High Energy Physics Detector R&D Program

CPAD 2025 Workshop

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DOE Office of High Energy Physics

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Outline

- HEP Mission and Research Program
  - Detector R&D Program
    - Goals, Funding, Effort, Process
- Budgets
- Funding Opportunity Announcements
  - HEP Comparative Review
  - Other NOFOs
  - DOE Early Career Research Program

HEP Mission

- Understand 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
- In pursuit of its mission HEP enables discovery science by
  - Building Projects
  - Operating Facilities
  - Conducting a Research program

HEP Research Program

- The P5 Science Drivers identify the scientific motivation
- Research Frontiers are useful categorization of experimental techniques and serve as the basis of the budget process
  - **Energy Frontier** Experimental Physics accelerates particles to the highest energies ever made by humanity and collide them to produce and study the fundamental constituents of matter
  - **Intensity Frontier** Experimental Physics uses a combination of intense particle beams and highly sensitive detectors to make extremely precise measurements of particle properties, to study some of the rarest interactions predicted by the Standard Model, and to search for new physics
  - **Cosmic Frontier** Experimental Physics uses naturally occurring cosmic particles and phenomena to reveal the nature of dark matter, understand the cosmic acceleration caused by dark energy and inflation, infer certain neutrino properties, and explore the unknown.
  - **Theoretical and Interdisciplinary Physics** provides the framework to explain experimental observations and gain a deeper understanding of nature
  - **Accelerator and Technology R&D** fosters innovative research methods and enabling technologies that emerge from AI/ML, QIS, microelectronics, accelerators, and **instrumentation** that will advance scientific knowledge in HEP and in a broad range of related fields, advancing DOE's strategic goals for science
    - **Detector R&D Program overarches/undergirds Research in all three experimental Frontiers and overlaps with national/SC technology initiatives in AI/ML, Microelectronics, and QIS**

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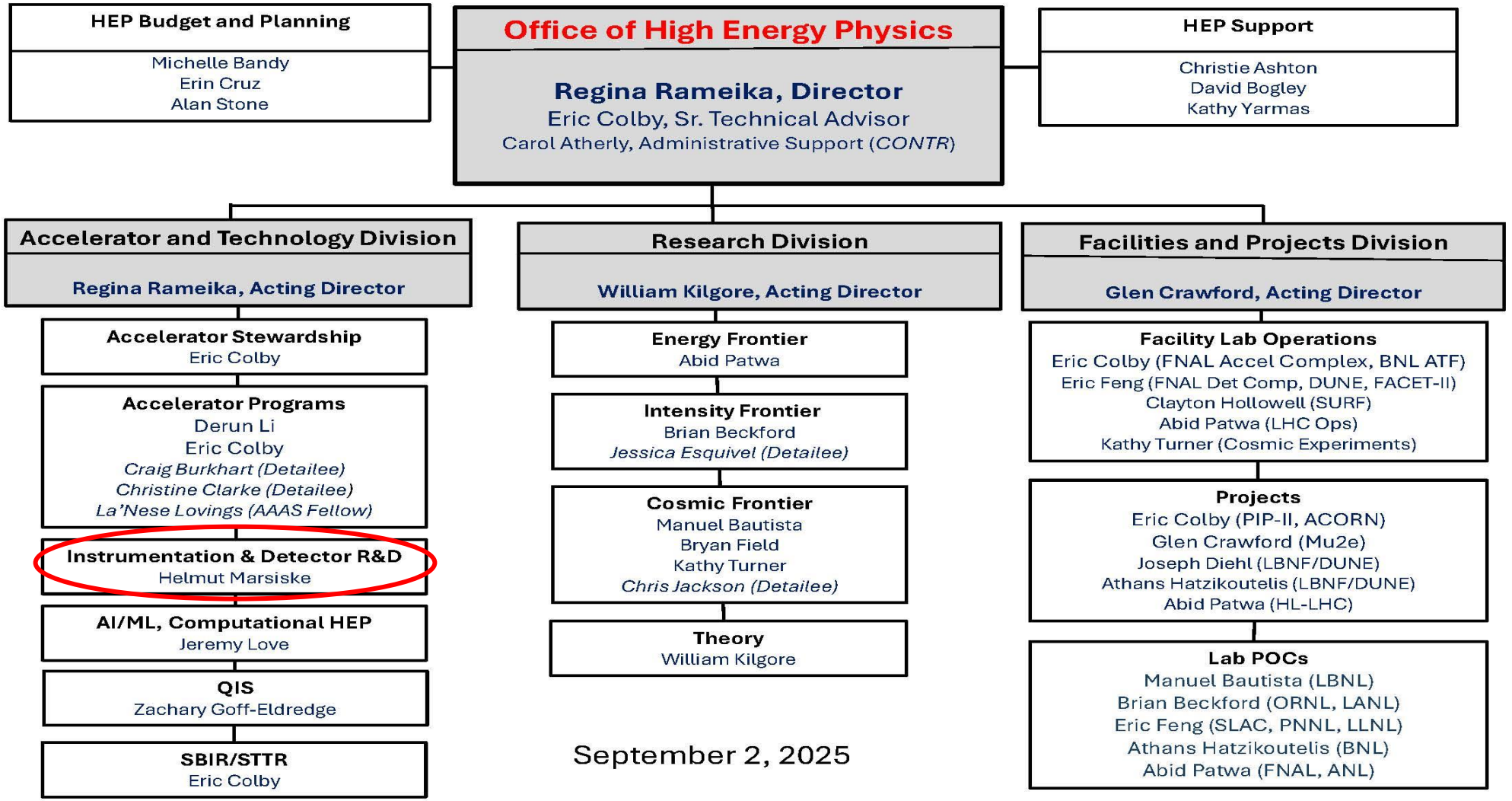
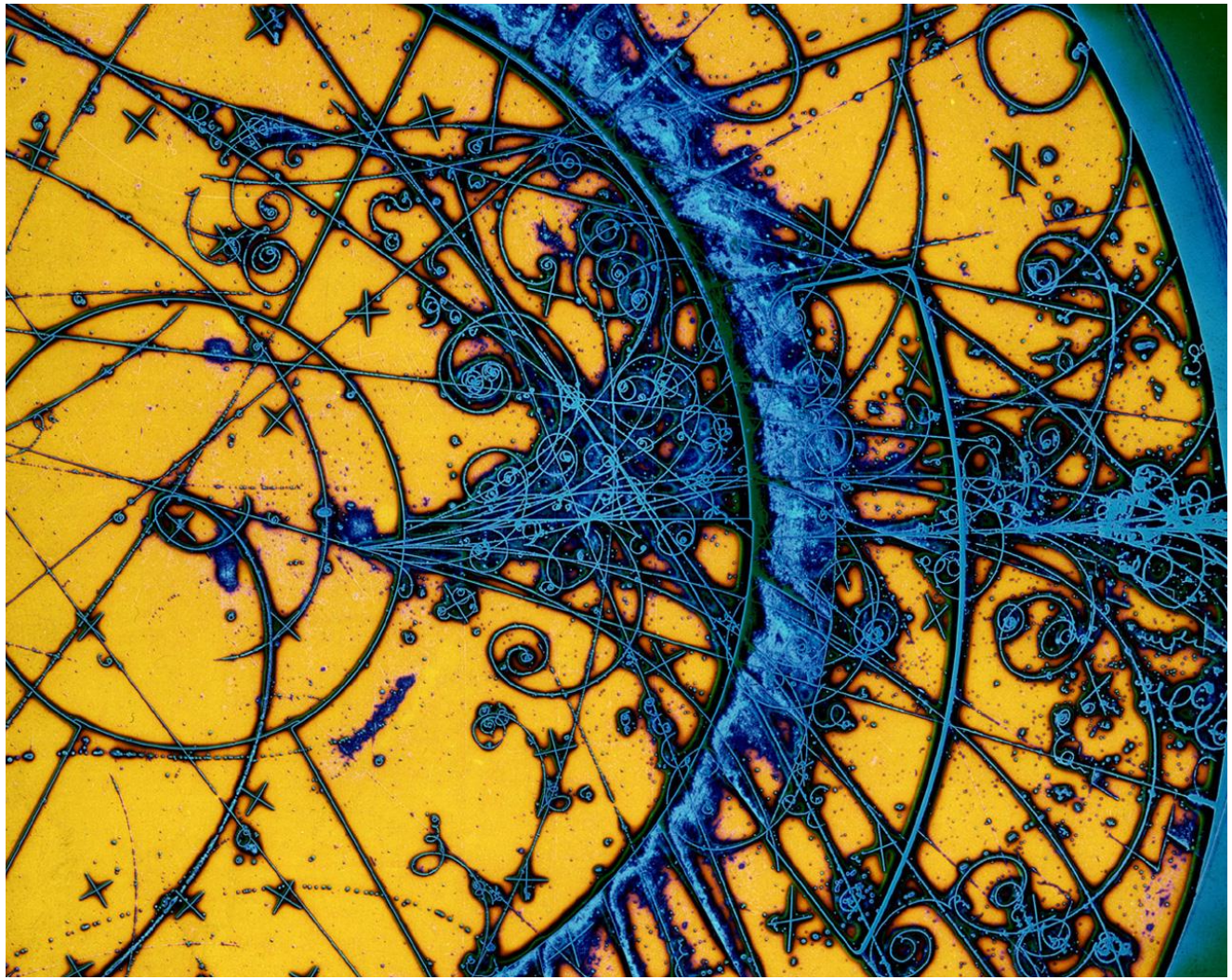


HEP Detector R&D Program



Detector R&D Program Goals

1. Support research leading to fundamental advances in the science of particle detection and develop the next generation of instrumentation for HEP. Program should be
   - Properly balanced along multiple axes, e.g.,
     - incremental, near-term, low-risk vs. **transformative, long-term, high-risk R&D** (i.e., Generic R&D / Blue Sky R&D)
     - universities vs. labs
   - Focused on strategic areas that hold future promise and have the potential for U.S. leadership
   - Outward looking and engage researchers from other fields and from industry

Detector R&D Program Goals, cont.

2. Provide (under-)graduate and post-doctoral research training in instrumentation
   - Foster next generation of detector experts
3. Support “infrastructure”—technical personnel, equipment, “facilities”, and test beams—required for experimental detector R&D and fabrication
   - “local” technical support and equipment can be requested in a Detector R&D proposal

Program Guidance

- 2023 P5 science drivers and priorities
- 2020 Basic Research Needs (BRN) Study
  - Strategic technology areas, aligned with the strengths of the US community, that future long-term R&D efforts should focus on to provide/enhance science capabilities
  - Priority Research Directions/Key Challenges to push well beyond the current state of the art, potentially leading to transformative technological advances with broad-ranging applicability
  - BRN Report published in August 2020: https://science.osti.gov/-/media/hep/pdf/Reports/2020/DOE_Basic_Research_Needs_Study_on_High_Energy_Physics.pdf
- Other community input via CPAD, Snowmass, etc.

Program Funding/Effort/Process

- FY 2025 Funding (in round numbers) was $35M, including all special Initiatives/NOFOs (i.e., Core, Microelectronics, AI/ML, QIS, Traineeships, Early Career, US-Japan, EPSCoR, workshops, etc.)
  - Research funding is $31M, $22M/$9M at labs/universities
    - $12M / $2M / $1M in Microelectronics / AI/ML / QIS
  - Facilities/test beam operation is $4M (all at labs)
- Efforts at labs and universities:
  - ~60 FTEs at 9 labs: ANL, BNL, FNAL, LANL, LBNL, LLNL, ORNL, PNNL, and SLAC
  - ~35 FTEs at ~25 universities w/ ~30 PIs

Program Funding/Effort/Process, cont.

- Process to determine funding/effort:
  - Labs: annual budget briefings, field work proposals (FWPs), and lab comparative review (last in fall of 2022)
  - Universities: notices of funding opportunity (NOFOs) and annual university comparative review (since 2012)
- Separate mechanisms for funds distribution
  - Labs: monthly Approved Funding Program (AFP) direct from HQ
  - Universities: via grants from the Chicago office usually in annual allotments
    - Any university funding requires a proposal
    - Any university award above $1.5M is to be fully-forward-funded in the first year

Program Funding/Effort/Process, cont.

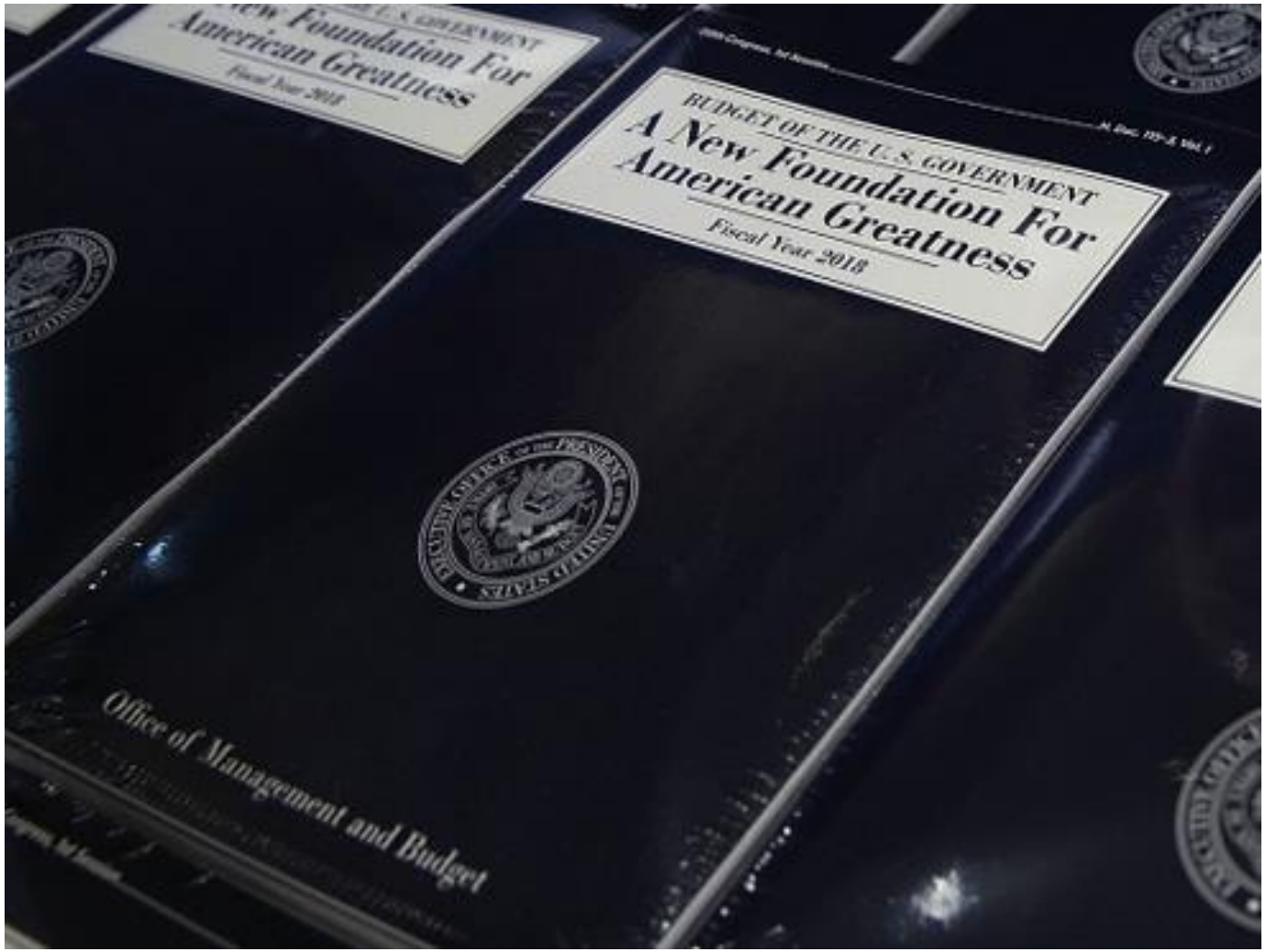
- Targeted NOFOs/LAB calls Detector R&D participates in:
  - AI/ML, Microelectronics, QIS
  - Early Career Research program
  - U.S.-Japan Science and Technology Cooperation Program In High Energy Physics
  - Instrumentation Traineeship (again in FY 2027?)

  - SBIR/STTR

Examples of Targeted NOFOs/Lab Calls

- LAB Call: Microelectronics Science Research Center Projects for Energy Efficiency and Extreme Environments
  - SC-wide LAB call with participation from ASCR, BES, FES, HEP, and NP
  - 16 4-year awards (FY24-27) with $178M total funding
    - 5 HEP-related awards with $20M HEP funding and $34M non-HEP funding
- NOFO and Lab Call: Quantum Information Science Enabled Discovery (QuantISED 2.0)
  - Many awards with significant Detector R&D component
- Lab Call: Hardware-Aware AI for HEP
  - Several awards with significant Detector R&D component

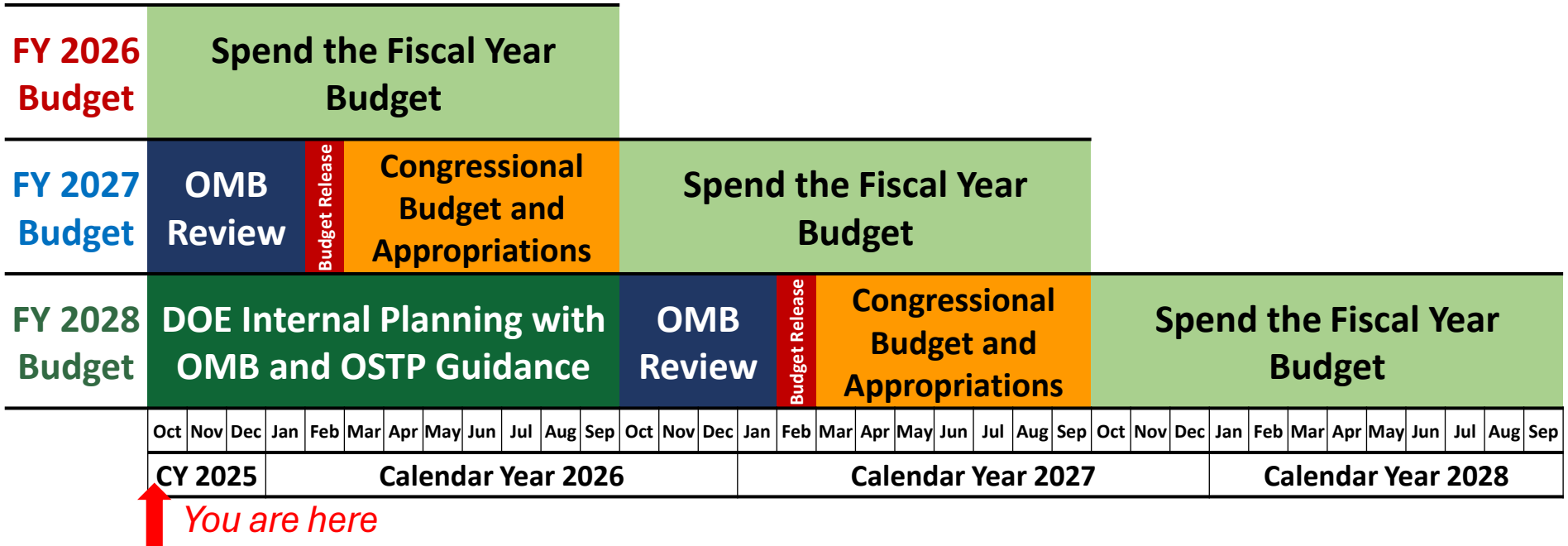
Budgets


A New Foundation For American Greatness
Fiscal Year 2018
BUDGET OF THE U.S. GOVERNMENT
A New Foundation For American Greatness
Fiscal Year 2018
Office of Management and Budget

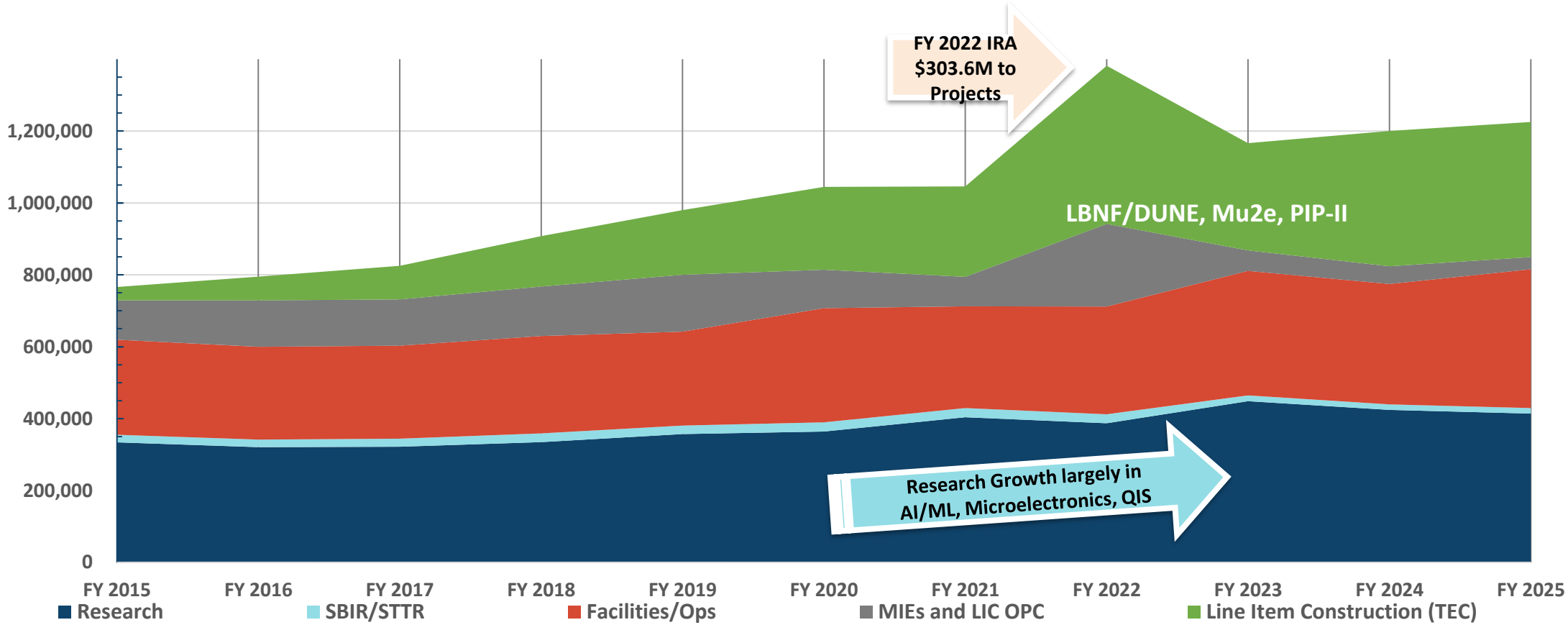
Federal Budget Cycle

Typically, three budgets are being worked on at any given time:

- Executing current Fiscal Year (FY; October 1 – September 30)
- White House Office of Management and Budget (OMB) review and Congressional Appropriation for next FY (FY+1)
- Agency internal planning for next-to-next FY (FY+2)



HEP Budgets FY 2015 – FY 2025 ($k)



	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025
Research	46%	43%	42%	41%	39%	37%	38%	30%	40%	36%	34%
Facilities/Operations	35%	32%	31%	29%	27%	30%	30%	22%	30%	29%	32%
Projects	19%	25%	27%	31%	35%	32%	32%	48%	30%	35%	34%
Total Budget ($k)	**766,000**	**795,000**	**825,000**	**908,000**	**980,000**	**1,045,000**	**1,046,000**	**1,381,630**	**1,166,000**	**1,200,000**	**1,234,570**

FY 2026 HEP President's Request Budget (PRB)

High Energy Physics Funding (dollars in thousands)				
	FY 2024 Enacted	FY 2025 Enacted	FY 2026 PRB	FY 2026 PRB vs FY 2025 Enacted
Subtotal, High Energy Physics	824,000	858,570	747,836	-110,734
Subtotal, Line Item Construction	376,000	376,000	365,000	-11,000
Total, High Energy Physics	**1,200,000**	**1,234,570**	**1,112,836**	**-121,734**

	FY 2025 Enacted	FY 2026 PRB
Research	424,275	302,160
Facilities/Operations	386,095	407,276
MIE and LIC Projects	424,200	403,400
HEP Total	**1,234,570**	**1,112,836**

Detector and Microelectronics Research Funding in the PRB

FY 2025 Enacted		FY 2026 Request Explanation of Changes		FY 2026 Request vs FY 2025
Detector R&D $ — (dollars in thousands)		**$12,254**		**– $1,816**
The Detector R&D activity was requested as part of the Advanced Technology R&D subprogram in FY 2025 with a comparatively adjusted funding level of **$14,070,000**.		The Request will maintain support for key expertise while sustaining essential aspects of Detector R&D, including the Traineeship Program in HEP Instrumentation.		Research funding will strategically focus on advanced particle detector technology in key areas such as novel devices and new modalities for calorimetry, tracking, and timing.
Microelectronics $ — (dollars in thousands)		**$10,456**		**$0**
The Microelectronics research activity was requested within the Detector R&D activity in FY 2025 with a funding level of **$10,456,000**.		The Request will continue supporting microelectronics development at multiple national laboratories and universities as well as support for the Microelectronics Science Research Center projects.		No changes.

In addition, FY 2025 funding from AI/ML and QIS initiatives in support of hardware AI and quantum sensing

Notices of Funding Opportunity (NOFOs; previously FOAs)

FY 2026 & FY 2027 University Comparative Review

- **HEP University Comparative Review for FY 2026 was implemented via the FY25 SC Open Call DE-FOA-0003432**
  - FY26 pre-proposals by July 31, 2025
  - FY26 proposals to be considered in the Comparative Review by September 4, 2025
    - Proposals out for review
    - Multi-institutional team proposals discouraged
- **HEP University Comparative Review for FY 2027 has been implemented via the FY26 SC Open Call DE-FOA-0003600**
  - FY27 pre-proposals by July 30, 2026 ← **strongly encouraged!!!**
  - FY27 proposals to be considered in the Comparative Review by September 3, 2026
    - Multi-institutional team proposals discouraged

HEP Detector R&D Proposals

- Proposed research will review best if broadly aligned with the DOE/HEP mission and program, i.e., the P5 strategy
- "Generic" detector research that is not specific to a single HEP experiment but is more broadly applicable
  - Proposals broadly aligned with the Priority Research Directions identified in the previous HEP Detector R&D Basic Research Needs study
  - Proposals for "Blue-Sky" research on innovative technologies not already in contention for implementation in future DOE HEP projects

Detector R&D Research Consortia

- **Multi-institutional (consortium) proposals** were encouraged in FY 2025 as a way to address significant technology R&D challenges beyond the scope of typical single-investigator awards
  - Received half dozen consortium proposals, mostly from the CPAD RDCs
    - Could award only two due to budget limitations
    - Difficult to evaluate comparatively since very dissimilar to (small) single-PI proposals
- Was planning different process for FY 2026 (and anticipated P5-enhanced budget)
  - Consortium proposals not encouraged in university comparative review
  - Dedicated NOFO/LAB call for (RDC) consortium proposals, separate from the university comparative review
    - No authorization to issue dedicated NOFO and funding levels as per FY26 President's Request Budget make this plan very challenging; realization will depend on final Congressional appropriations

FY 2026 Targeted Review: Multi-institutional team applications for HEP Detector R&D

- HEP expects to convene a merit-review panel in June 2026 for multi-institutional team applications submitted to the topic, proposing high-risk, high-reward blue-sky research that address significant challenges beyond the scope of typical single-investigator awards.
- Implemented via the FY26 SC Open Call DE-FOA-0003600
  - Pre-proposals by February 27, 2026 ← **mandatory!!!**
  - Encouragement / discouragement decisions by March 27, 2026
  - **Encouraged** proposals by May 1, 2026
  - Check for additional details in the NOFO and the forthcoming Lab Call

(Inter)National Detector R&D Landscape

- Somewhat complicated landscape right now
  - Europe: ECFA Detector R&D Roadmap ➔ Detector R&D collaborations (DRDs) have been formed
    - Focused on R&D for FCC_ee
  - US: CPAD ➔ Detector R&D Collaborations (RDCs) have been formed
    - Focused on generic/Blue Sky R&D
  - US: HFCC ➔ Structure and process for Higgs Factory Detector R&D being set up
    - Very little funding available in FY25/26
  - US: Muon Collider ➔ Growing interest in Detector R&D
    - No dedicated funding available

Other Funding Opportunities

- SC “Open Call”: Continuation of Solicitation for The Office of Science Financial Assistance Program [DE-FOA-0003600]
  - HEP uses this to implement university comparative review for FY 2027, a number of targeted reviews; and for supplemental proposals, experimental operations support, and conferences
- SC Workforce Development (WDTS) programs
  - Office of Science Graduate Student Research fellowships (SCSGR)
    - Supports graduate student research at a DOE lab, 3 to 12 months
    - Convergence Research Topical Areas
      - (a) Microelectronics (ASCR, BES, HEP)
- U.S.-Japan Science and Technology Cooperation Program In High Energy Physics
  - Detector R&D for HEP

Early Career Research Program (ECRP)

- SC plans to issue an FY 2026 Funding Opportunity Announcement for the next round of Early Career applications
- SC-wide program with HEP component
  - HEP part includes Detector R&D subprogram
    - Detector R&D connects with (hardware) AI/ML and QIS

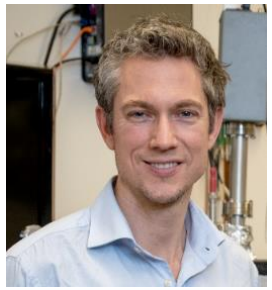
- Look to https://science.osti.gov/early-career/ for further updates

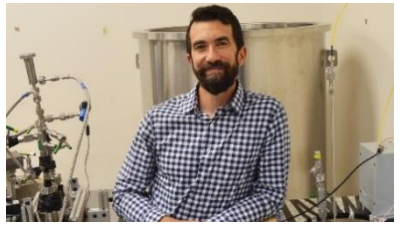
Early Career Awards in Detector R&D

- FY 2017
  - Ahmed Zeeshan, SLAC
    - Multiplexing CMB detectors
- FY 2018
  - Aritoki Suzuki, LBNL
    - Producing CMB detectors
  - Javier Tiffenberg, FNAL
    - Skipper-CCD development
  - Daniel Bowering, FNAL (QIS)
    - Microwave Single-Photon Sensors
- FY 2019
  - Peter Sorensen, LBNL
    - Crystalline Xenon TPC
  - Jingke Xu, LLNL
    - Low-noise liquid Xenon detectors
- FY 2020
  - Jonathan Asaadi, UT Arlington
    - Multi-modal pixel-based noble element TPCs









Early Career Awards in Detector R&D, cont.

- FY 2021
  - Farah Fahim, FNAL (AI/ML, Microelectronics)
    - Frontend Implementation of AI-Machine Learning Neural Networks for On-Detector Radiation-Hard Edge Computing
- FY 2022
  - Matt Pyle, UC Berkeley
    - Developing TES with Sensitivity to meV Scale Excitations for Light Mass Dark Matter Searches and other Applications
  - Noah Kurinsky, SLAC (QIS)
    - Superconducting Qubit-Based Sensors for meV-Scale Particle Detection
- FY 2023
  - Silvia Zorzetti, FNAL (QIS)
    - Advancing Quantum Sensors and Sensor Networks with High-Efficiency Transduction
- FY 2024
  - Shawn Westerdale, UC Riverside
    - Developing low-threshold liquid argon time projection chambers with photo-sensitive dopants for dark matter and neutrino experiments

Early Career Awards in Detector R&D, cont.

- FY 2025
  - “Silent negotiations” with successful applicants but still no public announcement; declinations have gone out for unsuccessful proposals

Parting Thoughts…

- Priority is to support long-term, high-risk research into potentially transformational, broad-impact “Blue Sky” technology advances
- Community input is sought for identifying strategic Detector R&D opportunities—CPAD, Basic Research Needs Study, Snowmass community planning exercise, P5, etc.
- Need to organize/optimize the program across the lab/university, domestic/international, multi-program landscape
- Need to learn how to take advantage of the (growing) SC initiatives in AI/ML, Microelectronics, and QIS

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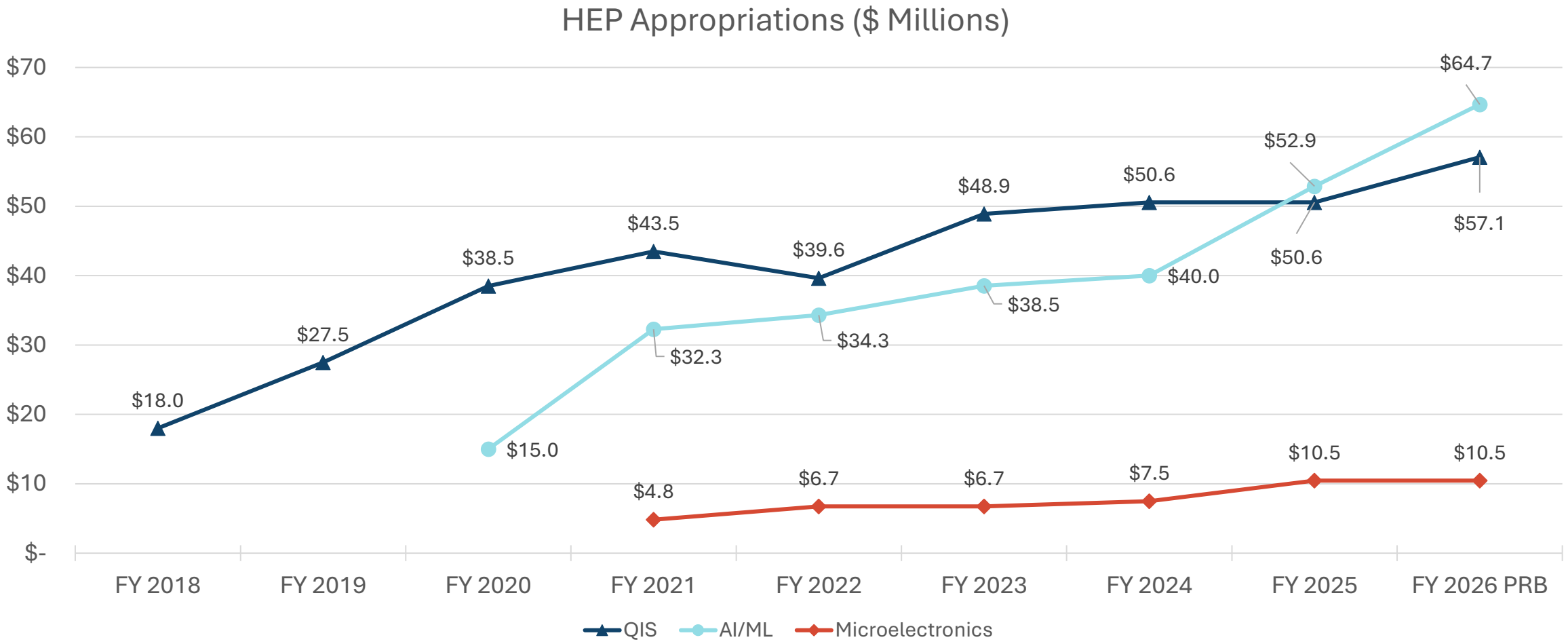
AI/ML, Microelectronics, and QIS Funding



CompRev Review and Award Process and Timeline

Pre-review

- August: Pre-applications received via DOE's Portfolio Analysis and Management System (PAMS). Reviewer selection and review planning at DOE-HEP.
- September: Proposals received. NOFO compliance checks at DOE-HEP: scope, PI qualifications, page limits, budget pages, etc.

Panel Review

- September-October: Proposals assigned to *at least* three mail reviewers.
- November: Panel discussion of all proposals and all senior personnel. Make comparative evaluation.

Post-review and award

- December: Assessment of each proposal and each PI by DOE/HEP using merit review, grant monitor input, programmatic priorities, budget constraints
- Early-to-mid January: Prioritized budget guidance sent to PIs and requests for revised budgets and budget justifications using proper DOE forms
- End-January - March: Route proposal's procurement packages through DOE/SC and DOE Chicago Operations Office for approval
- March-April: Awards to university from DOE Chicago Operations Office