U.S. DEPARTMENT OF ENERGY | Office of Science

High Energy Physics Detector R&D Program

2022 CPAD Workshop, Stony Brook, NY

November 28 – December 2, 2022

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Office of High Energy Physics

Outline

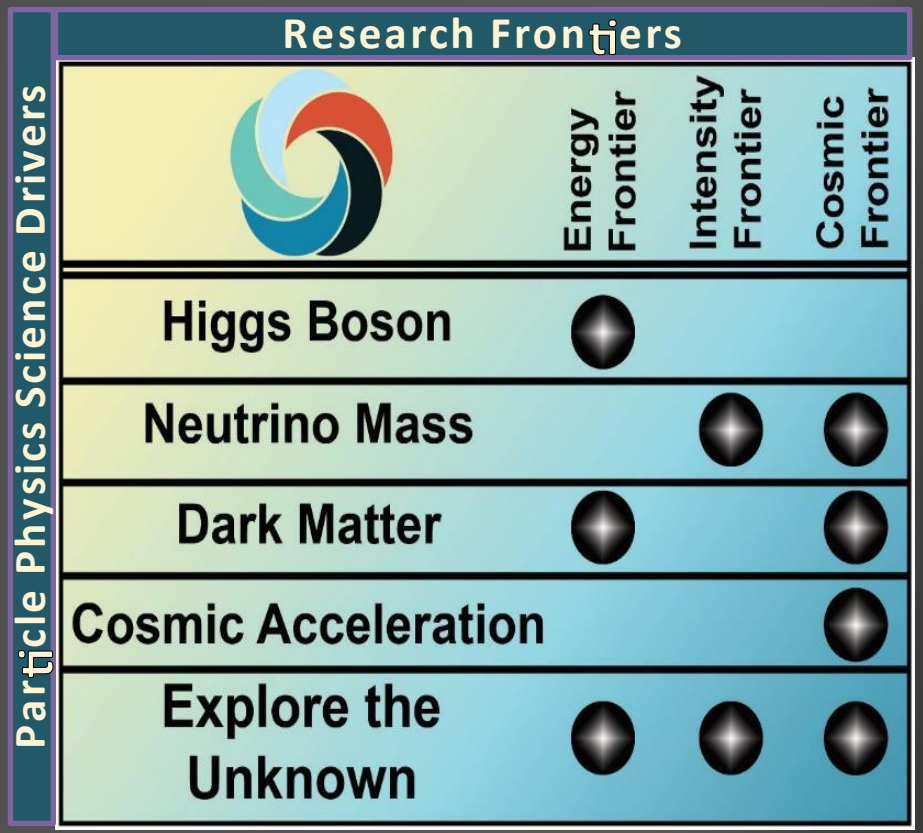
- HEP Mission and Research Program
- Detector R&D Program
  - Goals/Guidance/Process/Funding/Efforts
- Budgets
- Funding Opportunities

HEP Mission

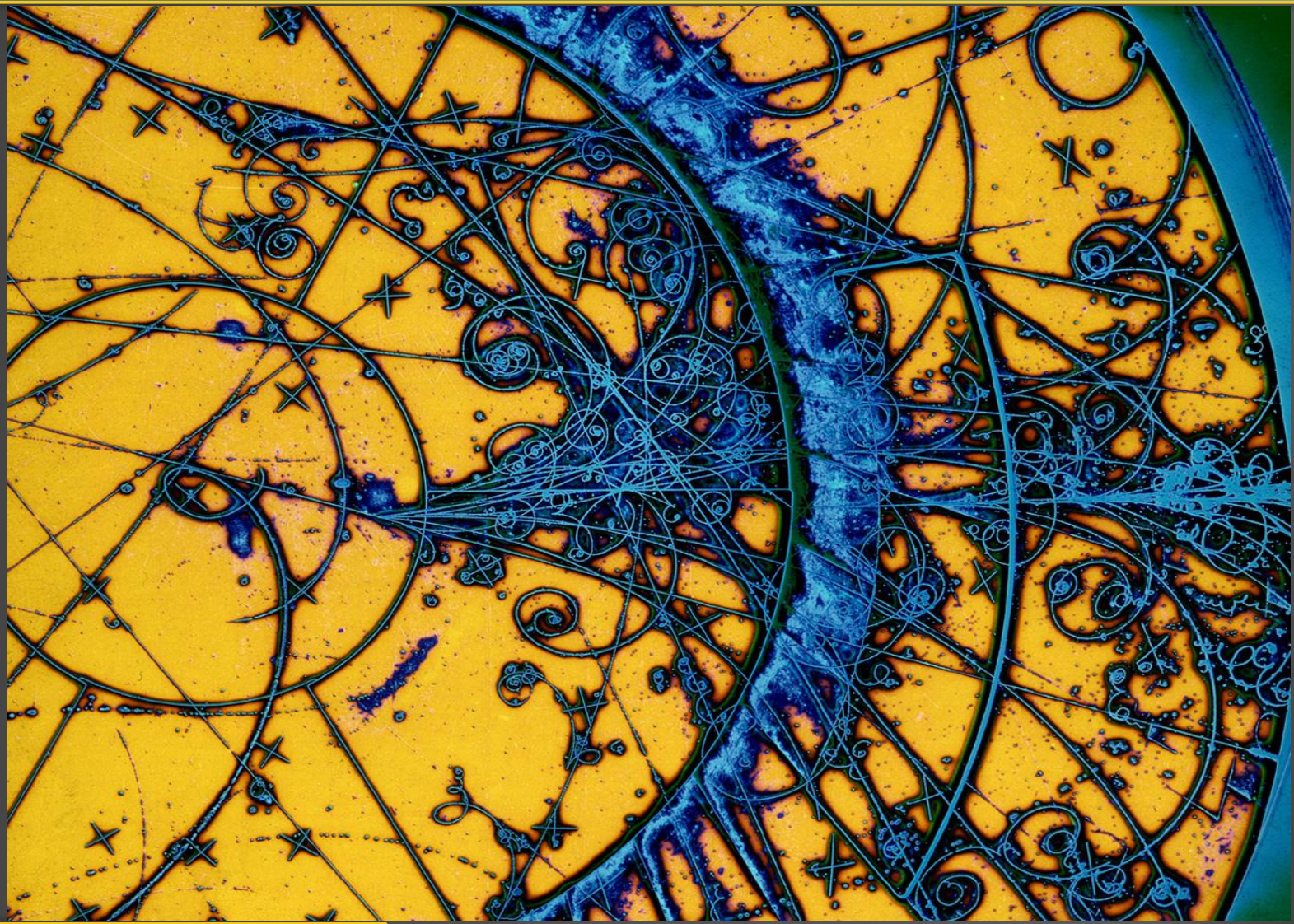
- Understand how the universe works at its most fundamental level:
  - Discover the elementary constituents of matter and energy
  - Probe the interactions between them
  - Explore the basic nature of space and time
- In pursuit of its mission HEP enables discovery science by
  - Building **Projects**
  - Operating **Facilities**
  - Conducting a **Research** program

HEP Research Program

- P5 Science Drivers identify the scientific motivation
- Research Frontiers are useful categorization of experimental techniques and serve as the basis of the budget process
- Research Frontiers are complementary
  - No one Frontier addresses all science drivers
  - Each Frontier provides a different approach to address a science driver
  - Enables cross-checking scientific results
- Detector R&D Program overarches/undergirds Research in all three Frontiers



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
   - Properly balanced between…
     - …incremental, near-term, low-risk and transformative, long-term, high-risk R&D;
     - …universities and labs, etc.
   - Focus on strategic areas
     - Future promise and (potential for) U.S. leadership
   - 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
   - Next generation of detector experts
3. Support "infrastructure"—technical personnel, equipment, "facilities", and test beams
   - Crucial resources for experimental detector R&D and fabrication

Program Guidance

- P5 science drivers and high-priority projects
  - In 2015/206, near-term focus was on
    - LHC phase-II upgrade projects
    - Short- and long-baseline neutrino program
    - Dark Matter, Dark Energy, CMB projects
  - Since then, refocus on long-term, high-risk, high-reward efforts: Blue-Sky R&D
- Basic Research Needs (BRN) Study in 2019/2020
  - 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 to push well beyond the current state of the art, potentially leading to transformative technological advances with broad-ranging applicability
  - "Key Challenges" where technological breakthroughs could lead to game-changing experimental capabilities for HEP
- Community input via CPAD, Snowmass, etc.

Program Process

- Process to determine funding/effort:
  - Labs: annual budget briefings, field work proposals (FWPs), and lab comparative review every few years (last in September 2022)
  - Universities: annual funding opportunity announcement (FOA)—university comparative review (since 2012)

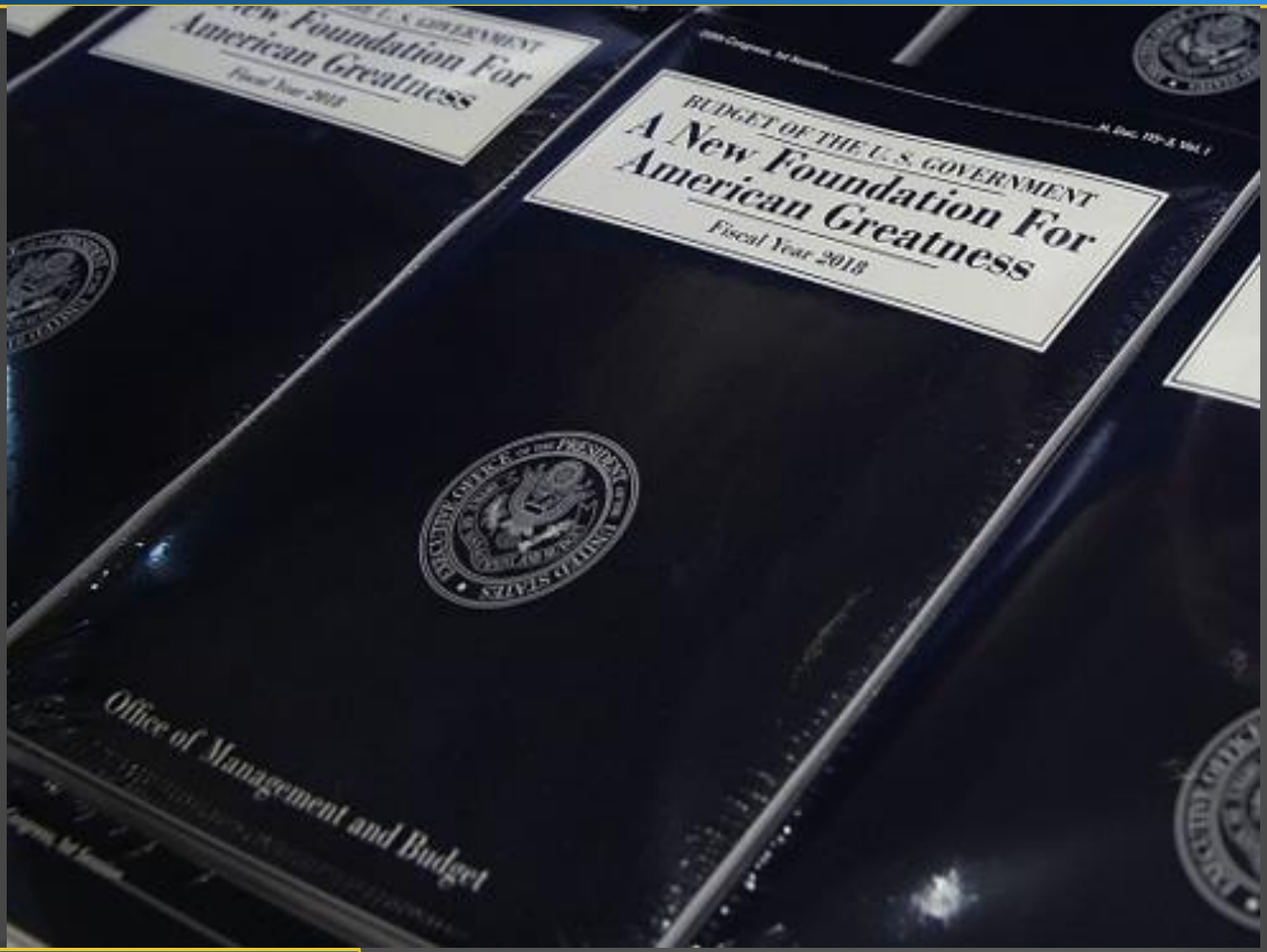
Program Process, cont.

- Targeted lab calls/FOAs Detector R&D program participates in:
  - Early Career Research Program
  - U.S.-Japan Science and Technology Cooperation Program In High Energy Physics
  - Instrumentation Traineeship
  - Microelectronics Co-design
  - AI/ML
  - SBIR/STTR

Program Funding/Effort

- Funding (in round numbers) was $29M in FY 2022
  - Research funding is $22M, ~70-75% at labs
    - Including Microelectronics, AI/ML, US-Japan, Early Career Awards, Traineeship, special FOAs
  - Facilities/test beam operations is $7M
- Efforts at labs and universities:
  - 50-60 FTEs at 8 labs: ANL, BNL, FNAL, LBNL, LLNL, ORNL, PNNL, and SLAC
  - 20-30 FTEs at ~25 universities w/ ~30 PIs

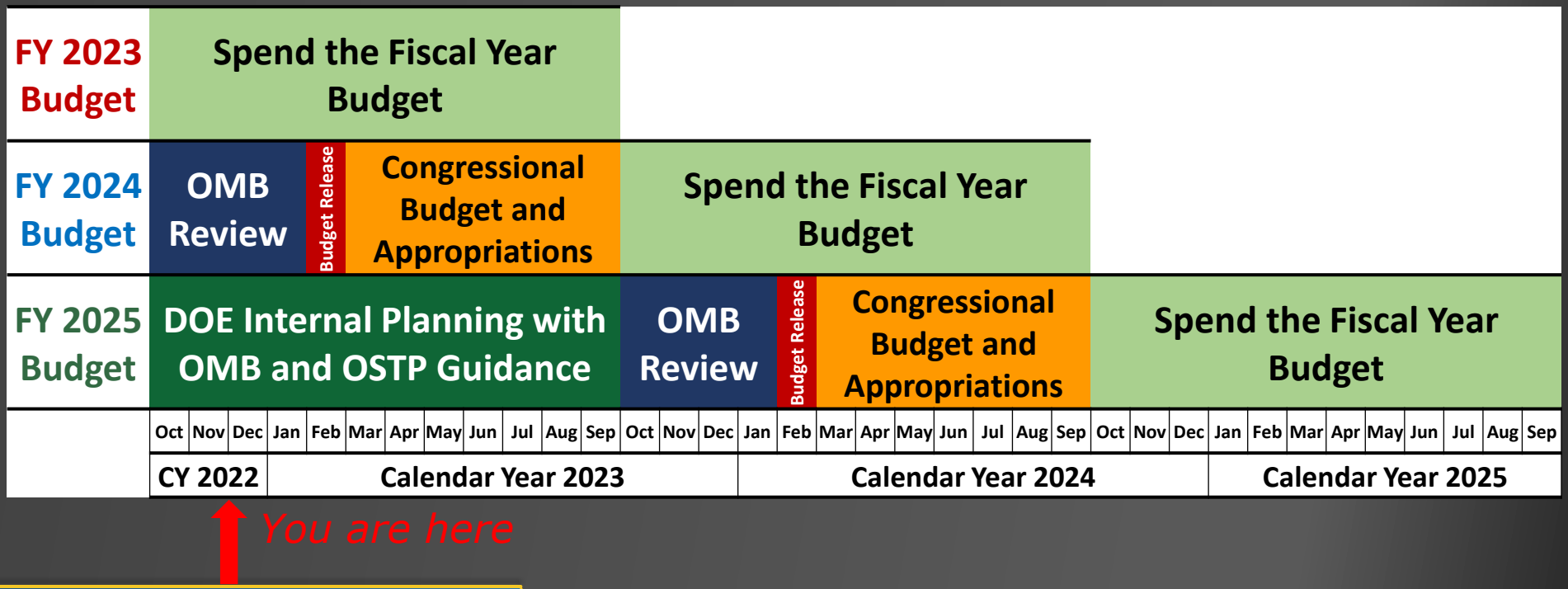
HEP Budgets


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

Federal Budget Cycle

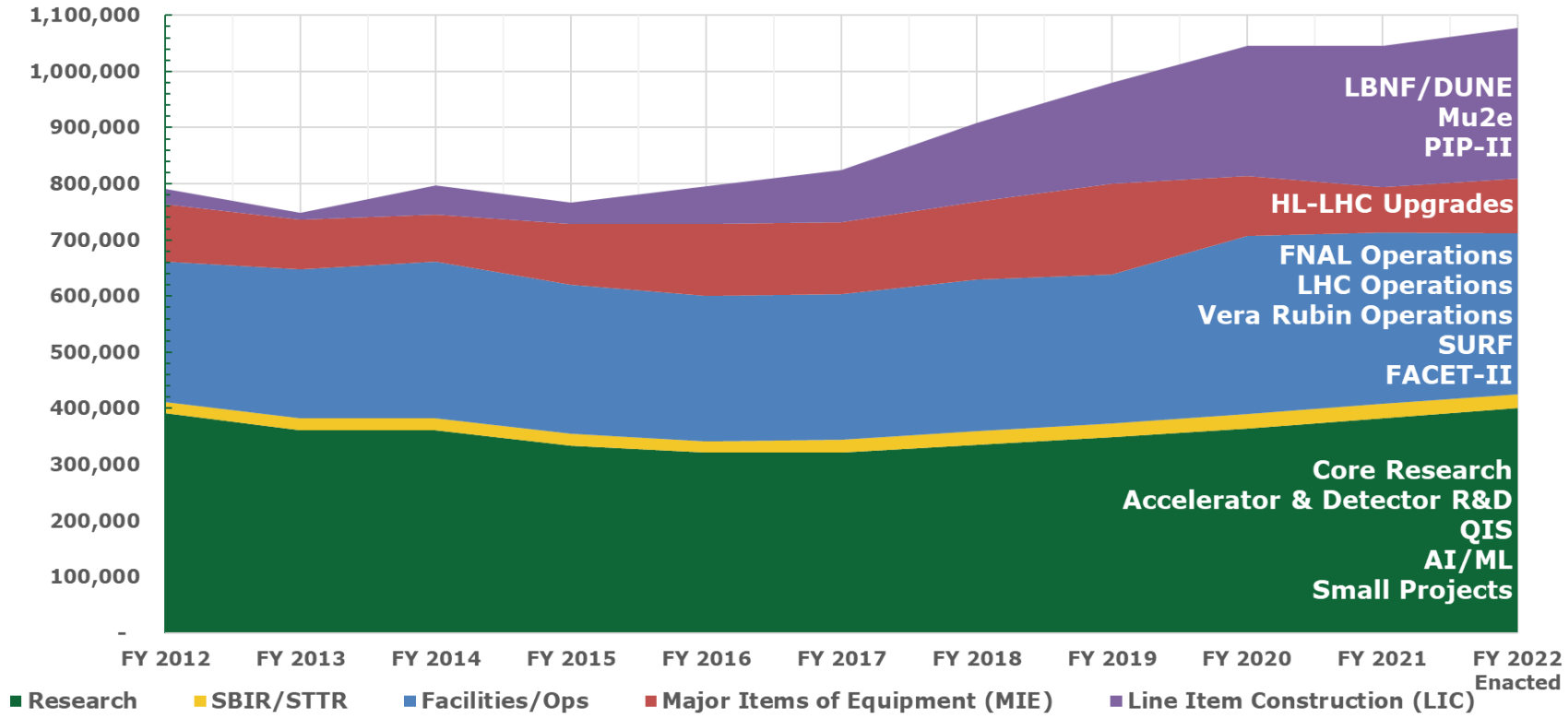
Typically, three budgets are being worked on at any given time:

- 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)

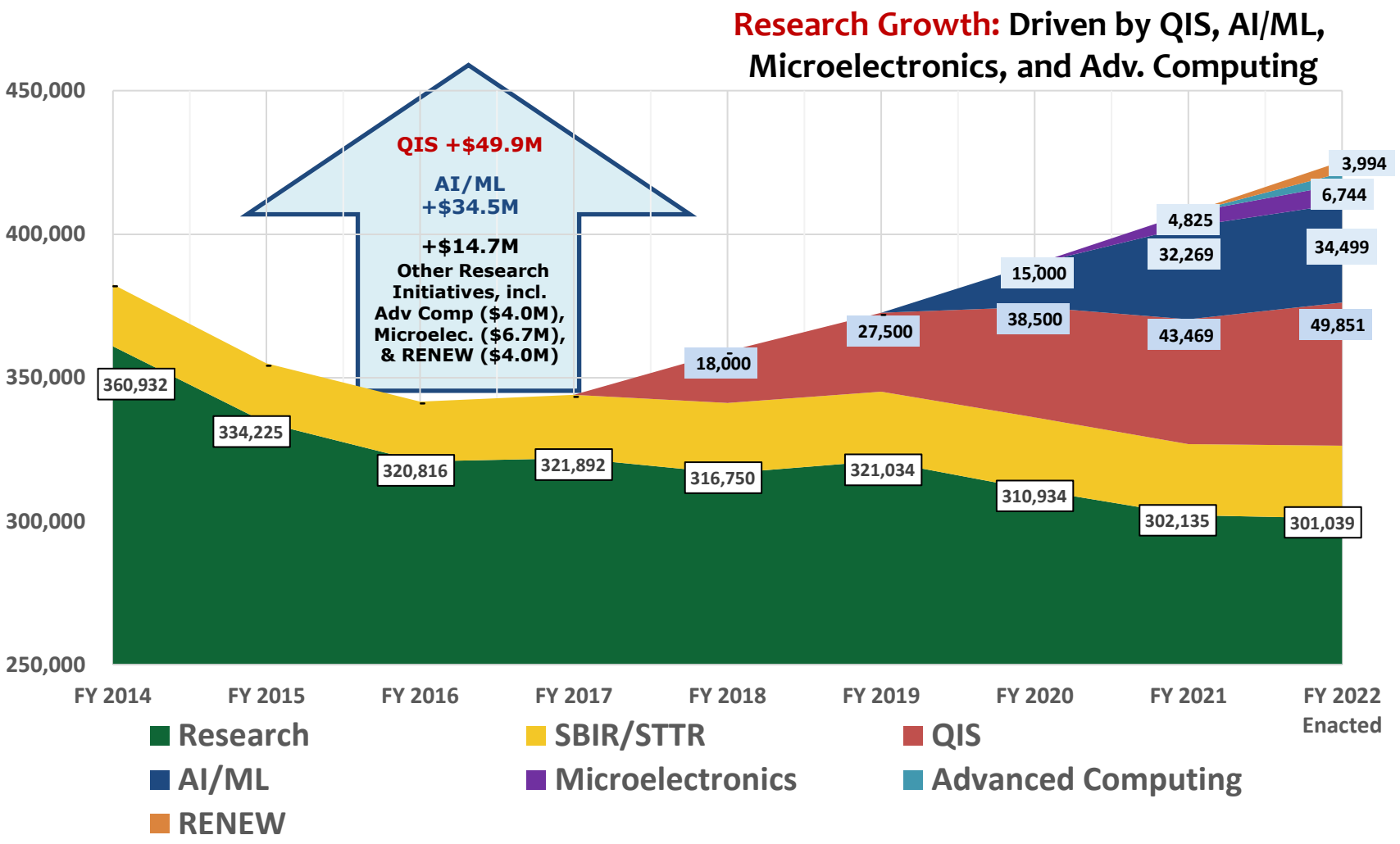


HEP Budgets FY 2012-2022

HEP Funding ($ in k)	FY 2017 Actual	FY 2018 Actual	FY 2019 Actual	FY 2020 Actual	FY 2021 Actual	FY 2022 Enacted	FY 2023 President's Request
TOTAL	825,000	908,000	980,000	1,045,000	1,046,000	1,078,000	1,122,020



HEP Research FY 2014-2022



Funding Opportunity Announcements

University Comparative Review

- FY 2023 Research Opportunities in High Energy Physics [DE-FOA-0002832]
  - Primary HEP FOA for research at universities
    - Includes Detector R&D subprogram
  - Letters of Intent are strongly encouraged and may be submitted before Wednesday, November 16, 2022, at 5 PM Eastern Time
  - Applications are due on Wednesday, December 21, 2022, at 11:59 PM Eastern Time
    - Talk to the HEP program manager you plan to submit to!

Other Funding Opportunities

- SC "Open Call": Continuation of Solicitation for The Office of Science Financial Assistance Program [DE-FOA-0002844]
  - HEP uses this primarily 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)

Other Funding Opportunities, cont.

- U.S.-Japan Science and Technology Cooperation Program In High Energy Physics
  - Detector R&D for HEP – laboratory led
- DOE Traineeship in HEP Instrumentation
- Microelectronics Co-design
  - Multi-program efforts – laboratory led
- AI/ML R&D at the High Energy Physics Frontiers
  - AI/ML on the Detector

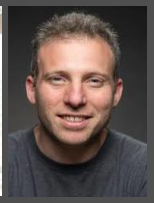
Early Career Research Program

- 2023 DOE Office of Science Early Career Research Program [DE-FOA-0002821]
  - SC-wide program with HEP component;
    HEP component includes Detector R&D subprogram
  - Pre-applications are mandatory and are due on Thursday, January 5, 2023, at 5:00 PM Eastern Time
  - Applications are due on Thursday, March 23, 2023, at 11:59 PM Eastern Time
    - Only those applicants that receive notification from DOE encouraging a formal application may submit full applications
    - Talk to the HEP program manager you plan to submit to!
    - Don’t give up after an unsuccessful try!

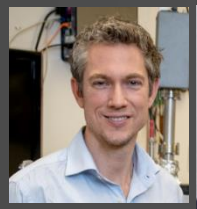
Early Career Awards in Detector R&D

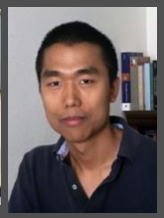
- FY 2017
  - Ahmed Zeeshan, SLAC
    - Multiplexing CMB detectors

- FY 2018
  - Aritoki Suzuki, LBNL
    - Producing CMB detectors
  - Javier Tiffenberg, FNAL
    - Skipper-CCD development

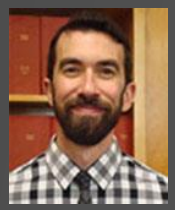


- FY 2019
  - Peter Sorensen, LBNL
    - Crystalline Xenon TPC
  - Jingke Xu, LLNL
    - Low-noise liquid Xenon detectors





- FY 2020
  - Jonathan Asaadi, UT Arlington
    - Multi-modal pixel-based noble element TPCs



- FY2021
  - Farah Fahim, FNAL
    - 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
    - Superconducting Qubit-Based Sensors for meV-Scale Particle Detection

HEP Detector R&D Summary

- Need to preserve/invigorate innovation in Detector R&D within constrained budgets and make a compelling case for growing the budget
- Near-term priority had been to support P5 projects
- Long-term priority is to support research into potentially transformational, broad-impact, high-risk "Blue Sky" technology advances
- Community input for identifying strategic Detector R&D opportunities—CPAD, Basic Research Needs Study, Snowmass 2022 planning exercise, P5, etc.
- Need to optimize the program across the whole lab/university landscape, nationally and internationally, using cost-effective, collaborative models

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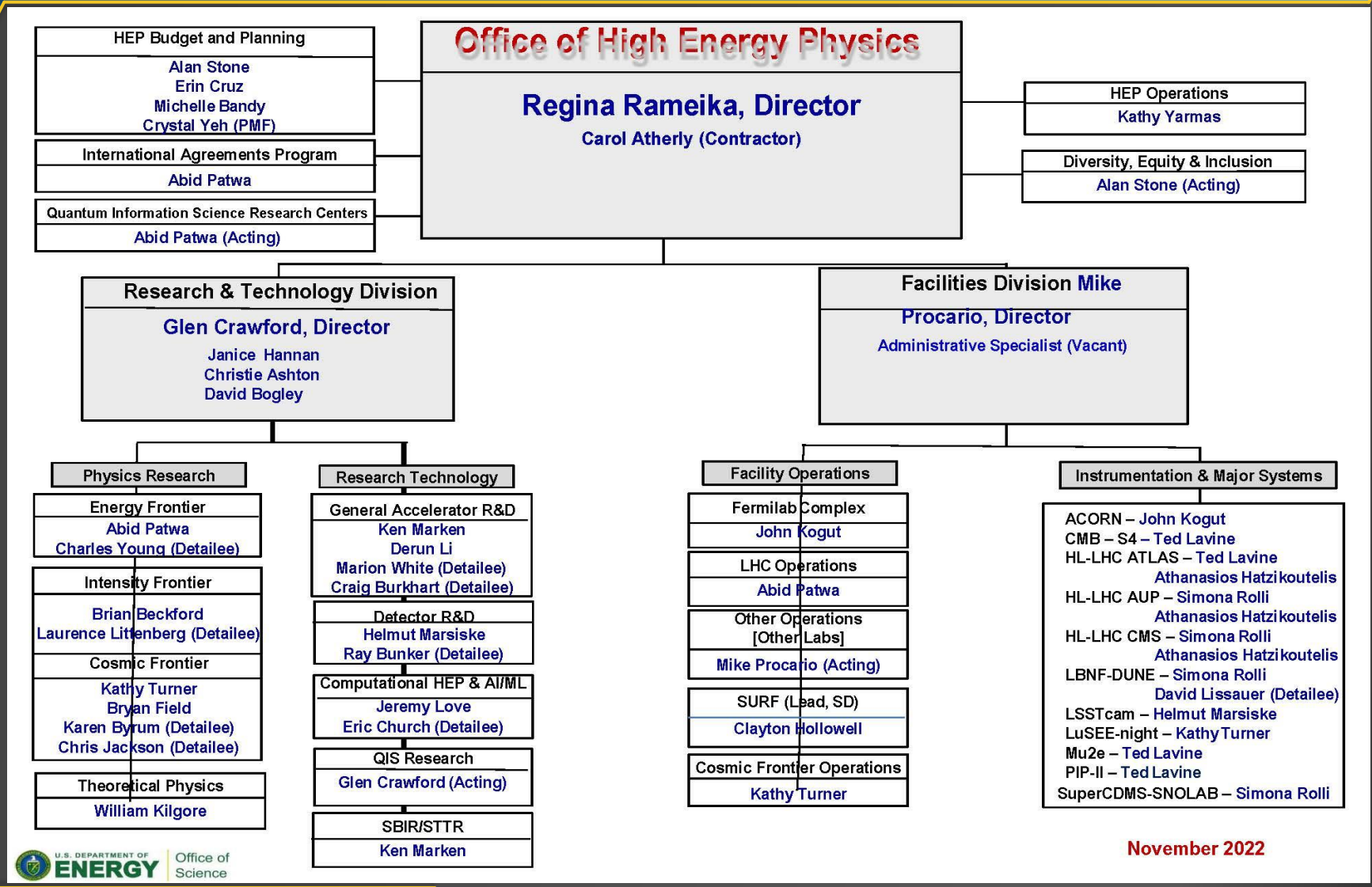

FY 2023 HEP Budget Request

HEP Funding Category ($ in K)	FY 2021 Actual	FY 2022 Enacted	FY 2023 Request	FY 2023 vs. FY 2022
Research	398,203	410,000	420,000	+10,000
Facilities/Operations	314,297	302,000	310,000	+8,000
Projects	333,500	366,000	392,000	+26,000
Total	**1,046,000**	**1,078,000**	**1,122,000**	**+44,000**

- FY 2023 President's Budget Request is overlay of Administration, SC, P5 priorities
  - SC: interagency partnerships, national laboratories, accelerator R&D, QIS, AI/ML, microelectronics
  - HEP: continue successful P5 execution, advance Administration and DOE/SC initiatives
- FY 2023 HEP Budget continues support for P5-guided investments
  - Research: Continue U.S. leadership in LHC, muon experiments, international neutrino experiments at Fermilab, dark matter, dark energy, and vibrant theory program; QIS; AI/ML; Microelectronics (with ASCR, BES, and FES); Accelerator Science and Technology Initiative; Traineeships in accelerator science, instrumentation, high-performance scientific computing
  - Operations: Support HEP user facilities and running P5-recommended experiments
  - Projects and Line Item Construction: Project support for HL-LHC Accelerator and ATLAS & CMS Detectors, CMB-S4, and ACORN (new start); LIC support for LBNF/DUNE, PIP-II, and Mu2e

Detector R&D Research Consortia

- University Comparative Review FOA language:
  - Multi-institutional (consortium) proposals are encouraged as a way to address significant technology R&D challenges beyond the scope of typical single-investigator awards
    - Single proposal developed by multiple institutions
    - One member of the consortium serves as the prime recipient/consortium representative (lead organization)
    - May result in one award to the prime recipient with subawards to the other consortium members
    - Consortia must have appropriate management structures and processes