U.S. DEPARTMENT OF ENERGY | Office of Science

Cosmic Frontier Experimental Program →Status & Funding Opportunities

July 21, 2022 (at Snowmass in Seattle)

Cosmic Frontier Program Managers:
Kathy Turner (Kathy.Turner@science.doe.gov),
Karen Byrum (Detailee)
Elgin Leary (DOE Scholar Intern, summer 2022)
**** Bryan Field, new PM starting in August*
Office of High Energy Physics

OUTLINE

- HEP Program: Mission, Planning and Budgets
- Cosmic Frontier Program
- DOE/HEP Research Funding Programs

A view of Mayall Telescope at Kitt Peak which houses DESI. (Credit: Marilyn Sargent/Berkeley Lab)

HEP – Carrying out the Mission

Program Model: Science Mission-driven

Develops and support a **specific portfolio of projects** → emphasis placed on planning, building experiments, operating, and publishing results

HEP carries out the DOE mission and objectives through a balanced portfolio to work at the cutting edge of science

- Make significant, coherent contributions to **project design & construction**
- Operate **experiments and facilities** that provide discovery capability
- Supporting **scientific research** to produce discovery science
  - HEP model is to support science collaborations in all stages, leading to the best possible science results
- Support R&D for the future including detector technologies, QIS, etc.
- Theoretical efforts provide the vision and the mathematical framework for understanding and extending our knowledge of fundamental matter & energy.

Form **partnerships** with other agencies (*e.g.,* NASA, NSF, international) to help deliver our mission

→HEP works proactively with labs & university community to carry out the P5 portfolio of facilities, projects & experiments.

HEP Program Guidance

FACA panels & subpanels provide official advice:

- **High Energy Physics Advisory Panel (HEPAP)**
- Advises **DOE & NSF:** **Provides the primary advice for the HEP program**
- Subpanels:
  - 2009 Particle Astrophysics Science Advisory Group (PASAG) – Strategic Plan
  - 2014 Particle Physics Project Prioritization Panel ("P5"): 10-year Strategic Plan
  - Next P5 in 2023

- **Astronomy and Astrophysics Advisory Committee (AAAC)**
- Advises **DOE, NASA, & NSF** on issues of overlap, mutual interest and concern
- Subpanels: CMB-S4 Concept Definition Taskforce (2017), Gemini-Blanco-SOAR Telescopes roles (2019)

Advice also Provided by: National Academy of Sciences (NAS)

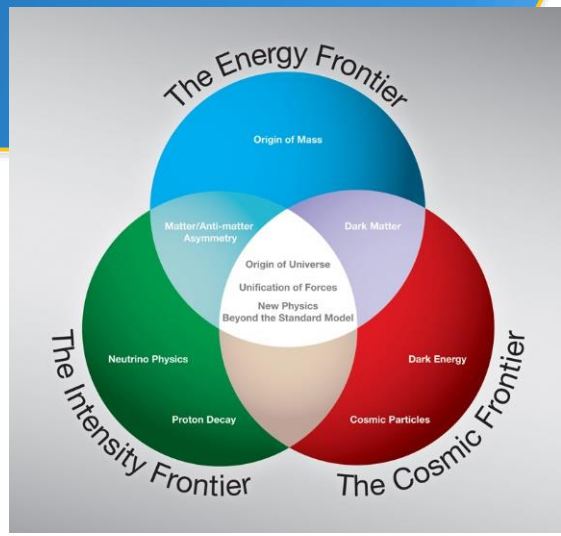
- **Decadal Surveys in Astronomy & Astrophysics (Astro2010→Astro2020)**
- Decadal Survey of Elementary Particle Physics is starting (following Snowmass)
- Board on Physics & Astronomy, Committee on Astronomy & Astrophysics

Other Input & Coordination

- Community studies & input, e.g. Snowmass, APS/DPF
  - Basic Research Needs (BRN) studies – develop new HEP initiatives (e.g. DMNI)

HEP Program Layout

<u>HEP is carried out along 3 Frontiers</u>:
Advancements at all 3 frontiers are needed to achieve the long-term goals of the field.
→HEP is primarily a Particle Accelerator based program: **Energy & Intensity Frontiers**

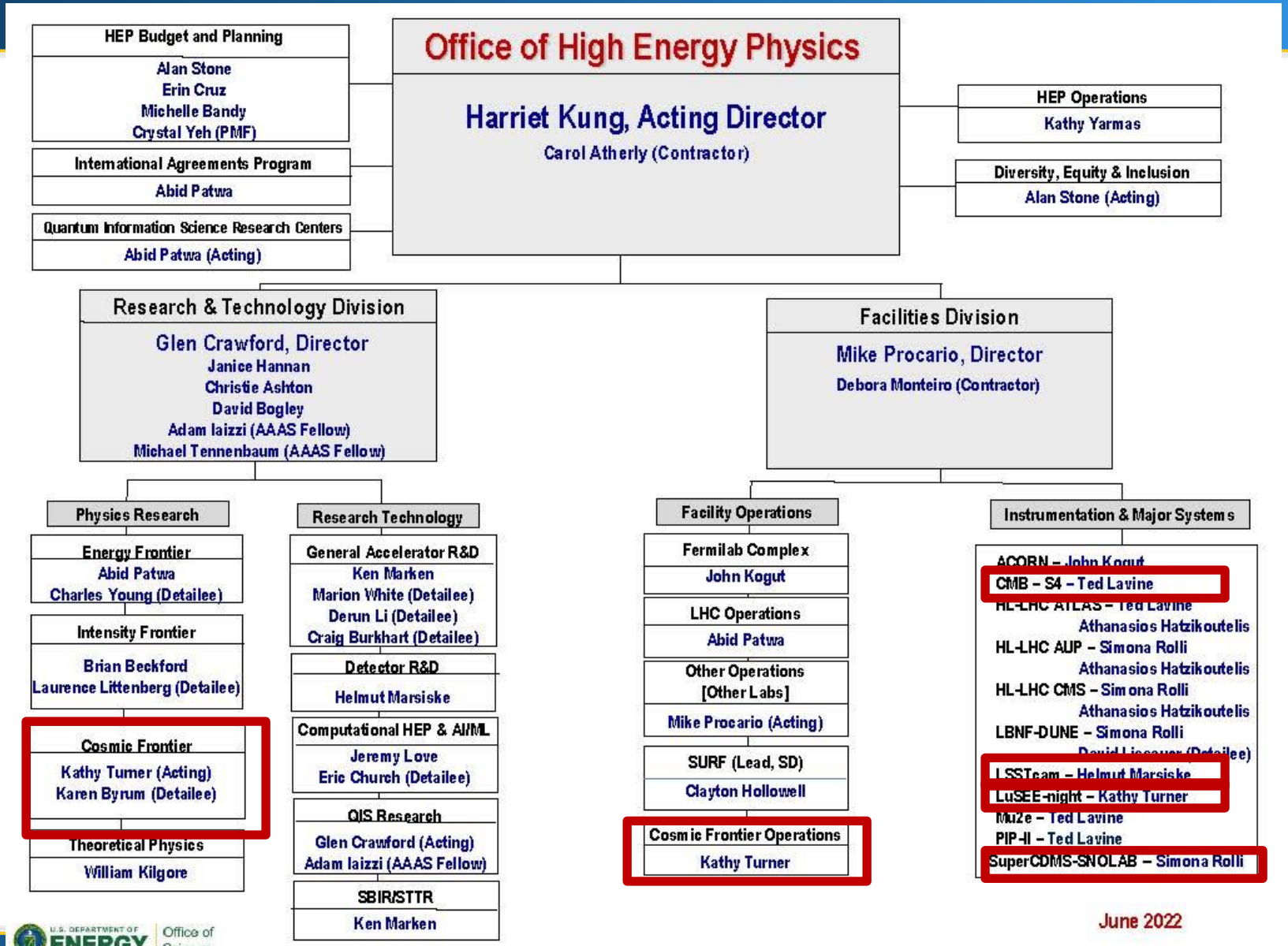


→Cosmic Frontier uses naturally occurring data to study of the fundamental nature of matter, energy, space and time in areas complementary to accelerator experiments.

- **Increasingly important area for discovery**
- **In the last decade, Cosmic Frontier has grown into an integral and priority part of the HEP program.**

<u>Crosscutting HEP subprograms</u>:
- Theoretical research, High Performance Computing & Computational HEP, Advanced Detector R&D, Quantum Information Science (QIS).

HEP Organization



HEP Program Execution
- Priorities for Participation

Priority for selecting and supporting roles & responsibilities on partnership projects or experiments → follow 2009 PASAG Criteria:

- Participate in select, high impact experiments and projects that make significant leaps in science, aligned with the P5 science drivers

- Carry out Roles & Responsibilities that make significant, coherent, contributions that
  - are aligned with HEP program and priorities, responsibilities and science.
  - make use of the expertise of DOE researchers and take advantage of DOE capabilities, resources and infrastructure commensurate with the science return expected (for multi-science projects)

- Achieve earliest, best, and most cost-effective U.S. science results for HEP interests in the project

- Partnerships with US international collaborators as needed & appropriate

HEPAP/PASAG (2009) Developed Prioritization Criteria for the Program

The science addressed by the project is necessary

- Addresses fundamental physics (matter, energy, space, time).
- Anticipated results: either at least one compelling result or a preponderance of solid, important results. Check that anticipated results would not be marginal, either in statistics or in systematic uncertainties, relative to the needed precision for clear science results.
- Discovery space: large leap in key capabilities, significant new discovery space, and possibility of important surprises.

Particle physicist participation is necessary

- Transformative techniques and know-how to have a major, visible impact; project would not otherwise happen.
- Leadership is higher priority than participation
- The particle physics community participation brings needed expertise in terms of science, technology, or computing, etc.

Scale matters, particularly for projects at the boundary between particle physics and astrophysics.

- Relatively small projects with high science per dollar help ensure scientific breadth while maintaining program focus on the highest priorities.

Programmatic issues: International context: cooperation and coordination vs. duplication/competition.

HEP Program Execution - Collaboration Model

HEP strength is our Science Collaboration Model!

- Support structured science collaborations that participate in all stages, leading to the best possible results from state-of-the art projects.
- Scientists are intimately involved & have roles & responsibilities in project design & fabrication (hardware, software), commissioning, experimental operations, science planning & data analysis
- Students & postdocs are trained by participation in all phases to gain experience and expertise; opportunities to work at a lab or experiment site

- **Priority for Research support is for efforts directly in line with HEP roles and responsibilities as well as our science goals.**

➔Peer Reviews reflect HEP collaboration model & work style

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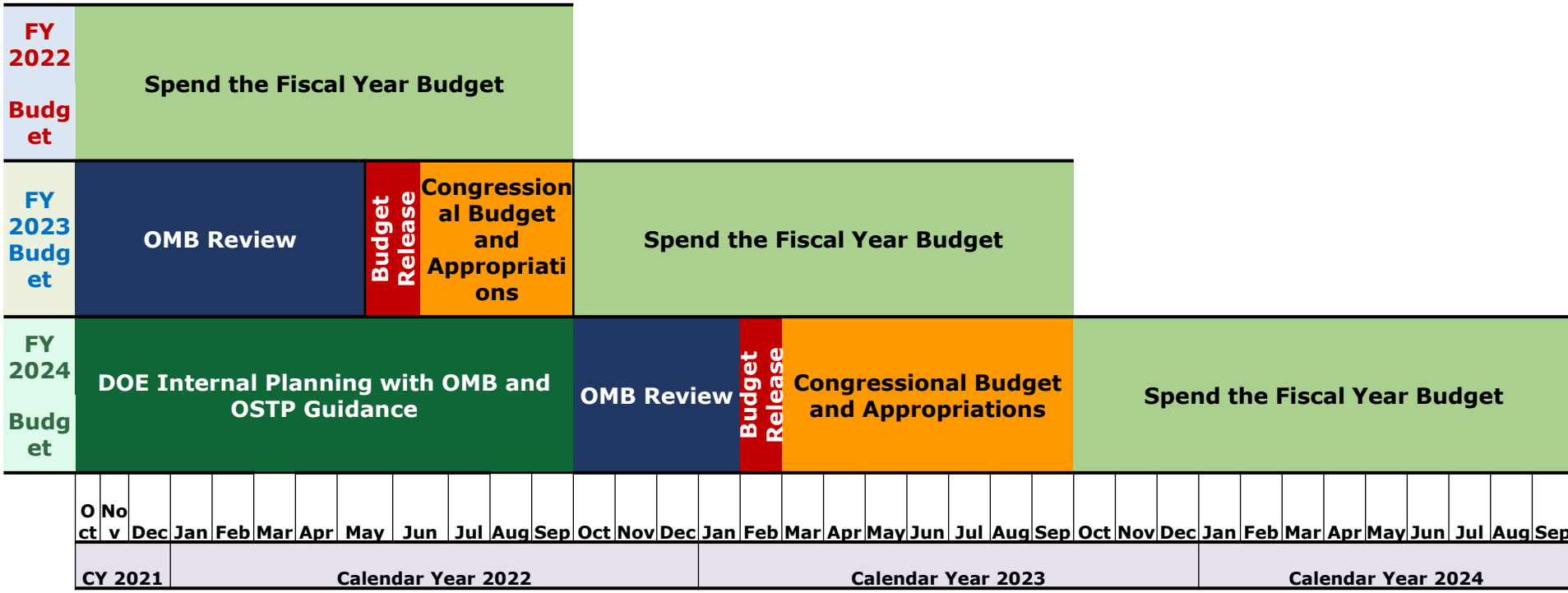
HEP Budget

The U.S. Federal Budget Cycle

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

- Executing current Fiscal Year [FY; October 1, 202*x* – September 30, 202(*x*+1)]
- Office of Management and Budget (OMB) Review & Congressional Appropriation for next FY
- Agency internal planning for the second FY from now



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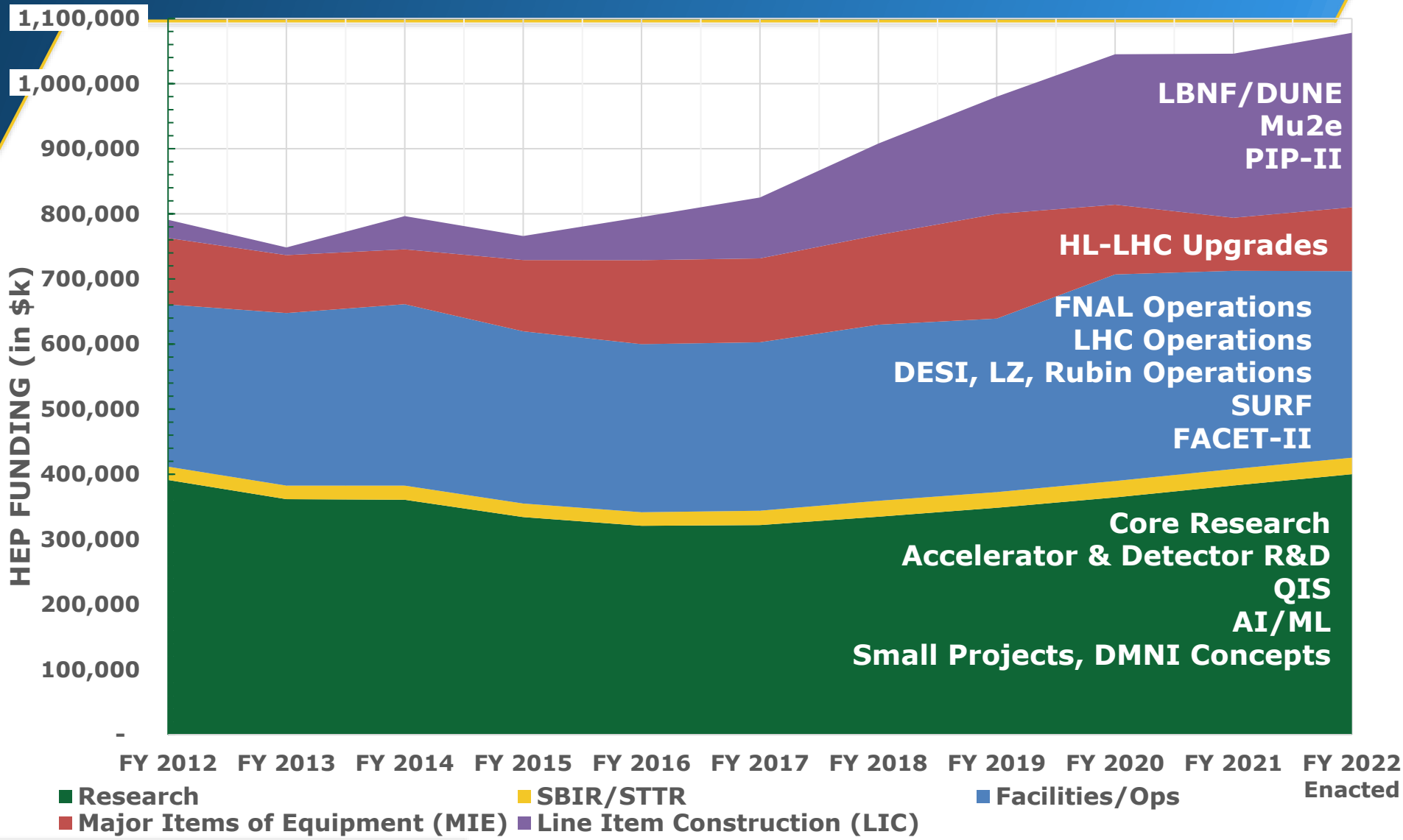
FY 2022/23 HEP Budget Highlights

HEP Budget ($ in K)	FY 2020 Enacted	FY 2021 Enacted	FY 2022 Enacted	FY 2023 Request	FY 2023 House Mark
HEP Research*	814,000	794,000	810,000	824,020	860,000
Line-Item Construction	231,000	252,000	268,000	298,000	298,000
HEP Total	**1,045,000**	**1,046,000**	**1,078,000**	**1,122,020**	**1,158,000**

** In this table, HEP Research includes everything except line-item construction (i.e. MIEs and Operations)*

- High priority areas for **core HEP research** include theoretical and experimental activities in pursuit of discovery science; fostering a diverse, highly skilled workforce; building R&D capacity; driving technology innovation; and conducting world-leading advanced technology R&D
- HEP supports **SC-wide research initiatives**:
  - QIS, AI/ML, Microelectronics, Integrated Computational and Data Infrastructure, Accelerator Science and Technology, Reaching a New Energy Sciences Workforce (RENEW), Accelerate Innovations in Emerging Technologies (Accelerate), and Funding for Accelerated, Inclusive Research (FAIR)
- Facilities support includes operations of **Fermilab Accelerator Complex** and **FACET-II**, infrastructure improvements at SURF
- HEP supports **LBNF/DUNE**, **PIP-II** and **Mu2e** Line-Item Construction projects and **HL-LHC Accelerator**, **ATLAS**, and **CMS** upgrade projects, **ACORN**, and **CMB-S4** Major Item of Equipment (MIE) projects
- HEP supports laboratory-based accelerator and detector test facilities and supports the maintenance and operations of large-scale experiments and facilities that are not based at a DOE National Laboratory, including: **ATLAS** and **CMS** at the LHC; **SURF** and the **LZ** experiment; **Vera C. Rubin Observatory**; **DESI**; experiments in Canada, Japan, and on the International Space Station

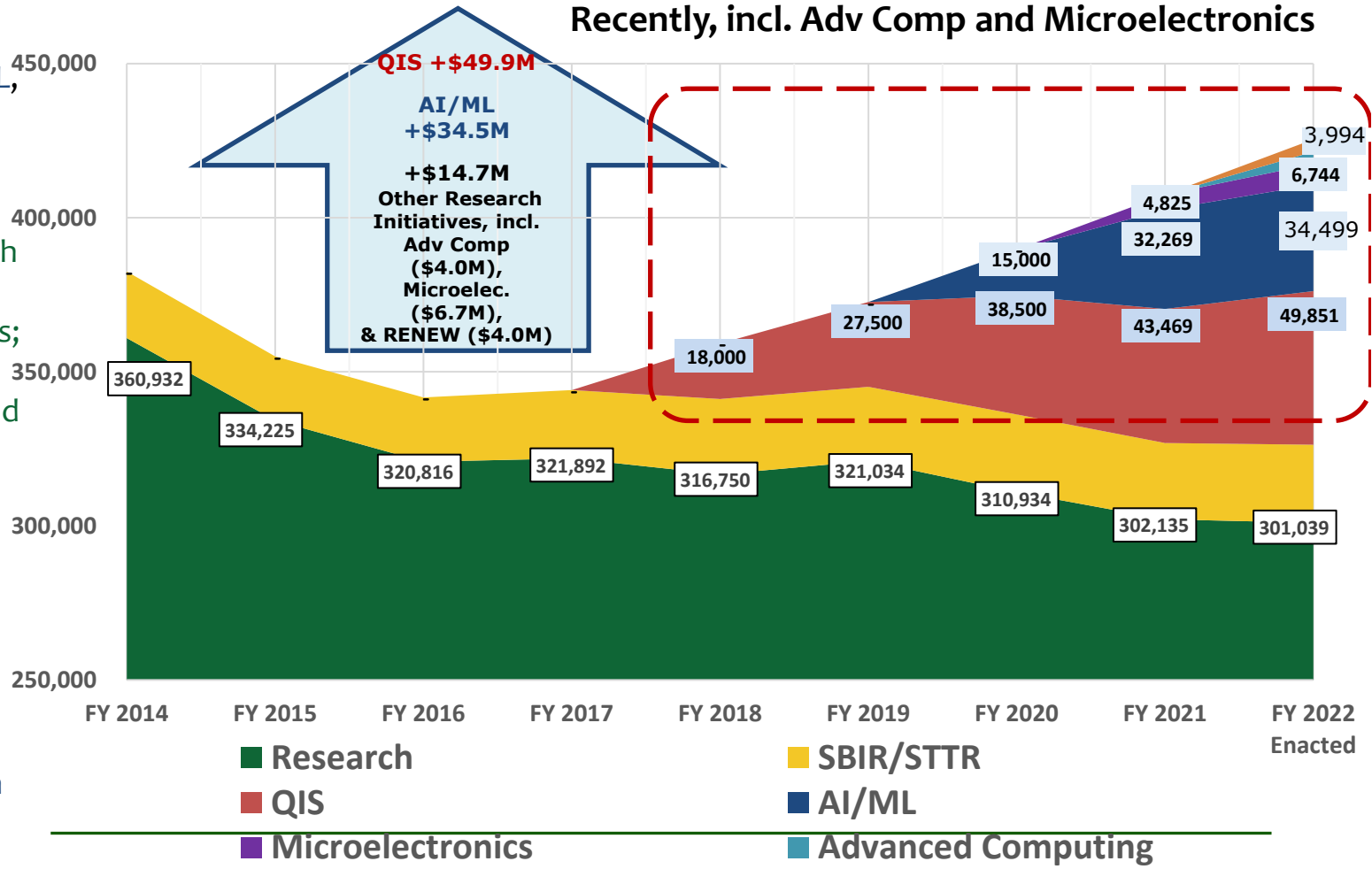
HEP Budget ($k) History, Contents - FY 2012-2022



DOE-HEP Research ($k): FY 2014-2022

- Distinguishing HEP Research into: HEP "Core" Research, QIS, AI/ML, and Other Research Initiatives
- HEP "Core" Research ≈ Energy, Intensity, and Cosmic Frontiers; Detector and Accelerator R&D; and HEP Theory
- In recent years, incl. FY 2022, dedicated AI/ML, Adv Computing, and Microelectronics funds have helped offset some fraction of reductions in "Core" Research

Research Growth: Driven by QIS and AI/ML; Recently, incl. Adv Comp and Microelectronics



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Cosmic Frontier

Guidance, Budget, Program & Detailed Status

Cosmic Frontier – Program Guidance
(details in backup)

PASAG – gave criteria for HEP roles & responsibilities

Astro2010 recommended DOE/NSF partnership on LSST (Rubin)

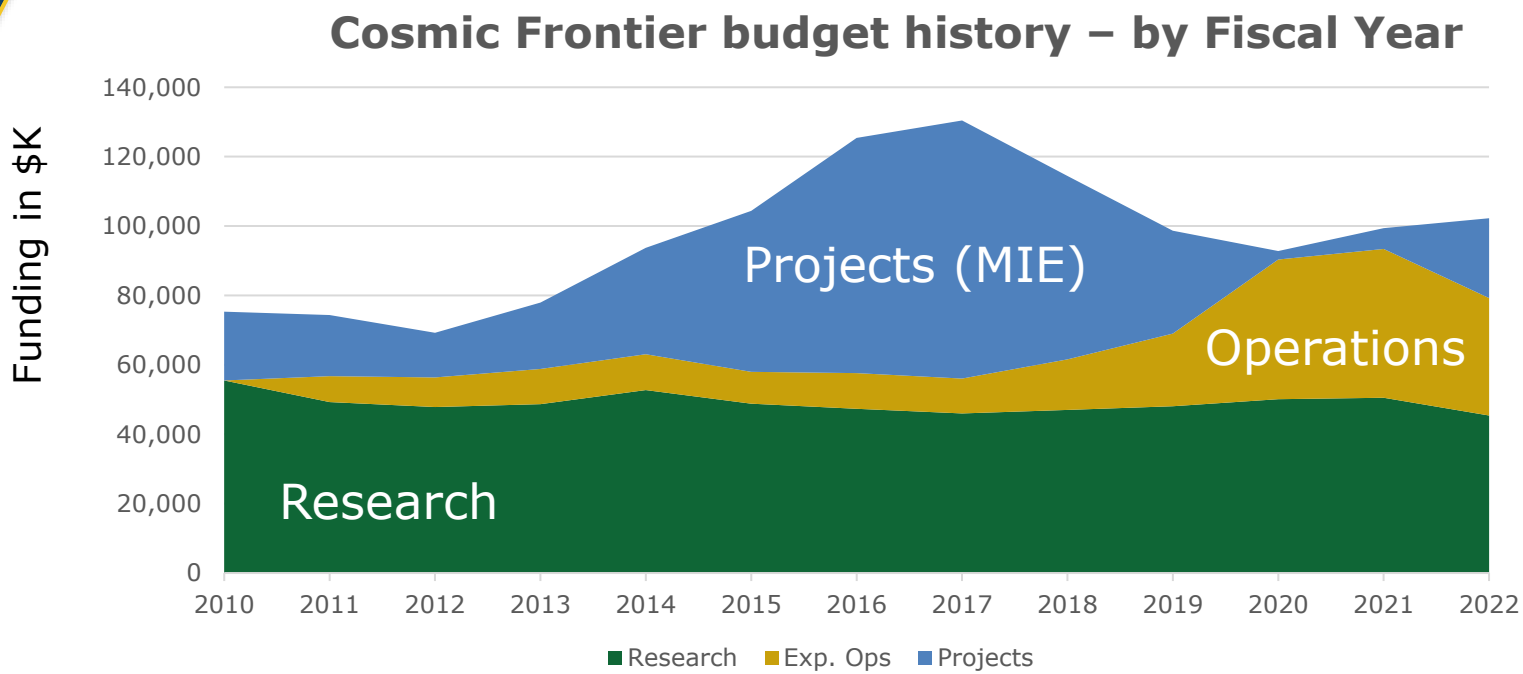
P5 (2014) strategic plan recommended projects and a program aligned with the science drivers

- **Cosmic Acceleration:**
  - **Dark Energy**: build **LSST (Rubin) & DESI**
  - **CMB**: support as part of the core program within multi-agency context; carry out multi-agency **CMB-S4** project later in the decade
- **Dark Matter:** suite of "generation 2" direct detection experiments to detect DM particles
- Maintain a portfolio of small projects

Astro2020 recommended:

- **DOE/NSF partnership on CMB-S4**
- Efforts on diversity, equity, inclusion, demographics, data, etc. (joint with NSF & NASA)

Cosmic Frontier Budget History



Research: Scientist support for world-leading efforts in design and optimization in their planning, fabrication, commissioning, operations and data production/analysis.

Experimental Operations: Commissioning and facility operations planning for LSST/Rubin; operations of FGST/LAT, SPT-3G, ADMX-G2, DESI, LZ; pre-operations activities for SuperCDMS-SNOLAB. As the current Projects complete, estimated needs ramps up to ~ $55M to $60M by FY2024; levels to ~ $40M by FY2030.

Projects: CMB-S4, LuSEE-Night; SuperCDMS completing in FY23

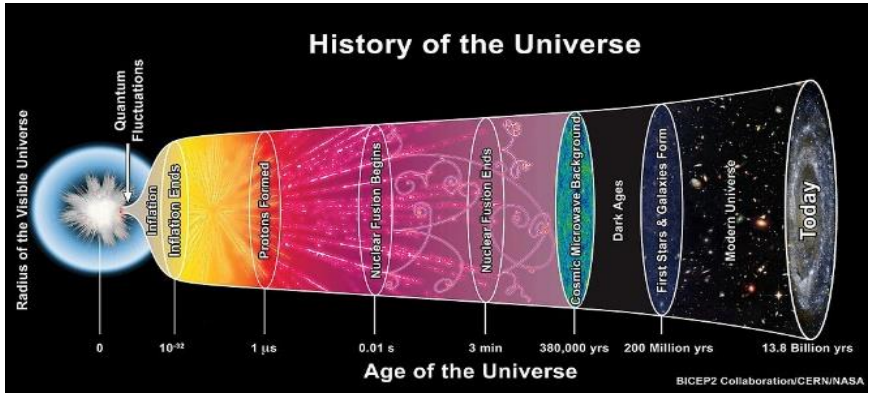
Future opportunities: Compelling Cosmic Frontier Projects will be considered and supported within available overall HEP Project funds. Guidance from Astro2020, Snowmass, P5 (2023)

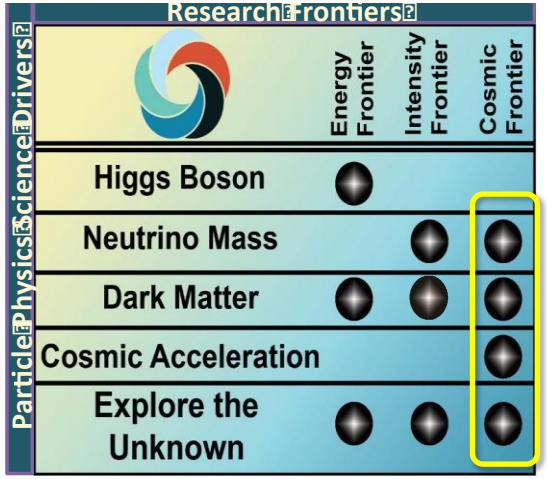
Cosmic Frontier – Experimental Program

→ In the last decade, Cosmic Frontier has grown into an integral and priority part of the HEP program.

- Naturally occurring data is used to study of the fundamental nature of matter, energy, space and time in areas complementary to accelerator experiments.
- Program to reveal the nature of dark energy and dark matter, comprising ~95% of the universe, understand the cosmic acceleration caused by dark energy and inflation, infer neutrino properties, and explore the unknown.

→ Cosmic Frontier is carrying out a program with specific projects recommended by P5 & aligned with Science Drivers

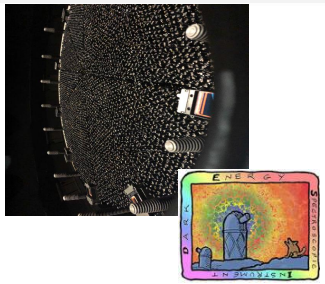




Partnerships w/NSF (PHY, AST, OPP) NASA (AST, ISS, CLPS), and/or International

Significant contributions & support from other HEP areas (e.g. Theory, Advanced Detector Development, Computational HEP, QIS, AI/ML) and other SC areas (e.g. ASCR Supercomputing)

Cosmic Frontier – Current Program



ADMX AXION DARK MATTER EXPERIMENT

SUPER CDMS Cryogenic Dark Matter Search

Cosmic Acceleration – Phases of the Cosmos

- Nature of **Dark Energy** using imaging & spectroscopic surveys
  - Stage 3 - **eBOSS** (completed 2020), **DES** doing final data analyses
  - **Stage 4 - DESI** (operating); **LSST** Camera (completed, now commissioning) for Rubin Observatory (ops planning; survey starts ~ end 2024) w/**DESC** (planning)
- Peer into era of **Inflation** with **SPT-3G (operating), CMB-S4 (concept design)**
- Search for the **Dark Ages** signal using **LuSEE-Night** pathfinder

Dark Matter:

- Direct Detection searches (WIMPs, Axions) using a variety of methods and technologies: **ADMX-G2**, **LZ, SuperCDMS SNOLAB**, **DMNI** concepts
- Indirect searches: **VERITAS**, **HAWC**, **Fermi-LAT** (now ops only), **AMS** on ISS

Neutrino properties constrained using dark energy & CMB measurements Small project

Exploring the Unknown - Always interested in New Physics!

Black: HEP support ended
Green: funding continues

Dark Energy Spectroscopic Instrument (DESI) Experiment

DOE's DESI started its 2nd year of operations in May.

- World's premier multi-object spectrograph w/5,000 fibers, positioned robotically

First **Stage IV dark energy;** Will measure spectra of > 40 million galaxies

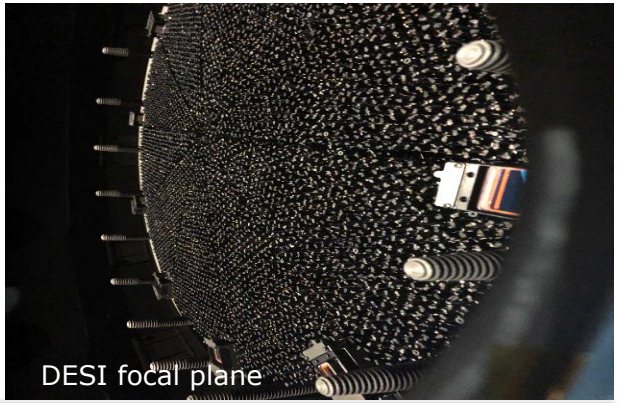
Continues successful data-taking: >10 Million extra-galactic redshifts recorded (more than all other surveys combined)

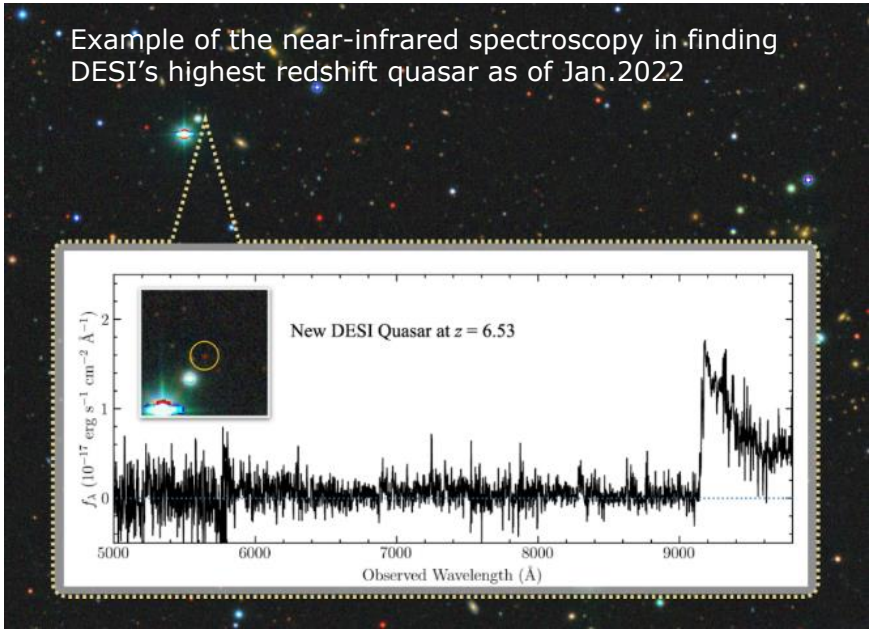
Schedule: ahead of projected timelines

*** mid-June fire at Kitt Peak – operations are on hold but will start back up ~ August**

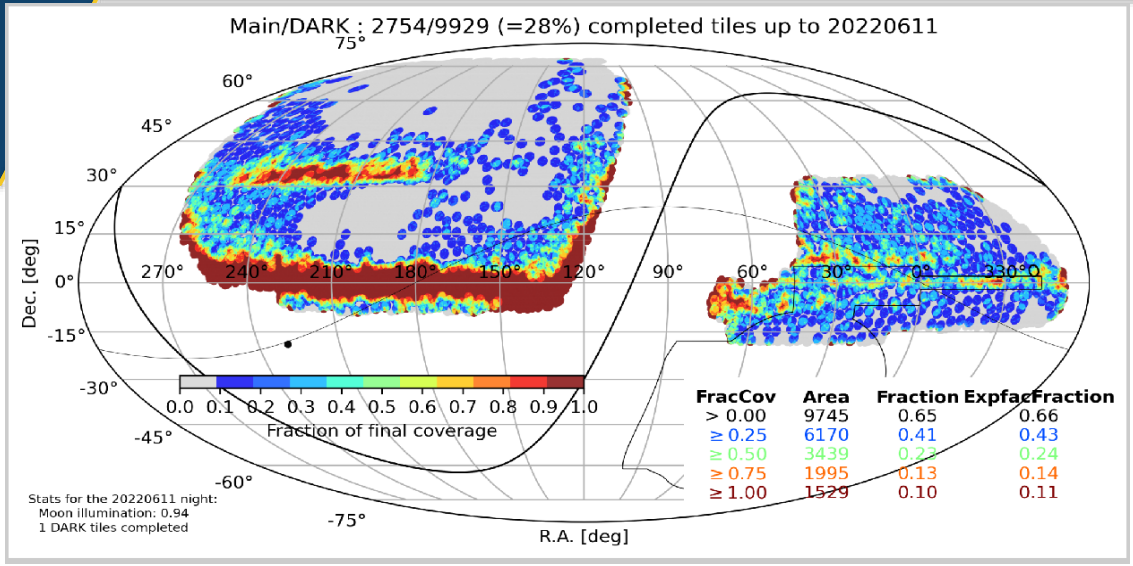
DOE/LBNL Project: Instrumentation, Data Management System, & Upgrades of NSF's Kitt Peak Mayall telescope (including MOSAIC camera).

Operations: DOE provides full support for NSF's Mayall telescope.

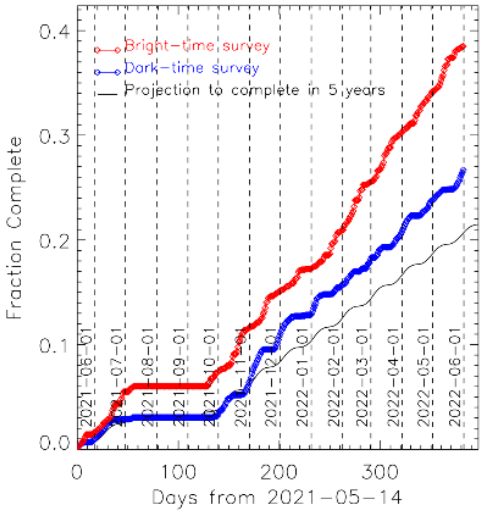




DESI Highlights

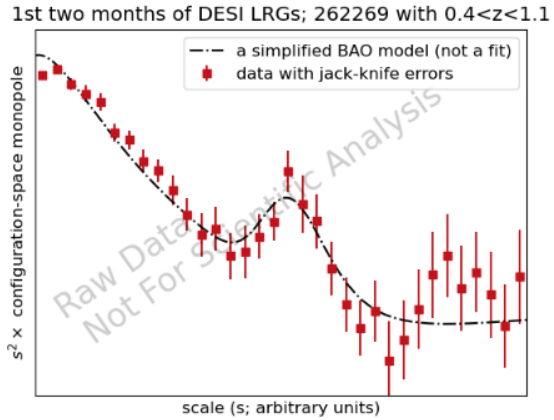


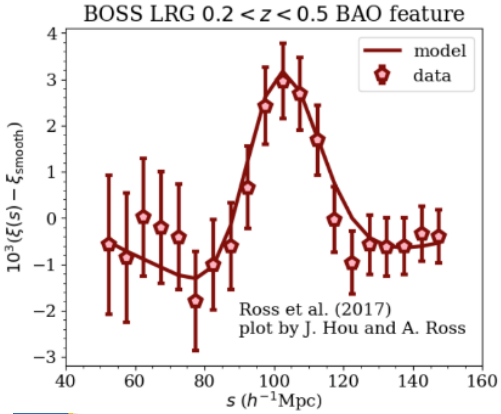
1st year of main survey observations concluded May 14, 2022.



- **Dark time survey > 28% complete; Bright time survey ~ 40% complete.**

May – July 2021 data of 370k Luminous Red Galaxies. **Raw data shown here as a comparison to BOSS 2008-2014 data**.





Outreach & Education

The team presented at the Smithsonian National Museum of American History in April 2022 on Making the Largest Map of our Universe

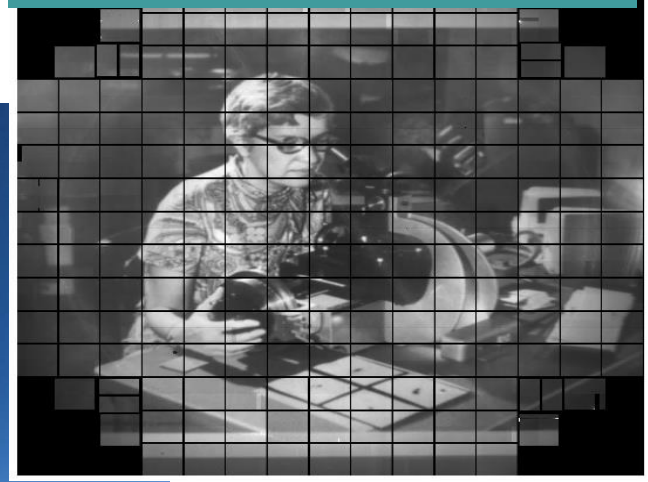
Vera C. Rubin Observatory

A next-generation, ground-based facility, providing time-lapse imaging of faint astronomical objects across the entire visible sky every few nights.

NSF (AURA) and DOE (SLAC) partnership, with private, international contributions

- Project: DOE responsible for the 3 billion pixel LSST Camera fabrication; MIE project completed Sept. 2021.

Pinhole camera 3.2Gpixel iSSTCam image of Vera C. Rubin

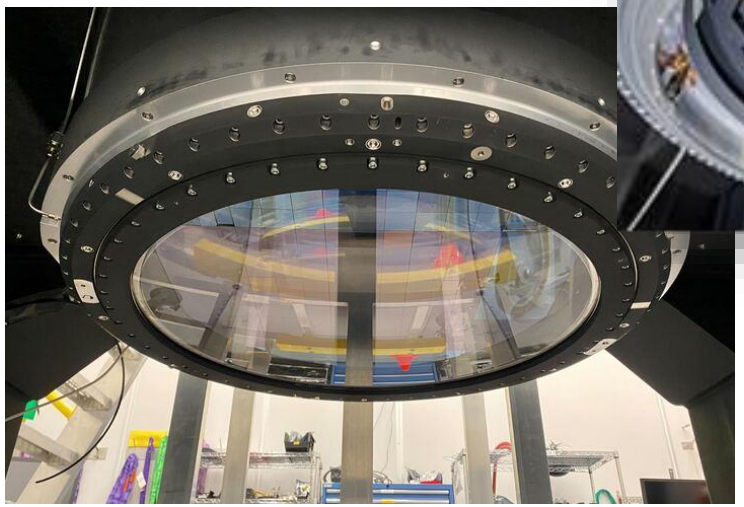


Commissioning

HEP Commissioning roles – LSST Camera

- Moving forward with new "pumped coolant" refrigeration system due to stability issues in the current system; Final Design Review being held Aug. 2022
- Assembly and verification at SLAC + preparations in Chile
- Ready to ship to Chile (~ Spring 2023)

Final lens, L3, installed on the cryostat. L1 and L2 installation planned for June w/alignment through July.

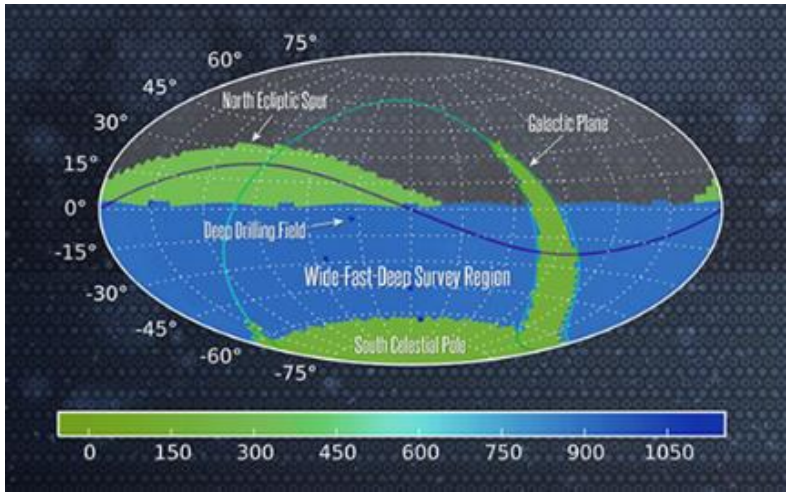


Vera C. Rubin Observatory – Facility Operations

The Rubin Observatory will conduct a 10-year deep, wide, fast, optical imaging Legacy Survey of Space and Time (LSST) using DOE's LSST Camera & the Simonyi Survey Telescope

Facility Operations: 50/50 DOE & NSF split; DOE responsible primarily for camera maintenance and operations, US Data Facility

- Planning underway
- Full data-taking starts ~ end 2024.
- Dark Energy Science Collaboration (DESC) continues simulations & planning



International in-kind contributions

- in exchange for early access to data
- Agreements are being drafted

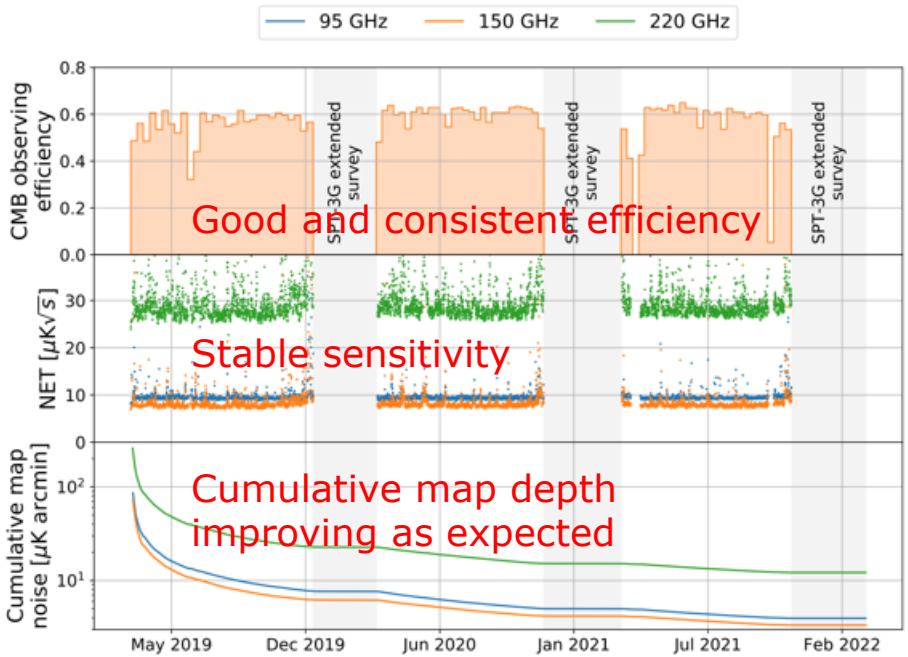
CMB & South Pole Telescope (SPT-3G)

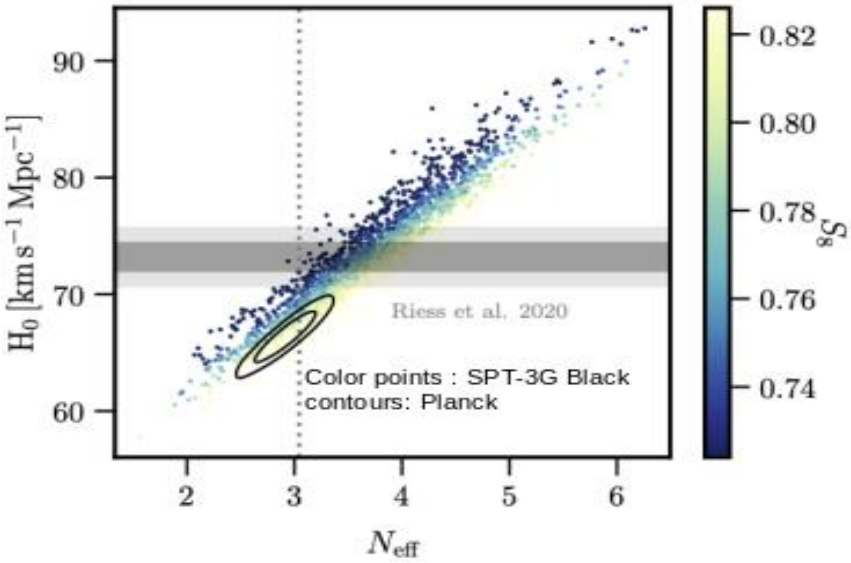
Gain insight into inflationary epoch at the beginning of the universe, dark energy & neutrino properties by studying oldest visible light.

- **P5 recommended DOE should support CMB experiments in the core program.**
- **P5 recommended CMB- S4; planned to be the next flagship HEP project**

SPT-3G: NSF & DOE partnership

- HEP supported major upgrade: fabrication of th 16,000-detector focal plane, greatly increasing sensitivity
- Survey started 2018; continues to operate smoothly with high observing efficiency; First





- EE/TE Parameter Constraints
- Better confining the value of H_0

Balkenhol et al. DOI:10.1103/PhysRevD.104.083509
Submitted to Physical Review D

From 2019/2020 data, a galaxy cluster catalog is being made

Astro2020 Science Theme:
New Messengers and New Physics → CMB

Priority Area: New Windows on the Dynamic Universe

Capabilities include:

- Discover and characterize the brightness and spectra of transient sources
- Ground-based ELTs to see light coincident with mergers
- Radio observatory to detect the relativistic jets from neutron stars & black holes
- **Next generation CMB telescopes to search for the polarization produced by gravitational waves in the infant universe**
- Upgrades to current ground-based gravitational wave detectors & technology development
- Improvements in the sensitivity and angular resolution of high energy neutrino observatories

Recommendation(p. 7-26): DOE/NSF partnership on CMB-S4

NSF & DOE should jointly pursue the design & implementation of the next generation ground-based cosmic microwave background experiment.

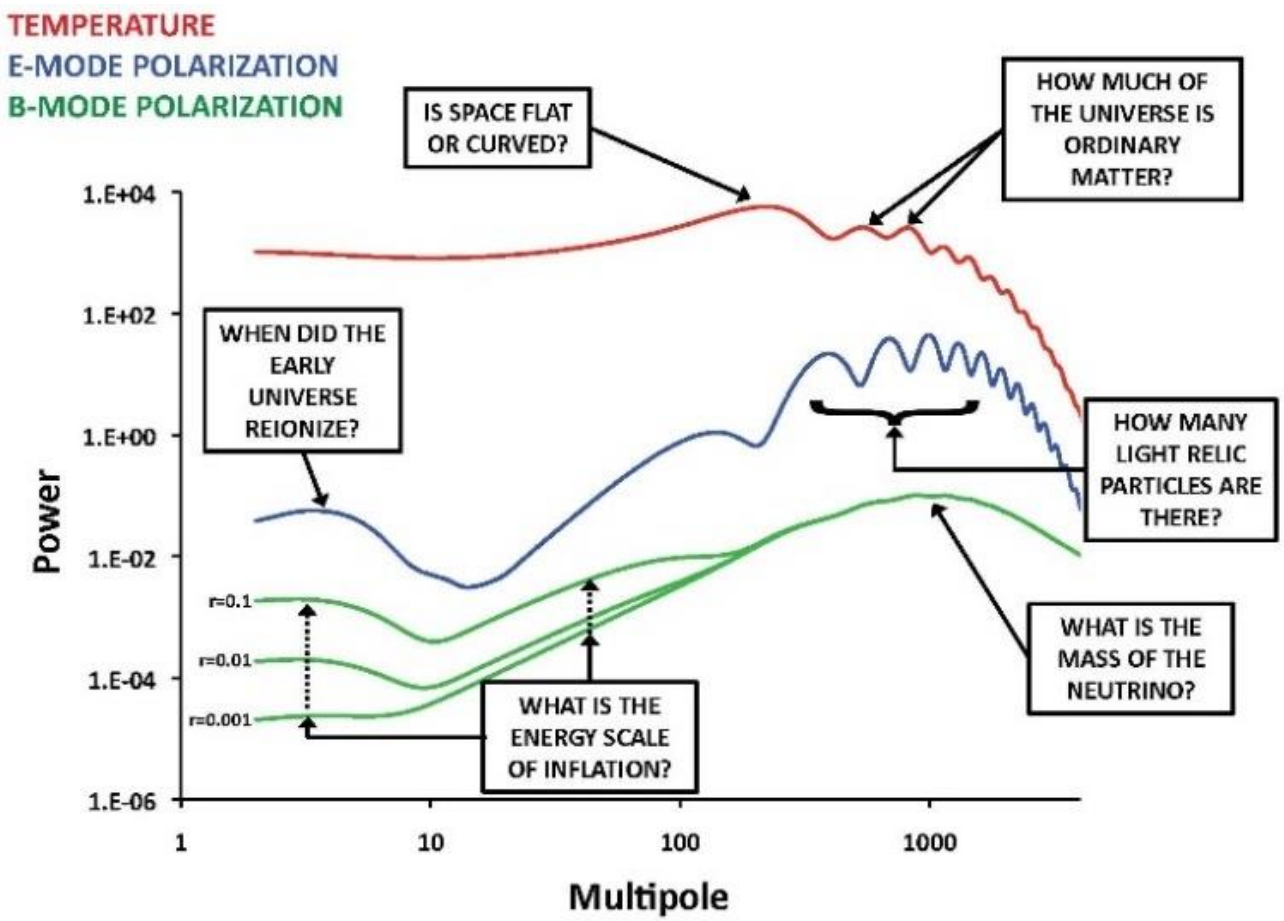
Key Attributes

Balanced program between DOE (60%) and NSF (40%) for all phases
Brings wide range of technical & scientific expertise from community & national labs
Total design, development and construction cost: $660M; First observations ~ 2030

"An important requirement for our strong endorsement is that the project broadly engage astronomers beyond the traditional CMB community.

CMB-S4 science

Goal: cross critical science thresholds, including definitive tests of Inflation



Cosmic Microwave Background Stage 4

- ***CMB-S4*** *recommended by 2014 P5 and as a DOE/NSF partnership by Astro2020*
- **Major leap in science & technology**
- **Goal: cross critical science thresholds, including definitive tests of Inflation**
  - B-mode CMB polarization signatures of primordial gravitational waves & inflation
  - Maps 50% sky, every other day from 0.1-1 cm with unprecedented sensitivity
  - Broad science including systematic time domain science

  - CMB-S4 was being designed since 2014 P5 as 1 large and 18 small telescopes at the SP, and 2 large telescopes in Chile

Learned in early 2022 that required South Pole infrastructure to support the original concept is not available.

- Project activities in the near term will center on developing an updated concept with a footprint at the Pole that fits within infrastructure availability **AND carries out the science goals as planned.**

Astro2020: Science Panel on Cosmology → Dark Ages

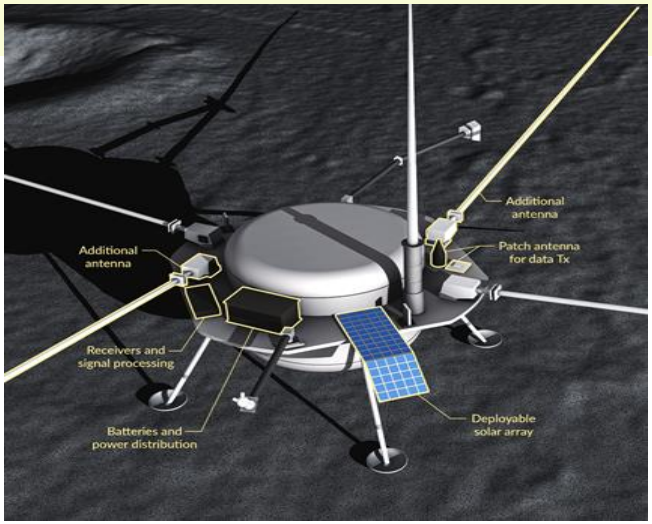
The **Panel on Cosmology** identified **4 Questions**:

- What set the hot Big Bang in motion?
- What are the properties of dark matter and the dark sector?
- What physics drives the cosmic expansion & large-scale evolution of the universe?
- How will measurements of gravitational waves reshape our cosmological view?

The **Panel on Cosmology** identified as a **Discovery Area** using the **Dark Ages as a cosmological probe with great potential.**
"The panel sees 21 cm and molecular line intensity mapping of the Dark Ages and reionization era as both the discovery area for the next decade and as the likely future technique for measuring the initial conditions of the universe in the decades to follow."

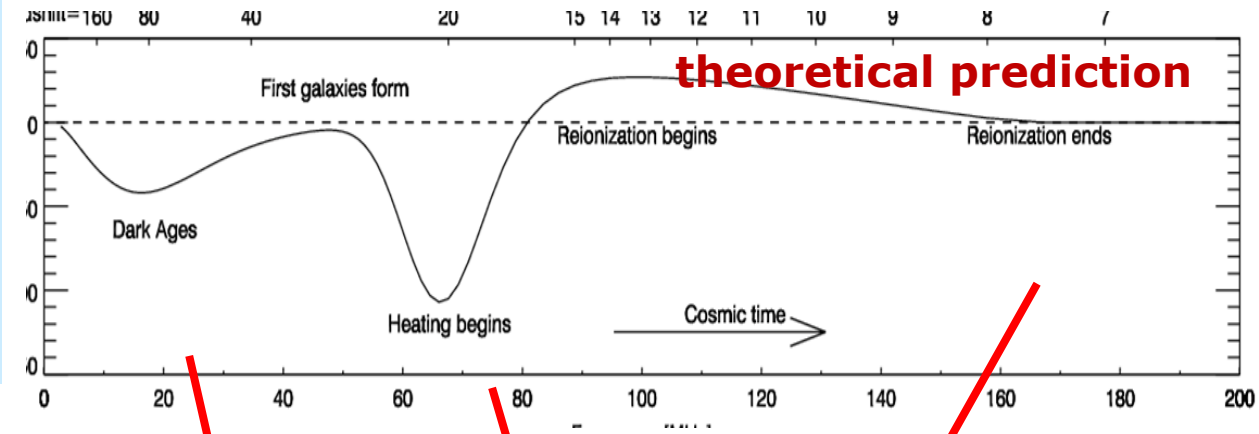
➔The Dark Ages signal has never been observed. A first discovery would be a significant step in understanding this phase of the universe.

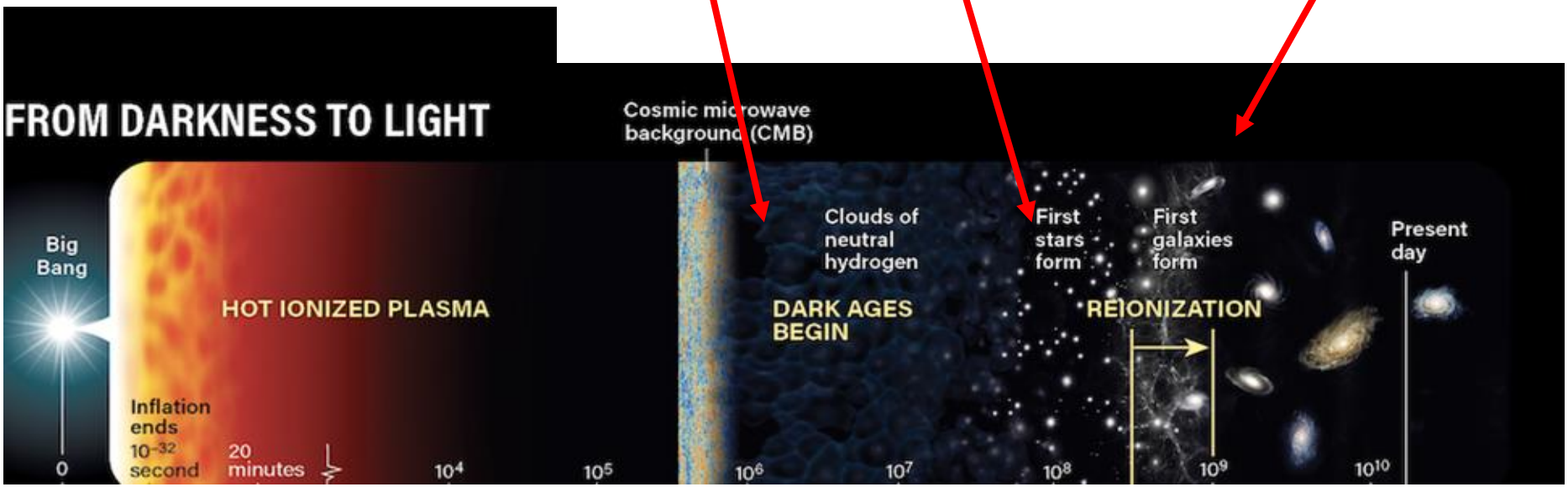
- Detecting and characterizing the Dark Ages monopole dip in the 21cm radiation is the first step in the exciting program to explore Dark Ages



Discovery of the Dark Ages

Measurements of the low-frequency (<50MHz) radio sky are sensitive to 21cm emission from neutral hydrogen at high redshift (z>30)"

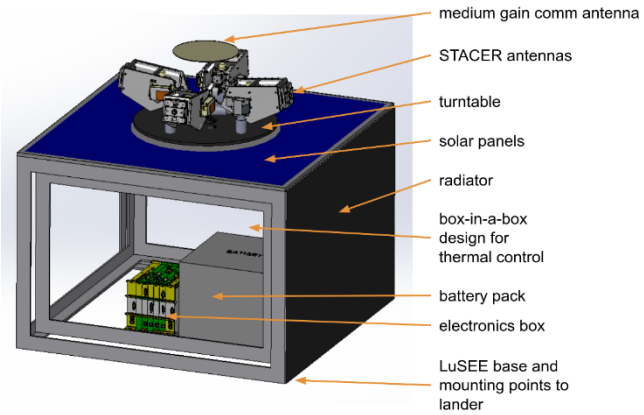




DOE/NASA Partnership on LuSEE-Night → Pathfinder to the Dark Ages

DOE/NASA high level MOU to continue partnerships signed in Oct. 2020, led to:

- **DOE/NASA partnership** on Lunar Surface Electromagnetics Experiment at Night (**LuSEE-Night**)
  - Pathfinder mission to place the most sensitive constraints to date on the **Dark Ages signal** & potentially discover the Dark Ages signal.
  - Capability to measure the radio environment and observe the long-wavelength radio signal through the lunar night (launch early 2025).

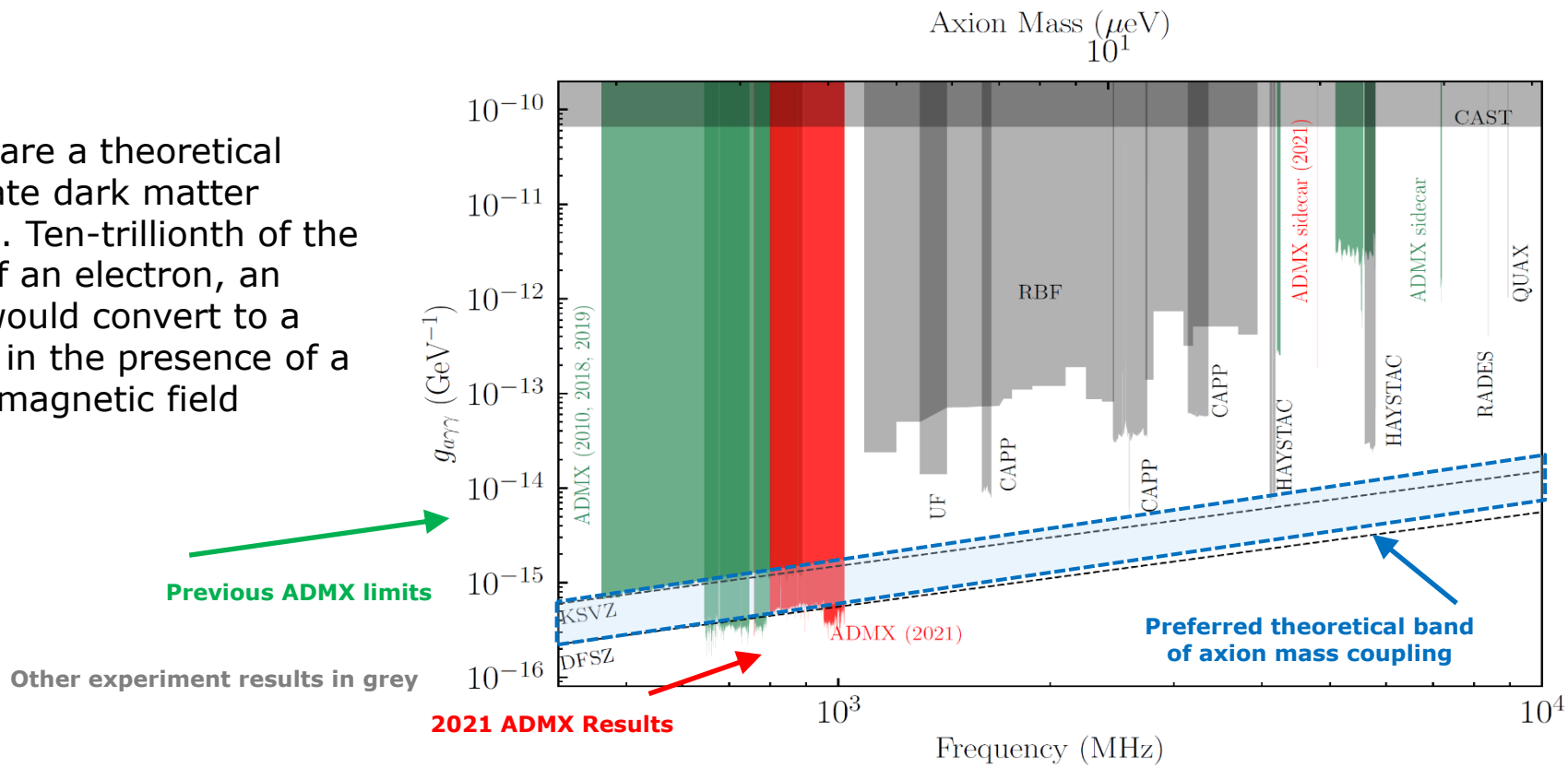


Milestones/Schedule

- **Nov. 2021**: DOE approval of Critical Decision 0; DOE lead is Brookhaven Lab
- **March 15, 2022** approved as a DOE Major Item of Equipment (MIE) Project by the FY 2022 omnibus appropriations bill; Full funds provided.
  - **Project started in FY 2022** and is delivered to the UCB/SSL project office by early 2024
  - Launch in early 2025 by NASA's Commercial Lunar Payload Service (CLPS) mission.

Direct Detection Dark Matter 2nd Generation (DM-G2): ADMX-G2

Axions are a theoretical candidate dark matter particle. Ten-trillionth of the mass of an electron, an axion would convert to a photon in the presence of a strong magnetic field



Axion Dark Matter eXperiment Generation 2 continues operations at U. Washington

- 2021 results (shown) are 5-orders of magnitude better than previous limits, ruling out axion DM hypothesis in this mass-coupling range
- Continues operations & planned upgrades to search next mass range

DM-G2: LZ – First Results

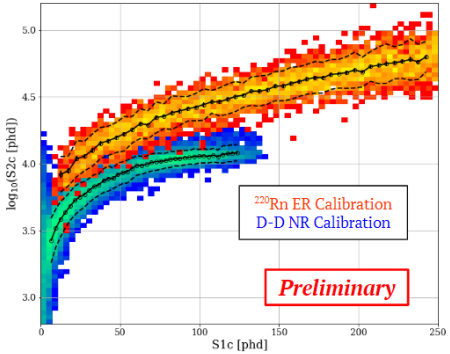
Berkeley Lab Researchers Record Successful Startup of LUX-ZEPLIN Dark Matter Detector at Sanford Underground Research Facility (lbl.gov)

Gen-2 Direct Detection WIMP Dark Matter search

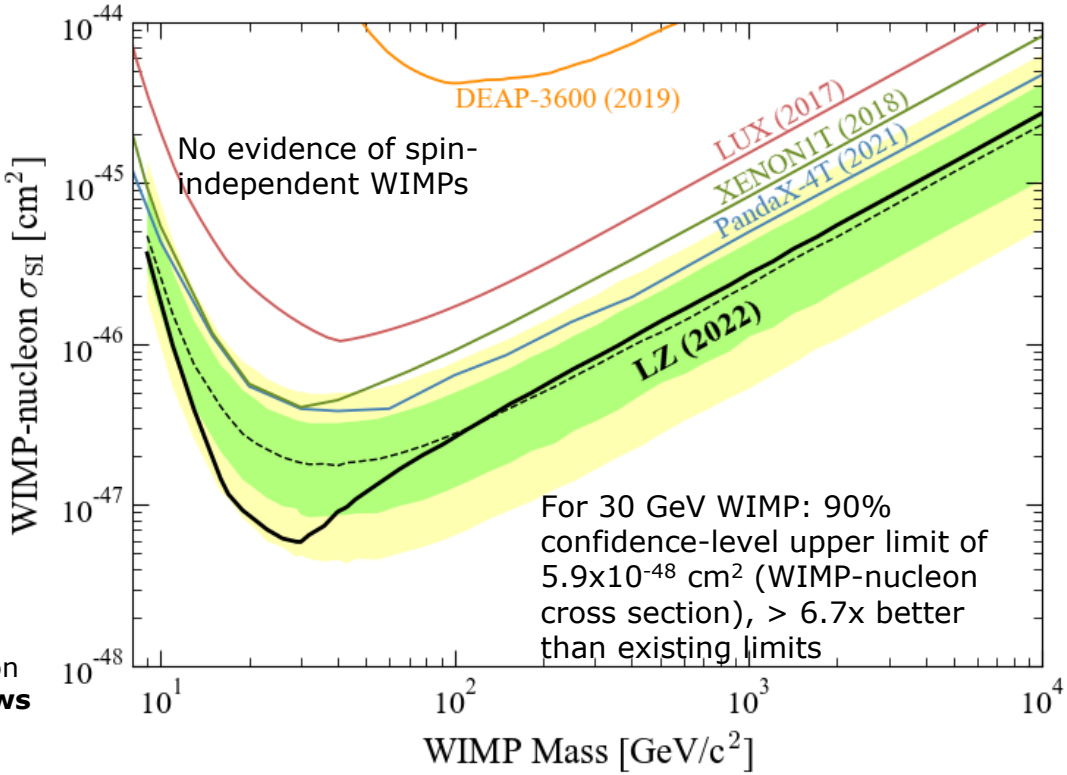
- Time Projection Chamber with 7 tonnes liquid Xenon
- Located nearly 1 mile underground at SURF in Lead, SD.
- Project completed Sept. 2020; Installation & Commissioning through Dec. 2021; Science Run 1 complete July 2022

➔July 7, 2022: First science results released!

With only 60 days of data, LZ already has the world's most sensitive dark matter results (1000 days planned)



LZ Calibration plots during commissioning: D-D neutrons for nuclear recoils (NR) and ^{220}Rn injection electronic recoils (ER). **The plot shows well defined bands as expected**.

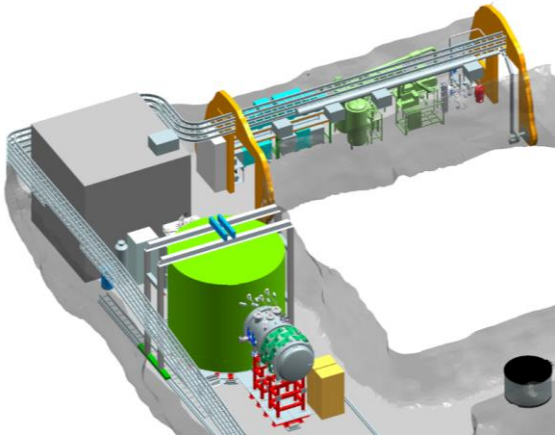


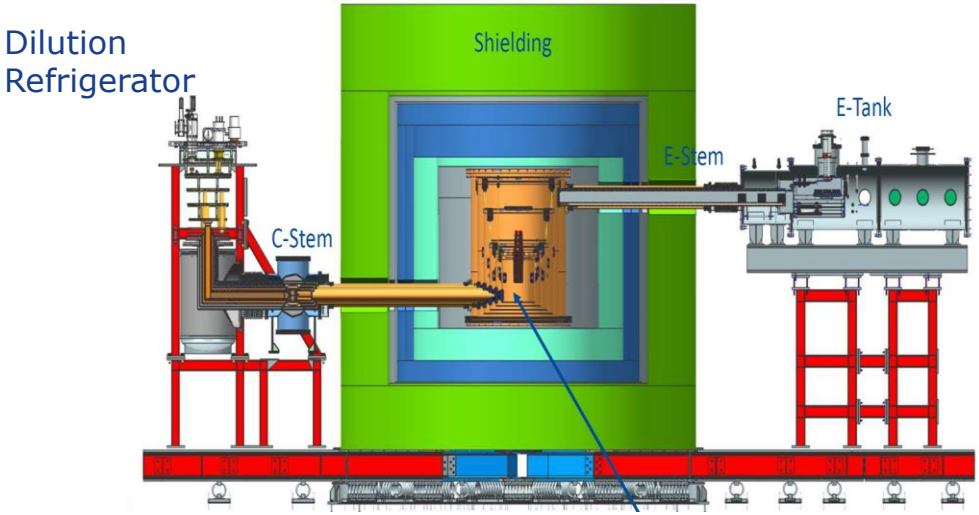
DM-G2: SuperCDMS SNOLAB

SuperCDMS SNOLAB in Canada at the Creighton nickel mine (HEP+NSF partnership)

Cryogenic solid-state crystal WIMP search; ~1-10 GeV mass

Project fabrication was restructured due to issues with cryostat procurement & covid-19; Rebaselined end of FY2021.



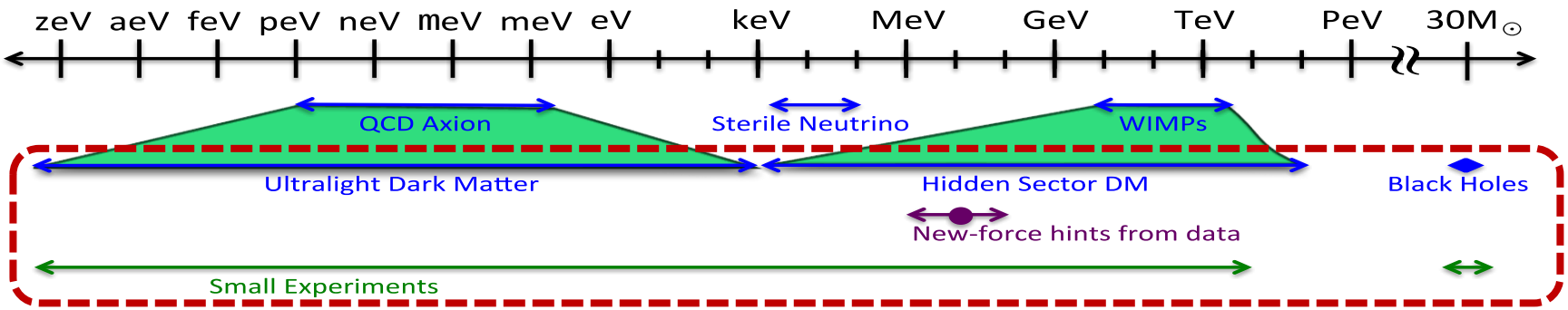


- Expect full fabrication completion in late 2022; full science operations start in 2024; Start operating with partial detector beforehand.

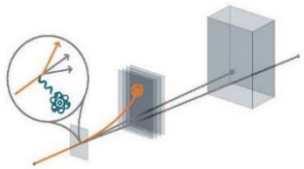
Dark Matter New Initiatives (DMNI) for small projects

P5 recommended the search for Dark Matter particles as a high priority & also that the program should include small projects

- Recent theoretical advances and development of new technologies opened new avenues to explore dark matter

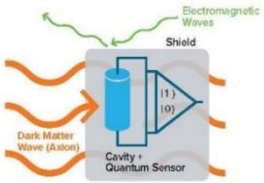


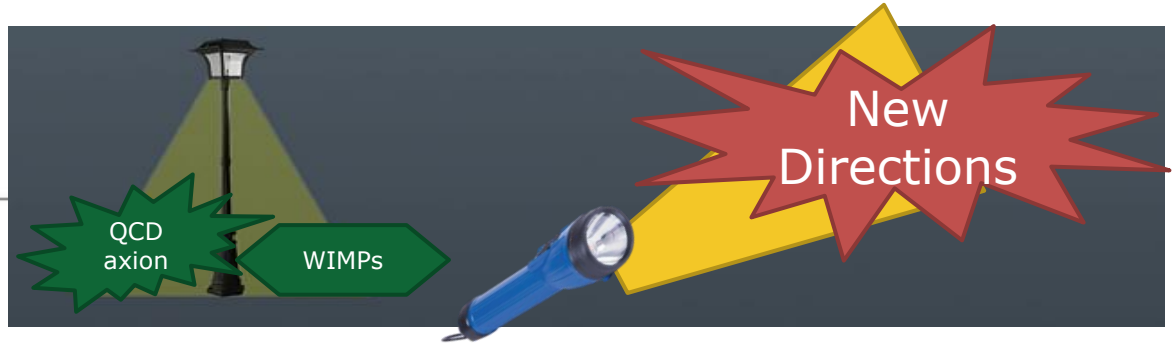
PRD 1
Create and Detect DM at Accelerators.



PRD 2
Detect Galactic DM Underground.

PRD 3
Detect Wave DM in the Laboratory





- **2017** Community Workshop, https://arxiv.org/abs/1707.04591
- **2018-2019**: Basic Research Needs (BRN) study developed 3 Primary Research Directions (PRD) https://science.energy.gov/hep/community-resources/reports/

Dark Matter New Initiatives (DMNI) – Concept Studies

➢**2019: Funding Opportunity Announcement (FOA); Six proposals aligned with the PRD's selected to develop concept & execution plans for potential small projects**

→Following the FOA, HEP is supporting 6 concept teams to carry out near-term technology R&D and to develop design and execution plans for small projects in new areas of phase space and with new technologies. Develop plans that can be reviewed and considered for advancing to small project fabrication phase.

Cosmic Frontier:

- **ADMX Extended** (axions 2-4GHz), 9-17 μeV, A. Sonnenschein (FNAL)
- **OSCURA** (low noise "Skipper" CCD detector) 1MeV-1GeV, J. Estrada (FNAL)
- **DM-Radio** (axion search), <μeV, K. Irwin (SLAC)
- **TESSERACT** (Multiple detectors, w/TES readout), >10 MeV, D. McKinsey (LBNL)

Intensity Frontier (accelerator based)

- CCM Beam Dump exp at FNAL, ~1-40 MeV, R. van der Water (LANL)
- Light Dark Matter Experiment (LDMX) ~ 10-300 MeV, T. Nelson (SLAC)

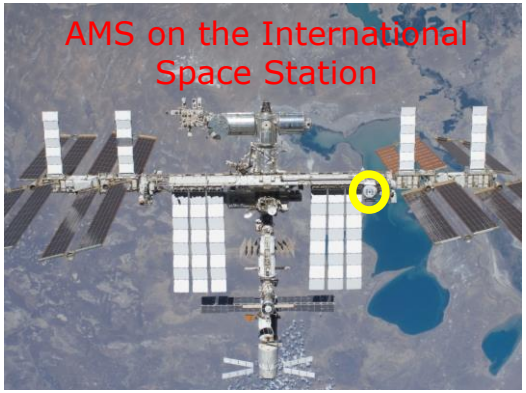
Annual status review of the DMNI concepts held June 2022.

Exploring the Unknown

Use ground-based arrays, space telescopes, & an experiment on the International Space Station to explore the unknown, e.g. indirect searches for dark matter

Fermi/GLAST - Large Area Telescope (LAT) (w/NASA)

- Space-based gamma-ray observatory, launched in 2008
- HEP/SLAC led the fabrication of the LAT; Continues to support critical efforts at the LAT Instrument Science Ops Center at SLAC



AMS *(w/NASA)*

- Launched and mounted on International Space Station in 2011
- DOE-HEP is responsible for management of the science program, led by Prof. Ting (MIT) and has roles in operations; Can continue through 2028+
- Multi-purpose particle-physics spectrometer detects cosmic-rays up to multi-TeV; search for anti-matter, dark matter etc.

HAWC *(w/NSF)*

Gamma rays and cosmic rays between 100 GeV and 100 TeV

- HEP operations support completed early FY2021.

VERITAS *(w/NSF)* – HEP support for operations ended in 2019.

Black: HEP support ended
Green: funding continues

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HEP Research Support

- Priorities
- What it supports
- Model for working in the Program
- Process

HEP Cosmic Frontier Experimental Research Program

Cosmic Frontier Research DOES support ➔

Research funds support **scientists at universities and DOE labs working on all phases of projects and experiments in the Cosmic Frontier program.**

- Includes scientist efforts on all phases of an experiment - design, fabrication, operation & experimental data planning & analysis, primarily as part of the Collaboration; also planning for the future.
- Support research efforts directly in line with program & project priorities, responsibilities & science goals
- Critical, leadership efforts to carry out our roles and responsibilities on the projects and/or experimental operations are especially valued.

- Priority is to support efforts to plan and carry out priority science topics on our experiments, i.e. need to make sure the science it was designed for is carried out and the experiment delivers the best science!

Note: Distribution of efforts across areas will necessarily change to support changing priorities

HEP Cosmic Frontier Experimental Research program

Cosmic Frontier Research Does NOT Support ➔

Not everything cosmic or "dark sector" is considered for Cosmic Frontier support!

- Other science topics on our projects/experiments besides those used for our selection
- Any significant operations and/or project-related activities:
  Engineering, materials, supplies, consumables, computer professionals, etc.
- Other world-leading dark energy, cmb, dark matter etc experiments that are not part of the HEP Cosmic Frontier program (i.e. supported by other agencies).
- Other astrophysics/cosmology topics that are not part of the HEP Cosmic Frontier program, e.g. Gravitational waves (LIGO), Astronomy, Heavy Ion (RHIC), AMO, Planet searches, etc.
- General "cosmic" or "dark sector" research outside of a Cosmic Frontier experiment may still be within HEP under the Detector R&D or Theory Research programs.
- Theory/simulations/phenomenology/computational efforts are supported by the Theory research program.
  - However, these efforts that ARE in direct support of the Cosmic Frontier experiments can be supported; typically the person is participating in and carrying out efforts prioritized by the Collaboration (not publishing efforts on his/her own).
- Generic Detector R&D efforts not for a specific Cosmic Frontier are supported by the Advanced Detector R&D program.
  - However, Cosmic Frontier may support the faculty salary, while ADRD supports the group, technical personnel etc.

University Research Grants - What it supports

- **Faculty PI (or PI's) and their group of postdocs & students are supported on the Research grants**
  - Typically, the *full* research time of the faculty member throughout the whole year is supported by providing 2 months summer salary and support for the group. Summer support should be adjusted according to % time the faculty is on research effort. Should take commensurate support from the grant if they have other grants.
  - Associated expenses, travel (though sometimes the experiment's operations team funds this), personal computers, etc.
  - Faculty needs to justify the group personnel and size needed, e.g. what are your responsibilities and why do they need a postdoc and 2 grad students, etc. Funding is not prioritized for independent students and postdocs.
- Research Scientists can be part of the group but typically face a higher hurdle
  - Need to be carrying out research efforts that support the Cosmic Frontier program
  - Support may be provided, but due to long-term expectations, need to consider case-by-case on merits: whether the roles and responsibilities are well-matched with individual capabilities and cannot be fulfilled by a term position, i.e. postdocs
  - Efforts should be related towards research; not *long-term* operations and/or project activities

Model for Working in the Cosmic Frontier

Typical HEP researcher:

-- Not funded for one particular study or effort here and there

- Has an experimental program that may involve operations and data analysis on one experiment while planning, designing or constructing the next experiment.
- Makes **long term commitments** to our experiment/project/science as a **closely integrated** member of the collaboration.
- These responsibilities may evolve over time as the experiment progresses through phases & may change depending on needs of the experiment.
- Even if your grant was for particular responsibilities and efforts, it is fine to spend a fraction of your time on planning for the future.

For calibration: Faculty typically "ramps-up" to a level*** of one graduate student and one postdoc after they've been funded several rounds and have excellent reviews. It may take several rounds for new faculty to be funded.

*** Of course, this is based on funding availability, review, programmatic priorities

A Note on Program Stability:

- In the HEP Model, our university scientists have Roles & Responsibilities on all phases of a Project/Experiment. Peer reviews typically support this mode →Grants are "renewed" if they review well and are doing excellent work, that is critical and timely.

In this way, the **Project/Experiment can count on the PI for the long term**.

Cosmic Frontier University Grants – New Efforts

Model for new PI's to starting to work in the field & get an HEP Cosmic Frontier grant:

- Get involved in experiment/science and take on responsibilities for the collaboration and then submit proposal.

- Have involvement in the community so that you are part of the HEP community! (e.g. DPF meetings)

- Lot of science topics may be in, e.g., dark energy plan or related to dark energy but need to think of what is the priority & main efforts needed and which are needed now!

- Have responsibilities for the experiment – not just your own science simulations & analysis.

- Many people have program working on a series of experiments (e.g.) DES operations/analysis while participating in LSST planning and construction. Not all has to be funded by HEP!

- Show track record and have responsibilities before funding starts.

- Transitioning to a new project/field requires a lot of work to get up to speed.
  - best for faculty to take the time to really learn the field and take on responsibility first

HEP Program Managers are happy to talk to you to helping you navigate the process!
Contact us when you are starting out or at any time.

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Funding Opportunities & Reviews

See Bill Kilgore's DOE Funding Opportunity Announcement (FOA) talk on July 19 for details about opportunities & requirements.

- Please read all FOA's carefully and follow the requirements!

HEP University Research Grants - Process

Solicitation (FOA)

Drafted by HEP
Reviewed in SC-HQ by Grants and Contracts and Budget
Then handed to procurement channel
Additional reviews by dollar level
DOE Leadership (Secretary, Deputy Secretary, Undersecretary, SC Director) may exercise oversight
Published by contracting officer (STRIPES to FedConnect) and SC Grants and Contracts (grants.gov, PAMS, SC Website)

Pre-Award

Proposal submitted via Grants.gov. (Institutions submit on behalf of PI)
Proposal transfers to PAMS (S2S integration)
Grants and Contracts validates submission, assigns to program manager
Program Manager conducts initial review, oversees merit review
May be multiple stages
Recommendation recorded in PAMS
Silent negotiation (revised budget, aims, scope) and selection statement
Declination justification

Award Made

Recommendation for funding transfers from PAMS to STRIPES as a requisition
Chicago Office negotiates and finalizes award
Funds transferred from HQ to Chicago outbound account
Award issued

Post Award

Normal events ensue—continuations, prior approval actions, renewals, supplements

Ultimately, closeout
Final reports (progress, inventions, financial, property)

New for All FOAs in FY 2023:

There are a number of changes to the FOA for FY 2023:

- New "Research and Related Senior/Key Person Profile (Expanded)" form.
  - The form requires a profile for each Senior/Key person on the proposal
  - Separate Biographical Sketches and reports of Current and Pending Support are attached to each Senior/Key Person's profile. They are no longer submitted in Appendices 1 and 3.
- Changes to the formats of Biographical sketches and reports of Current and Pending Support.
  - Both are available through SciENcv (preferred) or from NSF as fill-in pdfs.
- Changes to the way Collaborators and others who should not be used as reviewers are reported.
  - A Template (Excel Spreadsheet) is available from Office of Science web-site
- New Appendix concerning the Recruitment and Retention of Students and Early-Stage Investigators (in FY2022)

HEP University Research FOA - Comparative Reviews

- **Since FY 2012, DOE/HEP uses a process of comparative grant reviews for university research grants – those scheduled for renewal and any new proposals**
  - **The FY 2023 FOA marks 12th round in the process**
  - **Each HEP subprogram at the DOE national laboratories is also reviewed every 3-5 years**
- **Process was recommended by several DOE advisory committees, including the 2010, 2013, 2016 and 2020 HEP Committee of Visitors (COV):**
  - 2010 COV: *"In several of the cases … proposal reviewers expressed negative views of the grant, but only outside of their formal responses. Coupled with the trend in the data towards very little changes in the funding levels over time, this suggests that grants are being evaluated based on the historical strength of the group rather than the current strength or productivity of the group. This is of particular concern when considering whether new investigators, new science, or high-risk projects can be competitive. Comparative reviews can be a powerful tool for addressing these issues and keeping the program in peak form."*
    - use comparative review panels on a regular basis
  - 2013 COV: Continue comparative reviews. Augment with independent mail-in reviews
  - 2016 *and* 2020 COV: Continue comparative reviews
    - Continue communicating with PIs about program priorities at DOE-HEP PI meetings
    - Provide guidance to reviewers on, e.g., more uniform scoring, DE&I, …

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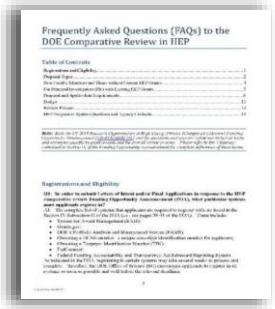
Goal: improve overall quality and efficacy of the HEP research program by identifying the best proposals with highest scientific impact and potential

FY 2023 HEP University Research – "Comparative Review" FOA and FAQ

- **DE-FOA-000xxx issued: Still under DOE Review**
- **Six HEP research subprograms**
  - Energy, Intensity, and Cosmic Frontiers
  - HEP Theory, Accelerator Science and Technology R&D, and Detector R&D
- **Letter of Intent (strongly encouraged) due: TBA**
- **Final Proposal deadline: TBA**
- **Review process: October 2022(?) – February 2023**

PIs and university SROs should read the FOA carefully to comply with all requirements prior to submitting a proposal.

- **In addition to the FOA, an FAQ will be available to address topics:**
  - Registration and eligibility requirements
  - Proposal types and requirements;
  - Guidance for new faculty and those without current grants
  - Guidance for PIs with existing HEP grants
  - Budget information and guidance on scope of request(s)
  - Letter of Intent
  - Information on overall scientific merit review process
  - Contacts for program- or system-related questions



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Both the FOA and FAQ will be available at: *https://science.osti.gov/grants/FOAs/Open*

New in FY 2023 HEP University Research FOA:

- There are changes to the "Comparative Review" FOA for FY 2023:
  - New instructions on the Project Narrative.
    - No change in page limits, but clarifications about topics to be included
  - Alternative ways to submit sub-program budgets for multi-task proposals.
  - Changes to the Merit Criteria, including a new Merit Criterion regarding Recruitment and Mentoring Plans for junior personnel.

Other Requirements in the HEP University Research FOA

- All Research proposals submitted to DOE Office of Science (SC) must have a Data Management Plan (DMP)
  - Includes HEP comparative review and Early Career but not proposals for conferences, workshops, operations, or projects
  - Any thrust in a proposal without a DMP will **be declined without review**
  - A DMP that is blank or states "not applicable" will not be accepted
- All Renewal proposals must submit "proposal products" (publications, etc.) *after* the application is submitted
  - PIs are notified via PAMS and typically have about 7-10 days to respond
  - We cannot review incoming renewal proposals until this step is completed
  - These 'products' are captured with your annual Progress Report, but for this review process, applicants can update their entries prior to merit review process
- **Explicit merit review criterion: quality and efficacy of recruitment & mentoring plan**
  - **Supports an Appendix 9 narrative that aims to address similar subject matter**
- Recurring submissions of research applications (*initiated in FY 2018*)
  - *"A previously declined application may be resubmitted to this FOA, but **only after it has undergone substantial revision**. An application submitted to this FOA that has not clearly taken into account the major concerns from prior DOE reviews may be **declined without review and will not be considered for funding**."*
- Each FOA has different eligibility, technical requirements, page limits, etc.
  - **Prior to any proposal submission, please read the specific FOA carefully**

HEP University Research FOA - Things to Keep in Mind

- Proposed research reviews best if closely aligned with the DOE/HEP mission, its program, and current P5 strategy
- Investigators in experimental HEP research frontiers [Energy, Intensity, Cosmic] review best if they are closely integrated into HEP collaborations and have key roles and responsibilities
- "Generic" research that is not carried out as part of a specific HEP experimental collaboration should be directed to the Detector R&D or HEP Theory programs, as appropriate
- Read the FOA carefully and follow the requirements on content, length, etc.
  - Several requirements in the FOA are set from outside the DOE/HEP office, and there is little to no flexibility to modify. Non-compliant proposals submitted to the FOA will not be reviewed.
  - In recent years, ~3-5% of incoming proposals are declined without review. Requirements most often missed or overlooked include:
    - DMPs, page limits, separate budget sheets (if needed) for each research subprogram or thrust, and inclusion of Personally Identifiable Information (PII)

Merit review criteria and corresponding questions are given in Section V of the FOA

Program Policy Factors, which are also used in selections for an award – including those pertaining to the availability of funds – are given in Section V of the FOA

During and prior to the proposal submission, work with your university sponsored research/program office to ensure all FOA requirements are met

Recruitment and Mentoring

- DOE-HEP introduced a new Merit Criterion into last year's review process and plans to include this year: Quality and Efficacy of Recruitment and Mentoring Plan
  - Evaluate the past performance of the investigator(s) for mentoring and advancing career opportunities of students and other early-stage personnel in their research team
  - Evaluate any proposed plan for future recruitments and whether the plan will lead to successful outcomes –
    e.g., passing forward the scientific training and developing the critical thinking skills needed in the workforce
  - Evaluate whether the proposed plan helps ensure a diverse, equitable, and inclusive research environment

- PIs encouraged to include a dedicated Appendix 9 Narrative in the proposal to address this criterion
  - PIs may also describe such plans in their 9-page research narrative
  - Panelists are encouraged to comment on the plan during this review as well as provide their knowledge about the performance of the group's recruitment and mentoring efforts

- Such plans need not be limited to personnel currently on-board or planned to be supported by any grant. A more inclusive or comprehensive plan is welcome, including mentorship activities with other early-stage members of their scientific collaboration(s) or the broader community.

- A large fraction of HEP Research funding is devoted to students and postdocs. It is appropriate that we consider the effectiveness of the applicants' record and plans in the allocation of research funds.

Artificial Intelligence / Machine Learning

- **AI/ML continues to be a priority in the Administration and the U.S. Congress**
  - Dedicated funds since the FY 2020 appropriation for DOE/HEP Research Program to advance AI/ML initiatives

- Development and implementation of machine (or deep) learning tools, techniques, and algorithms are part of many analyses and project design efforts.

- Typically two categories in a proposal narrative for AI/ML-based activities
  1. PIs and research team explicitly lead efforts to develop ML tools and algorithms for the collaboration to enhance sensitivity in physics studies, improve triggers, etc.
  2. End-user: PIs and research team are implementing ML-based algorithms in an analysis, which was developed by other collaborators on the experiment

- FY 2023 FOA plans to continue encouraging investigators to narrate in the proposal any of the research group's AI/ML efforts, where applicable
  - Prefer a proposal's narrative to describe aspects of the above category #1 in research proposals
  - Identify any personnel and resources (*e.g.,* students, postdocs, etc.) devoted to efforts

- During panel deliberations, reviewers are encouraged to provide any input on AI/ML activities of a group on an experiment

Cross-cut, Multi-thrust, or Transitional Proposals

- Applications where an investigator is proposing to conduct research across multiple HEP research subprograms during the project period are planned to be considered

- PIs are encouraged to submit only one application describing:
  - Overall research activity, including fractional time planned in each subprogram
  - Plan to continue for the FY 2023 FOA: in proposal's budget material (*i.e.,* a dedicated Appendix), include a
    level-of-effort table for any transitions of efforts during the next project period

- As part of their overview of the subprogram and review process, DOE Program Managers (PMs) will provide the panel with details regarding such research plans across multiple HEP thrusts

- Reviewers with appropriate topical expertise in the research area(s) will assess the full scope, relevance,
  and impact of the proposed research in the merit review process — *e.g.,* merit review questions consider:
  - Are plans for such cross-cutting efforts reasonably developed and balanced?
  - Does the scope of the full proposed program provide synergy or additional benefits to the HEP mission beyond the individual thrusts?
  - Will PI's overall efforts across multiple thrusts add value to HEP program goals and mission and have impact?

Notes & Considerations

Proposed research reviews best if closely aligned with the DOE/HEP mission, its program, and P5 strategy

Reviewers look to see **close engagement within** the experimental collaborations & give priority to scientists with significant/leadership/major/key roles responsibilities that are

- aligned with for priority needs of the collaboration/experiment
- carrying out Cosmic Frontier responsibilities

Typically, scientists have roles on project/operations as well as data planning and analysis aligned with the key science drivers for which DOE is participating in the experiment.

Justify your proposed group size and members students and postdocs – how are they supporting you in your research?

Helps to describe if you're working in a group that includes people from other universities (e.g. photo-z group) – otherwise there's confusion.

Impact, if any, on the Cosmic Frontier research, current projects, experimental operations, or future planning if proposal was ***not*** funded?

Basics to Keep in Mind

The word "proposal" denotes something for the future. You should provide content on your past work to show your capabilities & experience, but the bulk of the proposal should be on your future efforts. Narrative is typically 9 pages per PI.

In your proposal:

- Explain your long term program (past 3 years), how it progresses over time & how pieces fit together.
- Details on what you're doing the next 3 years, your responsibilities and efforts, why they're important to the project/experiment and why they're important and a priority NOW.
- Explain what fraction of time you're working on each effort (whether or not HEP funded).
- Describe your overall time commitment – 50% of your research time?

- Supporting 2 months summer salary is typically considered for efforts that 100% of research time throughout the year.

- Don't just answer the merit questions! Provide a research plan!

Comparative Merit Review Critera

MERIT REVIEW CRITERIA	REVIEW CRITERIA SUB-QUESTIONS FOR MERIT REVIEWER'S EVALUATIONS
SCIENTIFIC AND/OR TECHNICAL MERIT OF THE PROJECT	• What is the scientific innovation of the proposed research? • What is the likelihood of achieving valuable results? • How might the results of the proposed work impact the direction, progress, and thinking in relevant scientific fields of research? • How does the proposed work compare with other efforts in its field, both in terms of scientific and/or technical merit and originality? • Is the DMP suitable for the proposed research? To what extent does it support the validation of research results? To what extent will research products, including data, be made available and reusable to advance the field of research?
APPROPRIATENESS OF THE PROPOSED METHOD OR APPROACH	• How logical and feasible are the research approaches? • Does the proposed research employ innovative concepts and methods? • Are the conceptual framework, methods, and analyses well justified, adequately developed, and likely to lead to scientifically valid conclusions? • Does the applicant recognize significant potential problems and consider alternative strategies?
COMPETENCY OF APPLICANT'S PERSONNEL AND ADEQUACY OF PROPOSED RESOURCES	• What is the past performance and potential of the research team? • How well qualified is the research team to carry out the proposed research? • Are the research environment and facilities adequate for performing the research? • Does the proposed work take advantage of unique facilities and capabilities? • Are the senior investigator(s) or any members of the research group that are being reviewed leaders with the proposed effort(s) and/or potential future leaders in the field? • For senior investigator(s) proposing to work across multiple research thrusts, are the plans for such cross-cutting efforts reasonably developed and will the proposed activities have impact?
REASONABLENESS AND APPROPRIATENESS OF THE PROPOSED BUDGET	• Are the proposed budget and staffing levels adequate to carry out the proposed research? • If multiple research thrusts are proposed, is the balance of proposed efforts reasonable and well-matched to the proposed research goals? • Is the budget reasonable and appropriate for the scope?
ALIGNMENT OF THE PROPOSED RESEARCH TO THE PRIORITIES ESTABLISHED IN THE P5 STRATEGIC PLAN	• How does the proposed research of each senior investigator specifically contribute to the mission, science goals, and programmatic priorities of the subprogram in which the application is being evaluated? • Is the proposed research consistent with the priorities and strategic plan described in the P5 report? • For multi-thrust proposals, does the scope of the full proposed program provide synergy or additional public benefits within HEP's Congressionally-authorized mission-space beyond the individual thrusts? • How likely is the research to impact the direction of the overall HEP program? • For applications proposing work and/or a transition across multiple research thrusts, will the overall efforts add value in the broader context of the program goals described in the P5 strategic plan?
QUALITY AND EFFICACY OF RECRUITMENT AND MENTORING PLAN	• What is the past performance of the investigator(s) for mentoring and advancing career opportunities of students and other early-stage personnel in the research team? • Does the proposed plan to recruit and retain students and early-stage investigators provide sufficient mentorship, either towards completion of a degree or advancing their career? • Are the plans proposed for recruiting additional scientific and/or technical personnel including new senior staff, students, and postdocs reasonable, justified, and appropriate? • Is the proposed plan likely to lead to satisfactory outcomes and an advancement in career opportunities for students and other early-stage personnel? • Does the proposed plan by the team help ensure a diverse, equitable, and inclusive research environment?

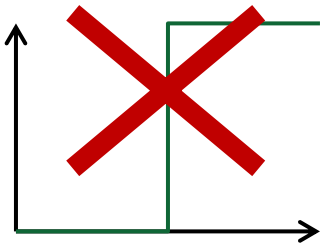
Proposal Reviews: Comparative Evaluation & Scores

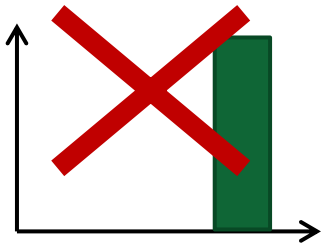
DOE Program Managers will need to determine:

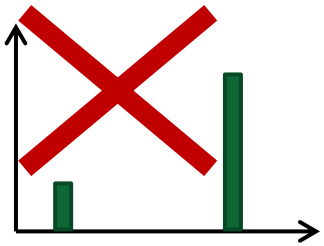
- The threshold for funding each proposal
- The level of support for each funded proposal

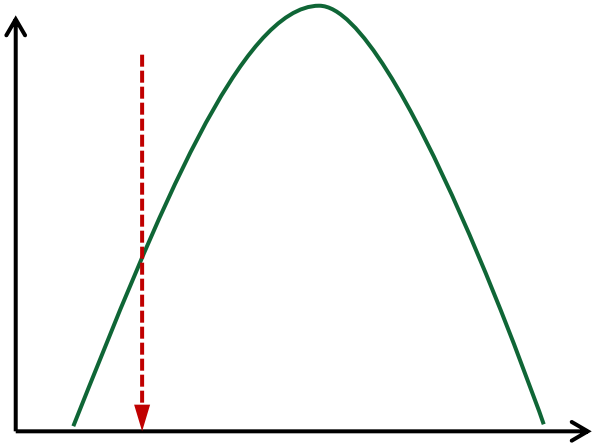
"*Comparative*" evaluation:

- Reviewer scores / rankings of the proposals and senior investigators provide essential (additional) input to DOE's process of optimizing resource allocations for the University research program
- Not everyone can be "Above Average" in the peer group – **use the full range of scoring!**









Comparative Review – Reviewer Considerations

- **Comparative Review: head-to-head reviews of PIs working in similar areas**
- **Panels discuss relative strengths and weaknesses of individual proposals and PIs**

- **Many factors weigh into final funding decisions**
  - **Compelling research proposal for next ~3 years**
    - ☑ Interesting? Critical responsibility? Significant? Plausibly achievable?
    - ☒ Incremental? Implausibly ambitious? Poorly presented?
  - **Significant *recent* contributions in last ~3 years**
    - Synergy and collaboration within group (as appropriate)
    - Contributions to the research infrastructure of experiments
  - **Alignment with programmatic priorities**

HEP – final decisions

- **Written reviews and panel discussions inform HEP program managers' decisions and provide the basis for those explanations.**

- ***HEP uses the reviewer reports & also considers:***
  - *Alignment* with programmatic priorities
  - *Availability* of funds

- **Supportive of excellent people, including excellent *new* people, even when times are tough!**

- **Corollary: Some proposals or personnel ranked below average may *not* be funded.**

Comparative Review → Applicant Feedback

At the end of the process, the PI of the grant will get a review report that contains individual reviews & panel summary

We encourage reviewers to provide feedback about what did and did not work in a proposal.

- Excessively terse reviews ("Good proposal from a strong group. Fund it." or "I see nothing new here.") do nothing to help the applicants/PIs make sense of how to improve future proposals.

Panel summaries capture the context of discussions that would otherwise be invisible to the applicant.

- Where did the proposal rank overall? (Be descriptive but don't give a numerical rank e.g. "Good but not among the best, because …". Do not state "14th of 23".)
- Did a reviewer comment get amplified by the discussion; was a new issue raised; …?
- What assets/flaws of the proposal featured in the discussion?
- How could they improve

HEP Program Managers may also write a summary at the end of the review document; e.g. to give more info on what did/didn't review well, explain why a proposal was declined or why it was funded at a level below the request, and provide other information.

***** You are always welcome to meet with the program manager (e.g. at the annual PI meeting) to discuss details of the review and outcome.**

Proposals: What To Do

Do Follow Instructions and Guidelines

Read the current FOA thoroughly, as well as any supporting materials, e.g. FAQ, PI meeting slides

SC rules & procedures and HEP program requirements are regularly updated

Do seek out advice & support from trusted colleagues & mentors

Your institution has invested a lot of time and money hiring you. They want you to succeed. Let them help you

Request a pre-review of the proposal.

There are resources at most institutions; and/or seek guidance from collaborators

Do learn the rules, regulations, and costs of your institution

Funds are awarded to the institution. Understand direct and indirect rates, benefits, and restrictions

Establish a relationship with your budget office or sponsored research office. Remember they submit the proposal for you!

Do follow through on any past reviewer feedback

Give weight to the critical reviews

Arguing with HEP that 3 out of 5 reviewers thought your proposal was excellent does not address the 2 reviewers who had a different opinion

Read the panel summaries from past reviews. Those contain the panel discussions of your proposal

Do be clear and follow proper English grammar and composition

Be clear: avoid reviewers guessing about your research plan;

Careless editing will annoy or confuse reviewers

Have someone proof-read your proposal

Do ask for what you reasonably need

Standard research requests

- Salary (PI and co-PIs)
- Other Personnel including post-docs, students, etc.
- Travel (domestic and foreign)
- M&S, Tuition remission

Realistic funding expectations

- Early Career >$150k Univ & >$500k Lab
- 50% FTE to proposal
- Stagger personnel

Proposals: What Not To Do

Do Not submit a proposal late

- You should assume that applications received after the deadline will not be reviewed or considered for award
- Use the weeks or months after the FOA is made public to prepare and then submit your proposal early

Do Not brag or exaggerate

- Be professional and objective.
- Fully list your accomplishments in the bio-sketch; Include your mentoring.
- Accurately and reasonably describe research plan

Do Not bury the message

- The narrative should be accessible to a review panel with a wide range of expertise
- Avoid jargon when possible. Same with acronyms.
- Describe in clear and concise language.

  Tell a story...

Do Not overly dwell on the past

- General rule of thumb (1/3:2/3).

  No more than one-third of proposal devoted to past efforts; Future since DOE funds are meant for next period
- Majority of proposal narrative should be forward looking

Do Not submit a sloppy budget or budget justification

- The budget sheets and justification should be prepared with the same care as the narrative
- Reviewers will call out any:
  - Excessive or inappropriate requests
  - Arithmetic errors
  - Poorly justified expenses
  - Start guessing if not adequately explained

Do Not be discouraged

- Competition is strong.

  Some very good proposals are declined due to limited resources.

  That first feedback is so valuable.

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Other Funding Opportunities
Federal Career Opportunities

Other SC Research Programs - Funding Opportunities

- **Early Career Research (open to lab and university PI's within 10 years of their PhD), see** https://science.osti.gov/early-career

- **REACHING A NEW ENERGY SCIENCES WORKFORCE for HIGH ENERGY PHYSICS (HEP-RENEW) FOA, see**

https://science.osti.gov/Initiatives/RENEW/Funding-Opportunities

- **SC "Open Call"** – new version posted annually, see *https://science.osti.gov/grants/FOAs/Open*
  - HEP uses this primarily for conferences, experimental operations, and emergencies (e.g. equipment failure).

Early Career Proposals

- Plan to issue a FY 2023 FOA around the Fall of 2022 for the next round of Early Career applicants
  Stay tuned for further updates at: *https://science.osti.gov/early-career*

- In addition to the merit review criteria in the FOA, the following guidance should be considered while preparing the proposal narrative:
  - What challenges/problems are you trying to solve? Communicate this in the proposal.
  - Is someone else doing it already?
    - Alternatively, aren't those research activities already being funded elsewhere?
    - *i.e.,* if you carry-out these efforts, discuss why are they unique and require "you"?
  - How does your research plan exploit/engage the unique capabilities of your institution?
  - What resources are needed to complete the project?
  - Does your proposal address a 5-year timeline with key deliverables and personnel profiled during this project period?
    - If funded, what will be the outcome after 5-years?

  - Leadership:
    - Have you led the activities that you are proposing?
    - Why are you a future leader in HEP? For e.g., identify past & present leadership activities in the Collaboration; any in HEP, your institution, or the broader scientific community?
    - Update your CV (bio-sketch) that is part of the overall proposal

HEP Research Program – RENEW FOA (still open in FY2022)

In FY2022, DOE announced $40 million to provide research opportunities to historically underrepresented groups in STEM and diversify American leadership in the physical and climate sciences through internships, training programs, and mentor opportunities.

The REACHING A NEW ENERGY SCIENCES WORKFORCE for HIGH ENERGY PHYSICS (HEP-RENEW) FOA will support training and research experiences in particle physics for members of underserved communities**, with the goals of supporting investigators and building research infrastructure at institutions which have not traditionally been part of the portfolio and encouraging underrepresented populations to pursue STEM careers**.

- DE-FOA-0002759 issued: May 25, 2022
- Final Proposal deadline: August 15, 2022

The FOA and informative Webinar slides are available at:
https://science.osti.gov/Initiatives/RENEW/Funding-Opportunities

Other DOE Funding Opportunities

- Workforce Development (WDTS) programs: https://science.osti.gov/wdts
  - **Office of Science Graduate Student Research fellowships (SCSGR)**
    - Supports grad student research at a DOE lab, 3 to 12 months
    - Two calls per year, usually Feb/Aug
    - Applications typically due May/Nov for following Fall or Summer start
  - **Science Undergraduate Laboratory Internships (SULI)**
    - Supports undergraduate research at a DOE lab, 10 to 16 weeks
    - Three calls per year, for following Spring/Summer/Fall terms
  - **Visiting Faculty Program**
    - Summer research support for faculty/students from historically underrepresented institutions
    - One call per year, usually in Oct. Applications due in Jan.
  - **Community College Internships (CCI)**
    - Provides technical training for community college students at DOE laboratories; 10 weeks
    - Three separate internship terms: Summer, Fall, Spring – call opened recently on July 14, 2022, for the 2023 Spring term

Available funds have been increasing!

Career Opportunities for Scientists in Government

There are several career opportunities available at DOE (not just HEP, also other SC offices and DOE or government-wide programs):

- Internships for undergrads and graduate students:
  - **DOE Scholars** (formerly *Pathways)* for US citizens who are current or recent students in a STEM field : orise.orau.gov/doescholars/
  - **Minority Educational Institution Student Partnership Program (MEISPP)** for all US citizens who are full-time students; not limited to MSI students, underrepresented groups, or STEM: doemeispp.org
- Fellowships for post-graduates
  - **AAAS Science and Technology Policy Fellowship** for US citizens with a PhD in science or a MS in engineering, 1 yr renewable : aaas.org/page/fellowship-areas
  - **Presidential Management Fellowships** for advanced degree recipients, US gov't-wide, 2 yr program, convertible to Fed staff position : pmf.gov
- Federal jobs (variable education requirements, see individual postings)
  - All posted on usajobs.gov. Can be entry-level or more advanced.
  - Some agencies (NASA, NIST) have both research scientist (i.e. active research) positions as well as program management positions; others (DOE, NSF) have only program management with limited opportunities for independent research. Read job description carefully and consult with agency contacts if you have questions.

U.S. DEPARTMENT OF ENERGY | Office of Science

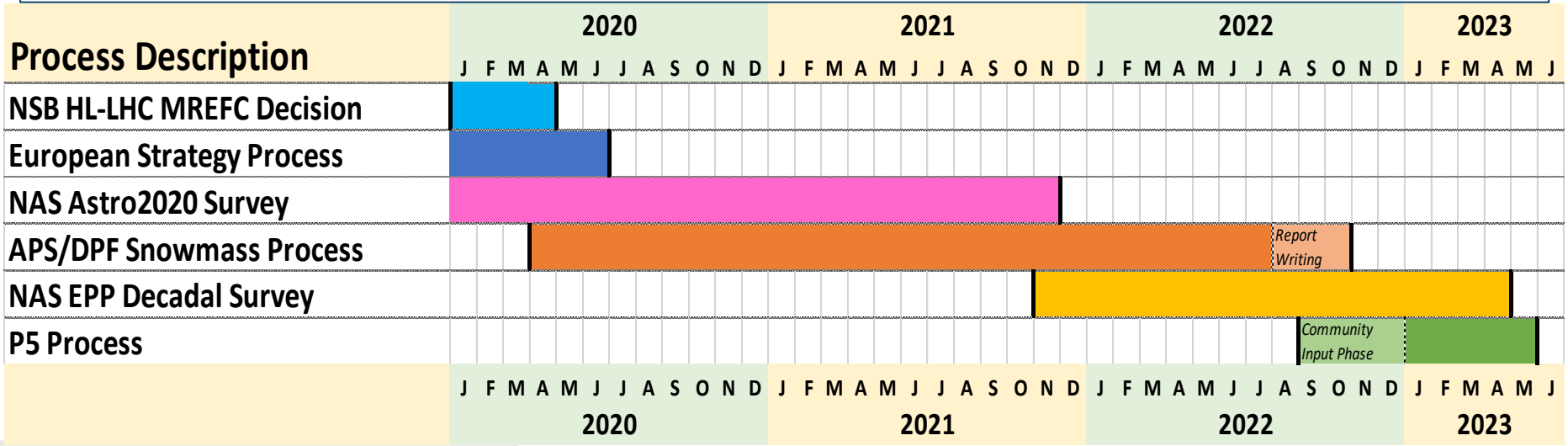
SUMMARY

HEP Next Strategic Planning Timeline

HEP community-wide "Snowmass" study process organized by the American Physical Society (APS) Division of Particles and Fields (DPF) & Division of Particles and Beams is in full swing. https://snowmass21.org/start

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 Cosmic Frontier – Summary & Future Planning

- **HEP continues to carry out the 2014 P5 strategic plan**
  - **The 2014 P5 projects will deliver results & CMB-S4 will be developed.**

- **Complete execution of the FY 2022 budget**
  - **Planning for FY 2023**
    - **Develop FY2024**

- **Future Planning:**
  Astro2020, Snowmass → P5

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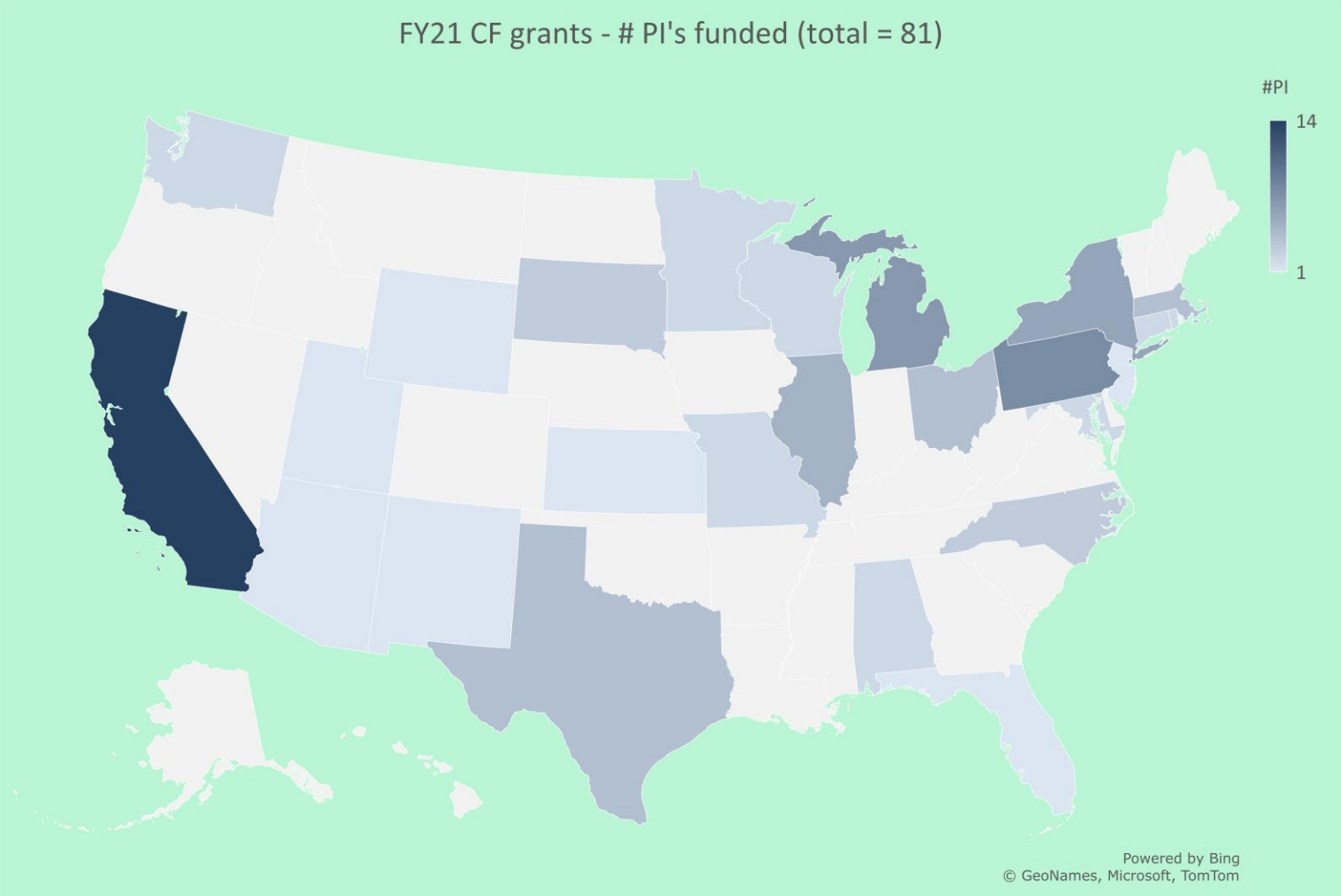
HEP Cosmic Frontier – university grant distribution



History of Reports – feeding into DOE HEP Cosmic Frontier planning

2004 HEPAP - Scientific Assessment Group for Experimental Non-Accelerator Physics (SAGENAP)
2006 AAAC - Task Force for CMB Research (TFCR)
2006 AAAC - Dark Energy Task Force (DETF)
2006 NAS - Elementary Particle Physics 2010 (EPP2010)
2007 NAS - Beyond Einstein: An Architecture for Implementation
2007 AAAC - Dark Matter Science Assessment Group (DMSAG)
2008 HEPAP - Particle Physics Project Prioritization Panel (P5)
2009 HEPAP - Particle Astrophysics Science Assessment Group (PASAG)
2010 NAS - Astro2010 NWNH (New Worlds New Horizons)
2012 AAAC - Dark Energy Task Force (Rocky III)
2013 APS/DPF Snowmass report, Planning the Future of Particle Physics
2014 HEPAP - Particle Physics Project Prioritization Panel (P5)
2017 AAAC - CMB-S4 Concept Definition Taskforce
2018 HEPAP HEP Portfolio Review of Operating Experiments
2018 AAAC – Gemini-Blanco-SOAR subpanel
2021 NAS – Astro2020 (Pathways to Discovery in Astronomy and Astrophysics for the 2020s)

NOTE: List of reports (most likely!) not complete, esp. before 2010

HEP by the Numbers

HEP RESEARCH SPANS

MORE THAN **160** ACADEMIC, NONPROFIT, AND INDUSTRIAL INSTITUTIONS

12 DOE NATIONAL LABORATORIES | **42** STATES AND WASHINGTON, D.C.

13 CORE RESEARCH THRUSTS

OVER **400** ANNUAL HEP PUBLICATIONS IN PEER-REVIEWED SCIENTIFIC JOURNALS

SUPPORTED RESEARCHERS

1,115 PH.D SCIENTISTS *(325 POST-DOCS)*

595 GRADUATE STUDENTS

HEP | BY THE NUMBERS (FY 2020)

HEP's mission is to understand how the universe works at its most fundamental level by discovering the elementary constituents of matter and energy, probing the interactions between them, and exploring the basic nature of space and time.

20 NOBEL PRIZES IN PHYSICS

$390 MILLION RESEARCH BUDGET

$25M SBIR/STTR, $118M UNIVERSITIES, $247M DOE LABS

2,215 USERS AT **3** HEP FACILITIES

FERMILAB ACCELERATOR COMPLEX, SLAC FACET-II, BROOKHAVEN ATF

PRESIDENTIAL EARLY CAREER AWARDS FOR SCIENTISTS AND ENGINEERS (PECASE) **15**

OVER **300** ACTIVE AWARDS

$317 MILLION SCIENTIFIC USER FACILITIES AND EXPERIMENTAL OPERATIONS BUDGET

LHC, SURF, RUBIN/LSST, DESI, LZ, AMS, TEST FACILITIES, ETC.

$338 MILLION LINE-ITEM CONSTRUCTION PROJECT AND MAJOR-ITEM OF EQUIPMENT BUDGET

LBNF/DUNE, PIP-II, HL-LHC-ACCELERATOR, HL-LHC-ATLAS, HL-LHC-CMS, CMB-S4, ACORN

CMB-S4 - details

Project plan sent to Astro2020

21 telescopes, in 2 aperture scales, at 2 sites:

- 2 large aperture (6m) in **Chile;** Deep & wide N_{eff} & Legacy Survey ~60% of sky
- 1 large (5m), 18 small (0.5m) at **South Pole;** Ultra-deep survey ≥ 3% of sky + delensing

Total 500,000 cryogenic sensors, superconducting readout; scale up of over x10 from all stage 3.

2014 HEPAP/P5 strategic plan recommended CMB-S4 as a joint DOE/NSF project

2016-2017 AAAC subpanel: CMB-S4 Concept Definition Taskforce study

2019 – DOE approved CD-0

2020 – LBNL chosen as DOE's lead lab

FY2021 - Congress approved DOE **Major Item of Equipment "project start"**

FY2022 - **Astro2020 recommended DOE/NSF partnership** on CMB-S4

FY2023 – focus on development of updated concept that aligns with infrastructure availability at the South Pole and carries out the science goals as planned.

Office of Science & HEP
-- [New] Initiatives in Research funding

HEP budget (in $K)	FY20 Enacted	FY21 Enacted	FY22 Enacted	FY23 Request
Artificial Intelligence & Machine Learning (AI/ML)	15.0	33.5	35.8	40.0
Integrated Computational & Data Infrastructure (renamed to Advanced Computing in FY23 Request)			4.1	5.1
Microelectronics		5.0	7.0	7
Quantum Information Science (QIS)	23.5	20.1	26.6	25.6
Quantum Center	15.0	25.0	25.0	25
Reaching a New Energy Sciences Workforce (RENEW)	0.0	0.0	4.0	8
Accelerate Innovations in Emerging Technologies				4
Accelerator Science and Technology Initiative (ASTI)	0	6.3	17.4	10
Funding for Accelerated, Inclusive Research (FAIR)				2

HEP Budget: FY2022 Enacted, FY2023 Request

HEP Funding Category ($K)	FY 2020 Actual	FY 2021 Request	FY 2021 Enacted	FY 2021 Actual	FY 2022 Request	FY2022 Enacted	FY2023 Request
Research	389,646	328,906	398,203	408,163	419,605	416,605	418,646
Facilities, Exp. Operations	317,310	285,725	314,297	304,337	309,395	290,395	313,374
Projects	338,044	203,500	333,500	333,500	332,000	371,000	390,000
Total	**1,045,000**	**818,131**	**1,046,000**	**1,046,000**	**1,061,000**	**1,078,000**	**1,122,020**

FY2022 Enacted

- HEP received $1,078M in the FY 2022 Congressional Appropriation, +$17M above the FY 2022 President's Budget Request, and +$32M above FY 2021 Appropriations
- Congressional direction fixed LBNF/DUNE, PIP-II, and Mu2e at 176M, 90M, and 2M respectively, which is +$16M over FY 2021 funding levels
- Additional direction provided floor and ceiling limits for SURF, **CMB-S4**, HL-LHC Upgrade projects and LBNF/DUNE OPC and approved **LuSEE-Night** (new project with NASA)
- Congressional direction at the SC level for QIS and AI/ML propagated down to HEP
  - AI/ML $35.8M, and QIS & QIS Center $51.6M → +$8.8M over FY 2021 funding levels

The U.S. Federal Budget Cycle (1)

- The President submits a Budget Request (PBR)
- Each house of U.S. Congress passes their vision of a draft budget (called a "mark")

For FY 2023, we are here

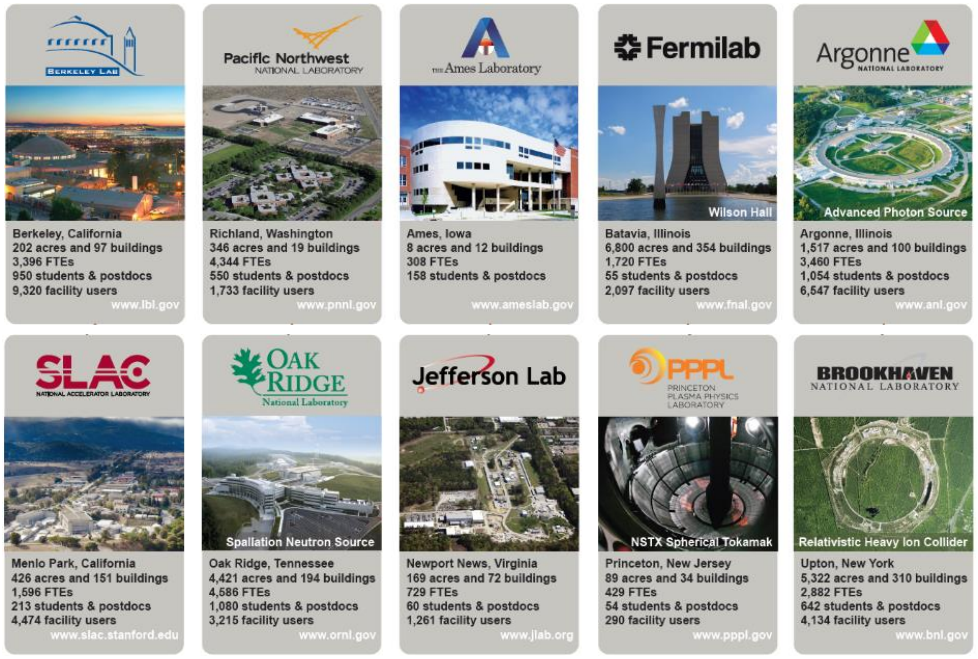
- Both houses agree on a single bill (through "reconciliation")
  - No amendments are allowed beyond this point, to ensure the process converges
- Congress passes this legislation
- The President signs it and it becomes law

"I'm Just a Bill"
Credit: America Rocks, 1976.
3rd season, Schoolhouse Rock.

- If this process is not completed by the end of a fiscal year (September 30th), Congress may pass a "continuing resolution", or without any action, U.S. Government can [partially] "shutdown"

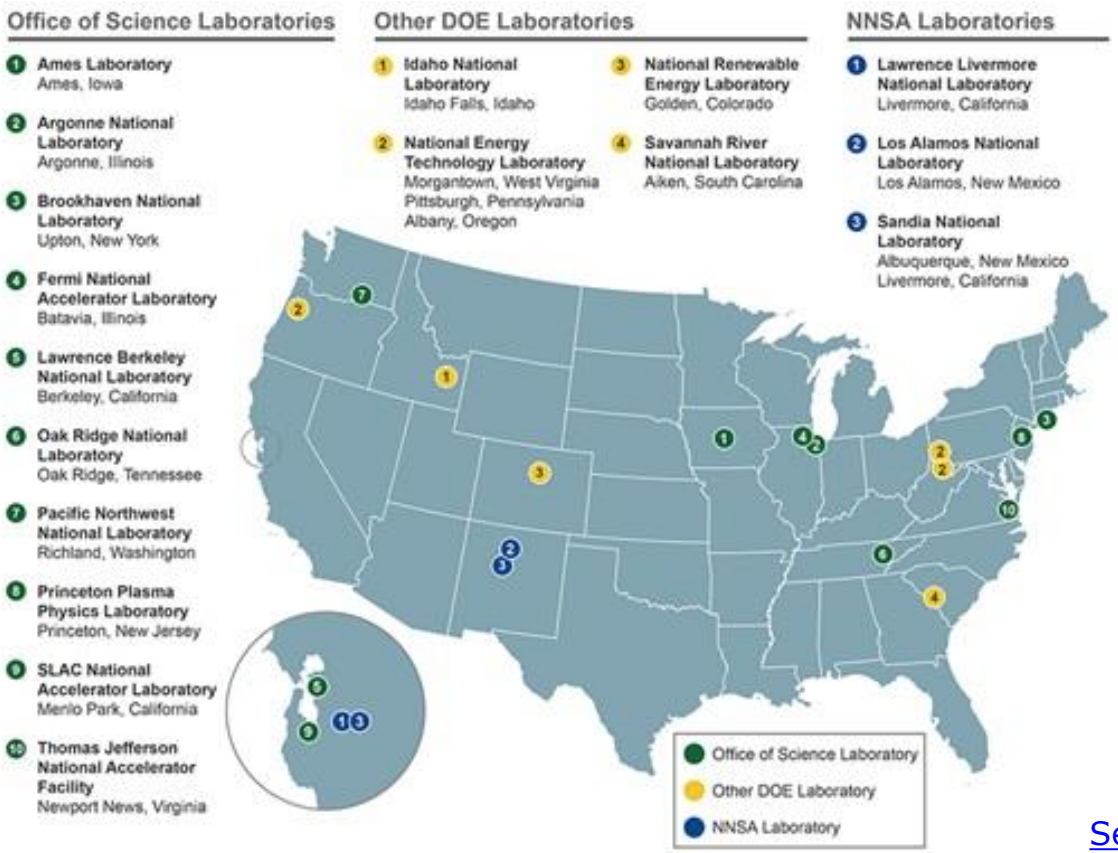
Mission of the DOE Office of Science

- The Office of Science (SC) mission is to deliver the scientific discoveries and major scientific tools that transform our understanding of nature and advance the energy, economic, and national security of the United States



DOE National Labs – Our Crown Jewels

Together, the 17 DOE laboratories comprise a preeminent federal research system, providing the Nation with strategic scientific and technological capabilities.



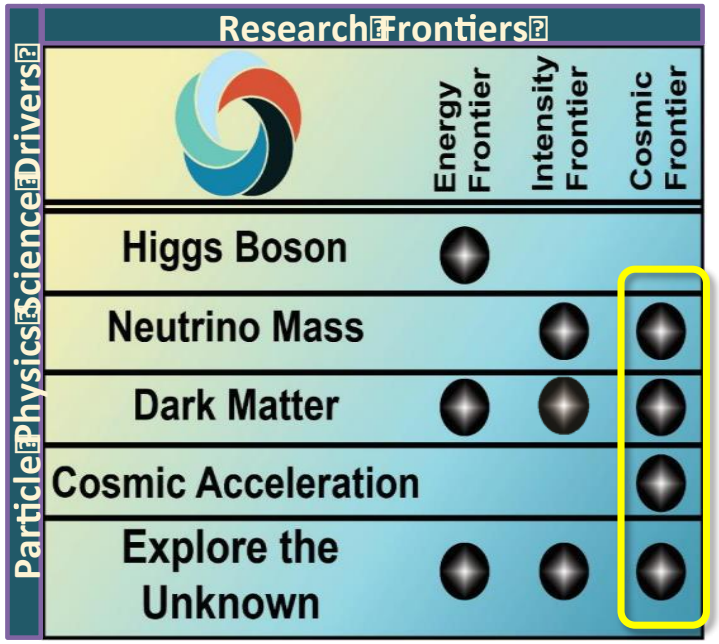
The laboratories:

- Execute long-term government scientific and technological missions, often with complex security, safety, project management, or other operational challenges;
- Develop unique, often multidisciplinary, scientific capabilities beyond the scope of academic and industrial institutions, to benefit the Nation's researchers and national strategic priorities; and
- Develop and sustain critical scientific and technical capabilities to which the government requires assured access.

See https://science.energy.gov/laboratories/

HEP – follows P5 Strategic Plan

HEP science priorities come from community via HEPAP advisory panel **Particle Physics Project Prioritization Panel ("P5")** strategic plan.



The 2014 report:

- provided the critical scientific questions
- recommended a portfolio of facilities and projects in Energy, Intensity, Cosmic Frontiers to optimally address the science within realistic constraints; also investments in Theory, Detector R&D, Accelerator R&D
- 10 year plan, with 20 year vision

→The **projects** selected for the (P5) strategic plan make significant leaps in addressing HEP science goals.

- HEP Community support of this process is a critical element of success
- Form partnerships with other US and International agencies (*e.g.*, NASA, NSF, international) to help deliver our mission