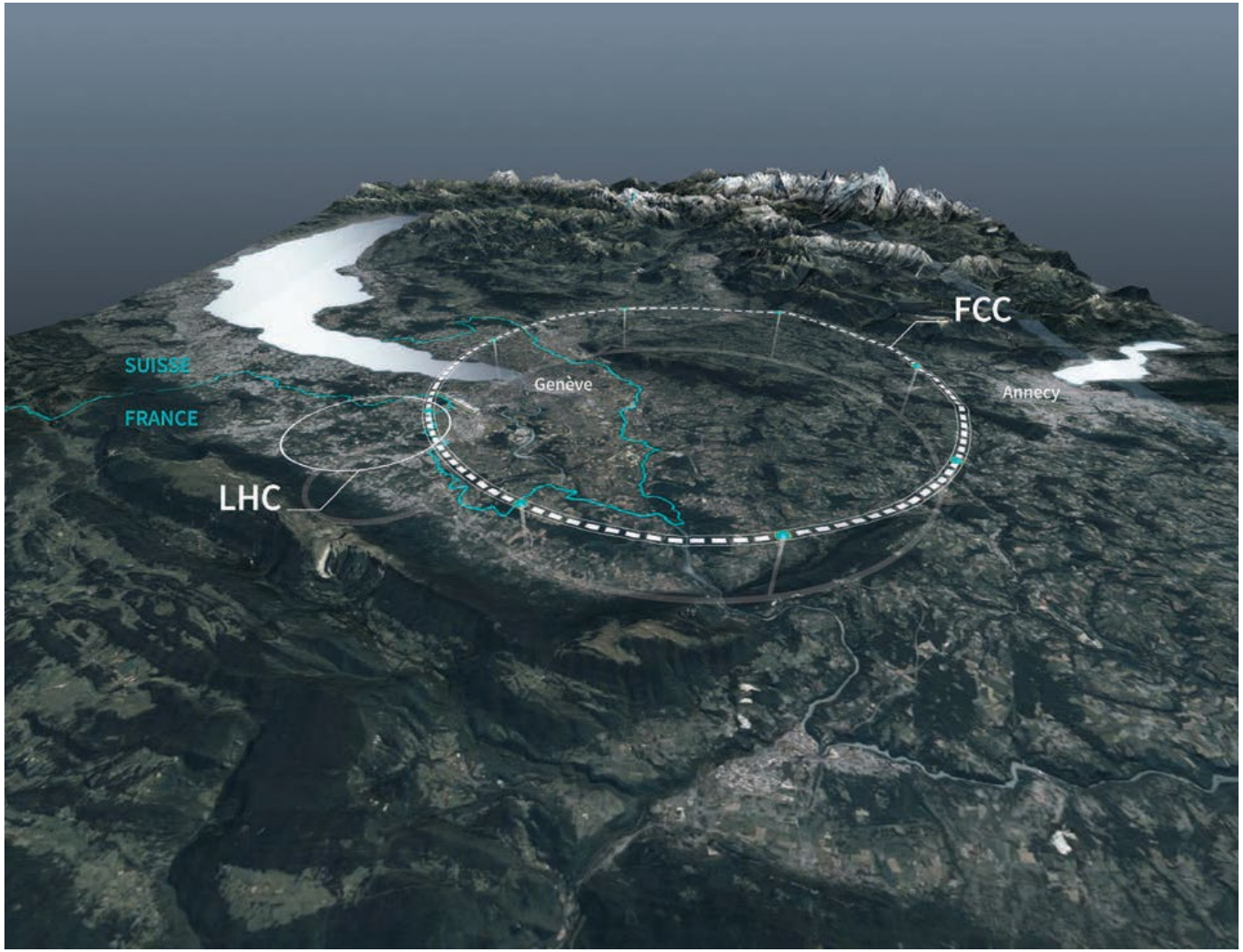
- **NSCF** – Near Site Conventional Facilities
- **B** – Beamline
- **ND** – Near Detectors

Currently together

Largest **DOMESTIC** project in Office of Science (TPC = $3.3B)

Future Circular Collider @ CERN

- 90 km circumference tunnel
- 1st use as an e+/e- collider to make precision measurements of Higgs
- Future use is a proton-proton collider to achieve ~100TeV collisions (10TeV parton center of mass)
  - Requires significant investment in high field magnet technology



Office of Nuclear Physics at a Glance

Mission: Discover, explore, and understand all forms of nuclear matter.

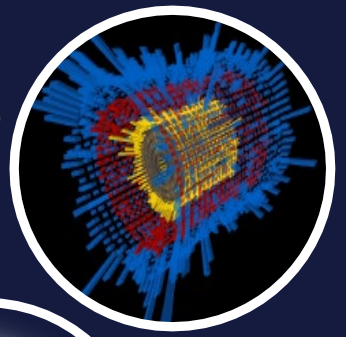
Seeks to understand **subatomic matter**, including exotic matter inside neutron stars and in the early days of the universe, **and how that knowledge can benefit society (critical technologies, medicine, and national security)**.

Largest supporter (>95%) of U. S. nuclear physics research

FY 2026 Enacted $866.141M

Supports over **1,400 Ph.D. staff** and **720 graduate students**

FY 2026 Research: 23%



Stewardship of **4** SC User Facilities**: ATLAS**, **CEBAF**, and **FRIB**, and **RHIC**

FY 2026 Operations: 57%

>4,000 users annually

In construction: Electron-Ion Collider will probe the inside of the proton

FY 2026 Construction: 20%

Nuclear Physics – Foundational Science of Matter

- More than 99 percent of the visible mass in the universe is nuclear matter. Protons and neutrons are the building blocks of atomic nuclei – their interactions are governed by the strong force.
- Exotic forms of nuclear matter were present in the early universe and continue to exist today in neutron stars.
- Nuclear physics is the study of nuclear matter – its formation, stability, and decay – to understand the fundamental forces in nature, their symmetries, and the resulting complex interactions between protons and neutrons in nuclei and among their sub-particles (quarks, gluons, etc.).
- Complementary to high energy physics that focuses on elementary particles and their interactions at extremely high energies.
- Community priorities documented in the Nuclear Science Long Range Plan.

Historically, DOE NP has supported ~95% of the nation's investment in basic research in nuclear physics in the U.S.

Nuclear Physics – Advancing Priority Research for the Nation

- NP is poised to *ensure unrivaled American leadership in critical and emerging technology*, advancing artificial intelligence (AI) and quantum information science (QIS) and providing unique microelectronics testing capabilities.
- NP aligns with Office of Management and Budget high-priority crosscuts:
  - Supports over 1,400 Ph.D. staff and 700 graduate students, producing highly-qualified personnel that fill critical S&T workforce needs in government, industry, and academia.
  - Genesis Mission and Emerging Technologies: Accelerates research output through AI and quantum computing, develops novel instrumentation based on QIS, and applies new microelectronics technologies in unique experimental environments.
  - Actively promotes data management and sharing, and stewards the National Nuclear Data Center, a Public Reusable Research (PuRe) Data resource for nuclear physics data for basic nuclear research and applied nuclear technologies.
  - Operates world-unique, accelerator-based user facilities that have hosted over 4,200 unique scientific users from across America and the world.
  - Expands world-class research infrastructure through construction of innovative scientific instruments, including the Electron-Ion Collider (EIC).

NP Avenues for Discovery

Probing Proton Substructure

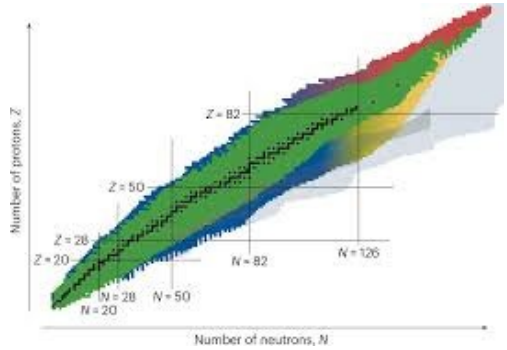
Reveals dynamics, structure, and spin for protons and neutrons

- Heavy ion collisions and electron scattering informs our understanding of nuclear phenomena and the formation of the universe
- U.S. provides the **world's highest intensity**, **polarized** electron beams for this science

Exploring the Isotope Landscape

Enables element and isotope discovery

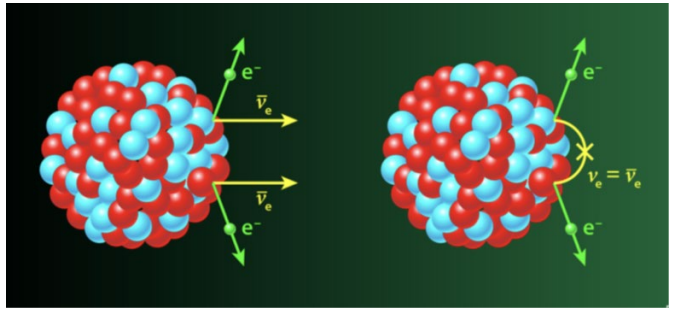
- Reaction rates and structure data for national priorities
- Superheavy elements provide a fertile ground for tests of theory
- **Nuclear data** and capabilities for characterization of electronics (e.g., defects, radiation-induced failures)



Studying Rare Decays

Targets natural processes that break conservation laws and symmetries

- **Data-driven science** to explain the matter-antimatter balance
- Extreme high-precision detectors translate to other applications
- Nuclear-science-based innovation for **Quantum Information Science**



Crosscutting: Theory, AI, Advanced Computing, Accelerator & Detector R&D

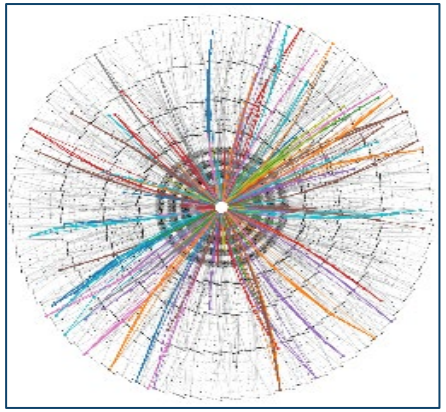
NP Programmatic Activities Across the National Labs

	Proton Substructure		Isotope Landscape	Rare Decays	Nuclear Theory	Nuclear Data	Accelerator R&D	QIS	AI
	Heavy Ions	Medium Energy	Nuclear Structure and Astrophysics	Fundamental Symmetries					
ANL		X	X	X	X	X	X	X	X
BNL	X	X		X	X	X	X	X	X
FNAL		X					X	X	X
LANL	X	X		X	X	X			X
LBNL	X	X	X	X	X	X	X		X
LLNL	X		X	X	X			X	
ORNL	X		X	X	X	X		X	
PNNL				X				X	
SLAC				X					
TJNAF		X			X		X	X	X

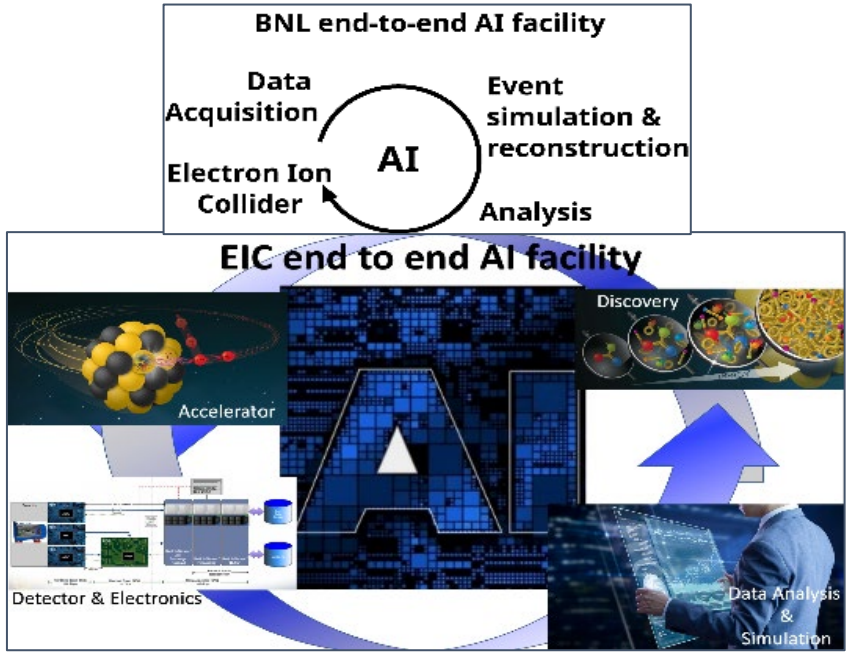
Labs in **bold face** have core capabilities for Nuclear Physics

Genesis Mission and Nuclear Physics

- Coordinating with ASCR, HEP, and other SC programs, **NP is advancing its mission through the development of AI-ready datasets and AI models that can take advantage of them.**
- Two discovery science national challenges targeted:
  - Unifying Physics from Quarks to the Cosmos
  - Enhancing Particle Accelerators for Discovery
- While the NP community has actively employed AI methods, the Genesis Mission offers a unique opportunity to overcome workflow pinch points and synthesize data from disparate domains.
- The development of domain-specific data standards and metadata for multi-modal data, including expert knowledge documentation, **will feed the American Science Cloud (AmSC)**, using the power of AI to accelerate **discovery of new physics** and progress on the fundamental questions on the nature of nuclear matter.



Event Reconstruction with Geometric Deep Learning



NP in Quantum Information Science

Supports one of SC's National QIS Research Centers

- Led by BNL, partners with IBM, PNNL, and 25 other institutions to build tools for scalable fault-tolerant quantum systems
- >350 team members, 5 subject inventions, 11 open-source packages, 173 publications

NP QIS Highlights:

- **Quantifying background radiation on qubits**. Scientists used a thermal kinetic inductance detector to measure disruptive events that were consistent with known terrestrial and cosmic sources of radiation. Such measurements are crucial to deduce the impact on coherence times of qubits that are subject to naturally occurring radiations.
- **Scalable quantum circuits**. Scientists at the InQubator for Quantum Simulations performed the one of the largest quantum simulations to date (more than 100 qubits) using IBM's quantum computers. The results from the quantum computer address the need for complex simulations of pre-collisional protons and heavy nuclei.
- **Detecting the decay of individual nuclei**. Scientists detected the decay of radioactive lead-212 embedded in helium by measuring the recoil of the helium atom. This was identified as a 2024 top 10 breakthrough by Physics World and demonstrates that very small forces (10^{-20} N) and accelerations (10^{-7} g) are in the realm of detection.

NP-funded Accelerator Facilities Underpin U.S. Capability for Radiation Effects Testing of (Micro)Electronics for Government and Industry

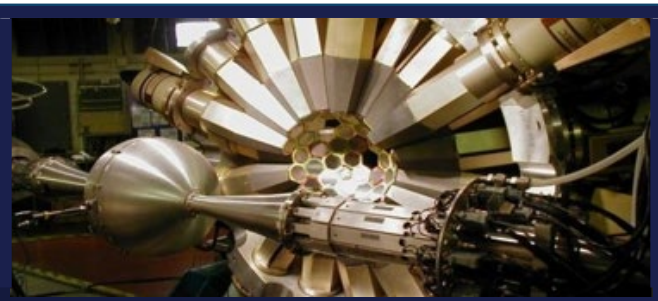
- Facilities
  - 88-Inch Cyclotron, Lawrence Berkeley National Laboratory (LBNL)
  - Cyclotron Institute, Texas A&M University
  - Facility for Rare Isotope Beams (FRIB), SC User Facility, Michigan State University
  - NASA Space Radiation Laboratory, part of the Relativistic Heavy Ion Collider hadron injector complex at Brookhaven National Laboratory
- An Interagency Agreement is in place with NASA for 500 hours of beam time annually at the 88-Inch Cyclotron at LBNL.
- The DOD has made investments in several of these facilities and is considering expanding capacity going forward.
- Primary industry interest is from aerospace, space exploration, and autonomous vehicles sectors.

NP user facilities provide critical capabilities to maintain U.S. scientific leadership

- Access to three accelerator-based facilities for exploring nuclear matter in all forms
  - **Facility for Rare Isotope Beams** and **Argonne Tandem Linac Accelerator System** study how protons and neutrons combine to form the atomic nucleus.
  - **Continuous Electron Beam Accelerator Facility** seeks to understand quarks and gluons, the elementary building blocks of protons and neutrons.
- Open to all scientists, this suite of facilities forms the backbone of the nation's nuclear physics research infrastructure.
- Over 4,000 users from the scientific community access these facilities annually.
- **Relativistic Heavy Ion Collider** ended operation in FY 2026 – support continues for users to analyze data and for hadron injector operations for isotopes and microelectronics testing missions.

RHIC@BNL

ATLAS@ANL



FRIB@MSU

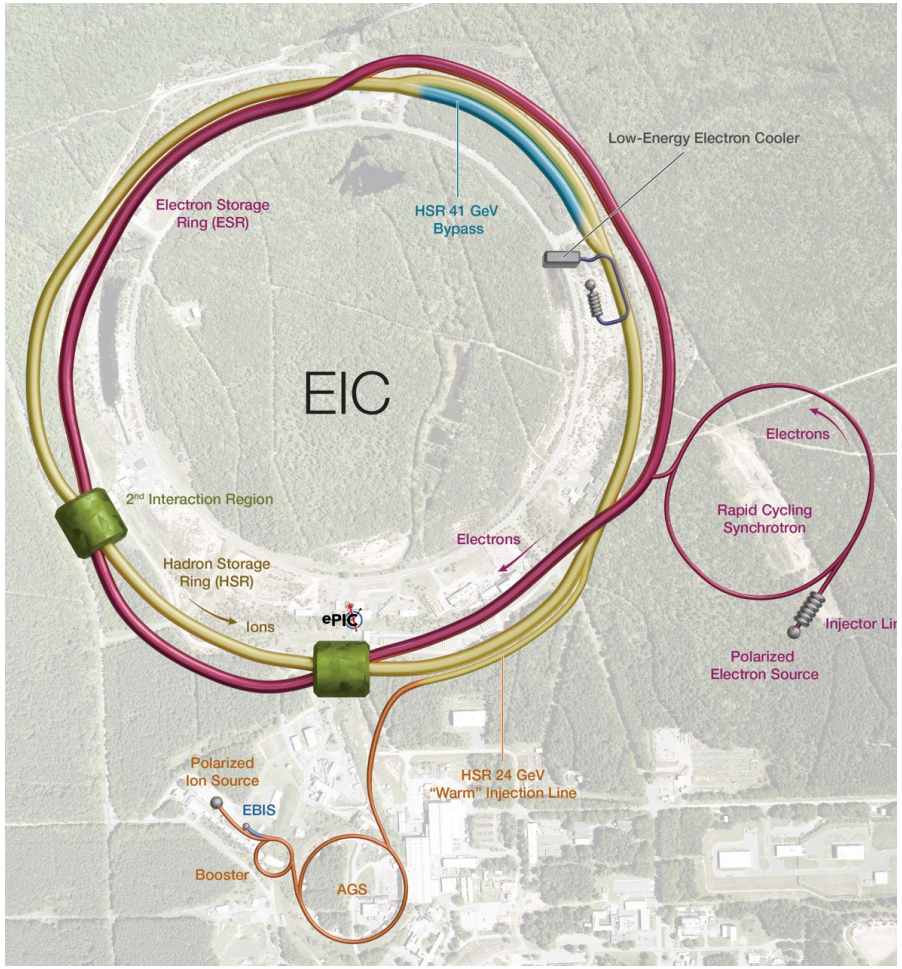
CEBAF@TJNAF

NP Projects Status

Project	Location	Status	Cost	CD-4
Construction Projects				
Electron-Ion Collider (EIC)	BNL	CD-3B	$1.7B to $2.8B (Est)	Q1 FY36 (Est)
Major Items of Equipment				
Gamma Ray Energy Tracking Array (GRETA) Fully Funded, Delegated	LBNL	CD-4A	$58.3M (TPC)	Q2 FY28
Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) Fully Funded	TJNAF	CD-2/3	$48.66M (TPC)	Q4 FY28
High Rigidity Spectrometer (HRS) High Transmission Beam Line (HTBL) SPectrometer Section (SPS)	MSU	 CD-2/3 CD-1	 $49.7M (TPC) $65.5M - $87.3M (Est)	 Q3 FY30 Q2 FY32 (Est)
Ton Scale Neutrinoless Double Beta Decay (TS-NLDBD) Near-term LEGEND-1000	 ORNL	 CD-0	 $409M to $665M (Est)	 TBD

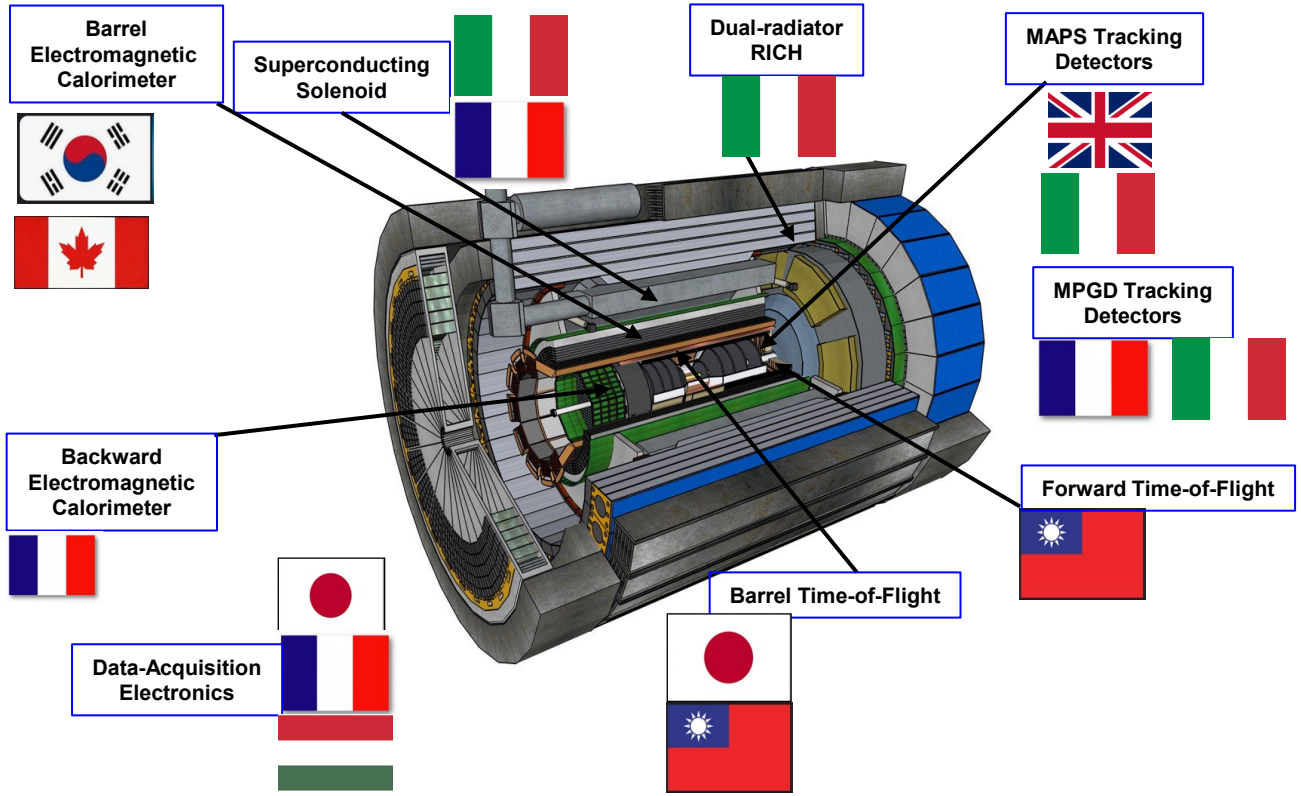
Electron-Ion Collider: Top Priority for New Facility Construction in the Nuclear Science Long Range Plan

- Located at BNL, using existing RHIC assets, with TJNAF as a major partner
- Estimated cost rage of $1.7 billion to $2.8 billion.
- In-kind contributions: New York State and International partners
  - $100M grant from New York supports civil construction
  - ~$90M anticipated for the detector ePIC (~30%)
  - ~$50M anticipated accelerator scope (~5%)
- Critical Decision-3A (long lead procurement): March 2024
- Critical Decision CD-3B (second long lead procurement request) approved January 2026
- Project elaborating its subproject strategy



NP International Engagement Continues to Grow

- Topics of mutual interest:
  - Alignment with NP mission and scope.
  - Alignment with mission and scope of international partners.
  - Capabilities of the participating international partners.
- EIC User Group: 1,562 members from 310 Institutions in 41 countries (March 2026)



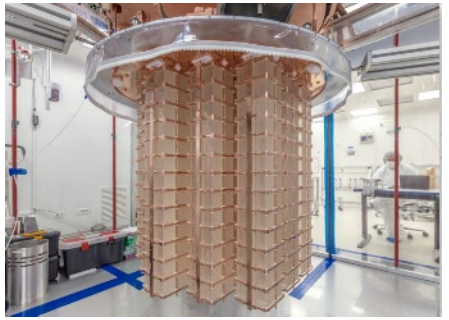
- Expressed interests in the ePIC central detector subsystems labeled by country

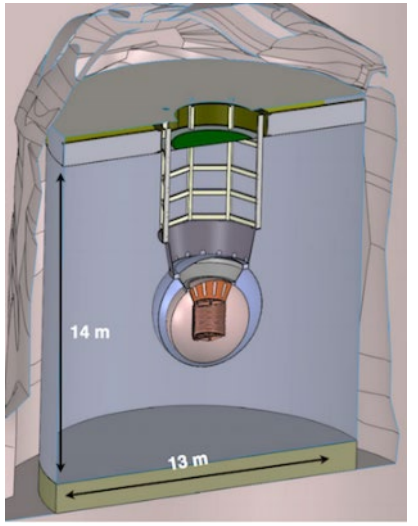
Neutrinoless Double Beta Decay: Top Priority for New Experiment Construction in the Nuclear Science Long Range Plan

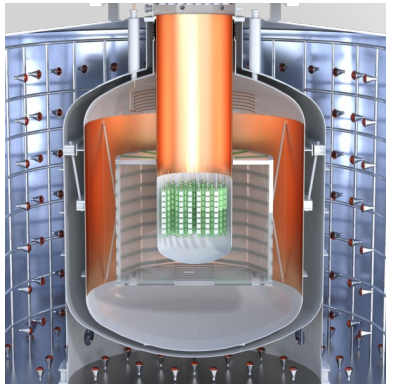
- Roughly $20.0M has been allocated since 2020 to explore three technologies: CUPID, LEGEND-1000, nEXO, and; supporting conceptual design and R&D.
- **In December 2024, LEGEND-1000 selected as the first priority for NP investment.** (est. cost $500 M)
- A multi-pronged campaign to detect neutrionless double beta decay is an international enterprise.
- Funding agencies representatives from Canada, France, Germany, Spain, United Kingdom, and the U.S. (DOE and NSF) are working to establish a framework for continued coordination.

Three proposed technologies:

- Scintillating bolometry (CUPID, ^{100}Mo enriched Li_2Mo_4 crystals)
- **Enriched ^{76}Ge crystals (LEGEND-1000, drifted charge, point contact detectors) – 1st priority for NP support**
- Liquid Xenon TPC (nEXO, light via SiPM, drifted ionization)





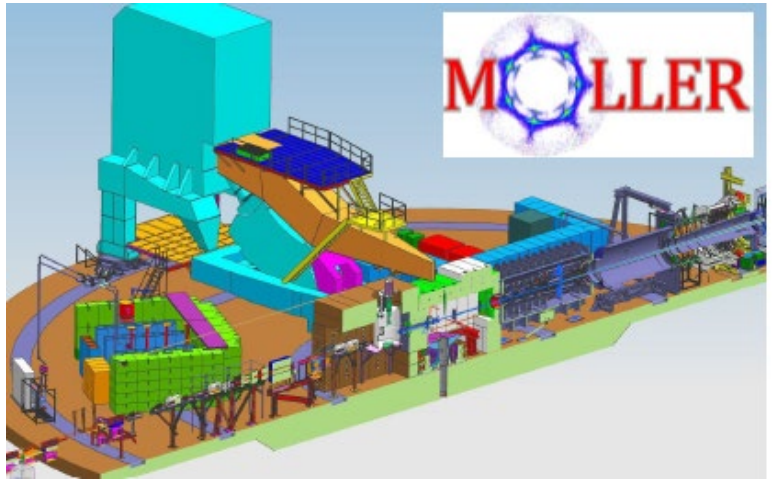


Status of other MIE projects

Gamma Ray Energy Tracking Array (GRETA)
for FRIB, ATLAS (LBNL)

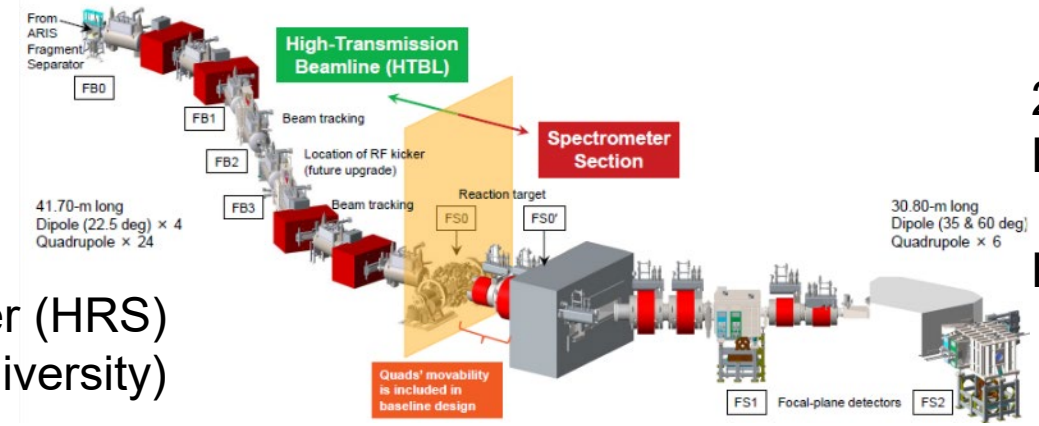
Fully funded and delegated: Approved for early science

Measurement of a Lepton-Lepton
Electroweak Reaction (MOLLER) for CEBAF



Fully funded: CD-2/3 achieved May 2024

High Rigidity Spectrometer (HRS)
for FRIB (Michigan State University)



2 subprojects – Spectrometer plus
High-Transmission Beamline (HTBL)

HTBL CD-2/3 achieved Feb 2025

HENP Summary

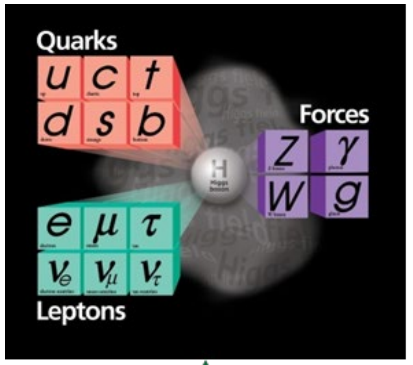
- The HEP and NP programs focus on answering the most fundamental questions about matter, energy, space and time.
- We do this by building and operating state-of-the-art facilities and instruments, collecting and analyzing large, complex data sets and publishing scientific results. Facility operations and data processing continue to be enhanced by the application of AI tools.
- Both programs have been guided by planning processes that evaluate the science and sets priorities such that the focus remains centered on answering the most pressing and compelling questions.
  - Budget realities have not matched outyear scenarios, making it challenging to execute the vision set out in the plans
  - HEP and NP are executing a portfolio of projects launched this decade and should have construction completed within the coming decade, setting us up for producing record breaking quantities of data and world leading results for decades to come.
- The synergies between HEP and NP will enable a smooth transition in support of the SC realignment.

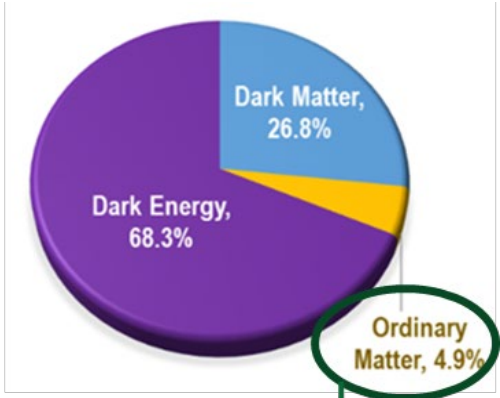
Additional Information

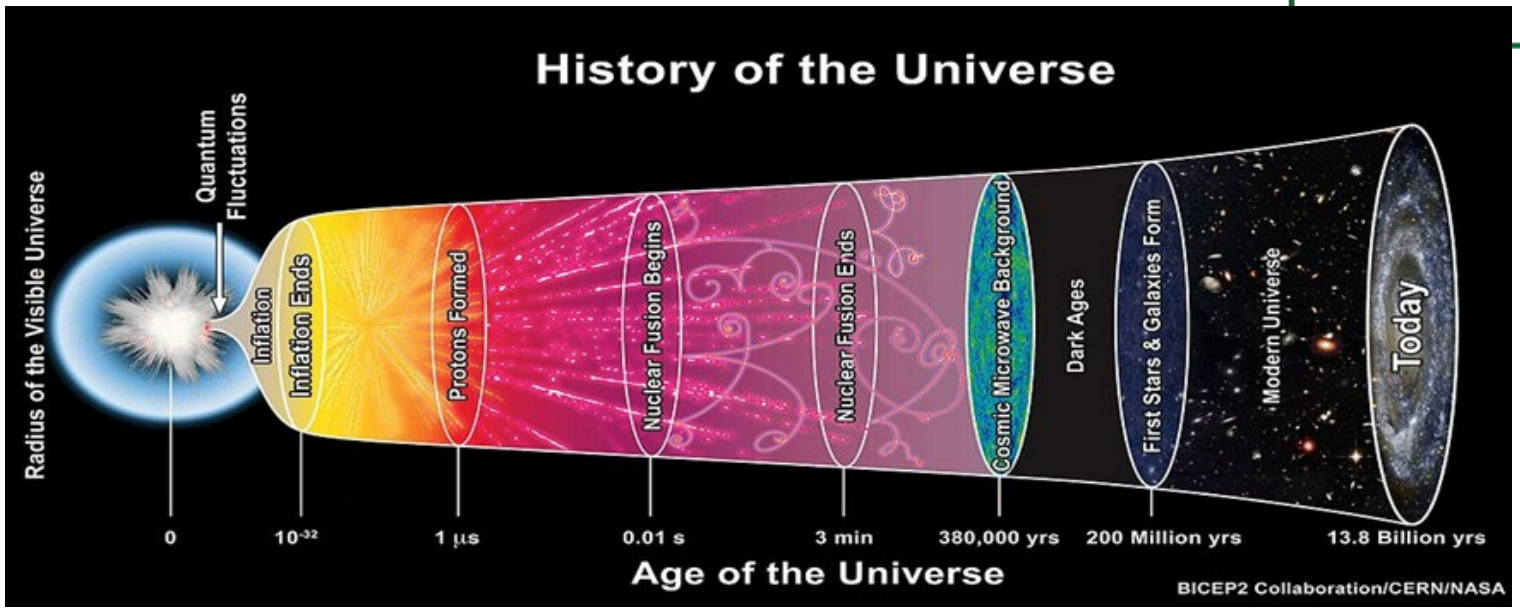
Office of High Energy Physics (HEP) Mission

Understanding the how the universe works at its most fundamental level

- Discover the elementary constituents of matter and energy
- Probe the interactions between them
- Explore the basic nature of space and time



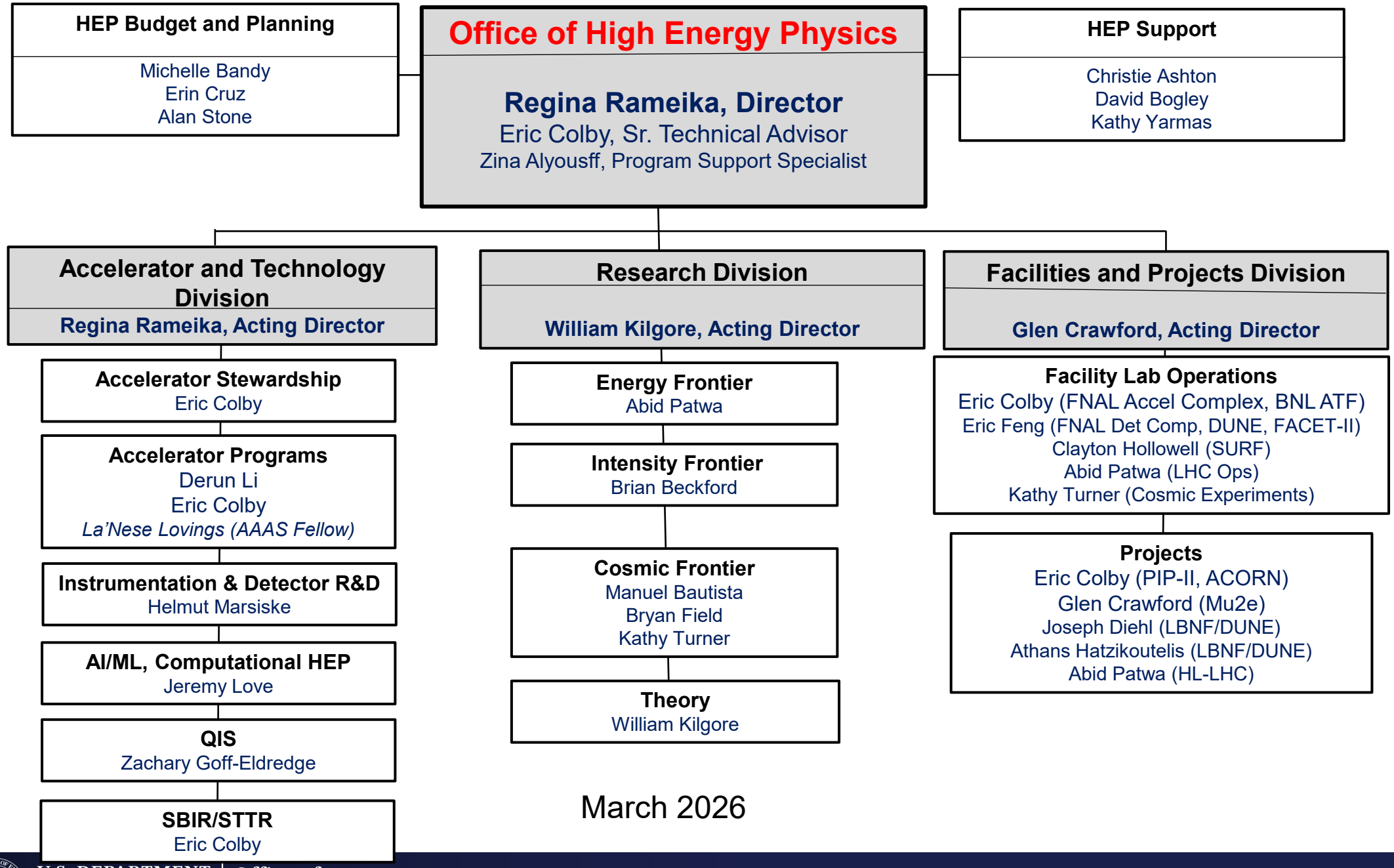




Where did we come from, what are we made of and where are we going???

HEP Wrap-up

- The SC HEP program is focused on answering the most fundamental questions about matter, energy, space and time.
- We do this by building and operating state of the art facilities and instruments, collecting and analyzing the data and publishing scientific results.
- Our HEP program has been guided by a planning process that evaluates the science and sets priorities such that the focus remains centered on answering the most pressing and compelling questions.
  - For the last couple of years we are trending at the lower budget scenario, making it challenging to execute the vision set out in the plan
- At the present time, we are executing a portfolio of projects that were launched in the last decade and should have construction completed within the coming decade, setting us up for producing record breaking quantities of data and world leading results for decades to come.

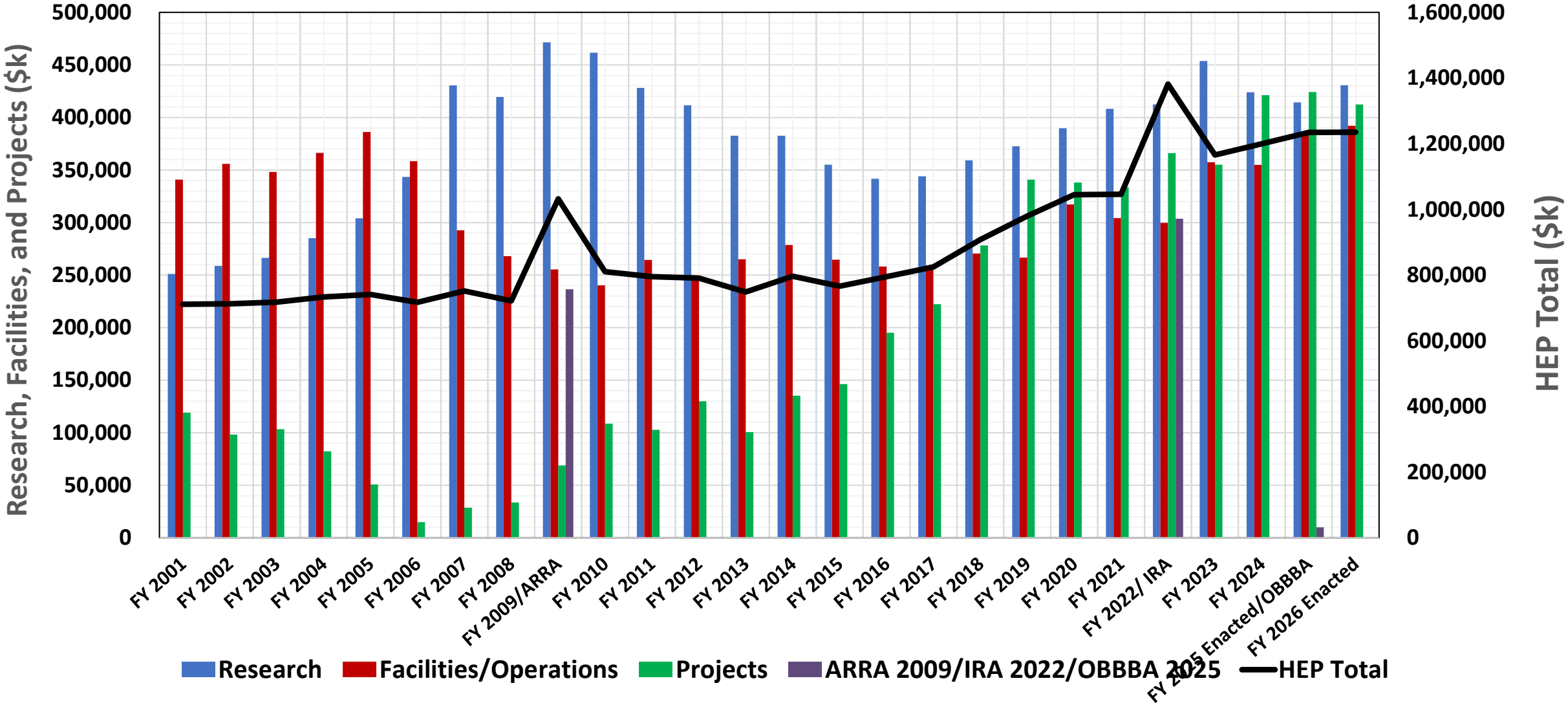

HEP Budget and Planning
Michelle Bandy
Erin Cruz
Alan Stone
Office of High Energy Physics
Regina Rameika, Director
Eric Colby, Sr. Technical Advisor
Zina Alyousff, Program Support Specialist
HEP Support
Christie Ashton
David Bogley
Kathy Yarmas
Accelerator and Technology Division
Regina Rameika, Acting Director
Accelerator Stewardship
Eric Colby
Accelerator Programs
Derun Li
Eric Colby
La'Nese Lovings (AAAS Fellow)
Instrumentation & Detector R&D
Helmut Marsiske
AI/ML, Computational HEP
Jeremy Love
QIS
Zachary Goff-Eldredge
SBIR/STTR
Eric Colby
Research Division
William Kilgore, Acting Director
Energy Frontier
Abid Patwa
Intensity Frontier
Brian Beckford
Cosmic Frontier
Manuel Bautista
Bryan Field
Kathy Turner
Theory
William Kilgore
Facilities and Projects Division
Glen Crawford, Acting Director
Facility Lab Operations
Eric Colby (FNAL Accel Complex, BNL ATF)
Eric Feng (FNAL Det Comp, DUNE, FACET-II)
Clayton Hollowell (SURF)
Abid Patwa (LHC Ops)
Kathy Turner (Cosmic Experiments)
Projects
Eric Colby (PIP-II, ACORN)
Glen Crawford (Mu2e)
Joseph Diehl (LBNF/DUNE)
Athans Hatzikoutelis (LBNF/DUNE)
Abid Patwa (HL-LHC)

March 2026

HEP's accelerator and detector facilities provide critical tools to foster U.S. scientific leadership

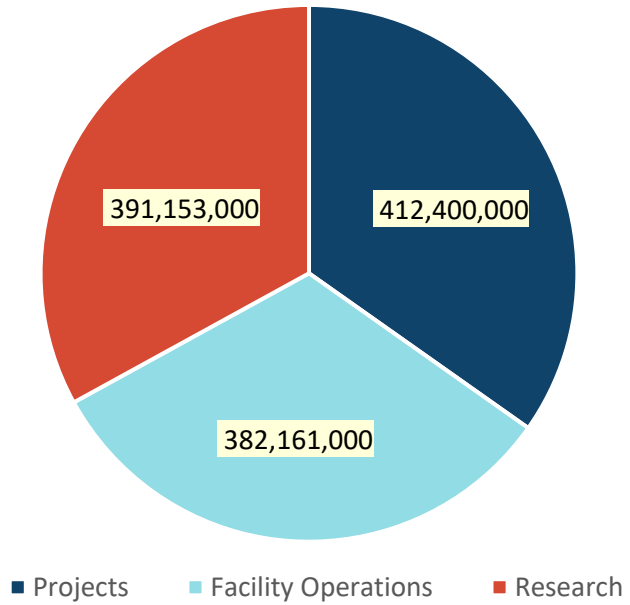
- HEP Facilities are complex and too expensive to duplicate, thus, HEP has become a highly internationalized field.
- At the **Energy Frontier** researchers accelerate particles to the highest energies ever made by humanity and collide them to produce and study the fundamental constituents of matter- The Large Hadron Collider at CERN in Europe is currently its centerpiece
- At the **Intensity Frontier** researchers use intense particle beams and highly sensitive detectors to make precise measurements and search for new physics – The accelerator at Fermilab in Batavia Illinois is currently the heart and home of this research
- At the **Cosmic Frontier** researchers seek to reveal the nature of dark matter and dark energy with a truly international program that uses telescopes, ground-based and in orbit and a variety of underground sensitive detectors



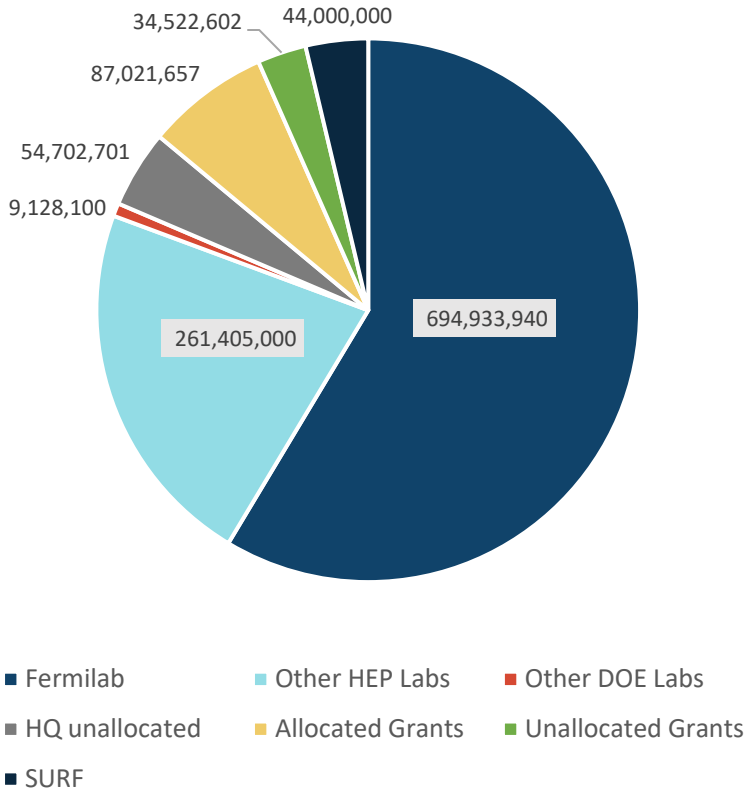
ARRA 2009 funds supported Research, Facilities, and Projects
IRA 2022 funds supported Projects only
One Big Beautiful Bill (OBBA) of FY 2025 funds Research only
FY 2026: formerly ARDAP program funds are merged into the HEP Budget

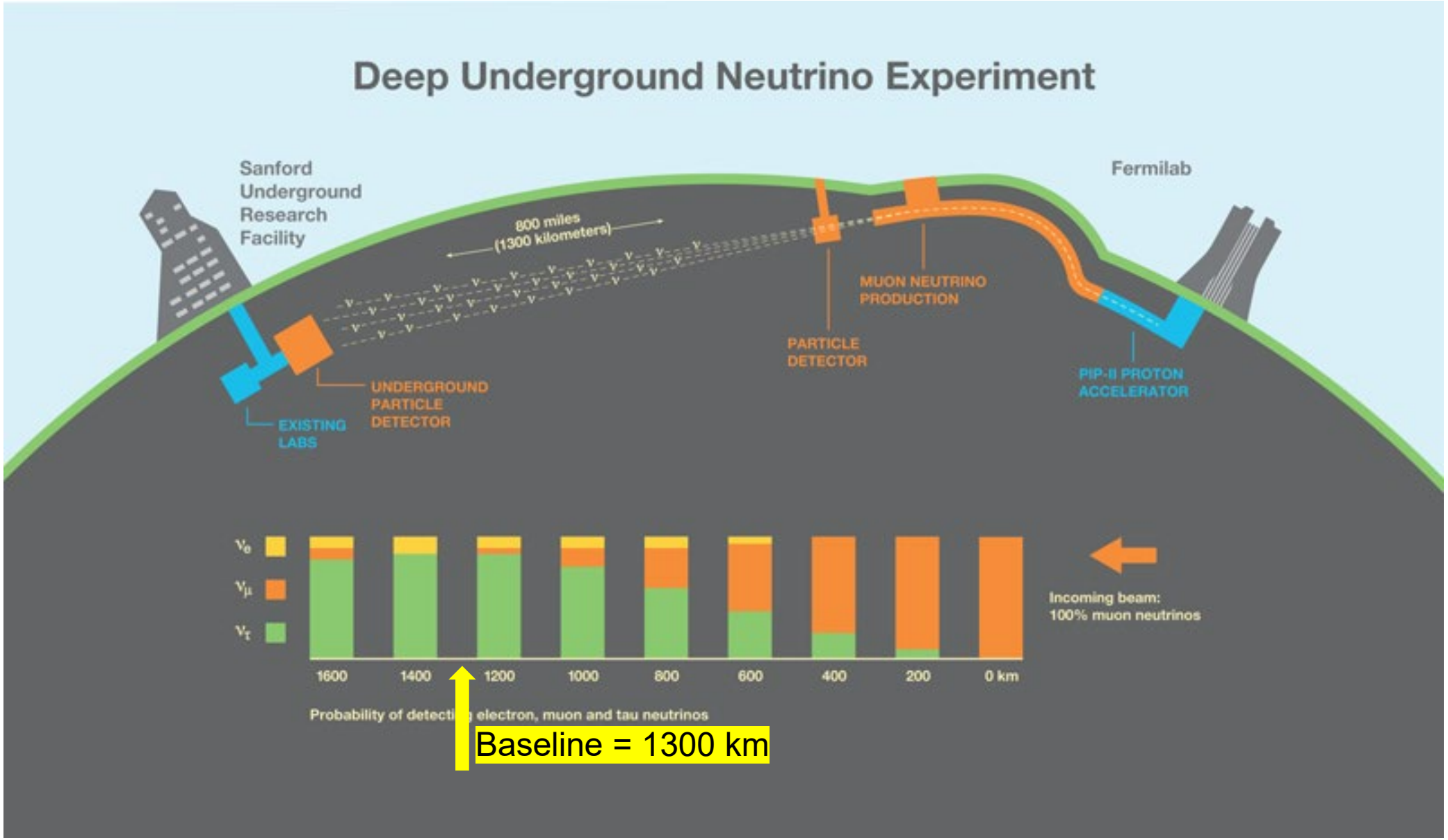
HEP Portfolio Balance - FY26 : $1.186 B*



* ARDAP, SBIR and SC Program Support removed

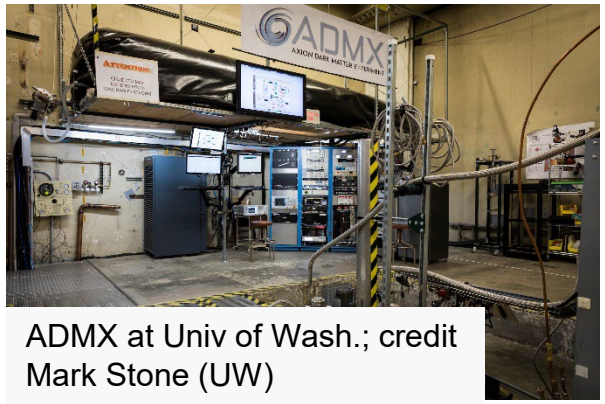
HEP FY26 Funding Plan - $1.186B




Deep Underground Neutrino Experiment
Sanford Underground Research Facility
Fermilab
800 miles (1300 kilometers)
MUON NEUTRINO PRODUCTION
PARTICLE DETECTOR
PIP-II PROTON ACCELERATOR
UNDERGROUND PARTICLE DETECTOR
EXISTING LABS
ν_e
ν_μ
ν_τ
1600
1400
1200
1000
800
600
400
200
0 km
Incoming beam: 100% muon neutrinos
Probability of detecting electron, muon and tau neutrinos
Baseline = 1300 km

We go deep to search for dark matter particles

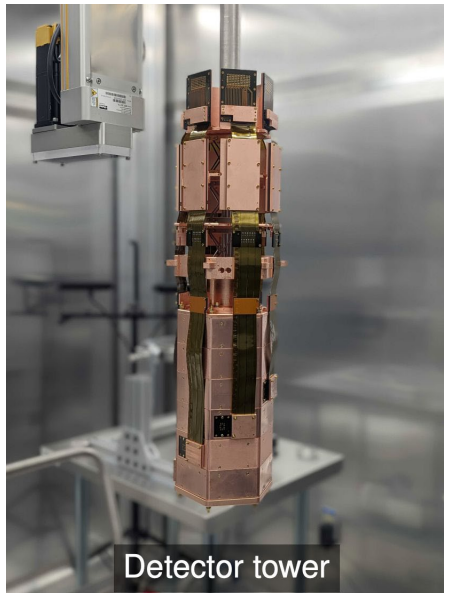
- Dark matter accounts for five times as much of the universe as ordinary matter, but we don't know what it is!
  - So far, only seems to interact through gravity
- Dark matter is not a Standard Model particle
  - Discovering its nature will change our understanding of the universe!

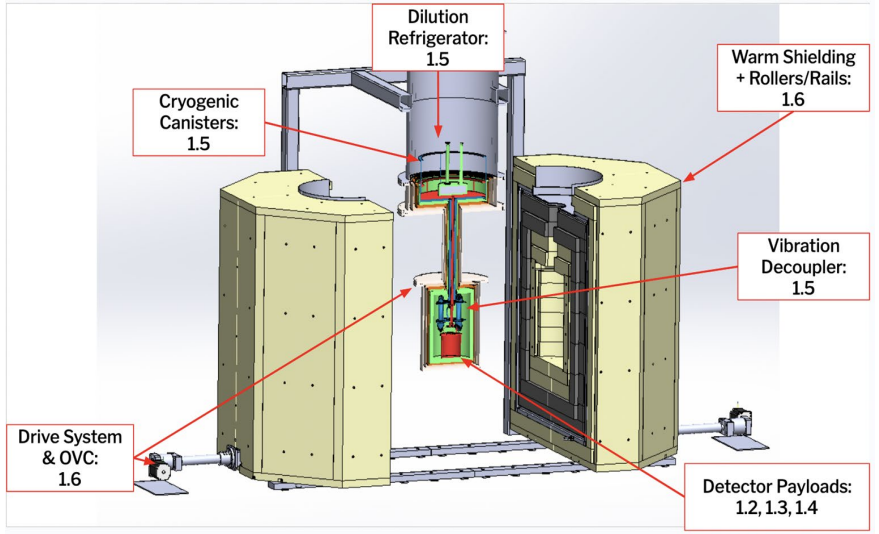


ADMX at Univ of Wash.; credit Mark Stone (UW)

LZ at SURF; taking data

SuperCDMS at SNOLAB – detector tower; data-taking starts soon!

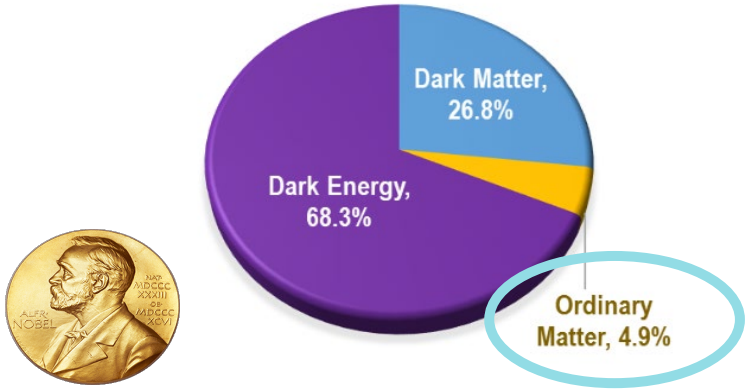




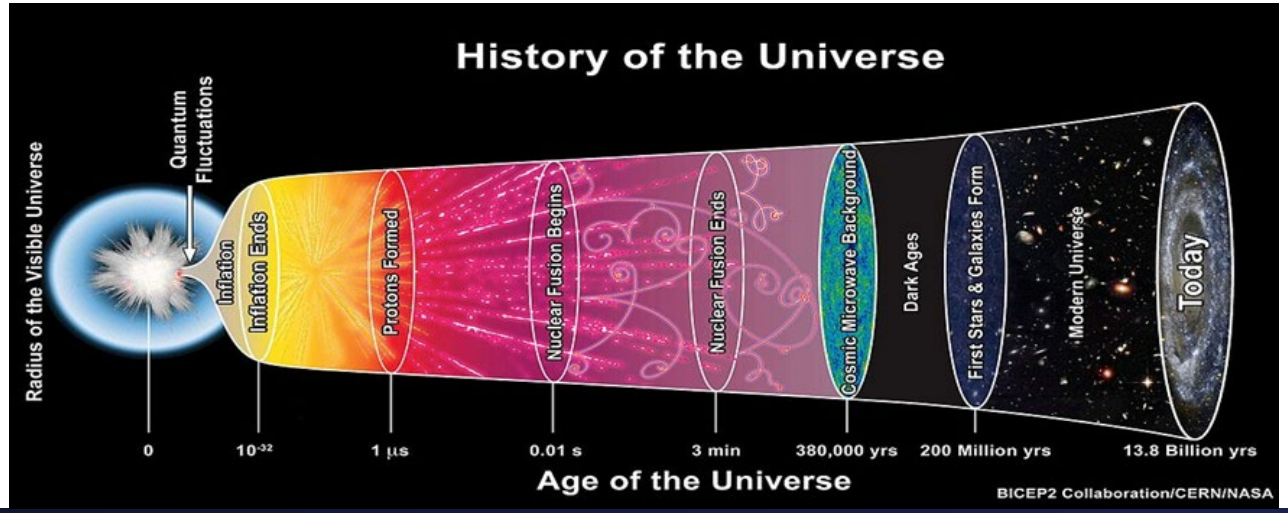
TESSERACT, Modan Underground Lab in France

Cosmic Acceleration: Inflation and Dark Energy

- Our universe has two major phases of cosmic acceleration:
  - The moment of "inflation" during the Big Bang
  - Ongoing accelerating expansion, beginning ~9 billion years later
- Inflation explains why the cosmic microwave background is so uniform. We are studying its details to determine what caused it to occur
- Ongoing expansion caused by dark energy, which accounts for ~70% of the total content of our universe! We determine its nature using spectroscopic & imaging survey data.



2011 Nobel Prize in Physics: Perlmutter/Schmidt/ Riess for the discovery of the accelerating expansion of the Universe through observations of distant supernovae



LSST Camera in clean room at Rubin

Studying the Inflationary era at the beginning of the Universe using the Cosmic Microwave Background — Observing the CMB sky from the South Pole

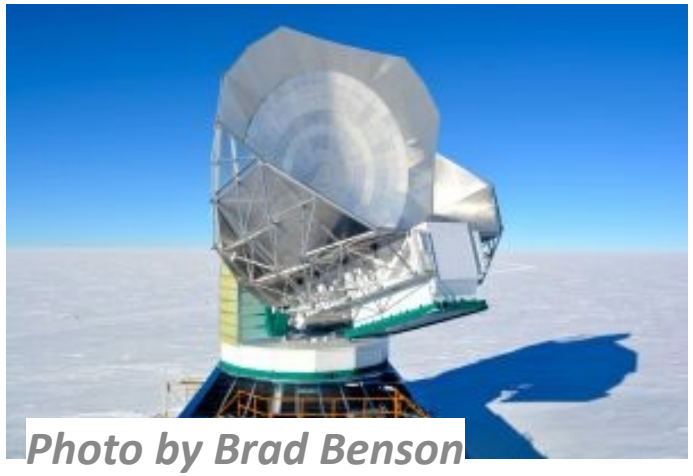
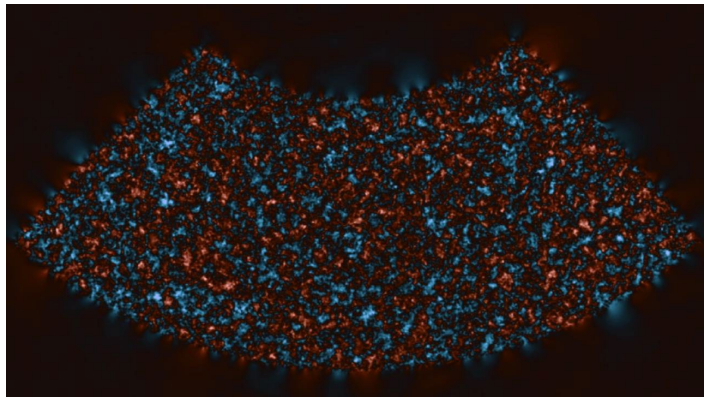


Photo by Brad Benson

South Pole Telescope Generation 3 – operating since 2019



SPT-3G CMB matter map showing tiny variations; courtesy Lloyd Knox (UCDavis)

Photo by Geoffrey Chen, UC Davis

South Pole Telescope Generation 3 & BICEP

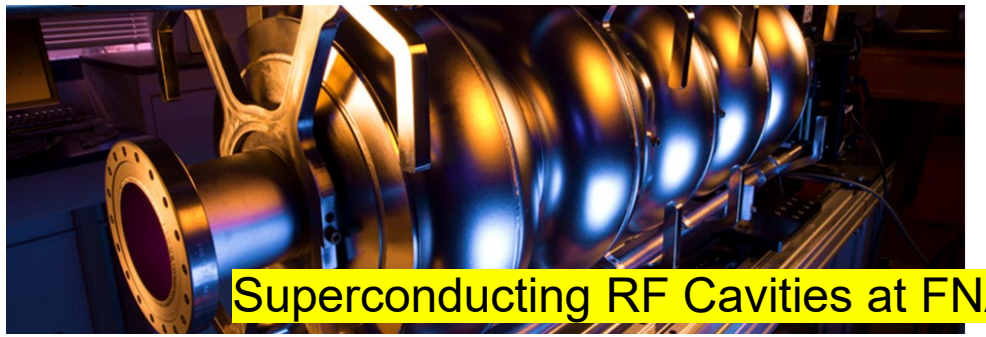
HEP is the steward of U.S. Accelerator Science

- Accelerator technology R&D
  - Accelerator and beam physics
  - High field magnets for future accelerators
  - Superconducting RF
  - High Power Targetry
  - Advanced Accelerator Concepts
- Accelerator workforce development and maintenance
  - HEP supports the US Particle Accelerator School
  - Accelerator expertise is cross-cutting : BES/BER, HEP and NP have commonalities

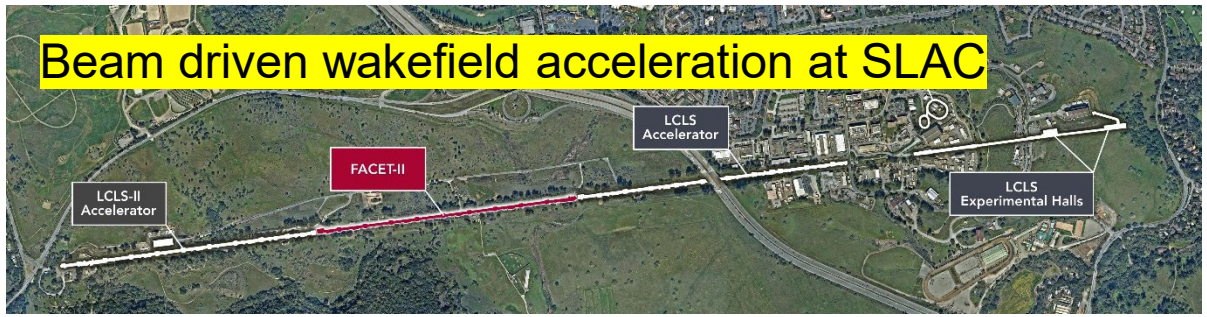
Niobium-Tin Quadrupole Magnet for HL-LHC
Developed by Fermilab, BNL, LBNL

Argonne Wakefield Accelerator

Laser-driven
Plasma Wakefield Channel *BELLA at LBNL*

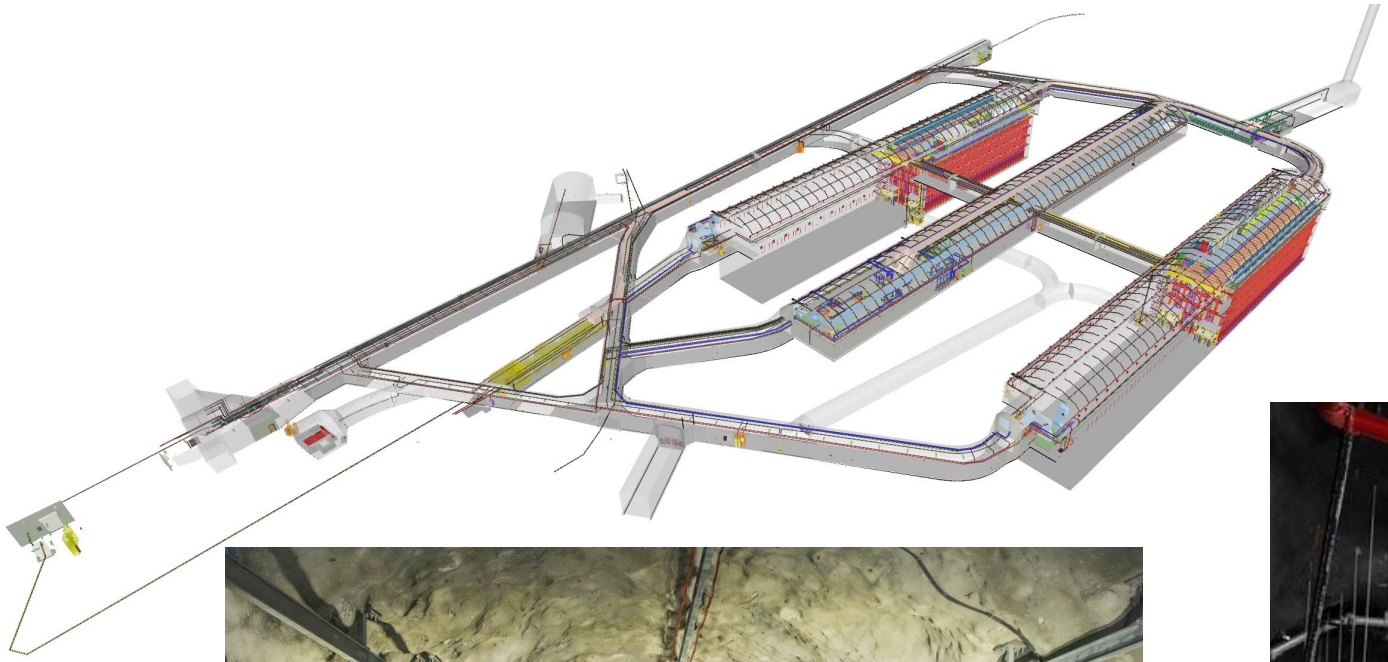


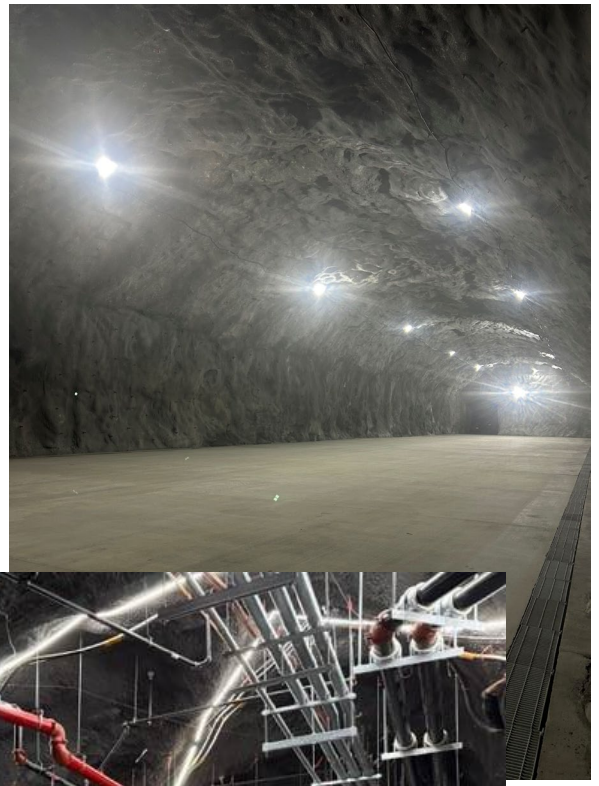
Superconducting RF Cavities at FNAL



Beam driven wakefield acceleration at SLAC

1 mile underground – Lead, South Dakota





August 15, 2024
Ribbon Cutting

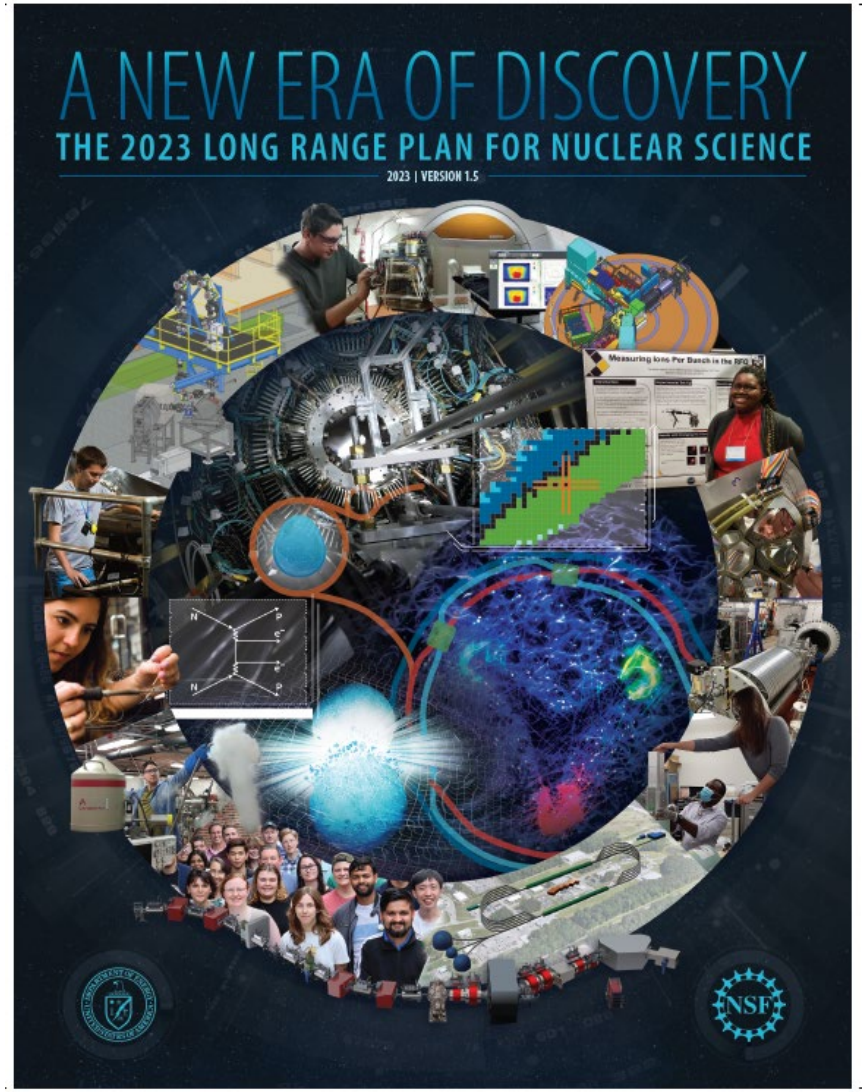
Cryostat installation beginning this summer

NP Priorities Build on a Community Vision for A New Era of Discovery

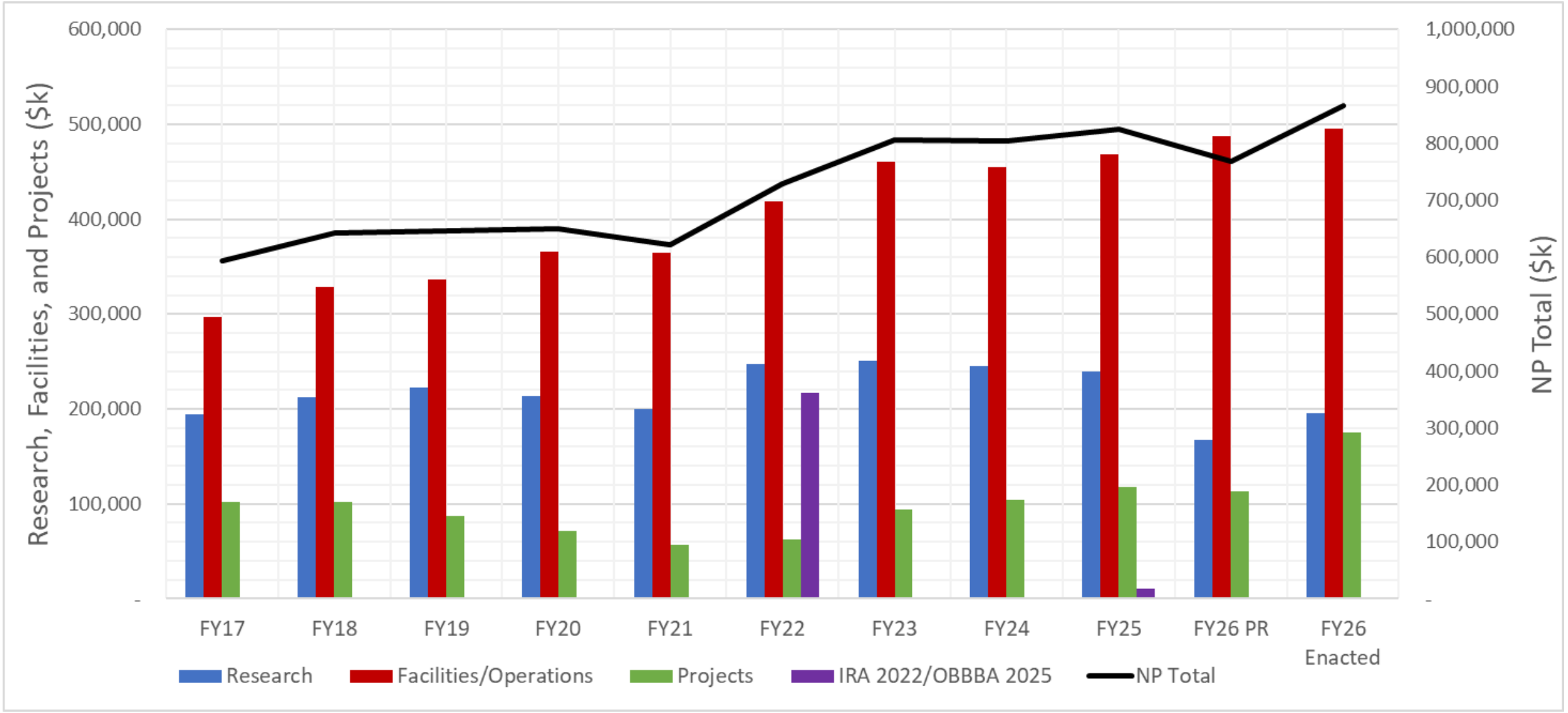
The DOE-NSF Nuclear Science Advisory Committee brought the community together to plan the future of Nuclear Physics Research for the Nation.

Increase research and grow subject matter expertise to capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States.

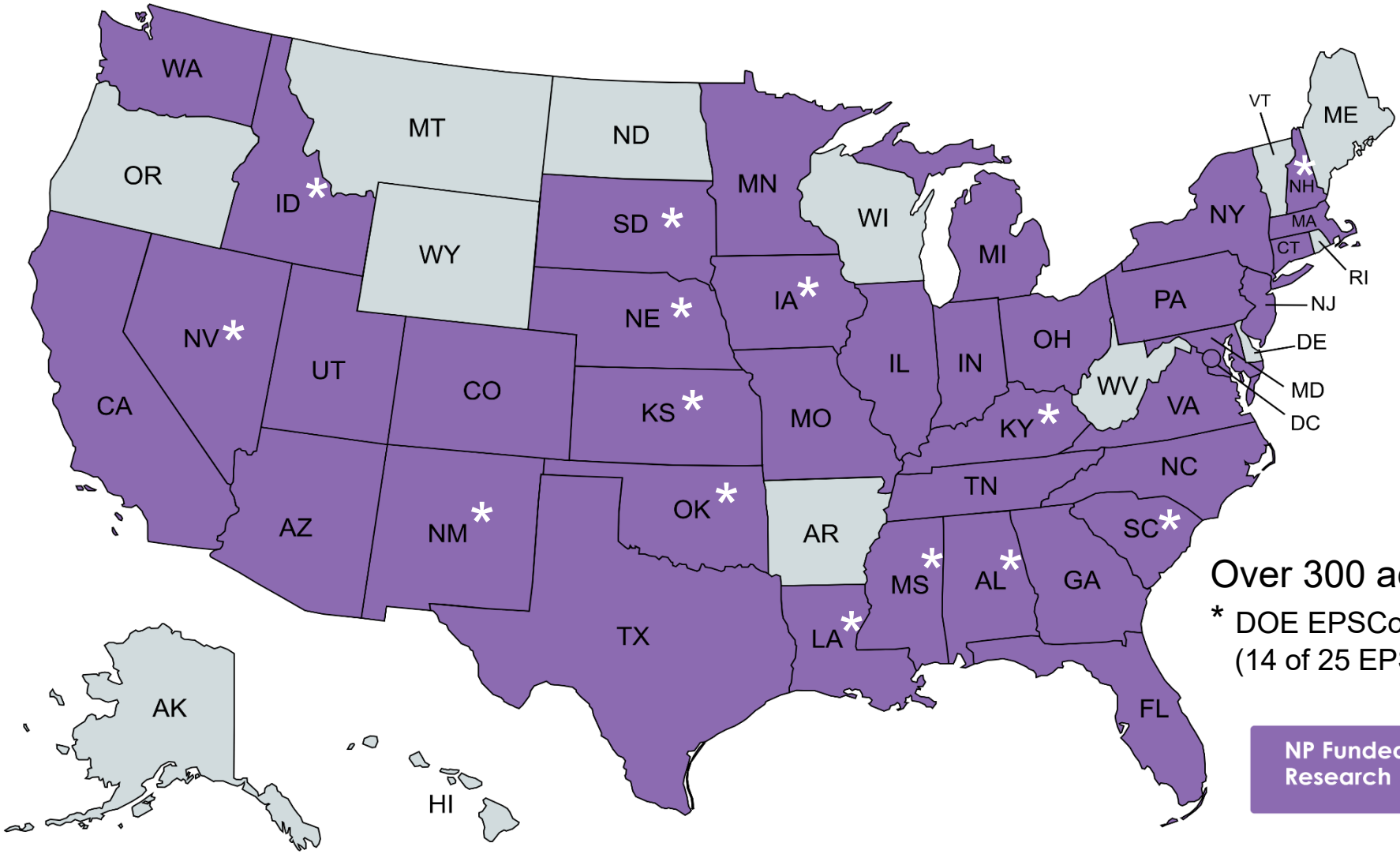
We reaffirm the exceptionally high priority of the following two investments in new capabilities for nuclear physics. The **Electron–Ion Collider (EIC)**, …will elucidate the origin of visible matter in the universe and significantly advance accelerator technology… **Neutrinoless double beta decay experiments**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



Trend in DOE-NP Appropriations



States With DOE NP Supported Researchers



Over 300 active awards

* DOE EPSCoR
(14 of 25 EPSCoR states)

NP Funded Research

Office of Nuclear Physics

Regina Rameika, Associate Director (Acting)

Associate Director's Office Staff
Dannette Keen, Financial Management Analyst
Linnette Quick, Program Assistant (CONTR)

Physics Research Division
Sharon Stephenson, Director
Saryna Cameron, Program Support Specialist (CONTR)

- **Heavy Ion Nuclear Physics** — Spyridon Margetis
- **Medium Energy & Quantum Information Science** — Gulshan Rai, Technical Advisor
- **Nuclear Structure and Nuclear Astrophysics** — Spyridon Margetis
- **Nuclear Theory** — Astrid Morreale; Robert Pisarski (Detailee)
- **Nuclear Data** — Keith Jankowski
- **Fundamental Symmetries** — Paul Sorensen

Facilities & Project Management Division
Paul Mantica, Director
Saryna Cameron, Program Support Specialist (CONTR)

- **Advanced Technology R&D** — Vacant
- **Nuclear Physics Facilities** — Manouchehr Farkhondeh
- **Nuclear Physics Major Initiatives** — Ivan Graff
- **Nuclear Physics Instrumentation** — Elizabeth Bartosz
- **Industrial Concepts** — Michelle Shinn

Organizations Using NP Facilities for Electronics Testing (partial listing)

- Aerospace Corp
- Alter Technology
- AMD
- Amazon
- Apex Technologies
- Apogee Electronics
- Astra Digital
- Astranis
- Axiom Space
- Blue Origin
- Boeing
- Broadcom
- CACI
- Crane Aerospace
- D-Orbit
- Discovery Superconductor
- EPC Space
- Frontgate Technologies
- Fuji Electric
- General Dynamics
- Honeywell
- Infineon Technologies
- L3Harris
- Lockheed Martin
- Luna Labs
- Microchip
- Micross
- MicroSat
- Millennium Space
- Mitsubishi Heavy Industries
- Mynaric
- Nanosonic
- Northrop Grumman
- Nucleon Space
- Panasonic Avionics
- PixArt Imaging
- Radiation Test Solutions
- Raytheon
- Reliable Microsystems
- Renesas
- Samsung
- SpaceX
- Starcloud
- Teledyne DALSA
- T2 Research
- Terran Orbital
- Texas Instruments
- The Radiation Team
- Troxel Aerospace
- United Launch Alliance
- Vicor Power
- Viasat
- Xilinx
- Zero-G

Industry Engagement in and Access to Nuclear Data

- NP stewards the **National Nuclear Data Center**, a Public Reusable Research (PuRe) Data **resource for nuclear physics data** maintained by the U.S. Nuclear Data Program (USNDP) **for research and applied technologies**.
- Three nuclear reactor companies, BWXT, Studsvik Scandpower, and Baker Hughes, are contributing to the USNDP Cross Section Evaluation Working Group.
  - BWXT and Kairos Power participated in the 2025 Workshop on Reactor Graphite Nuclear Data hosted by Brookhaven National Laboratory.
- Fission power companies attend the Workshop for Applied Nuclear Data Activities (WANDA) including Kairos, Westinghouse, X-Energy, and Terrapower.
  - Terrapower, working with the USNDP, received a Gateway for Accelerated Innovation in Nuclear (GAIN) award from DOE/NE to improve chlorine-35 data.
- The 2023 ND for Fusion Workshop held jointly with OSTP included industry attendees from TAE Technologies, General Atomics, Commonwealth Fusion, and First Light Fusion.
  - SHINE (fusion and isotopes) and TAE made presentations at WANDA 2024.