



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

# High Energy Physics Program Status

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High Energy Physics Advisory Panel

November 2021

*Jim Siegrist*

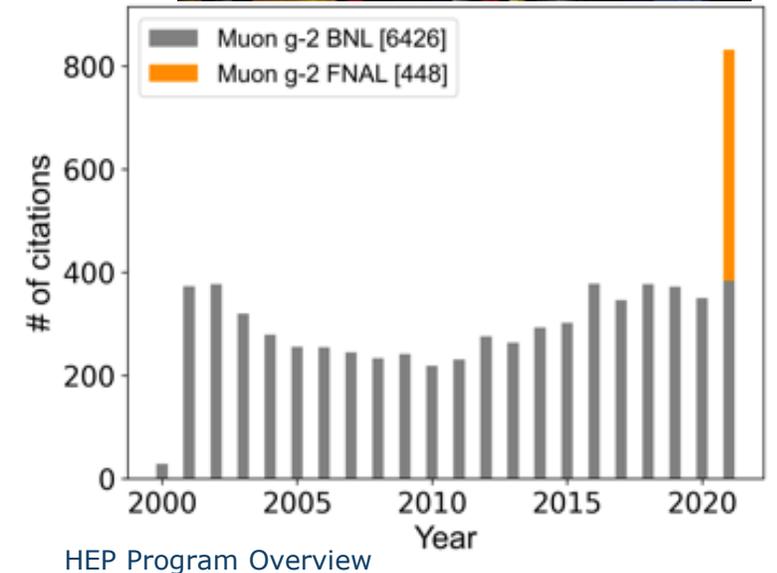
*Associate Director for High Energy Physics  
Office of Science, U.S. Department of Energy*

# Opening Remarks

- ▶ The DOE Office of Science (SC) is fully committed to fostering safe, diverse, equitable, and inclusive work, research, and funding environments that value mutual respect and personal integrity
  - ▶ *Julie Carruthers* will provide more information tomorrow at HEPAP
- ▶ The P5 report strategy continues to be successful
  - ▶ The HEP community is producing excellent science results
  - ▶ Support from the Administration, Congress, and international partners continues to be strong
  - ▶ Community engagement remains important as we lay the foundation for the next long-term strategic plan
- ▶ COVID-19 pandemic impacts
  - ▶ *Glen Crawford* will discuss research program impacts later today at HEPAP
  - ▶ *Mike Procaro* will detail project impacts tomorrow at HEPAP

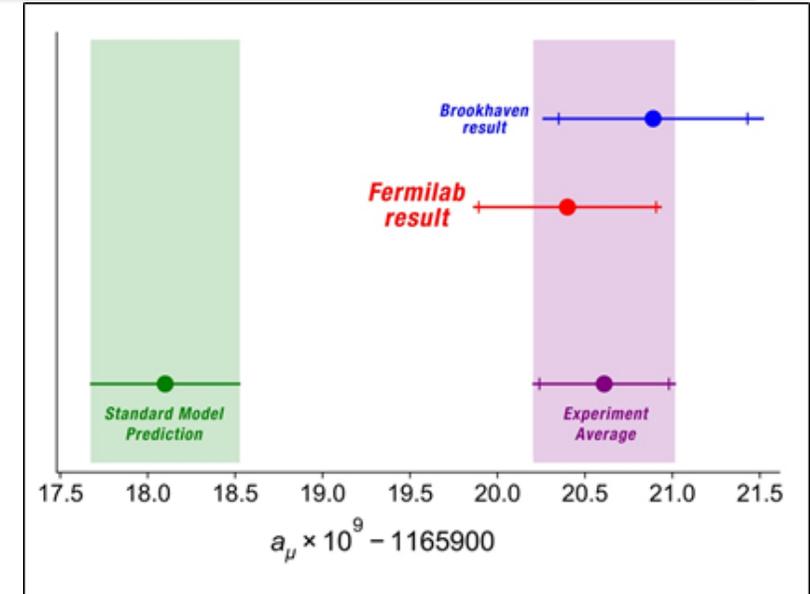
# Science Highlight: Muon g-2 Result

- ▶ The first results released April 2021
  - ▶ The result of Muon g-2 confirmed previous result from Brookhaven experiment
- ▶ Four simultaneous publications submitted
  - ▶ PRL (g-2), PRD (muon precession frequency), PRA (magnetic field), and PR-AB (beam dynamics)
- ▶ The announcement has had a wide reach including 448 citations so far, and an invited lecture by the Nobel Committee for Physics



# Muon g-2 Results and Broader Context

- ▶ Fermilab's Muon g-2 experiment measures to 460 ppb released April 2021
  - ▶ Combined results from Fermilab and Brookhaven show a difference with theory at **4.2 sigma**
  - ▶ Results reported are from 6% (Run-1) of total planned data
- ▶ Shaping up as the Century of Quantum in physical sciences!
  - ▶ Emerging ability to probe and manipulate basic systems "as they are"
  - ▶ Muon g-2 is outstanding example of probing the quantum properties of "empty space"
- ▶ Ability to **probe** quantum systems at their most fundamental level goes hand in hand with advancing our ability to **manipulate** quantum systems – in this sense Muon g-2 and QIS are two sides of the same coin
- ▶ Future of ultra-high sensitivity laboratory measurements like Muon g-2 has very large overlap with advances in quantum technology
  - ▶ Next-generation electric dipole moment experiments (a currently unobserved relative of the magnetic moment), and a variety of experiments looking for wavelike dark matter
- ▶ Challenges of following up emerging discovery from Muon g-2 will lead to new HEP experiments, which will act as powerful drivers of quantum and other technology advances

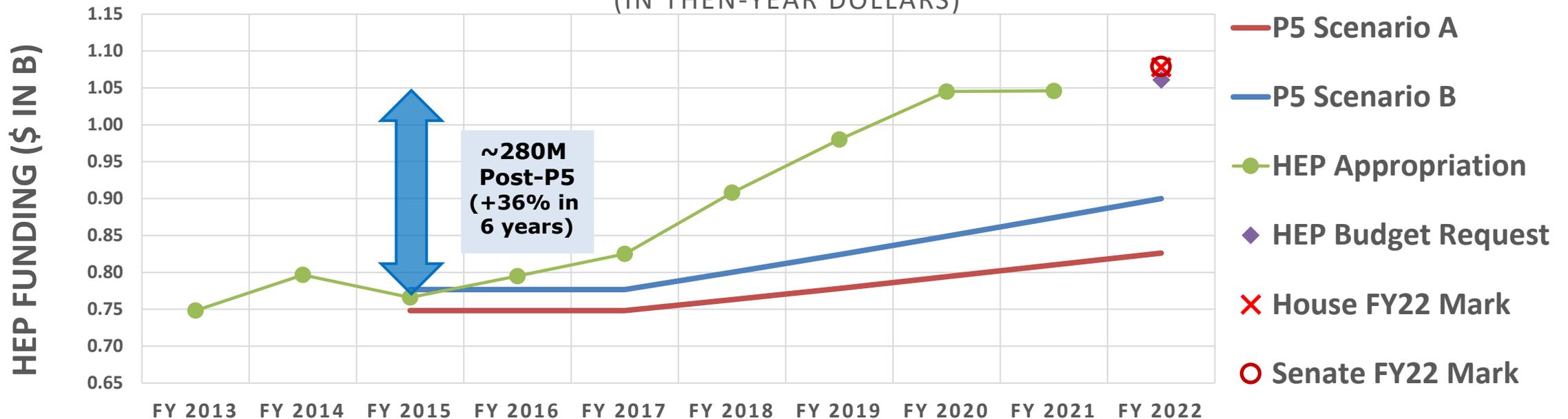


# U.S. Congress Supports P5 Strategy

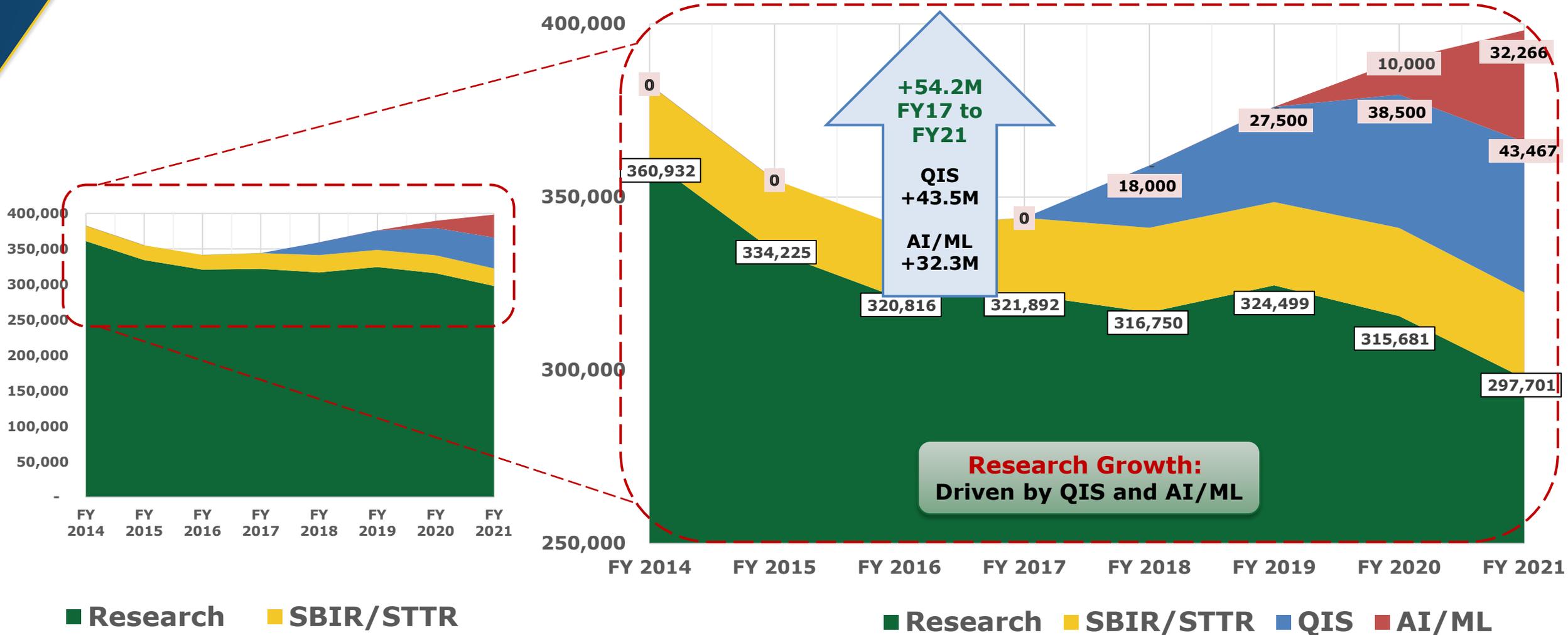
- ▶ U.S. Congress continues to show strong support for executing the P5 strategy, and for accelerating the pace of projects
- ▶ When the P5 report was released in May 2014, the FY 2015 budget was already in Congress and the FY 2016 budget was being formulated
- ▶ Arguably the first impact (success!) of the P5 report was not seen until FY 2016, and continues today...

## HEP BUDGET

(IN THEN-YEAR DOLLARS)



# HEP Research (\$k) FY 2014-2021



# FY 2022 HEP Budget Request

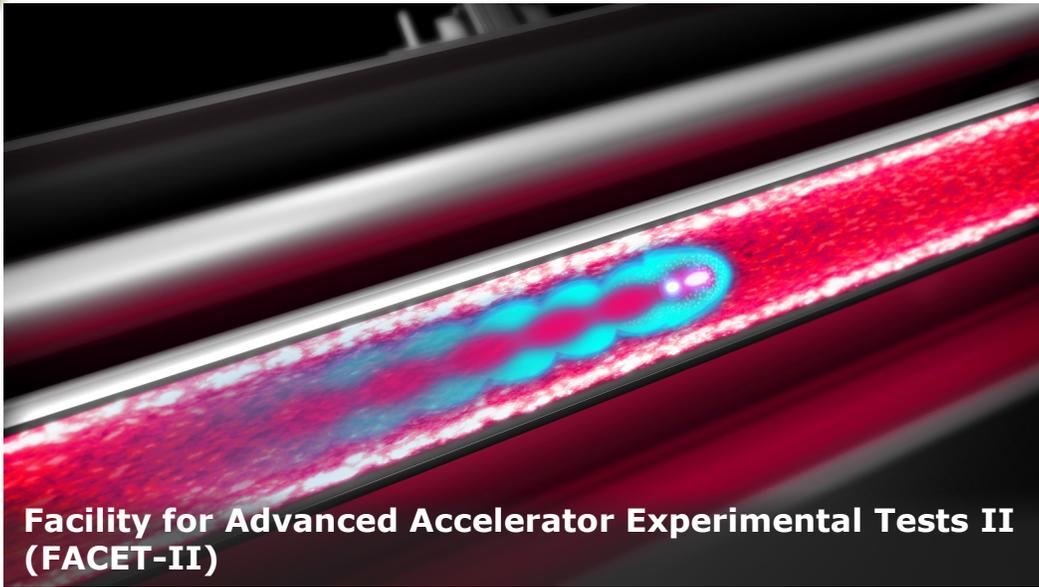
HEP Funding Category (\$ in K)	FY 2020 Actual	FY 2021 Enacted	FY 2022 Request	FY 2022 vs. FY 2021
Research	389,646	398,203	419,605	+21,402
Facilities/Operations	317,310	314,297	309,395	-4,902
Projects	338,044	333,500	332,000	-1,500
<b>Total</b>	<b>1,045,000</b>	<b>1,046,000</b>	<b>1,061,000</b>	<b>+15,000</b>

- ▶ FY 2022 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 2022 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

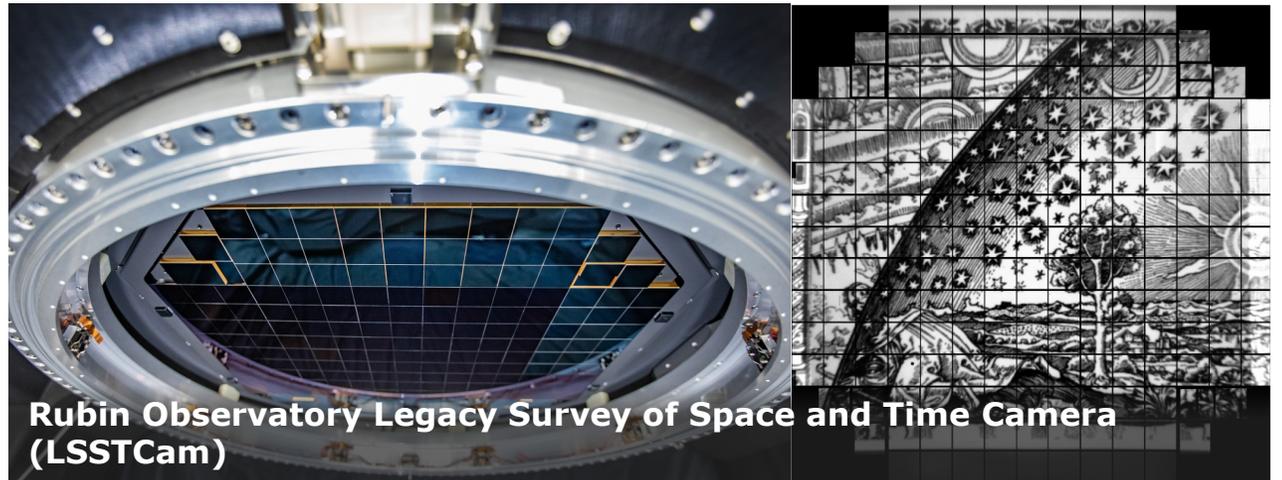
# Some Challenges

- ▶ The FY 2022 President's Request Budget for DOE/HEP is down \$1.5 million for projects compared to the FY 2021 Appropriation
  - ▶ PIP-II accelerator project request is below the approved baseline
  - ▶ LBNF/DUNE is below the planned level
  - ▶ HL-LHC projects took larger cuts on a percentage basis
- ▶ We remain committed to the P5 strategy and its priorities
  - ▶ Talking to CERN management about our ongoing commitment to and priority for HL-LHC
  - ▶ Discussing with international partners about plans for LBNF/DUNE and PIP-II
  - ▶ Responding to questions from U.S. Congress on impacts
- ▶ Congressional marks are slightly above the FY 2022 budget request for HEP, but final budget language will impact the allocation of any additional resources
  - ▶ HEP request: \$1.061B
  - ▶ House mark \$1.078B (+1.6%), Senate mark \$1.079B (+1.7%)

# Completed HEP Projects



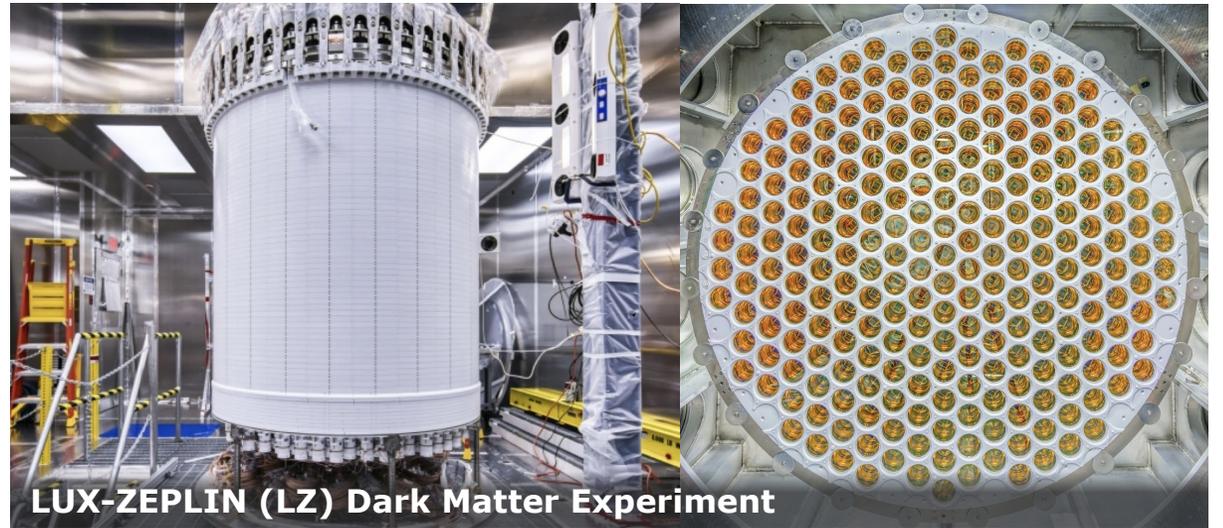
Facility for Advanced Accelerator Experimental Tests II (FACET-II)



Rubin Observatory Legacy Survey of Space and Time Camera (LSSTCam)



Dark Energy Spectroscopic Instrument (DESI)



LUX-ZEPLIN (LZ) Dark Matter Experiment

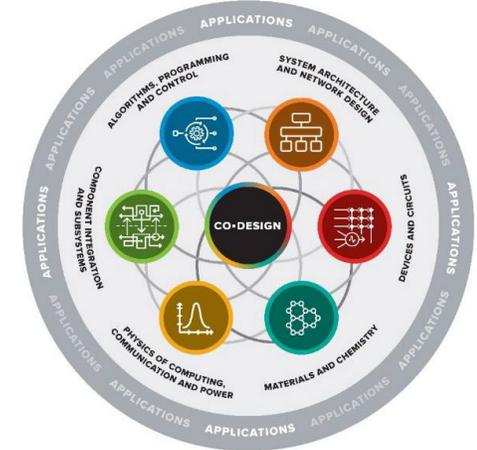
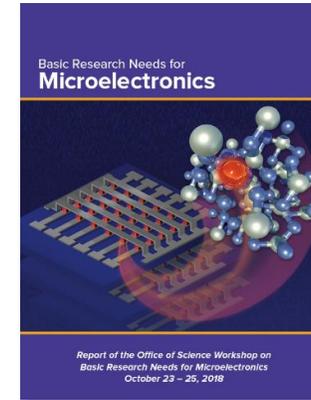
**More details in Mike Procaro's HEPAP presentation...**

November 2021

HEP Program Overview

# Advanced Microelectronics

- ▶ In FY 2022, **ASCR, BES, FES, HEP, and NP** will expand coordinated support for multi-disciplinary research to accelerate the advancement of microelectronic technologies in a co-design innovation ecosystem
- ▶ Emphasis will be on basic research to advance
  - ▶ New materials, chemistry, synthesis, and fabrication
  - ▶ New computing paradigms and architectures
  - ▶ Integrated sensing, edge computing, and communications
  - ▶ Microelectronics resilience in high radiation or cryogenic environments
- ▶ Microelectronics are:
  - ▶ Critical for clean energy generation and efficient energy use
  - ▶ Key to domestic manufacturing goals
  - ▶ An opportunity to expand the research community at underserved institutions and communities



# Artificial Intelligence & Machine Learning in SC

- ▶ The President has placed a high priority on American leadership in the Industries of the Future (IOTF):
  - ▶ artificial intelligence (AI), quantum information science (QIS), advanced manufacturing, biotechnology, and 5G/advanced wireless technologies
- ▶ As part of the AI initiative, FY21 appropriation includes \$100M in AI funding for SC, including \$32M for HEP
  - ▶ SC has prioritized investments in AI/ML for user facilities focusing on accelerator optimization, control, prognostics, and data analysis
- ▶ In 2021, HEP AI/ML funding contributed to:
  - ▶ Awards from dedicated FOAs (“Data, AI, and Machine Learning at DOE Scientific User Facilities”)
  - ▶ New and ongoing Early Career Research Awards
  - ▶ Ongoing Laboratory research programs
  - ▶ New and renewal applications under standard HEP FOAs (including “Comparative Review”)
- ▶ HEP will continue to support dedicated new AI/ML efforts while enhancing support for existing AI/ML embedded in the ongoing research program

# QIS is a National and DOE Priority

“Quantum Information Science represents a foundational shift in our understanding of physics and information science, with the potential for dramatic technology impact.”

– *Dr. Charles Tahan, Assistant Director for QIS, Office of Science and Technology Policy*

## QIS is an all-of-government effort, coordinated across agencies

- ▶ Quantum Sensing and Metrology
- ▶ Quantum Computing
- ▶ Quantum Networks and Communications
- ▶ Foundational Quantum Information Science Advances
- ▶ Supporting Technology
- ▶ Future Applications
- ▶ Risk Mitigation
- ▶ NQIA (National Quantum Initiative Act) Crosscut SC core and Centers span most of the above

## Major Milestones

- ▶ 2018: National Quantum Initiative Act Passed by Congress
- ▶ 2018: DOE Office of Science Quantum Initiative & Core programs
- ▶ 2020: National QIS Research Centers established by DOE



See also: <https://www.quantum.gov/>

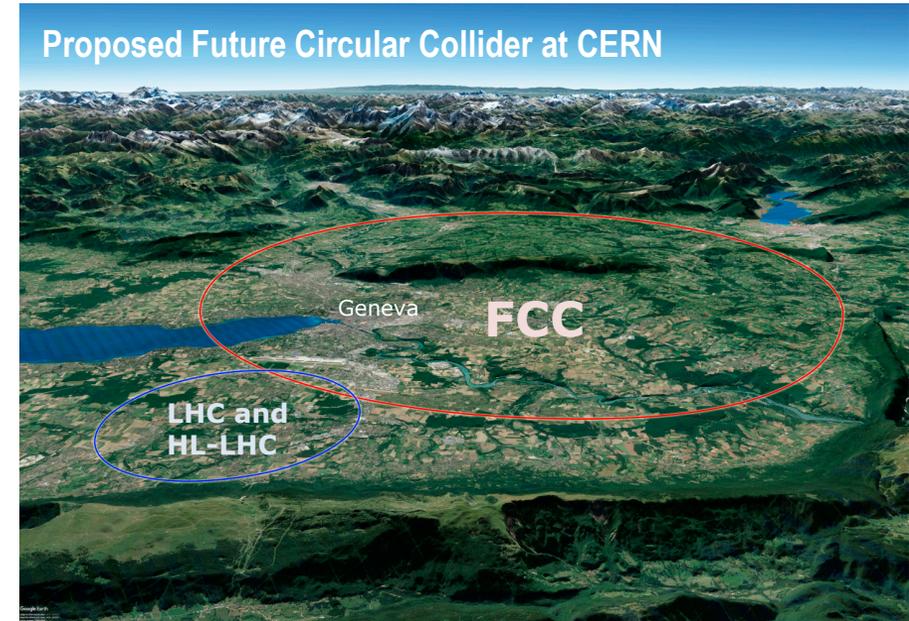
# International Cooperation Agreements

- ▶ Efforts actively continue at DOE to advance international cooperation with global partners to the HEP programs
  - ▶ Include the preparation and signing of DOE agency-level international agreements and MOUs
- ▶ DOE agency-level International Agreements
  - ▶ Nine agreements are currently in various preparation or active discussion phases, including substantial progress for those with **India**, **Italy**, **France**, and **Spain**
- ▶ Memoranda of Understanding
  - ▶ DOE MOU Working Group – chaired by Abid Patwa with membership from GC, SC, and Fermi Site Office – coordinating with Fermilab in developing multi-institutional MOUs for global HEP activities
  - ▶ **PIP-II Project** Planning Documents: *signed by Fermilab with UKRI-STFC and Italy-INFN; awaiting signatures with Poland's Wrocław University of Science and Technology; in-progress with India-DAE and France-CEA*
  - ▶ **Short-Baseline Neutrino program** multi-institutional MOU: *signed by Fermilab with CERN, INFN, and Switzerland-Bern; awaiting signatures with the UK and Brazil*
  - ▶ **DUNE program** multi-institutional MOU: *currently for DUNE's Far Detector #1, under discussions with Brazil, Canada, CERN, Czech Republic, Italy, Spain, Switzerland, and the UK*
  - ▶ **HL-LHC accelerator upgrade** MOU: *signed by Fermilab and CERN, March 2021*

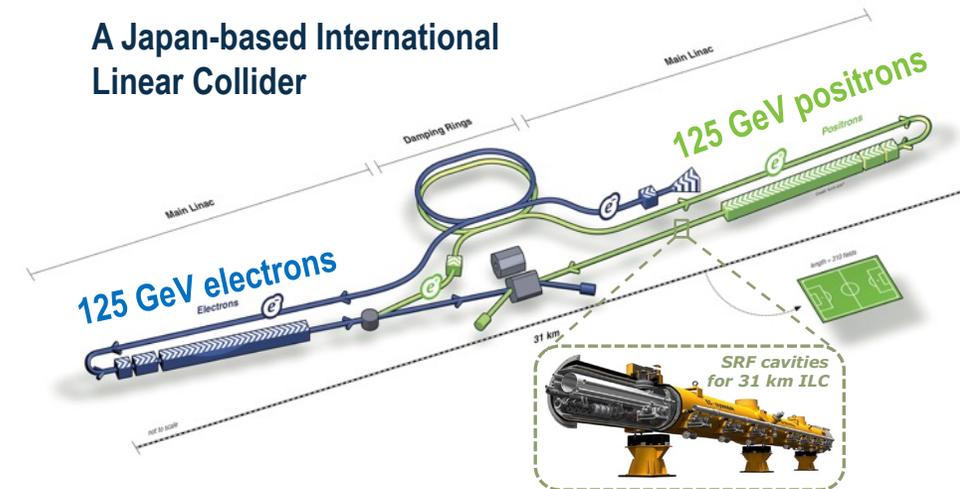


# Future Colliders

- ▶ DOE/HEP briefed The White House Office of Science and Technology Policy in August 2021 on the currently proposed future colliders
- ▶ For the FCC, DOE and CERN signed an agreement in December 2020 for DOE and the national labs to engage in the global FCC Feasibility Study
  - ▶ DOE continues to work with CERN on identifying R&D areas for FCC
  - ▶ DOE participating in the FCC International Collaboration Board
  - ▶ Tor Raubenheimer (SLAC) appointed FCC Accelerator Coordinator
- ▶ For the ILC, DOE has been coordinating efforts with ICFA's ILC International Development Team (IDT)
- ▶ Multilateral meeting held in October 2021 by MEXT (Japan) with funding authorities from France, Germany, UK, and the U.S. (DOE) to exchange opinions on the ILC
  - ▶ DOE encouraged MEXT to move forward to the pre-lab process
  - ▶ MEXT plans to continue discussions after a MEXT Advisory Panel completes its review of IDT's pre-lab proposal (~March 2022)

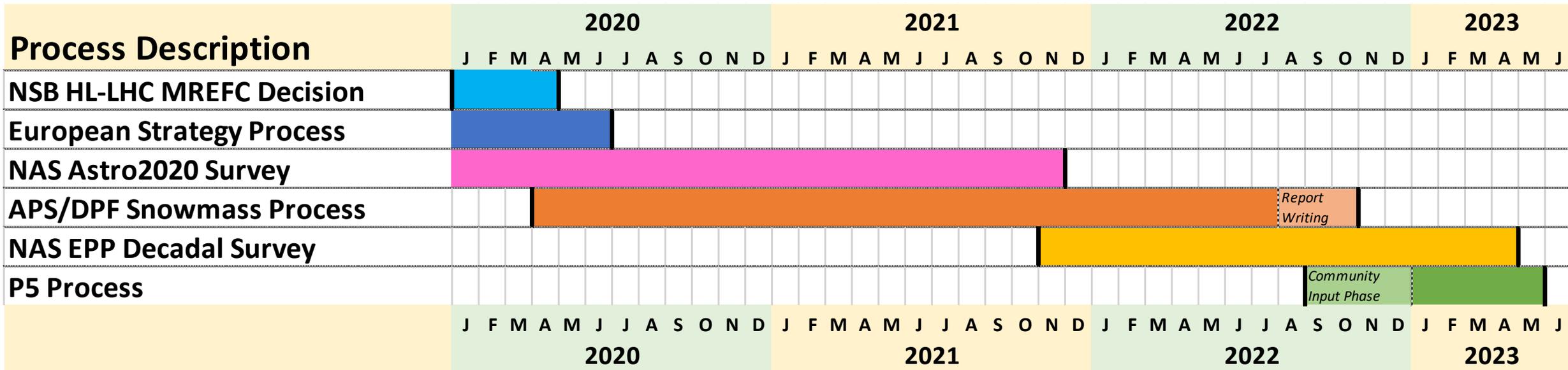


A Japan-based International Linear Collider



# Strategic Planning Timeline

- ▶ HEP community-wide “Snowmass” study process organized by the Division of Particles and Fields (DPF) of the American Physical Society (APS) has restarted (<https://snowmass21.org/start>)
  - ▶ Snowmass process was paused/slowed down due to the COVID; resumed full activities as of September 2021
  - ▶ “Community Summer Study” will take place July 17–27, 2022 at UW-Seattle (in-person)
  - ▶ Full Snowmass reports will be available by the end of October 2022
- ▶ New National Academy of Sciences (NAS) Elementary Particle Physics (EPP) Decadal Survey will run concurrently with and complement the community-driven Snowmass process
- ▶ Next P5 process to begin after Snowmass and NAS Decadal Survey, circa late 2022: **P5 report by May 2023 will inform FY 2024 Congressional actions & FY 2025 U.S. budget formulation**



# HEP Staffing Changes

## ▶ Outgoing:

- ▶ Drew Baden (IPA) returned to U. Maryland at end of August.
- ▶ John Boger retired at end of September.
- ▶ Eric Colby now full-time Associate Director for Accelerator R&D and Production (ARDAP).

## ▶ Incoming:

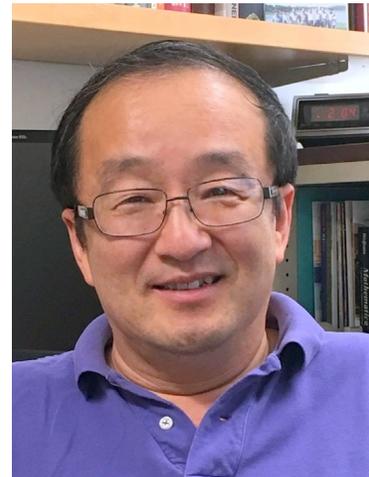
- ▶ Derun Li (Detaillee, part-time) now assisting with **Accelerator R&D**
- ▶ Jeremy Love new Fed program manager for **AI/ML and Computational HEP**
- ▶ Crystal Yeh (Presidential Management Fellow) new lead for **HEP Communications**

## ▶ Job Opportunities

- ▶ **Program Manager for Projects. *To be re-advertised, see next slide***
- ▶ **Program Manager for Cosmic Frontier.** Expect announcement soon. Short application window.
- ▶ We have an approved HEP staffing plan with 5 vacancies identified (including 2 positions above but not including recent staff departures).

## ▶ Help Wanted

- ▶ COV report reiterates request for HEP Theory IPA. Technology R&D is also short-staffed.
- ▶ Also identified other areas (project oversight, operations) that will likely need
- ▶ additional help as large P5 projects ramp-up and come on-line



# Program Manager for Projects

- ▶ We are looking for a new program manager to oversee projects to build new equipment and facilities
- ▶ Open to engineers and physicists with experience in project management
- ▶ HEP projects build highly technical systems and can cost from \$10 million to several billion dollars
- ▶ Relevant experience:
  - ▶ Acted as a project manager or project director for an Office of Science project
  - ▶ Worked as a lower-level manager (L2, L3) on an Office of Science project
  - ▶ Had a managerial role that involved oversight of an Office of Science project
  - ▶ Served on a OPA review committee or a director's review committee
  - ▶ Similar experience on a large technical project with an NSF or NASA project
- ▶ Job Announcement will go public in several weeks
  - ▶ You can contact Mike Procaro for more details

# Looking Forward

- ▶ The P5 strategy continues to receive strong support from the Administration and Congress
- ▶ The FY 2022 budget process is ongoing, but not yet complete
- ▶ The community is successfully implementing the P5 strategy by executing projects and producing excellent science, even while facing recent challenges
- ▶ We will continue to work with the community and our international partners as we begin the next phase of long-term community planning



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# International Cooperation Agreements (I)

- ▶ Efforts actively continue at DOE to advance international cooperation with global partners to HEP programs
  - ▶ Include the preparation and signing of MOUs and DOE agency-level international agreements

## **MOUs**

- ▶ DOE MOU Working Group (WG) — chaired by Abid Patwa and comprised of officials from DOE General Counsel, Office of Science, and Fermi Site Office — have been coordinating with Fermilab the development of multi-institutional MOUs for global HEP activities
- ▶ Project Planning Documents (“MOUs”) for the Fermilab-hosted PIP-II project
  - ▶ Memorializes cooperation between Fermilab and global partners on PIP-II while also specifying details of project scope and partners’ deliverables that are needed for DOE project reviews
    - ▶ Signed by Fermilab with UKRI-STFC and Italy-INFN
    - ▶ Fermilab now coordinating signatures with Poland’s Wrocław University of Science and Technology
    - ▶ Currently discussing drafts with India-DAE and France-CEA
- ▶ Multi-institutional MOU for collaboration in the Short-Baseline Neutrino program
  - ▶ Signed by Fermilab with CERN, INFN, Switzerland-Bern; now coordinating signatures with the UK and Brazil
- ▶ Multi-institutional MOU for collaboration in the DUNE program
  - ▶ Currently being reviewed by and discussed with global partners to DUNE’s Far Detector #1 (Brazil, Canada, CERN, Czech Republic, Italy, Spain, Switzerland, and the UK)
- ▶ MOU between Fermilab and CERN for U.S. contributions to HL-LHC accelerator upgrade signed March 2021

# International Cooperation Agreements (II)

## DOE Agency-level International Agreements

- ▶ Various agreements are at different stages of development and/or are nearing signature...



### India

Amendments to existing Project Annex agreements with India's Department of Atomic Energy (DAE) for PIP-II and DUNE to align each cooperation with project-specific processes such as equipment transfer procedures and the use of subsidiary MOUs

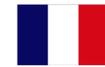
- Drafts negotiated, now being processed at DOE to authorize signature
- Anticipate to sign with DAE by end of calendar year 2021



### Italy

Two agreements in-progress with Italy's Ministry of Universities and Research:

- 1) Discussing with INFN draft Project Annex for cooperation on DUNE, includes Italy's in-kind contributions to the DUNE detector
  - 2) Discussing with INFN draft Project Annex for a Fermilab-INFN partnership to advance software and computing efforts for HEP programs
- Anticipate to sign by end-2021 or early-2022



### France

Three agreements in-progress:

- 1) Discussing an Implementing Arrangement draft with CEA for cooperation to PIP-II
  - 2) Project Annex draft with CNRS for PIP-II and DUNE, currently under DOE review
  - 3) Project Annex draft with CNRS for cooperation, including data access, on the Vera C. Rubin Observatory program is being prepared at DOE in-coordination with SLAC
- Anticipate to sign each with CEA and/or CNRS in 2022



### Spain

Two agreements in-progress with Spain's Ministry of Science and Innovation:

- 1) Office of Science (SC)-wide Implementing Arrangement for cooperation in SC programs, currently under review and awaiting C-175 authorization by the U.S. State Department
  - 2) HEP-specific Project Annex for cooperation on DUNE, currently under an initial review by DOE General Counsel
- Anticipate to sign each in early-2022

- ▶ Other written instruments in the pipeline include preparing an agreement with the UK for cooperation in the Rubin Observatory program, and with CERN for CERN's cooperative support for the 2<sup>nd</sup> LBNF cryostat