

Report from DOE-HEP

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Office of Science - High Energy Physics

US LUA Meeting

December 17-18, 2024



Office of Science

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

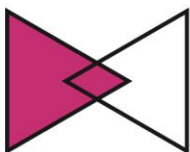
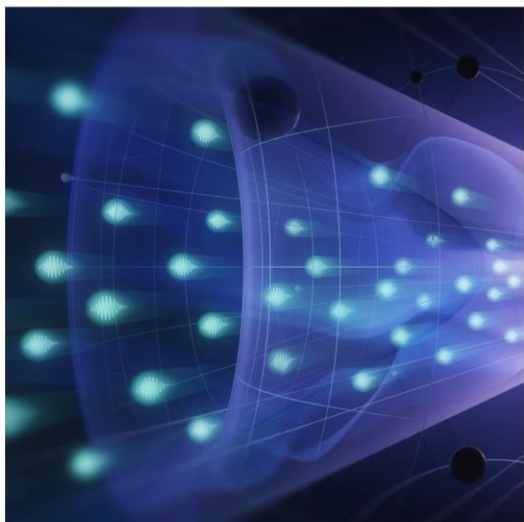
HEPAP P5 report Dec.2023

Report w/6 recommendations:

<https://www.usparticlephysics.org/2023-p5-report/>

Charge: Develop a 10-year strategic plan for US particle physics, in the context of a 20-year global strategy and two constrained budget scenarios (provided by HEP)

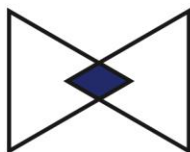
- **Low scenario** FY2024 President's Budget Request +2% inflation through FY2033
- High scenario Follows FY 2022 Chips & Science Act Authorization, then +3% inflation through FY 2035



Decipher
the
Quantum
Realm

Elucidate the Mysteries
of Neutrinos

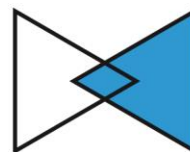
Reveal the Secrets of
the Higgs Boson



Explore
New
Paradigms
in Physics

Search for Direct Evidence
of New Particles

Pursue Quantum Imprints
of New Phenomena



Illuminate
the
Hidden
Universe

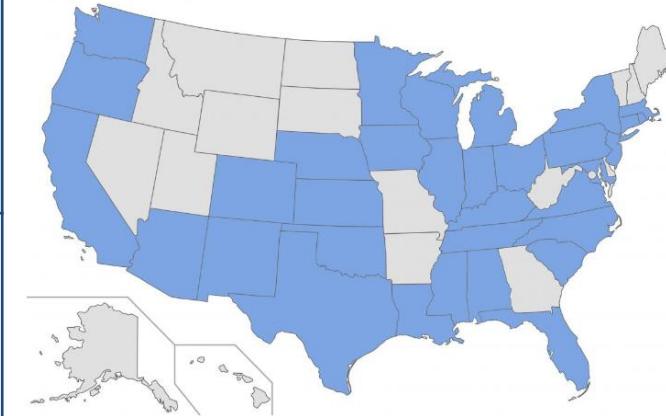
Determine the Nature
of Dark Matter

Understand What Drives
Cosmic Evolution

DOE/HEP Energy Frontier

Experiment	Location	Center-of-Mass Energy; Status	Science Topics	# Institutions; # Countries	# U.S. Institutions	#U.S. Collab.
ATLAS (<u>A</u> <u>T</u> oroidal <u>L</u> H <u>C</u> <u>A</u> pparatu <u>s</u>)	CERN, Large Hadron Collider [LHC; Geneva, Switzerland / Meyrin, Switzerland]	7-8 TeV; 13-14 TeV Run 1: 2009-2012 Run 2: 2015-2018 Run 3: 2022-2026 Run 4 to begin: 2030	Higgs, Top, Electroweak, SUSY, New Physics, QCD, B-physics	185 Institutions; 41 Countries	30 DOE Universities, 4 DOE National Labs; [11 NSF Universities]	607
CMS (<u>C</u> ompact <u>M</u> uon <u>S</u> olenoid)	CERN, Large Hadron Collider [LHC; Geneva, Switzerland / Cessy, France]	7-8 TeV; 13-14 TeV Run 1: 2009-2012 Run 2: 2015-2018 Run 3: 2022-2026 Run 4 to begin: 2030	Higgs, Top, Electroweak, SUSY, New Physics, QCD, B-physics	251 Institutions; 57 Countries	33 DOE Universities, 1 DOE National Lab; [18 NSF Universities]	655

States hosting members of the U.S. LHC experimental program



LHC data provided by the U.S. LHC collaborations, as of October 2024.

- Main scientific thrust: LHC at CERN (pp collider) – ATLAS and CMS Collaborations
- Modest support for studies on future collider initiatives
 - Support for Higgs factory efforts on FCC/CERN or ILC/Japan R&D and physics studies
 - or up to 25% of a DOE grant for the LHC may work on such future collider activities – past e.g., Snowmass or inputs for 2023 P5
- Key focus of Energy Frontier program: collaborate on the ATLAS and CMS experiments
 - U.S. ATLAS: ~19.5% of ATLAS collaboration (~15.9% DOE + ~3.6% NSF); 4 DOE labs: BNL (U.S. host lab), ANL, LBNL, and SLAC
 - U.S. CMS: ~29% of CMS collaboration (~23.7% DOE + ~5.7% NSF); 1 DOE lab: Fermilab (U.S. host lab)

U.S. HL-LHC/Phase-II Upgrade Project Status -DOE

- DOE HL-LHC Accelerator Upgrade Project (AUP)
 - DOE Critical Decision (CD)-0 [Mission Need] approved in Apr 2016 ⇒ initiated the ‘project’
 - Project is now baselined (CD-2) and in production
 - **DOE total project cost for U.S. HL-LHC AUP at \$266 million**
 - Since Nov 2023, delivery to CERN of U.S.-built magnet assemblies ongoing
- DOE HL-LHC ATLAS and CMS Detector Upgrades
 - DOE CD-0 approved in Apr 2016 ⇒ initiated each ‘project’
 - Both ATLAS and CMS HL-LHC [Phase-II] upgrade projects are baselined (CD-2)
 - Different detector subsystems are now in fabrication mode (or are nearing their respective production phases)
 - **DOE total project cost for U.S. ATLAS & CMS HL-LHC projects each at \$200 million**



HL-LHC AUP: Cyro-Assembly #1 at CERN.



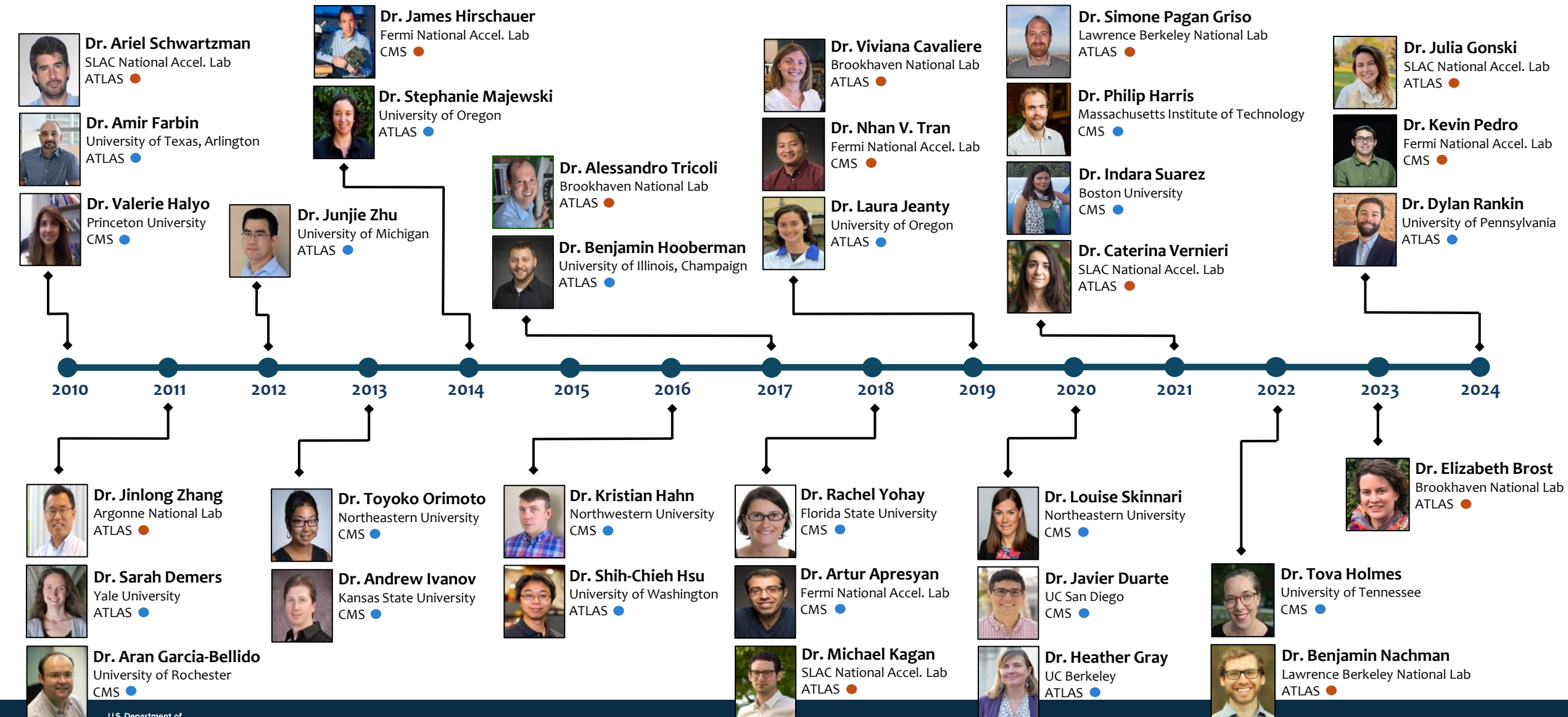
CMS HL-LHC: Outer Tracker-BTST at CERN.



ATLAS HL-LHC: Barrel Detector's Carbon Fiber Cylinder layers nested at CERN.

Energy Frontier Program

DOE/HEP Early Career Research Awardees: 2010-2024



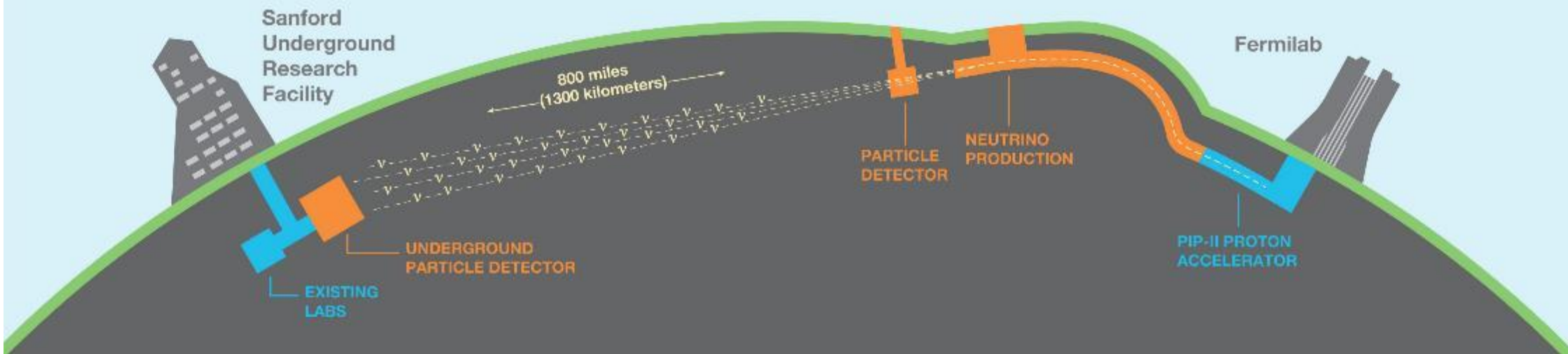
LBNF/DUNE-US Overview

Far Site – SURF in Lead, SD

Facility/Infrastructure and Far Detectors

Near Site – FNAL in Batavia, IL

Facility/Infrastructure, Neutrino Beamline, and Near Detectors



Three subprojects

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

Three subprojects*

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

*Formal DOE approval still needed to split NSCF and Beamline

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

LBNF/DUNE-US Far Site Status & Highlights

- **FSCF-EXC:** Substantially complete!
Excavation and concrete work done
- **FSCF-BSI:** Construction in progress
 - Surface work substantially complete
 - Underground work underway
- **FDC:** Preparing for CD-2/3 in 2025
 - Executing CD-3A & 3B long-lead procurements
 - CD-3C being sought NLT January '25 to sustain momentum through CD-2/3 approval
 - In-kind contributions are being shored up

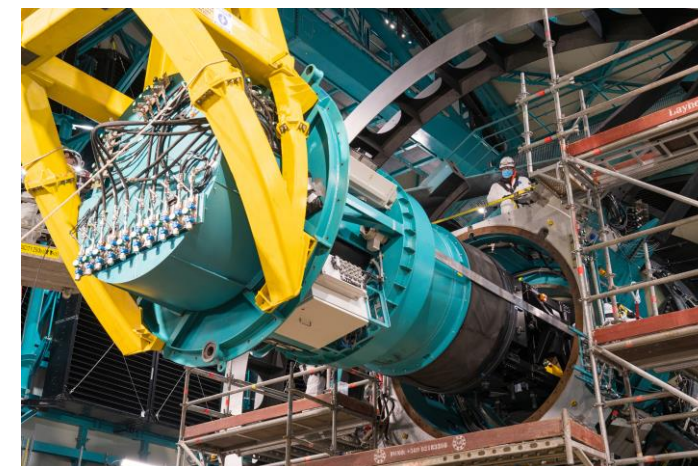


Far Detector Cavern – excavation and concrete complete!

LSSTCam shipped from SLAC to Chile in May. Electro-optical testing shows continued excellent performance.



- October: With the ComCam, the **NSF-DOE Vera C. Rubin Observatory** took first on-sky images and transferred it from Chile to SLAC for processing – first end-to-end test with images.
- LSSTCam will be installed on the Simonyi telescope in February and the survey starts late 2025.
- Observatory operations split ~ 50/50 NSF/DOE. DOE primarily responsible for LSSTCam M&O, US Data Facility at SLAC.



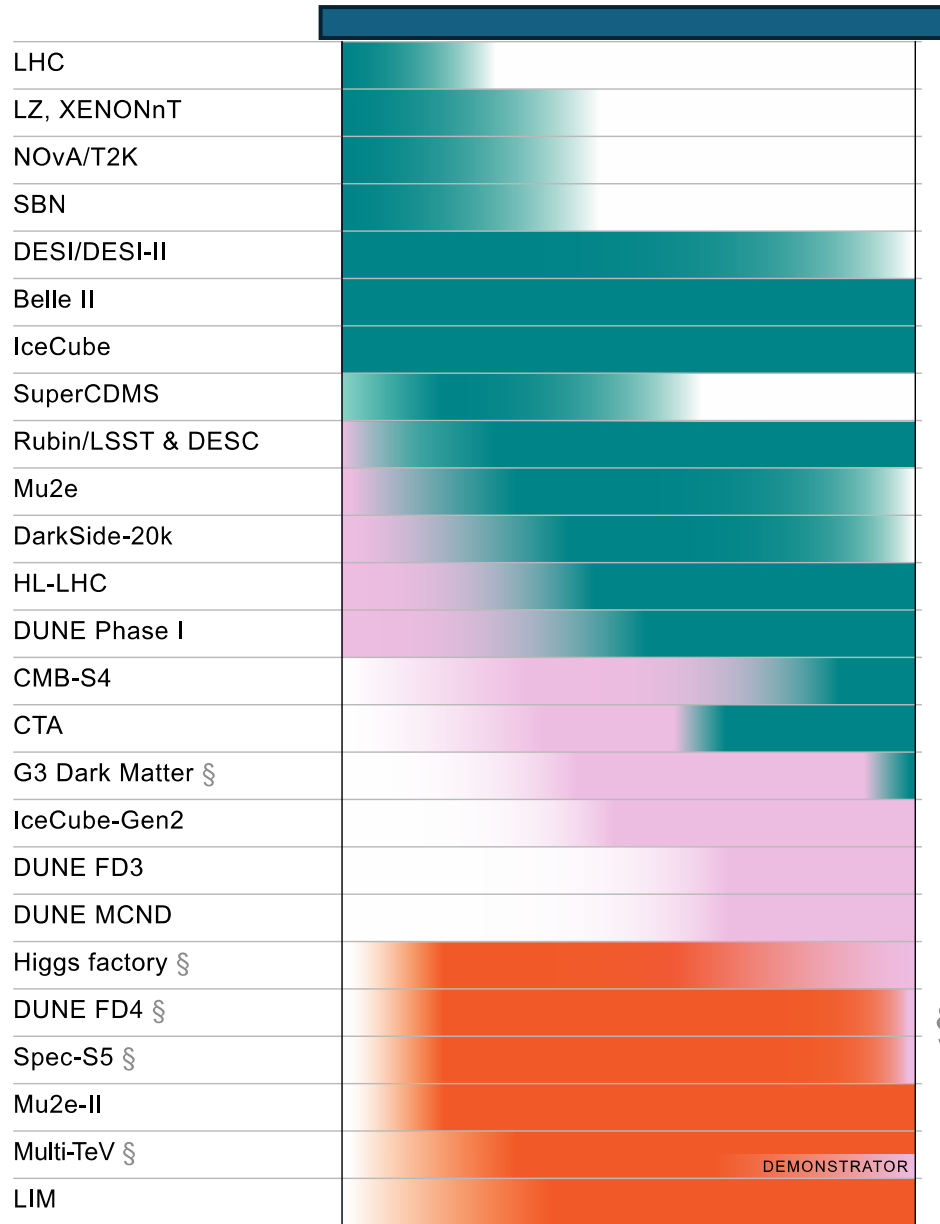
https://www.youtube.com/shorts/qY6YQsjP_7c

ComCam insertion Aug.2024. Credit: Rubin Observatory, NSF, AURA, Hernan Stockebrand

Outlook for DOE HEP Program in 5 years (~2030)

- High Lumi-LHC will be commissioning
- PIP-II and LBNF/DUNE Phase I should begin operating, and also Mu2e assuming complex is up from long shutdown
- A plan for the maintenance and improvements of the Fermilab complex should be in execution
- Rebalance investments in GARD to create space for more directed R&D for future high energy accelerator frontier endeavors
- A plan for the US participation in an “off-shore” Higgs Factory should exist
- LSST will be mid-survey
- DESI survey may be continuing with a modest upgrade
- G-2 Dark Matter searches should be completed (LZ and SuperCDMS); G-3 experiment should be being planned
- The future of Cosmic Microwave Background measurements should be understood.
- We hope to launch an ASTAE program, but this is very difficult in next few years

2024 2034



10 year state(~2035)

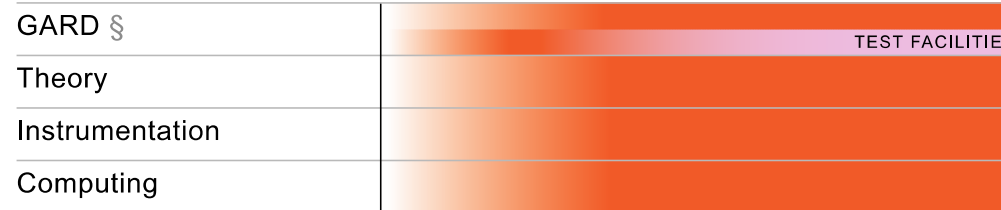
Index: ■ Operation ■ Construction ■ R&D, Research

2024 2034

Science Enablers

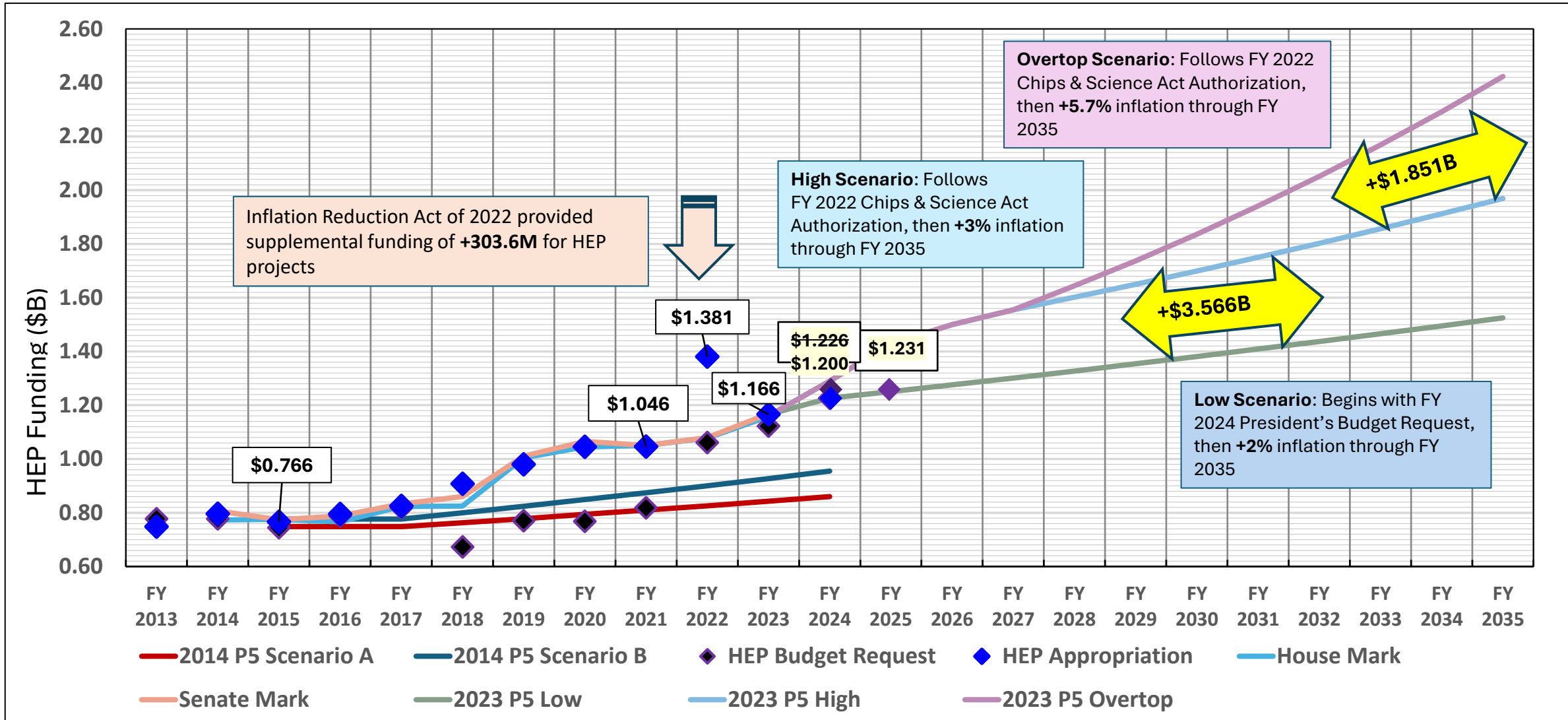


Increase in Research and Development



§ Possible acceleration/expansion in more favorable budget situations

HEP Budget History & 2023 P5 Budget Scenarios



FY 2024 HEP Budget

- Office of Science increased 1.7% from 8.1B in FY 2023 to 8.24B in FY 2024
 - Office of High Energy Physics increased 2.9% (+34M) from 1.166B in FY 2023 to 1.2B in FY 2024
- Congressional direction set LBNF/DUNE and PIP-II at 255M and 125M, which is **+\$80M over FY 2023 funding levels**
- Additional direction provided floor/ceiling limits for SURF, CMB-S4, ACORN, HL-LHC Upgrade projects, and LBNF/DUNE OPC.
- Congressional directional at the SC level for QIS and AI/ML propagated down to HEP and holds FAIR and RENEW at FY 2023 levels

	FY 2023 Enacted	FY 2024 Request	FY 2024 House	FY 2024 Senate	FY 2024 Approp
High Energy Physics	868.0	850.3	842.3	850.0	824.0
Construction					
LBNF/DUNE	176.0	251.0	225.0	251.0	251.0
PIP-II	120.0	125.0	125.0	125.0	125.0
Mu2e	2.0				
HEP Total	1,166.0	1,226.3	1,192.3	1,226.0	1,200.0

The agreement provides not less than \$35M for Sanford Underground Research Facility and not less than \$5M for the Accelerator Controls Network Research Operations

High Energy Physics	FY 2023	FY 2024
Research	446,037	424,561
SBIR/STTR	15,867	15,267
Facilities/Ops	349,096	334,972
Projects (excl LIC TEC)	57,000	49,200
Total	868,000	824,000

Funding for HEP Research, MIE Projects and Facility/Experimental Operations decreased 5% from 868M in FY 2023 to 824M in FY 2024.

Timeline of FY 2025 Budget Headlines

Debt Limit



3 Jun 2023

HR. 3786, Fiscal Responsibility Act, signed into law

Suspends debt limit through Jan 1, 2025.

Sets statutory caps on non-defense appropriations for FY 2024 (flat) and FY 2025 (+1%). No adjustments for inflation.

Enacted



9 Mar 2024

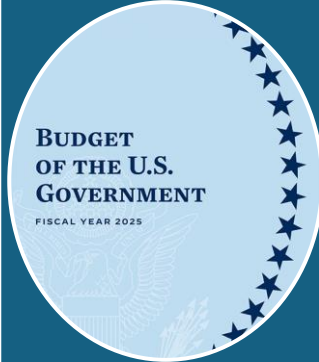
HR. 4366, Consolidated Appropriations Act, 2024, signed into law

Office of Science increases 1.7% from to 8.24B

Office of High Energy Physics increases 2.9%

1.200B HEP

Request



11 Mar 2024

President's 2025 \$1.67T discretionary budget request submitted to Congress

Would decrease non-defense appropriations by about \$60B (3.4%) over the 2024 Request

1.231B HEP

Markup



27 Jun 2024

House Appropriations Subcommittee for Energy and Water Development, and Related Agencies released a summary for the FY 2025 House Mark

1.218B HEP

Markup



1 Aug 2024

Senate Appropriations Subcommittee for Energy and Water Development, and Related Agencies released a summary for the FY 2024 Senate Mark

1.230B HEP

Cont. Res



27 Sep 2024

HR. 9747, Continuing Appropriations and Extensions Act, 2025, signed into law

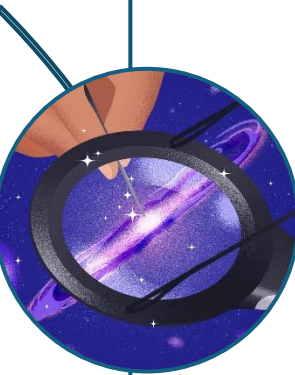
Continuing resolution temporarily extends fiscal year 2024 spending levels until **Dec 20, 2024.**



To avert a Dec 21st shutdown, Congress must pass a budget or another short-term CR.

Lawmakers must pass a final FY 2025 spending bill by the end of April 2025 or face across-the-board spending cuts to both defense and domestic programs (known as “sequestration”).

FY 2025 President's Request Highlights




Research \$395.8M (-\$30.4M, -7.1% from FY 2024 Enacted)

- **\$24M increase** for AI/ML. **\$8M increase** for RENEW and FAIR
- **\$4M decrease** as Accelerate Innovations in Emerging Technologies concludes
- QIS, Microelectronics, Advanced Computing, and Accelerator Science and Technology continue at the FY 2024 Enacted Level
- **\$59.9M decrease** to Core Research. Focus support on high-profile research topics and early research results; key contributions and critical U.S. commitments to experiments & projects; University research & training; other priority cross-cutting initiatives



Facilities Operations \$381.7M (+\$33.2M, +9.5% above FY 2024 Enacted)

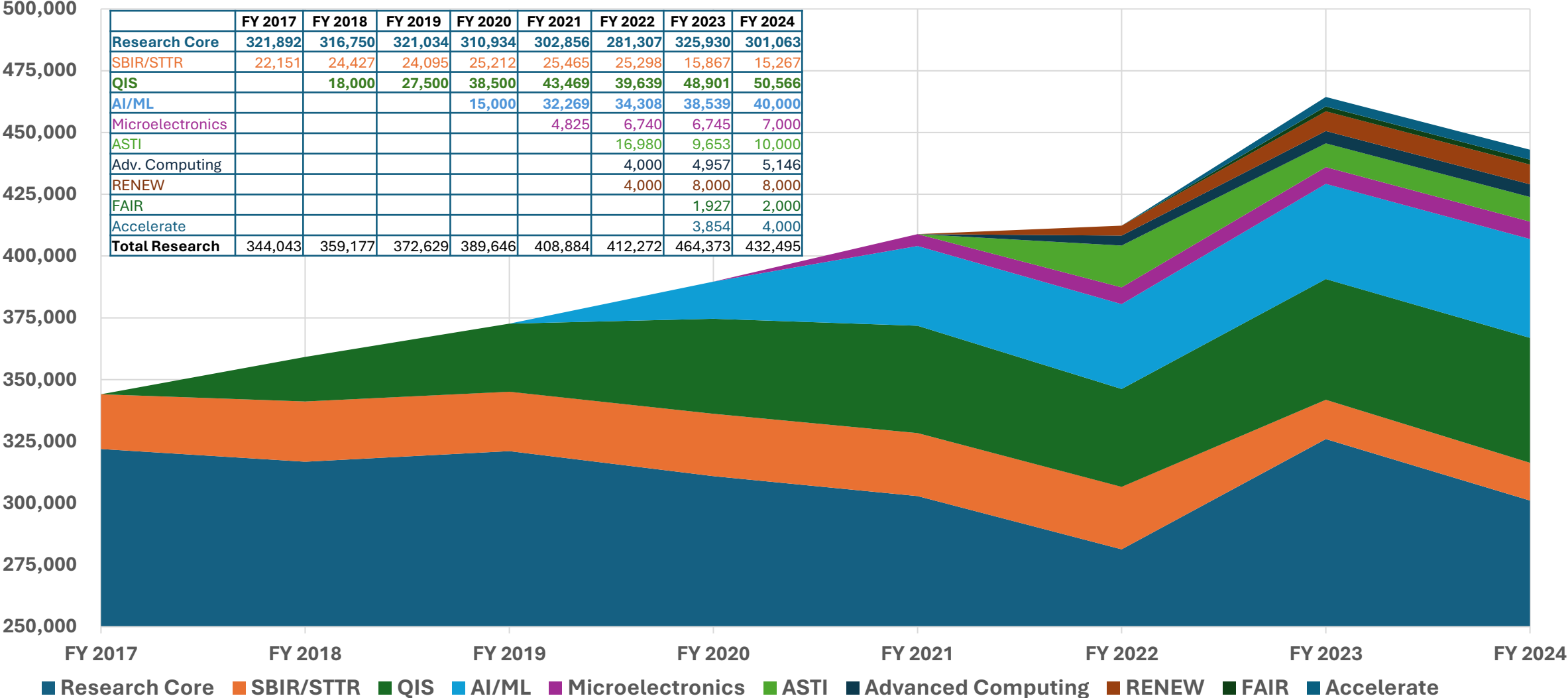
- **Fermilab Accelerator Complex** \$166.9M (+\$25.3M, +17.9% above FY 2024 Enacted): 5,180 hours
- **SLAC FACET-II** \$17.6M (+\$1.1M, +6.9% above FY 2024 Enacted): 3,120 hours
- U.S. LHC Detector Operations \$57.3M (+\$4.5M, +8.5% above FY 2024 Enacted)
- Vera Rubin Operations \$33M (+\$2.1M, +6.7% above FY 2024 Enacted)
- Sanford Underground Research Facility \$35M (**No change** from FY 2024 Enacted)



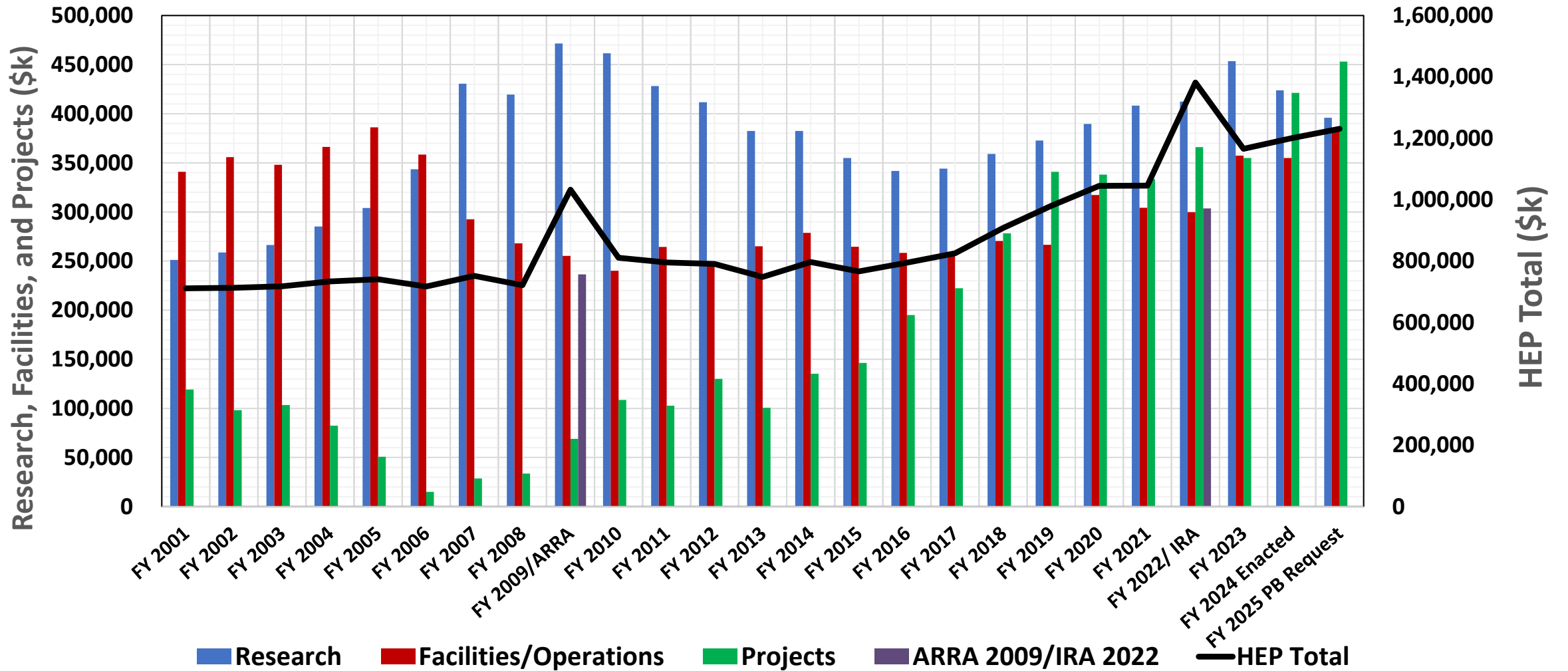
Projects \$453.2M (+\$28.0M, +6.6% above FY 2024 Enacted)

- **LBNF/DUNE** \$280M (+\$25M, +10% above FY 2024 Enacted to support LBNF/DUNE's five subprojects)
- **ACORN** \$10M (+\$5M, +100% above FY 2024 Enacted)
- **CMB-S4** \$4.5M (level funding from FY 2024 Enacted)
- **ATLAS and CMS Detectors** \$33.7M (-\$2M, -6% below FY 2024 Enacted): as per the baselined profiles
- **PIP-II** \$125M (level from FY 2024 Enacted): continue support for baseline profile

HEP Research Breakdown (\$k) FY 2017-2024



HEP Budget (\$K): Research, Facilities & Projects



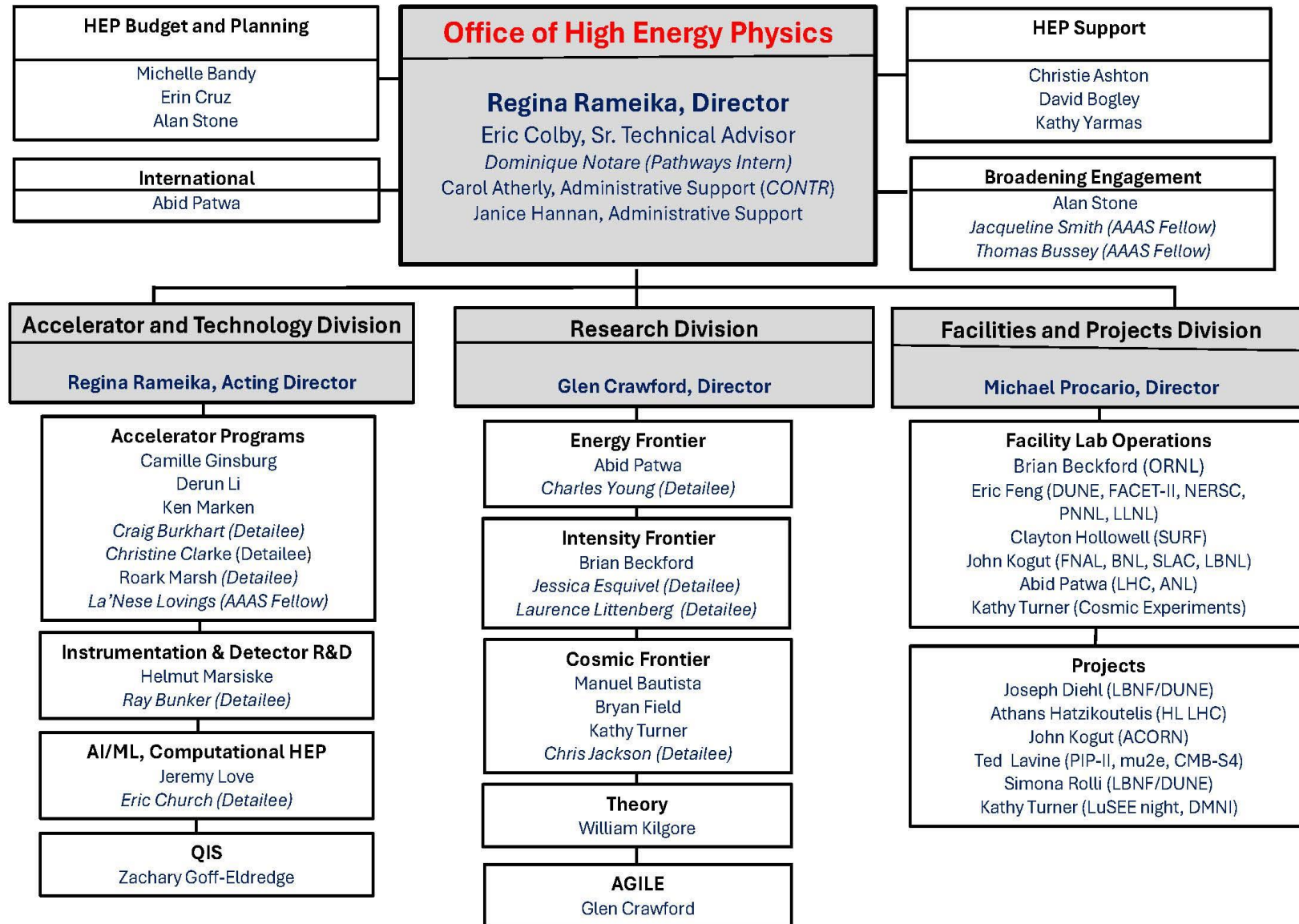
Note: A significant part of the growth of our research budget has been in new initiatives – Quantum, AI/ML

Status on FY 2026

- FY 2026 comes with a unique set of opportunities, challenges, and unknowns
- Opportunities
 - HEP will begin the implementation of 2023 P5 guidance during the [FY 2026 Formulation phase of the budget process](#)
- Challenges
 - Transition to a new Administration will come with new political appointees and S&T priorities
 - Communicating 2023 P5 to the 119th Congress. [New members: 66 \(of 435\) in House and 12 \(of 50\) in Senate](#)
 - The debt ceiling limit authority expires Jan 1, 2025
- Unknowns
 - [New Administration will reset the FY 2026 budget process](#). Anticipate a “skinny” budget with high level overview by early Spring, and a detailed President’s Budget Request about 2 months later.
 - Change in leadership in House and Senate may impact the level of support for Basic Research

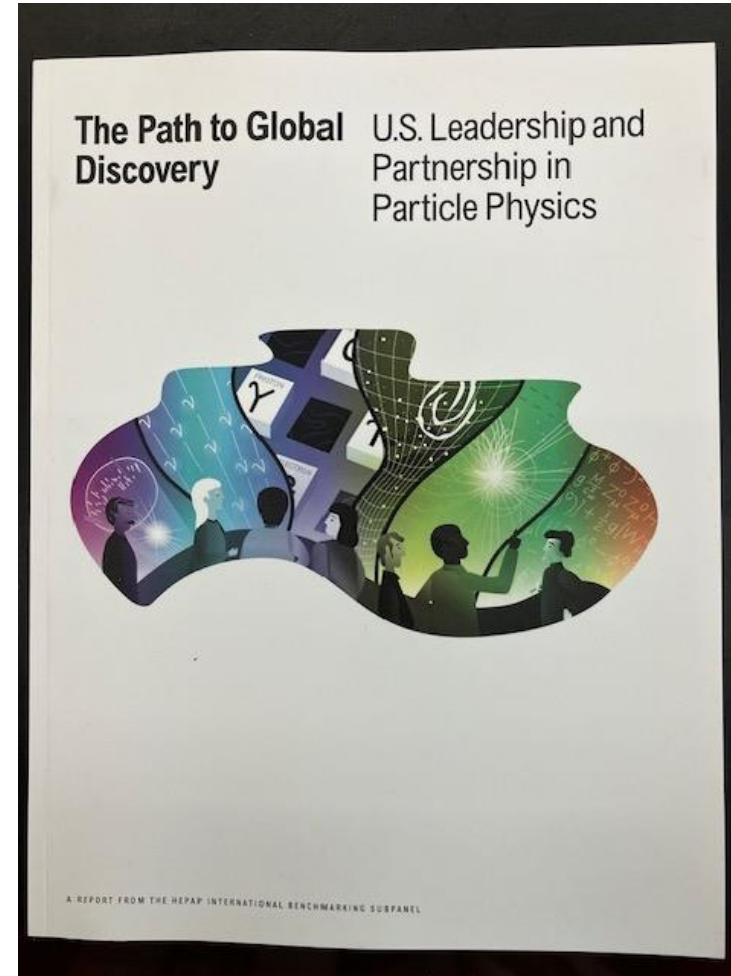
FY 2024 Budget	Spend the Fiscal Year Budget																																					
FY 2025 Budget	OMB Review			Budget Release	Congressional Budget and Appropriations									Spend the Fiscal Year Budget																								
FY 2026 Budget	DOE Internal Planning with OMB and OSTP Guidance												OMB Review			Budget Release	Congressional Budget and Appropriations									Spend the Fiscal Year Budget												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	CY 2023			Calendar Year 2024												Calendar Year 2025												Calendar Year 2026										

HEP Organization (Sept. 2024)



International Benchmarking Subpanel Report

- HEPAP charged to form a subpanel to conduct an international benchmarking study to evaluate U.S. leadership in particle physics in a global context in February 2022.
- Draft report delivered to HEPAP in October 2023 and approved in November 2023
- There were 7 Key Findings and Recommendations, and numerous sub-findings and recommendations
- A draft report was available to the 2023 P5 Panel
- The report did not address budget issues



Summary : US High Energy Physics in the DOE

- Planning is guided by the December 2023 P5 Report
- We are truly committed to the concept that HEP must be a global initiative, participating in projects “off-shore” as well as being a reliable host to programs hosted in the U.S.
- We are very constrained by budget realities
- Transition in government may lead to different priorities and/or initiatives – we need to be agile and recognize opportunities
- HEP is an exciting field that is poised to make important contributions to basic discovery science and technological innovation and advancement.
- Thanks to all of you for your dedication, commitment and contributions.