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# Office of High Energy Physics (HEP) Cosmic Frontier

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Report to the  
Committee on Astronomy & Astrophysics  
December 1, 2022

*Karen Byrum, Bryan Field, Chris Jackson, **Kathy Turner***

*Experimental Research at the Cosmic Frontier  
DOE, Office of Science (SC), Office of High Energy Physics*

## Report on the HEP Cosmic Frontier Program

- Astro2010 & 2014 P5 report – status of current program
- Astro2020 recommendations - DOE status, responses
- Planning for the Future



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# Current Program

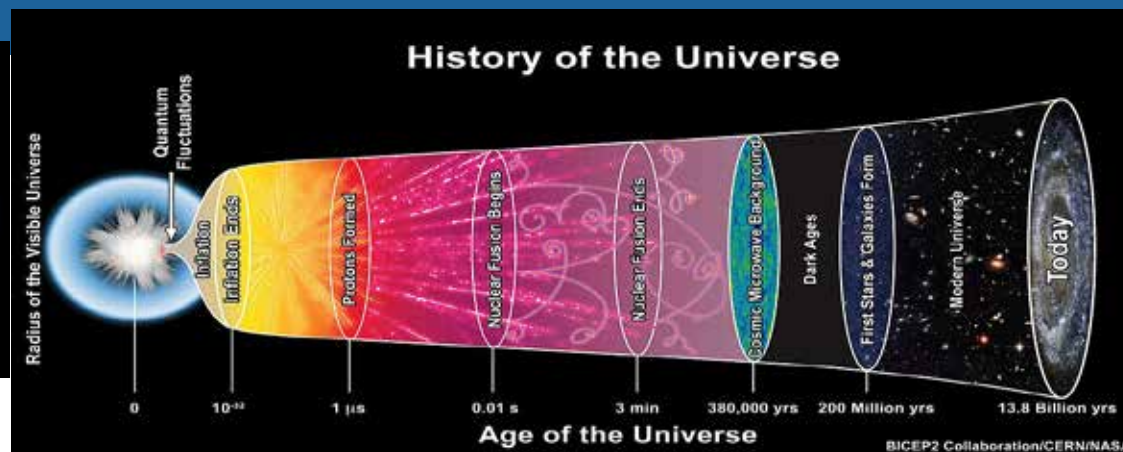
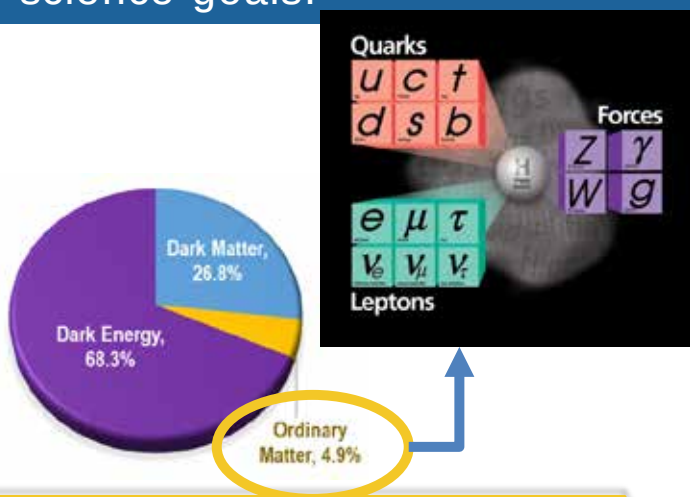
# HEP Program Mission

DOE is a mission-oriented agency à mission includes **maintaining a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity with clear leadership in strategic areas.**

**HEP's mission** is to understand the universe at the most fundamental level:

- } **Discover** the elementary constituents of matter and energy
- } **Probe** the interactions between them
- } **Explore** the basic nature of space and time

**Program Model: Science Mission-driven; Developed with Community Input** to carry out a specific portfolio of projects. è We work closely with our community and labs to design, construct and operate projects & experiments and to carry out its science goals.



è Scientific Areas are intertwined: High Energy/Particle Physics, Cosmology, Astrophysics, and Astronomy.



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# HEP Program Layout

## **HEP is carried out along 3 Frontiers:**

Advancements at all 3 frontiers are needed to achieve the long-term goals of the field.



à **Cosmic Frontier (CF)** is an increasingly important area for **discovery in HEP**. Experiments use naturally occurring data to provide additional input to the Standard Model picture: Cosmic Acceleration (Dark Energy, Inflation), search for Dark Matter particles, Neutrino properties, New Physics (e.g. relic particles, etc)

à HEP is primarily a **Particle Accelerator** based program: Energy & Intensity Frontiers. These also provide complementary science with CF, such as Dark Matter, Neutrinos, etc.

## **Crosscutting HEP subprograms:**

- } **Theoretical research**, High Performance Computing & Computational HEP, Advanced Detector R&D + New Initiatives

# 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:
    - 2008 Particle Physics Project Prioritization Panel (“P5”)
    - 2009 Particle Astrophysics Science Advisory Group (PASAG) – participation criteria
    - 2014 P5 provided HEP's 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)

- Advice also Provided by:** National Academy of Sciences (NAS)
- **Decadal Surveys in Astronomy & Astrophysics (Astro2010 à 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)

# Cosmic Frontier – Current Program Guidance

**PASAG (2009)** – 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:

- o **Dark Energy:** build **LSST (Rubin)** & **DESI**
- o **CMB:** support as part of the core program within multi-agency context; carry out multi-agency **CMB-S4** project later in the decade
- o **Dark Ages:** **LuSEE-Night** pathfinder

- **Dark Matter (DM)**: suite of “generation 2” direct detection experiments to detect DM particles; plan for the future

- **Neutrino Mass** – survey experiments provide information on neutrino properties

- **Explore the Unknown** – always of interest!

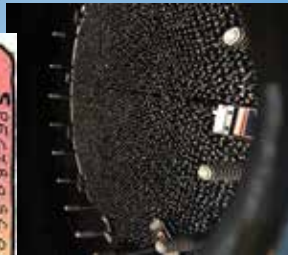
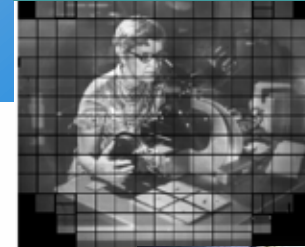
à Maintain a portfolio of small projects

| Particle Physics Science Drivers | Research Frontiers                                                                |                 |                    |
|----------------------------------|-----------------------------------------------------------------------------------|-----------------|--------------------|
|                                  |  | Energy Frontier | Intensity Frontier |
|                                  | Higgs Boson                                                                       | ●               |                    |
|                                  | Neutrino Mass                                                                     |                 | ●                  |
|                                  | Dark Matter                                                                       | ●               | ●                  |
|                                  | Cosmic Acceleration                                                               |                 | ●                  |
|                                  | Explore the Unknown                                                               | ●               | ●                  |



# HEP Cosmic Frontier: Cosmic Acceleration

Pinhole camera 3.2Gpixel  
image of Vera C. Rubin



SPT-3G

Dark Ages



Dark Energy

CMB



# Dark Energy Spectroscopic Instrument (DESI) Experiment



## DOE's DESI started its 2<sup>nd</sup> year of operations in May.

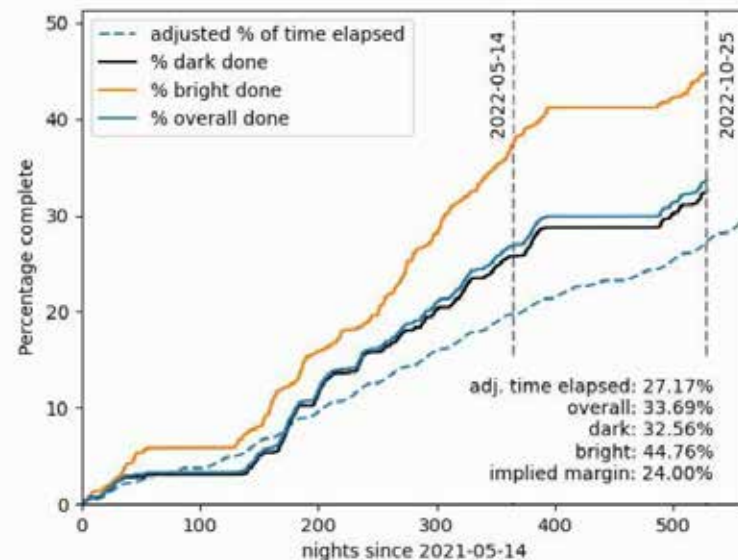
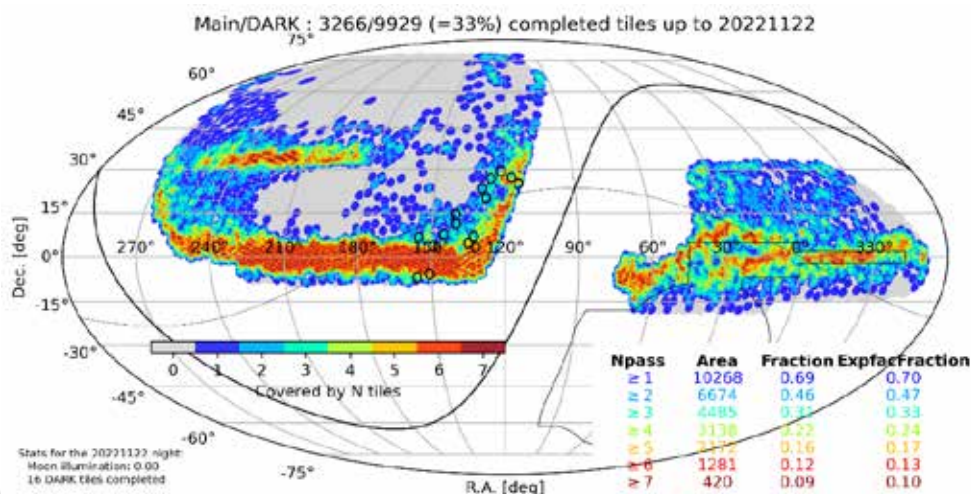
- World's premier multi-object spectrograph w/5,000 fibers, positioned robotically
- First **Stage IV dark energy**; Will measure spectra of > 40 million galaxies

**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.

à DESI is running ahead of project schedule (~ few months)

**Amazing data-taking:** ~ 100,000 spectra per night; 16.3 Million extra-galactic redshifts recorded (significantly more than all other surveys combined) + 5M stars



# DESI – June 2022 Contreras Fire



## Mid-June: Fire went through Kitt Peak

DESI operations were shut down on June 14 when fire was on the way; brush cleared; all instrumentation and telescope secured.

Bureau of Land Management video:  
[https://fb.watch/dKzbQM\\_YPg/?fs=e&s=cl](https://fb.watch/dKzbQM_YPg/?fs=e&s=cl)

**Thank you to fire fighters** and all the agencies that provided ground and aerial protection for the site.

The Collaboration made a thank you video:  
<https://www.facebook.com/desisurvey/>

Z:16  
2022-06-16 18:37:15  
KPNO Mayall 4m

There's still a ways to go: minimal internet, utility/generator power, problems with the roads, etc.

Z:1  
2022-06-17 05:49:11  
KPNO Mayall 4m



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# DESI – Status

**Back on sky mid- Sept. 2022. See Info at:**

<https://newscenter.lbl.gov/.../desi-resumes-cataloguing.../>



Collaboration Science News  
Survey Validation results (Aug.2022)  
- 8 papers submitted in support of  
the primary goals and conclusions  
including optimization of target  
selection, redshift of the BGS, LRG,  
ELG, and quasar target samples  
relative to the projections

Working on early science results including competitive BAO results based  
on first 2 months of data

**Public** data release of SV data plus 2 months of main survey data likely  
~ January 2023 (AAS mtg)





# 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) & DOE (SLAC) partnership, with private, international contributions**

**Construction Project:** DOE responsibilities

- **LSST Camera** MIE fabrication completed Sept. 2021; all key performance parameters demonstrated
- **Commissioning roles** - LSST Camera assembly, test, shipment, integration; effort on ComCam; data quality and verification studies

## **Facility Operations:**

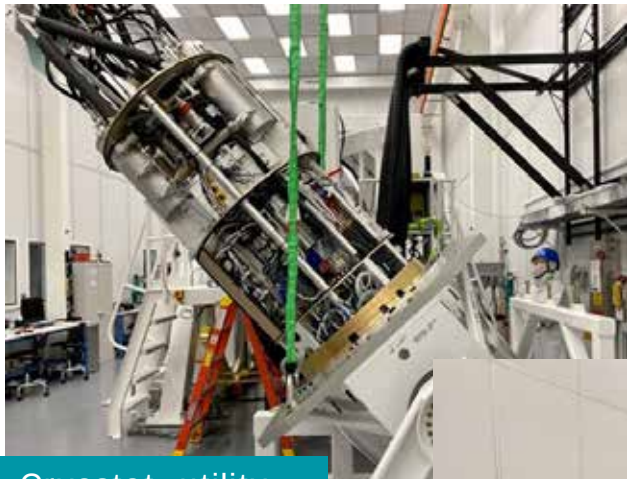
50/50 DOE and NSF split; DOE responsible primarily for camera maintenance & operations, US Data Facility



DOE people at Rubin, Sept 2022

# Camera Integration, Test & Commissioning – at SLAC

- LSSTCam is fully integrated at SLAC.
- Verification studies at SLAC + preparations in Chile – in progress
- Cold refrigeration system (for electronics) being replaced by a pumped-coolant system due to instabilities – in progress.
- Ready to ship to Chile (~ May 2023)



Cryostat, utility trunk, L3 mated to camera; Shutters

9/7/22 – Camera fully assembled at SLAC



Oct2022 – Camera on saddle stand



# Commissioning in Chile

The DOE team is participating in preparations for LSSTCam, Commissioning Camera (ComCam) and other commissioning activities.



As of mid-Nov., ComCam is cold and the CCDs are on.



## Rubin Construction Project status:

- EPO complete (closeout review as we speak)
- Telescope Mount Assembly nearly complete
- LSSTCam will be installed ~ Nov.2023
- Completion & full survey start still expected by end 2024.

# 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; Planning underway

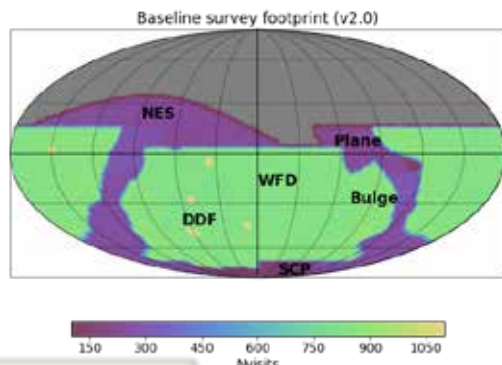
DOE responsible primarily for camera maintenance & operations, US Data Facility

- USDF has a multi-site processing model; hardware and initial services at SLAC; will have a hybrid model with Rubin Science Platform (user access) in cloud
- Dark Energy Science Collaboration (DESC) data is being used: Data Preview 0 uses DESC simulated data, DP0.1 served DESC data products (2021); DP0.2 (2022) simulated raw DESC data reprocessed with Rubin pipelines to generate LSST-like data products served on RSP in cloud

**International in-kind contributions** in exchange for early access to data

- Agreements are being drafted

*Baseline survey v2.0;  
typical visits to each  
point on sky ~850*



AAS  
meeting,  
Pasadena,  
June 2022





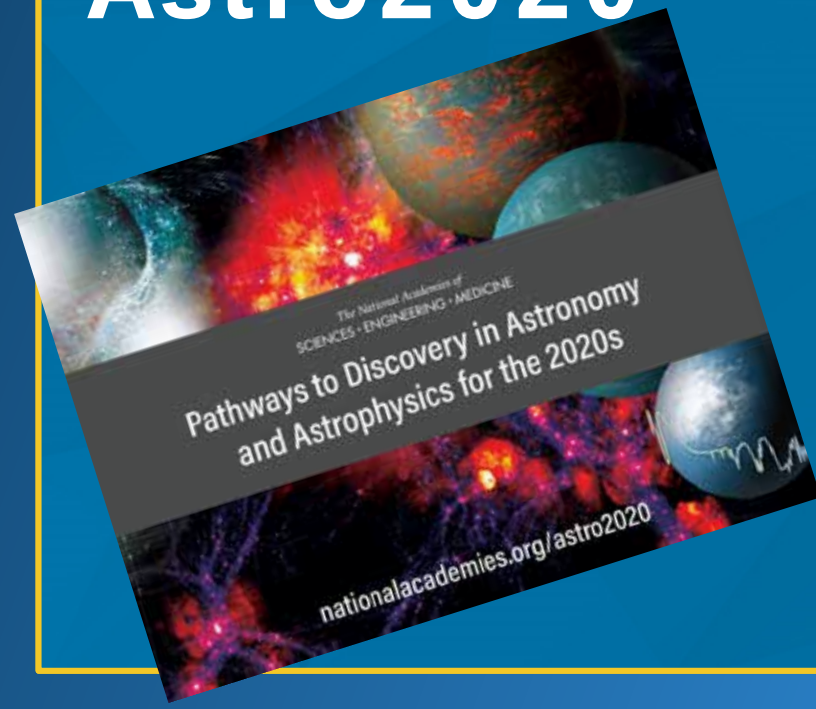
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## Astro2020

### Recommendations:

- DOE/NSF partnership on **CMB-S4**
- Dark Ages: Panel on Cosmology identified as a Discovery Area using the **Dark Ages** as a cosmological probe with great potential.
- Efforts on diversity, equity, inclusion, demographics, data, etc.



# Astro2020 Science Theme: New Messengers and New Physics è 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.**



# Cosmic Microwave Background Stage 4

**CMB-S4** builds on the foundation of decades of CMB measurements to take a major leap, pushing CMB science to the next level.

- } 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

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

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

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

**2019** – DOE approved CD-0

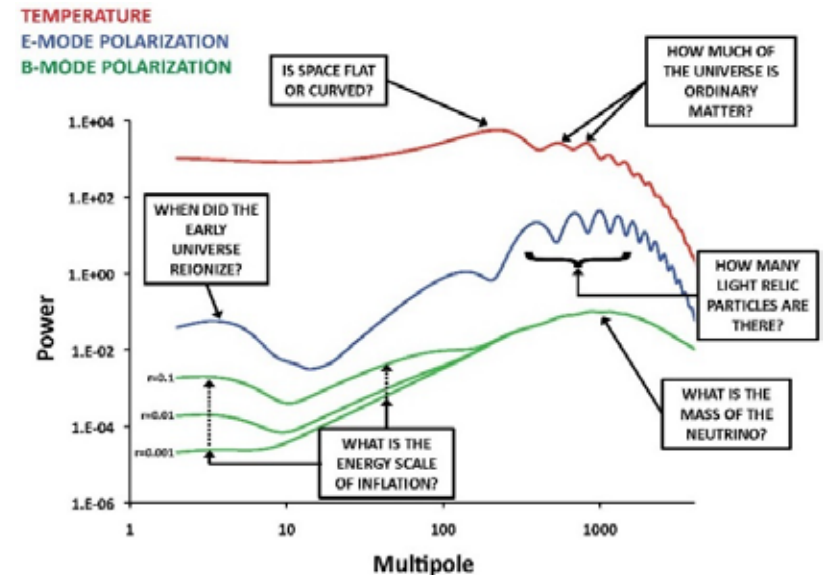
**2020** – LBNL chosen as DOE's lead lab; HEP status review

**2019-2020** – Plan to Astro2020

- 2 large aperture (6m) in **Chile**; Deep & wide  $N_{\text{eff}}$  & Legacy Survey ~60% of sky
  - 1 large (5m), 18 small (0.5m) at **South Pole**; Ultra-deep survey  $\geq 3\%$  of sky + delensing
- Total 500,000 cryogenic sensors, superconducting readout; scale up > x10 from all stage 3.

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

**Nov. 2021** - **Astro2020** recommended DOE/NSF partnership on CMB-S4



# CMB-S4 in 2022

DOE embraces the Astro2020 recommendation and is working with NSF to investigate opportunities to move CMB-S4 forward.

- Well aligned with P5 science drivers.
  - Technology, high performance computing needs, and project roles are well matched to DOE lab expertise and capabilities
- DOE & NSF continue regular meetings on CMB-S4; now every 2 weeks



**Early FY2022** – It became clear that the expected South Pole infrastructure and logistics (I&L) to support the original concept won't be sufficient. The agencies requested that the Project develop alternative concept(s) that fit within constraints of the expected SP I&L **AND** will still deliver the full science goals.

**July 2022** – new, permanent DOE Project Director on board -- Jim Strait

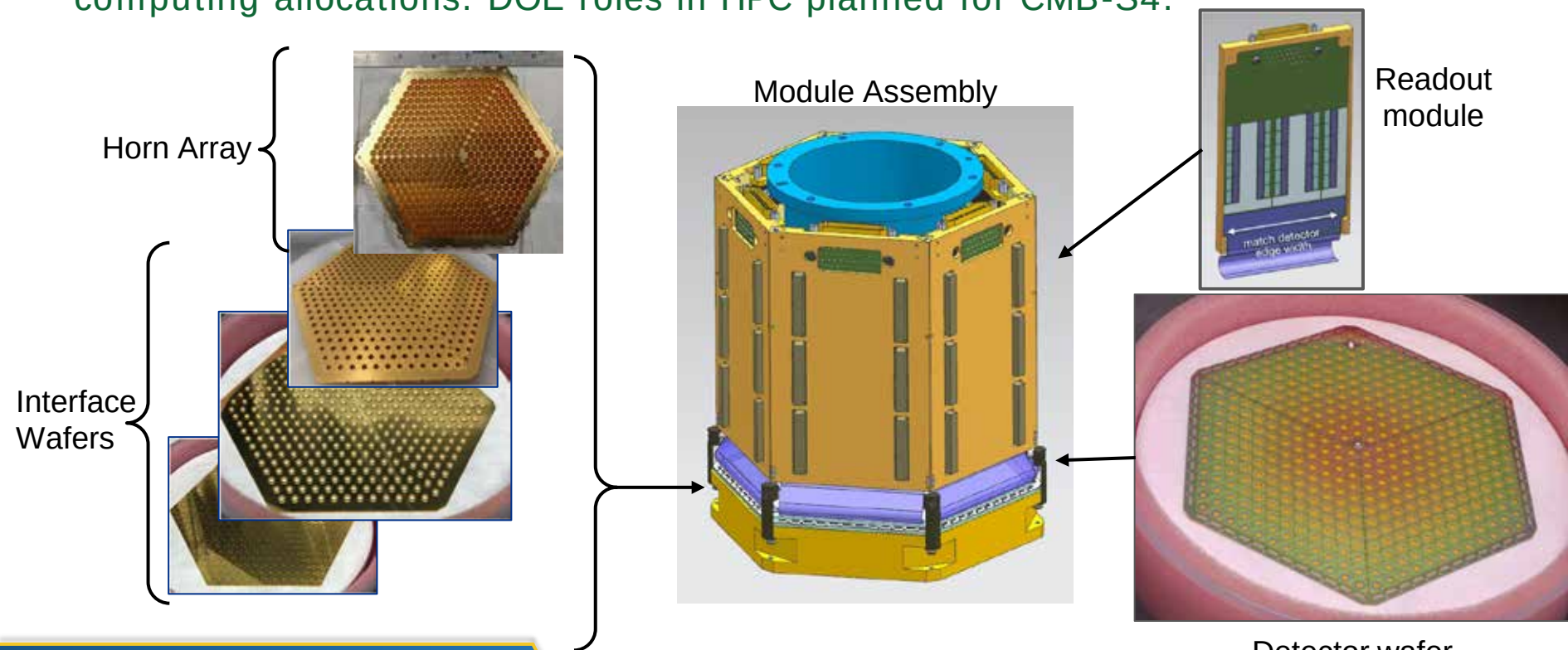
**Dec. 2022** – Project will brief agencies on the results of their Analysis of Alternative concept(s) that are compatible with their understanding of the Antarctica I&L requirements and capabilities and will reach the full science goals.  
è Agencies can then consider potential paths in planning & conceptual design

# CMB-S4 Development continues

HEP labs have done CMB technology R&D and instrumentation for decades.

- sensor and readout electronics technologies being developed for CMB-S4

**DOE / NERSC** has done a large fraction of the international CMB computing for decades. HEP has provided scientific support for this effort as well as NERSC computing allocations. DOE roles in HPC planned for CMB-S4.



# Astro2020: Science Panel on Cosmology à Dark Ages

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

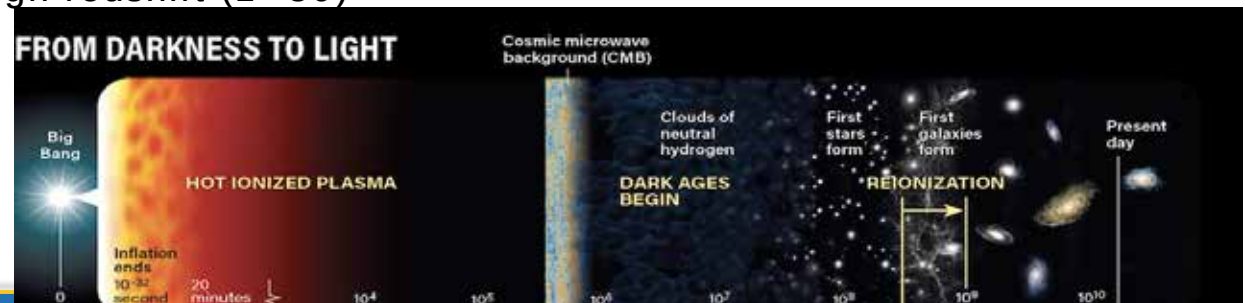
- What set the hot Big Bang in motion?
- What are the properties of dark matter and the dark sector?
- What physics drives the cosmic expansion & large-scale evolution of the universe?
- How will measurements of gravitational waves reshape our cosmological view?

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."

è The Dark Ages signal has never been observed. A first discovery would be a significant step in understanding this phase after CMB & when stars & galaxies form.

- Detecting and characterizing the Dark Ages monopole dip in the 21cm radiation is the first step in the exciting program to explore Dark Ages
- Measurements of the low-frequency ( $< 50\text{MHz}$ ) radio sky are sensitive to 21cm emission from neutral hydrogen at high redshift ( $z > 30$ )"





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

DOE/NASA high level MOU to continue partnerships signed in Oct. 2020, led to: **partnership** on Lunar Surface Electromagnetics Experiment at Night (LuSEE-Night)

- o Pathfinder mission to place the most sensitive constraints to date on the **Dark Ages signal** & potentially discover the Dark Ages signal.
- o Capability to measure the radio environment and observe the long-wavelength radio signal through the lunar night (launch early 2025).

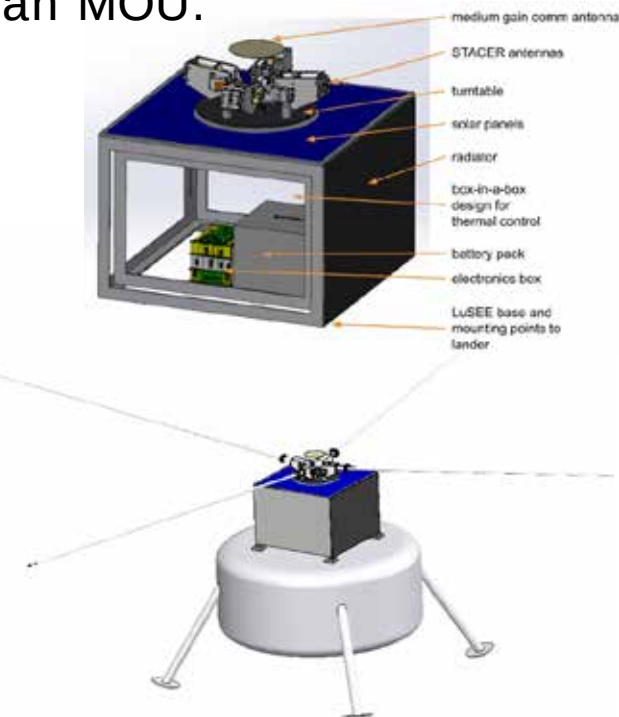
Agencies are meeting regularly and are developing an MOU.

## Milestones / Schedule

- **Nov. 2021:** DOE approval of Critical Decision 0  
BNL selected as DOE's lead 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;** deliver to the UCB/SSL project office by early 2024; Launch in early 2025 by NASA's Commercial Lunar Payload Service (CLPS).

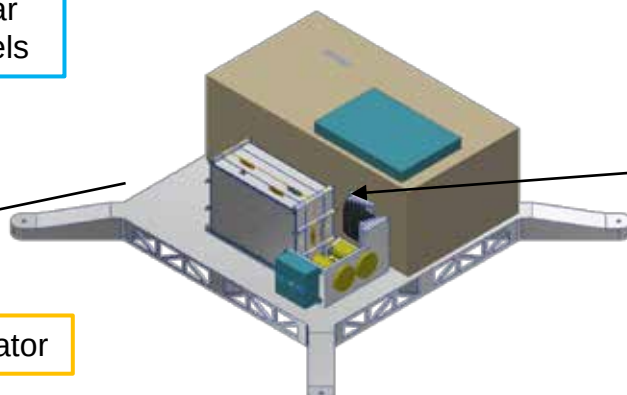
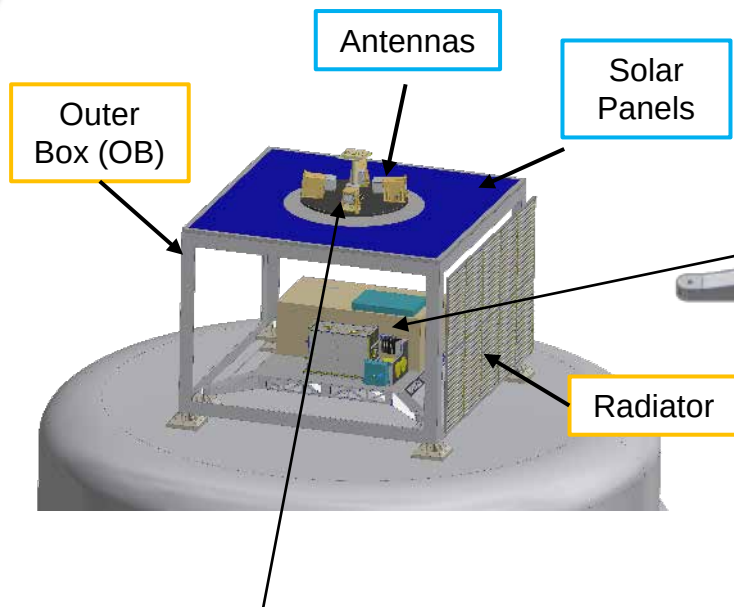
**LuSEE-Night** consists of instrumentation components from both UCB/SSL (NASA) and BNL+LBNL (DOE).

à UCB/SSL is overall lead for **LuSEE-Night** & **LuSEE-Light**

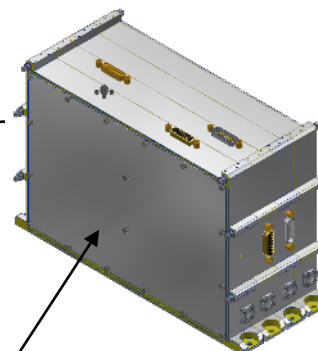


# DOE/BNL: Technical progress (as of Oct.2022)

- Project Manager: Sven Herrmann
- Project Scientist: Anze Slosar



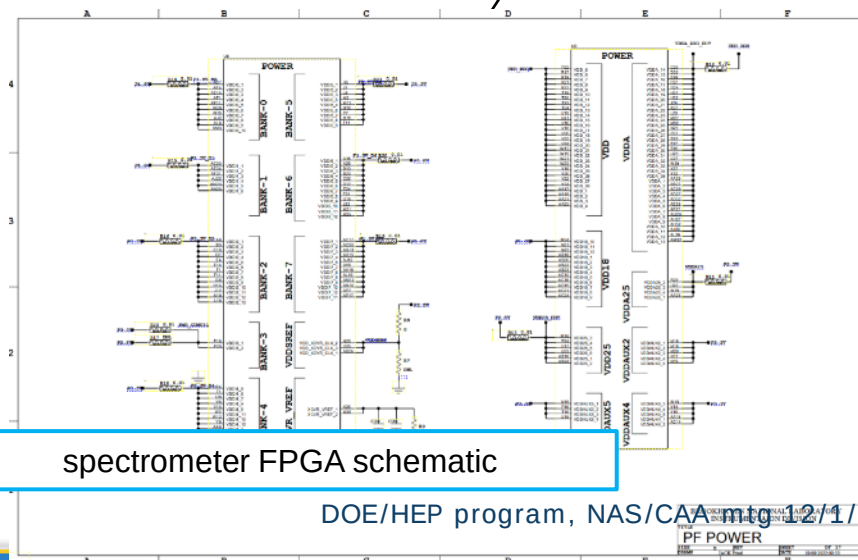
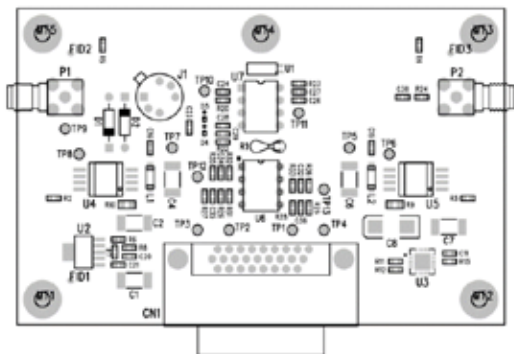
Inner Equipment Assembly (IEA)



Main Electronics Crate (MEC)

PRELIMINARY  
BROOKHAVEN NATIONAL LABORATORY  
LuSEE NIGHT PREAMPLIFIER BOARD

Preamp PCB



spectrometer FPGA schematic

DOE/HEP program, NAS/CAA mtg 12/1/22

# HEP Cosmic Frontier: Dark Matter

## Dark Matter Generation 3



Axion search .6-2MHz  
at U.Wash; started  
2017

WIMP search at SURF  
(SD); started FY22

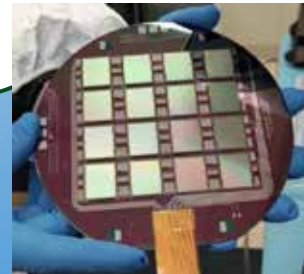


WIMP search at SNOLAB  
(Canada); partial data-  
taking starts 2023

## Dark Matter New Initiatives

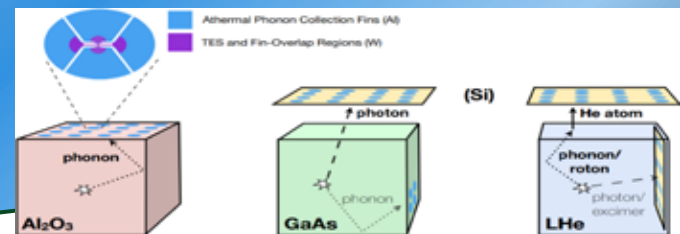


Axion search 2-4 GHz



OSCURA

TESSERACT



# Direct Detection of Dark Matter

**Staged suite of complementary direct detection experiments with multiple technologies to search for dark matter particles – WIMPs & axions**

## **3 Dark Matter 2<sup>nd</sup> Generation (DM-G2) projects**

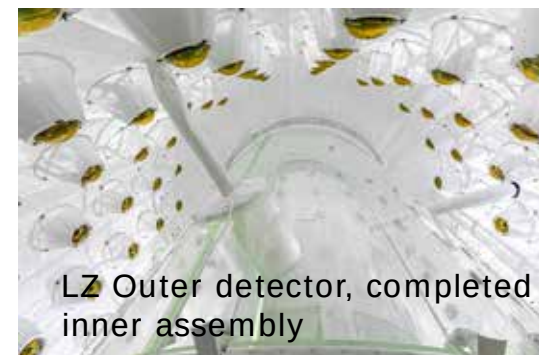
### **ADMX-G2** at Univ. of Washington

- Axion search 2-8  $\mu\text{eV}$ ; currently operating Run 1C
- Has reached DFSZ limit in regions scanned so far.
- Started 2017; Planned upgrades to step through frequencies



### **LZ** at Homestake Mine in South Dakota

- Dual phase liquid Xe WIMP search;  $\sim 10$ -1000 GeV mass
- *Data taking started Dec. 2021*
- **July 2022 – first results w/ 60 days of data; already has the world's most sensitive dark matter results**



### **SuperCDMS-SNOlab** in Canada (HEP+NSF partnership)

- Cryogenic solid-state crystal WIMP search;  $\sim 1$ -10 GeV mass
- Expect full fabrication completion early FY2022
- Full operations start in 2024; partial detector ops in 2023

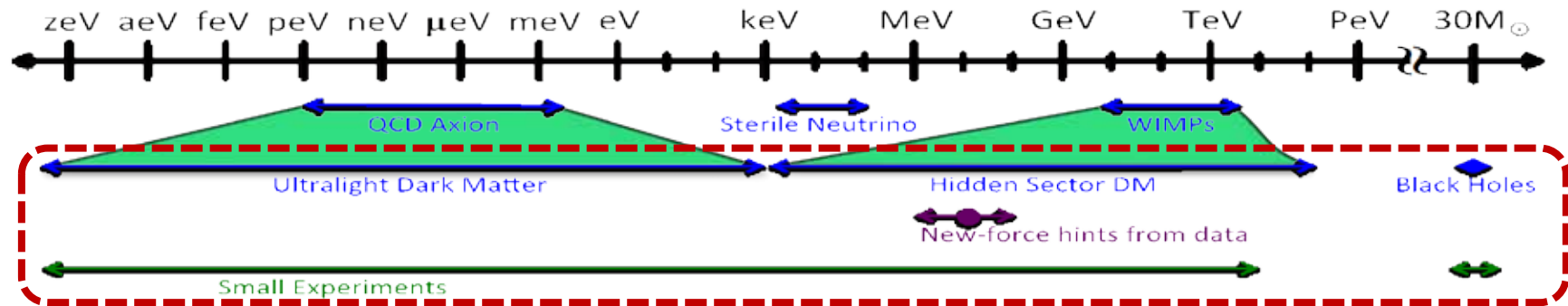


Indirect searches via cosmic-ray (e.g. AMS), gamma-ray (e.g. HAWC, Fermi/LAT), imaging survey and CMB data



# 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



**2018-2019:** Basic Research Needs study developed 3 Priority Research Directions (PRD)

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

## Cosmic Frontier:

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

## Intensity Frontier (accelerator based)

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

**Annual status review of the DMNI concepts was held June 2022. A few expect to have their design complete in 2023.**

# 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
- Continues successful operations; approved for 2023-2025
- 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.





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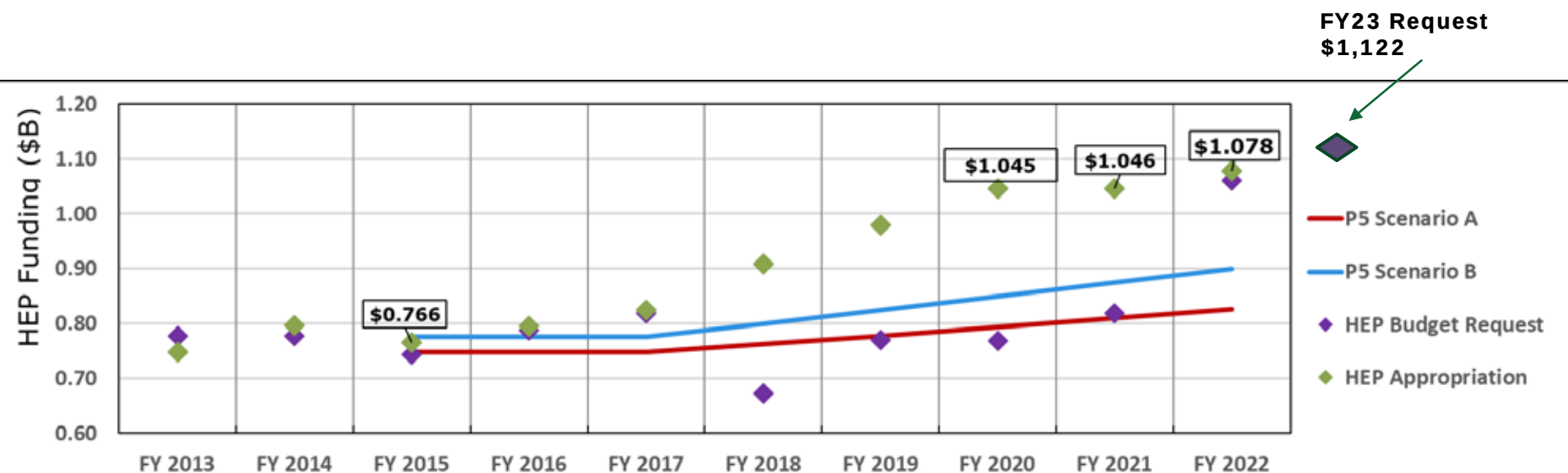
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# Budgets

# HEP is continuing to carry out the 2014 P5 Strategic Plan

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

- } 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 history, FY22 è FY23

| HEP Funding (\$ in k) | FY 2017 Actual | FY 2018 Actual | FY 2019 Actual | FY 2020 Actual | FY 2021 Actual | FY 2022 Enacted | FY 2023 President's Request (for Reference) | FY 2023 House Mark (for Reference) | FY 2023 Senate Mark (for Reference) |
|-----------------------|----------------|----------------|----------------|----------------|----------------|-----------------|---------------------------------------------|------------------------------------|-------------------------------------|
| TOTAL                 | 825,000        | 908,000        | 980,000        | 1,045,000      | 1,046,000      | 1,078,000       | 1,122,020                                   | 1,158,000                          | 1,168,000                           |

## FY2022 Enacted

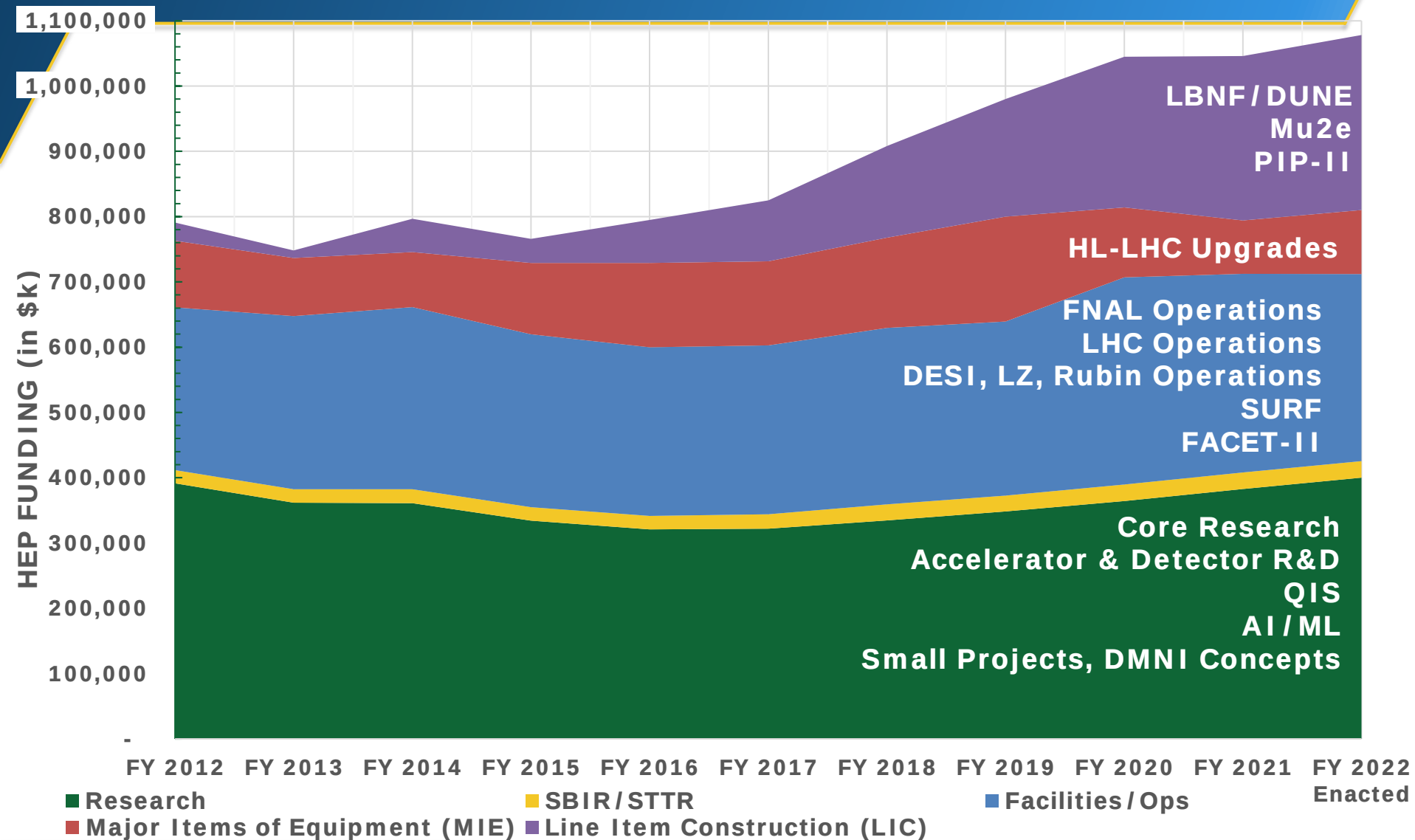
} HEP received \$1,078M in the FY 2022 Congressional Appropriation, +\$17M above the Request. Congressional direction fixed funds for some projects and provided floor/ceiling limits for **CMB-S4** and others. Congress all approved **LuSEE-Night**.

CMB-S4: \$8M in enacted funds plus the Inflation Reduction Act provided ~ \$12M to CMB-S4 (\$10M at the end of FY22).

**FY 2023 Request** focuses on the highest priorities research, operation, and projects identified in the 2014 P5 report.

- Research priorities in Theory & Experimental efforts for 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 in QIS, AI/ML, microelectronics, computing, RENEW and FAIR.
- CF projects: CMB-S4 and LuSEE-Night (all funds provided in FY22).
- CF operations: DESI, LZ and Vera C. Rubin Observatory

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



# Office of Science & HEP

## -- [New] Initiatives in Research funding

### HEP budget (in \$K)

|                                                                                                | FY20<br>Enacted | FY21<br>Enacted | FY22<br>Enacted | FY23<br>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               |



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# **Astro2020: Other Recommendations & Current Status**



# Astro2020 & AAAC-2022 – General Recommendations (Astro2020 unless noted as AAAC)

## Diversity, Equity & Inclusion

**Recommendation (p. 3-14):** Funding agencies should **increase incentives for improving diversity** among the college/university astronomy and astrophysics faculty, for example by increasing the number of awards that invest in the development and retention of early-career faculty and other activities for members of under-represented groups.

**Recommendation (p. 3-22):** NASA, NSF, and DOE should **reinvest in professional workforce diversity programs** at the division/directorate levels with purview over astronomy and astrophysics. Because academic pipeline transitions are loss points in general, supporting the creation and continued operation of “bridge” type programs across junctures in the higher-education pipeline and into the professional ranks appear especially promising.

**Recommendation (p. 3-23):** NSF, DOE and NASA should **implement undergraduate and graduate “traineeship” funding**, akin to the NIH MARC and NIH “T” training grant programs, to incentivize department/institution-level commitment to professional workforce development, and prioritize interdisciplinary training, diversity, and preparation for a variety of career outcomes.

**Recommendation (p. 3-30):** NASA, DOE, and NSF should consider **including diversity**—of project teams and participants—in the **evaluation of funding awards** to individual investigators, project and mission teams, and third-party organizations that manage facilities. Approaches would be agency specific, and appropriate to the scale of the projects.

# Astro2020 / AAAC – General Recommendations

## Harassment, Discrimination Issues

**Recommendation (p. 3-27):** NASA, NSF, DOE, and professional societies should ensure that their **scientific integrity policies** address harassment and discrimination by individuals as forms of research/scientific misconduct.

## Community Engagement

**Recommendation (p. 3-35):** The astronomy community should, through the American Astronomical Society in partnership with other major professional societies (e.g., American Physical Society, American Geophysical Union, International Astronomical Union), work with experts from other experienced disciplines (such as archaeology and social sciences) and representatives from local communities to define a **Community Astronomy model of engagement** that advances scientific research while respecting, empowering and benefiting local communities.

# White House: Scientific Integrity Task Force

**Background:** The Biden Administration issued a memorandum in January 2021, [Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policy Making](#), which called for Scientific Integrity Task Force representing agencies across the Federal government to review existing agency scientific integrity policies and and identify effective solutions for strengthening scientific integrity in specific areas. **DOE has been a member of this [Task Force](#).**

Jan.2022 report: *Protecting the Integrity of Government Science*, which includes a recommendation that all agencies update their scientific integrity policies and effective practices for implementation. It further specifies that scientific integrity policies need to be updated to address “...emergent issues of our time” including:

- § **Diversity, equity, inclusion, and accessibility,**
- § New technologies, including artificial intelligence and machine learning,
- § Emerging models of science, such as citizen science and community-engaged research, and
- § Coordination is needed with related policy domains, “...including open science...**promoting safe, equitable workplaces free from harassment and discrimination, and protection of research security and responding to research misconduct.**”

OSTP issued a [memo in March 2022](#) calling upon the agencies to respond to the recommendations and providing instructions for reporting back on their progress.

DOE is currently in the process of updating our scientific integrity policy.

# SC Efforts in Making Science More Equitable and Inclusive

## Recent News from SC (Oct2022)

As the largest federal sponsor of basic research in the physical sciences and a steward of public funding, DOE/SC has a responsibility to ensure that we are serving the broader public.

- See [SW-DEI SC Statement of Commitmen... | U.S. DOE Office of Science \(SC\) \(osti.gov\)](#)

SC is deeply committed to supporting diverse, equitable, inclusive, and accessible work, research, and funding environments that value mutual respect and personal integrity, which reflects the Biden Administration principles. We are committed to promoting people of all backgrounds, including individuals from groups and communities historically minoritized in STEM fields and careers.

Over the last few years, SC has initiated activities to live up to these principles

- Business processes for managing competitive research awards
- Removing barriers to research via our RENEW and proposed FAIR initiatives.

SC is encouraging our research communities to broadening participation:

- PIER plans required in proposals
- Conferences must have a code-of-conduct and recruitment and accessibility plan for attendees & speakers.

Efforts will continue!



# SC DEI efforts

**DOE/SC has been working on DEI aspects for a number of years.**

Dr. Julie Carruthers, head of DOE SC Office of Diversity, Inclusion & Research Integrity. See details at:

<https://www.energy.gov/science/diversity-equity-inclusion>

and her talk at:

[https://science.osti.gov/-/media/hep/hepap/pdf/202111/SC\\_DEI\\_Initiatives-Carruthers\\_HEPAP\\_202111.pdf](https://science.osti.gov/-/media/hep/hepap/pdf/202111/SC_DEI_Initiatives-Carruthers_HEPAP_202111.pdf)

In Sept. 2022, DOE released our first-ever [\*\*Diversity, Equity, Inclusion, and Accessibility \(DEIA\) Strategic Plan\*\*](#), which outlines actions to strengthen our Department's efforts to recruit, hire, develop, promote, and retain our Nation's talent; remove inequitable barriers to career and advancement opportunities; and build and sustain an inclusive and accessible work environment.

**See** [The Roadmap to Equity and Justice at the Department of Energy | Department of Energy](#)

# SC & Competitive Research Awards & Reviews

**In FY 2021, SC started requiring at least one DEI-promoting program policy factor in all FOAs and Lab Announcements.**

These are considered during proposal review and selection to provide for factors that are not indicators of the application's technical merit.

They serve to maximize the effectiveness of available Government funding and to best achieve DOE program objectives when all other things such as merit are reasonably equal, including e.g. promoting diversity of PI's, institutions, etc.

à When all other factors are equal, program managers can approve awards that promote diversity in the program.

**Starting in FY 2022, the HEP Research FOA** began requiring a specific appendix describing the PI's Recruitment and Mentoring Plan. An associated merit criterion was added as part of the proposal evaluation.

- HEP specifically considers diversity when **setting up review panels** for proposals as well as for projects, experimental operations and facilities.

# SC Requirement: *Promoting Inclusive and Equitable Research (PIER) Plan*

***Starting in FY 2023, all SC FOAs and National Lab Funding Opportunity Announcements (FOA) will require applicants to submit a PIER Plan as an appendix to their proposal narrative.***

*è These will be evaluated as part of the merit review process.*

PIER Plans should describe the activities and strategies applicants will incorporate in their own research groups to promote diversity, equity, inclusion, and accessibility in their individual research projects beyond the policies of the laboratory and/or university.

The overall goal is the promotion of safe, accessible, diverse, and inclusive workplaces that value and celebrate the diversity of people, ideas, cultures, and educational backgrounds across the country and that foster a sense of belonging in our scientific community.”

# SC DEI-related initiatives

## RENEW initiative – started in FY2022

*As a Part of DOE's "Reaching a New Energy Sciences Workforce (RENEW)" Initiative, Faculty and Their Students from HBCUs, MSIs, Community Colleges, and Other Institutions to have New Pathways for Collaborations with National Laboratory Researchers*

RENEW provides 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.

- See [Reaching a New Energy Sciences W... | U.S. DOE Office of Science\(SC\) \(osti.gov\)](#)

**The HEP RENEW FOA (\$4M planned in FY2022 and \$8M requested for FY2023)** is to 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.

- The HEP FY2022 FOA can be found [here](#).
- Proposals were due 8/15/22; reviews and decisions are planned for the fall.

## FAIR initiative – proposed for FY2023

The **HEP FY 2023 President's Request includes \$2M** for the new FAIR (Funding for Accelerated and Inclusive Research) initiative. FAIR is aimed at undergraduate students and faculty to address place-inspired R&D and loss points of personnel in the field.

# SC Workforce Development

**SC Office of Workforce Development for Teachers and Scientists (WDTS)** programs (see <https://science.osti.gov/wdts>). These include:

## Community College Internships (CCI)

- Supports students to work at a DOE laboratory, encouraging STEM careers

## Science Undergraduate Laboratory Internships (SULI)

- Supports undergraduate research at a DOE lab, 10 to 16 weeks

## SC Graduate Student Research fellowships (SCSGR)

- Supports grad student research at a DOE lab, 3 to 12 months

## Visiting Faculty Program

- Summer research support for faculty/students from historically underrepresented institutions

## Albert Einstein Distinguished Educator Program

- K-12 educators in STEM fields work in Federal agencies or US Congressional Offices; applying their knowledge to the national education program.

DOE Scholars Program <https://orise.orau.gov/doescholars/>

**Available funds for these programs have been increasing!**



# Traineeships, Workforce Development & Community Programs

## HEP traineeships

To address critical, targeted workforce development in fields of interest to the DOE mission, HEP has released **traineeship** FOA's in Instrumentation, Accelerator R&D, Computing, e.g. see

[https://science.osti.gov/-/media/grants/pdf/foas/2021/SC\\_FOA\\_0002496.pdf](https://science.osti.gov/-/media/grants/pdf/foas/2021/SC_FOA_0002496.pdf)

## Lab Programs

**DOE labs** have specific workforce development & community programs aimed at a diversity of educational levels.

For example, Fermilab has internship programs, fellowships geared towards high school, undergraduate and graduate students. See more [here](#).

Other labs have similar initiatives already in place

AMES <https://www.ameslab.gov/index.php/education-programs>

Brookhaven: <https://www.bnl.gov/about/sustainability/education.php>

Berkeley lab: <https://education.lbl.gov/>

Oakridge: <https://education.ornl.gov/high-school/>

Pacific Northwest: <https://www.pnnl.gov/distinguished-graduate-research-programs> ,  
<https://www.pnnl.gov/stem-internships>

SLAC: <https://careers.slac.stanford.edu/jobs-slac/educational-and-outreach-programs>

# Astro2020 / AAAC – General Recommendations

## Demographics

**Recommendation (p. 3-29):** NASA, NSF, and DOE should implement a cross-agency committee or working group tasked with establishing a consistent format and policy for regularly collecting, evaluating, and publicly reporting **demographic data** and indicators pertaining at a minimum to outcomes of proposal competitions.

## Proposal Metrics & Reviews

**Recommendation (p. 4-3):** The National Science Foundation, NASA, and the Department of Energy should **release data on proposal success rates** on an annual basis and should track metrics that allow them to analyze statistically what is being supported.

**AAAC 12-5:** The AAAC recommends continuation of the expansion of **dual anonymous reviews** within NASA, and requests that NSF and DOE develop and adopt similar reviews or other practices that provide the committee with sufficient evidence of bias mitigation in their review processes.

# Response – Demographics, Metrics

There is an ongoing WH study that addresses demographics, among other issues.

The EO: <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/>

In response to the EO, DOE issued the required DOE Equity Action Plan in April 2022. It includes a priority action on overcoming institutional barriers for demographic data collection. SC has already addressed many of the administrative hurdles to be able to collect demographic data in PAMS.

SC has also formed a small task group to assess options to accelerate and expand demographic data collection and will provide recommendations to the SC Director in the coming months. Efforts are underway to establish a baseline of demographic data currently disclosed in PAMS on applicants and awardees.

# Response – Demographics, Metrics

The DOE currently collects demographic information as required by OMB, guided by what is collected for census information.

- In FY 2021, SC started requiring that all external account holders in PAMS (applicants, reviewers) answer the demographic questions (but can answer “*Do Not Wish to Provide*”)
- In FY 2023, SC will start requiring the information for ALL Key Personnel on an application. Each person that doesn’t currently have a PAMS account will receive an email request to create one, which requests demographic information.
- SC is working on actions to improve the existing reporting function in PAMS and is assessing options for improving reporting/data analysis capabilities in the long-term.

Projects: Increasing project personnel data collection is something SC is working on, but there isn’t a short-term solution. Projects often include scientists, engineers, computing specialist, project management and budget specialists, technicians, etc etc.

Currently, we cannot release demographics data due to low N values (statistics) which may allow for the identification of specific persons of either proposed or awarded funds. Note that all awards in PAMS are currently publicly available.

Dual Anonymous: This is not straightforward to do in HEP. The DOE review criteria include experience of the PI. In HEP, we often have “umbrella” grants that cover many PI’s. Proposals include PI’s efforts on projects as well as data analysis.

# Astro2020 / AAAC – General Recommendations

## Data

**Recommendation (p. 4-20):** NASA and the National Science Foundation should explore mechanisms to improve **coordination among U.S. archive centers** and to create a centralized nexus for interacting with the international archive communities. The goals of this effort should be informed by the broad scientific needs of the astronomical community.

**Recommendation (p. 4-21):** The National Science Foundation and stakeholders should develop a plan to address how to design, build, deploy, and sustain **pipelines for producing science-ready data** across all general-purpose ground-based observatories (both federally and privately funded), providing funding in exchange for ensuring that all pipelined observations are **archived in a standard format for eventual public use**.

## Maximizing Science

**AAAC 13-8:** AAAC encourages inter-agency initiatives to **maximize the scientific yields of the Vera C. Rubin Observatory and Nancy Grace Roman Space Telescope** by considering survey designs that maximize the synergy between these two facilities.



# Response – Data & Maximizing Science

- Ø Though DOE isn't listed, we do have an interest and efforts in data simulations, processing, analysis, serving and archiving
- Ø All survey projects (DES, eBOSS, DESI, Rubin Observatory) are making data public after a proprietary period.
  - à We have started discussions on ways to proceed.
- Ø DOE is participating with NSF, NASA and the Rubin, Roman & US-Euclid to investigate possibilities for joint simulations, data processing and analysis to ensure we provide the best science within available funding levels. This will entail supercomputing resources and personnel to carry out these efforts.
  - à We will continue discussions and planning for optimizing science via our Three Agency Group (TAG).

# Astro2020 AAAC – General Recommendations

## AI/ML

**AAAC 12-4:** The AAAC recommends that the agencies continue the development of **Artificial Intelligence (AI) and Machine Learning initiatives** across astrophysics including the potential creation of institutes focused on AI in the context of astrophysics.

### **RESPONSE:**

SC has been ramping up efforts in this area.

- HEP recently announced FY2022 3-year awards of \$4.3M for research in AI/ML. Projects Span AI Applications to HEP to Studies of fundamental AI Techniques for Analysis and Discovery

# Astro2020 AAAC – General Recommendations

## Climate Change, Energy Usage

**Recommendation (p. 3-42):** The astronomy community should **increase the use of remote observing, hybrid conferences, and remote conferences**, to decrease travel impact on carbon emissions and climate change.

**AAAC 8-5:** recommends that the three agencies initiate cooperation on the topic of the **climate crisis** in the three broad domains of education and public engagement, reducing emissions in the profession, and conducting audits to assess the impact on the profession and preparing for the future.

**AAAC 10-6:** The initial collection of facts relevant to **energy usage** and reporting it at one of the annual committee meetings.

## RESPONSE:

Climate change and energy issues are of great importance to the DOE. Programs to address these are ongoing. Our labs are doing significant research in this area and are upgrading facilities to ensure energy efficiency. Many of our experiments now have remote data-taking (in Cosmic Frontier e.g. DESI, the underground dark matter experiments, etc. including plans for Rubin and CMB-S4).

à Will report more at next meeting.

# Astro2020 AAAC – General Recommendations

## Budgets

**AAAC 10-7 :** The agencies should identify budgetary options that would permit the recommended funding increases in the individual investigator research grants.

**AAAC 12-1:** The agencies should identify budgetary options that would permit the recommended funding increases in technology development.

## Tracking Astro2020

**AAAC 4-1:** There should exist a living document between NASA, The Department of Energy, and The National Science Foundation that links each agency's effort to the 2020 Decadal recommendations.

## RESPONSE:

The agencies have started development of this document.



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# Planning for the Future



# HEP - Strategic Planning Timeline

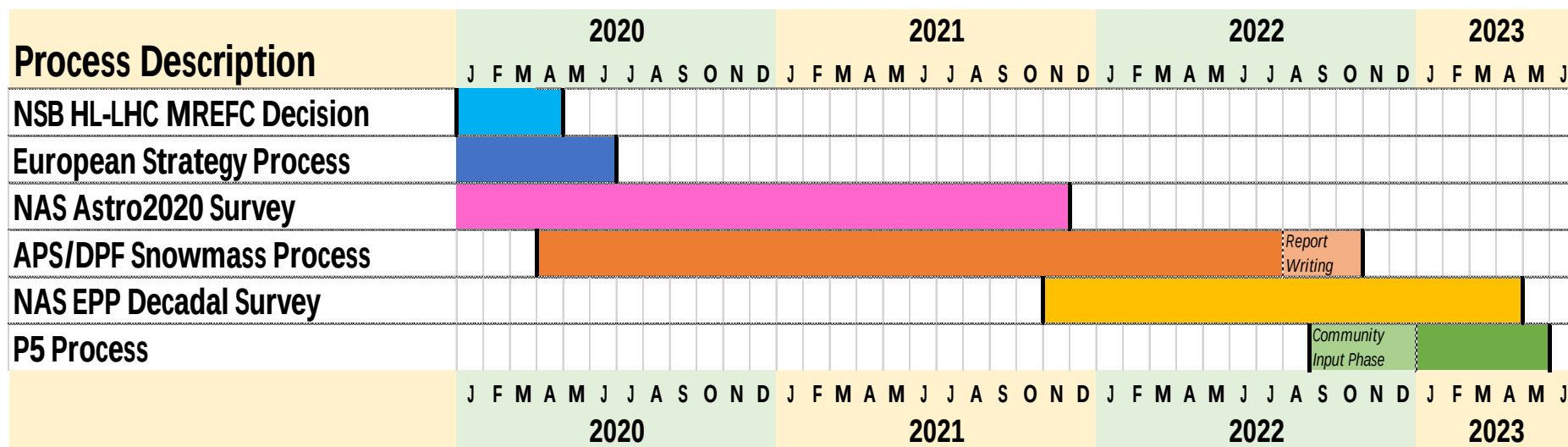
HEP community-wide “Snowmass” study process organized by the American Physical Society (APS) Division of Particles and Fields (DPF) & Division of Particles and Beams held July 2022. <https://snowmass21.org/start>

- Identify key science questions and directions & options to address them

DOE/NSF HEPAP P5 subpanel will convene in December to deliberate on the grand, long-term, and global vision and strategy of particle physics.

- Reports ~ end of 2023 with 10 year plan in 20 year context
- Inputs - Astro2020, Snowmass, European strategy, etc.

National Academy of Sciences (NAS) Elementary Particle Physics (EPP) Decadal Survey is running concurrently with and complementary to the P5 process.

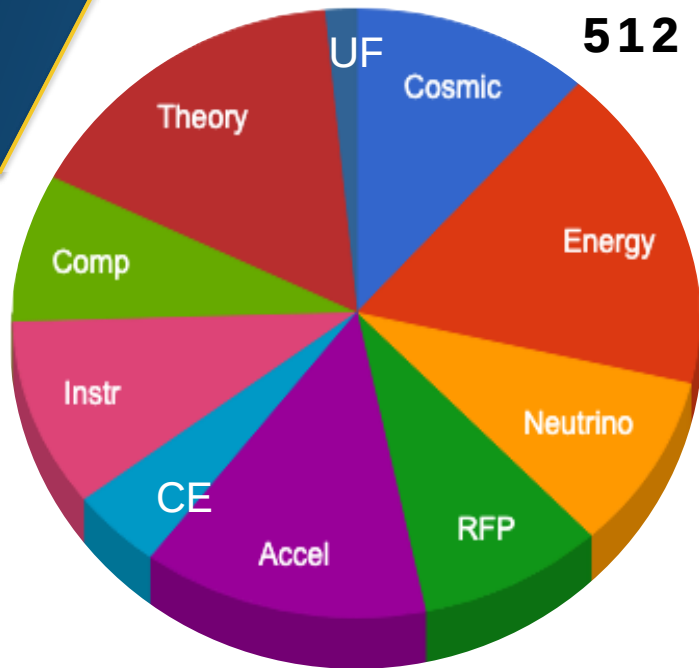


# Snowmass workshop held at Univ of Washington, July 2022 (followed 2 years of community study)

**512 White Papers**

## **10 Frontier Groups:**

Accelerator, Community Engagement, Cosmic, Computing, Energy, Instrumentation, Neutrinos, Rare & Precision Processes, Theory, Underground Facilities



# Snowmass workshop held at Univ of Washington, July 2022 (followed 2 years of community study)

## Summary Comments:

“The Cosmic Frontier is the bedrock of the field in the 21st century”.

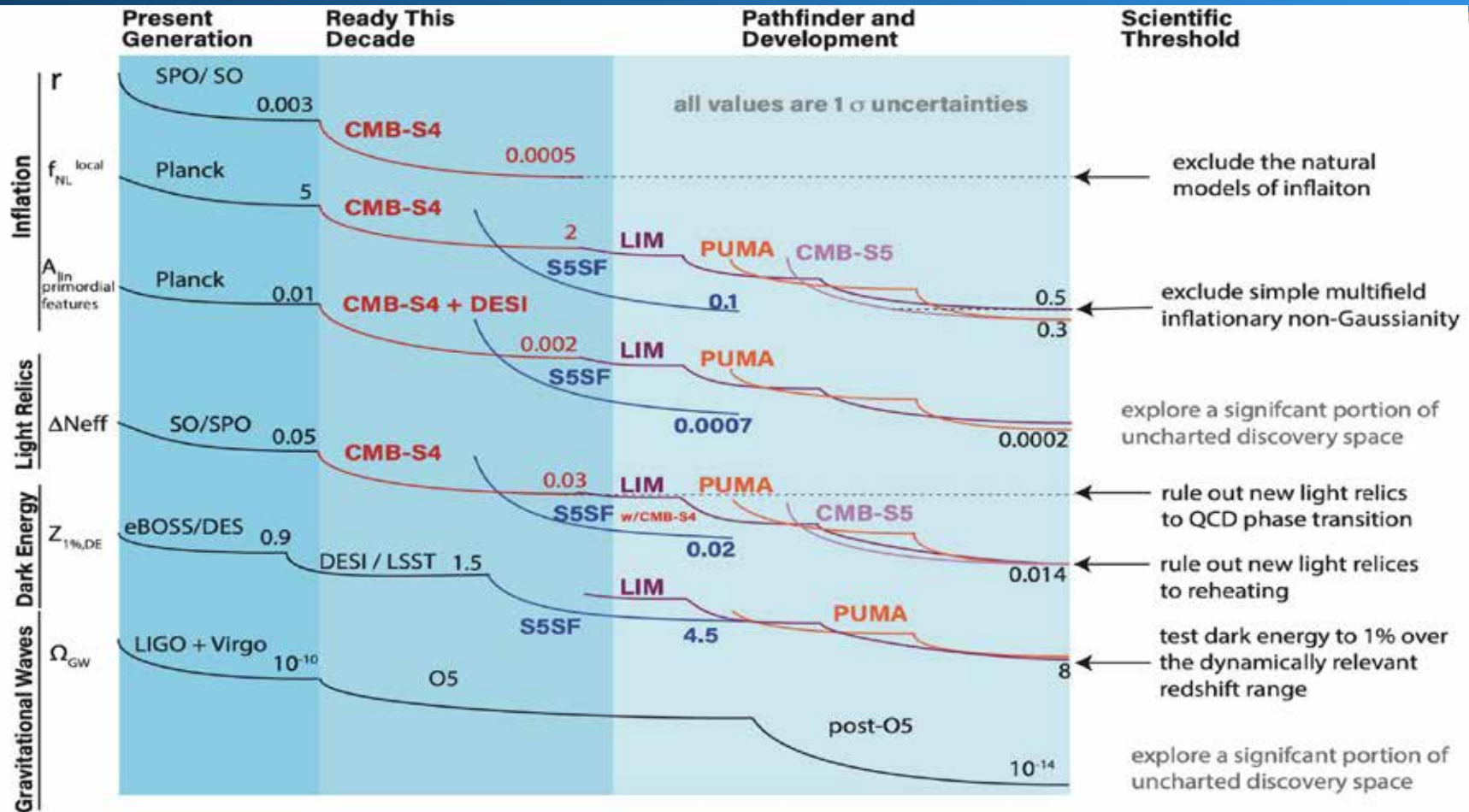
“Cosmic Frontier will address the most pressing questions facing fundamental physics today, aiming to discover the identity of dark matter, understand the physics of cosmic acceleration, and search for new particles, new forces, and new principles of Nature”.



**à Cosmic Frontier's top priority is to complete construction CMB-S4,** while launching new projects to delve deep and search wide for dark matter and make the next leap in dark energy and cosmic acceleration research, including cross-survey science leveraging the recently-completed projects DESI and LSST

# Snowmass Cosmic Frontier Summary - Cosmology

## Search Wide, Aim High

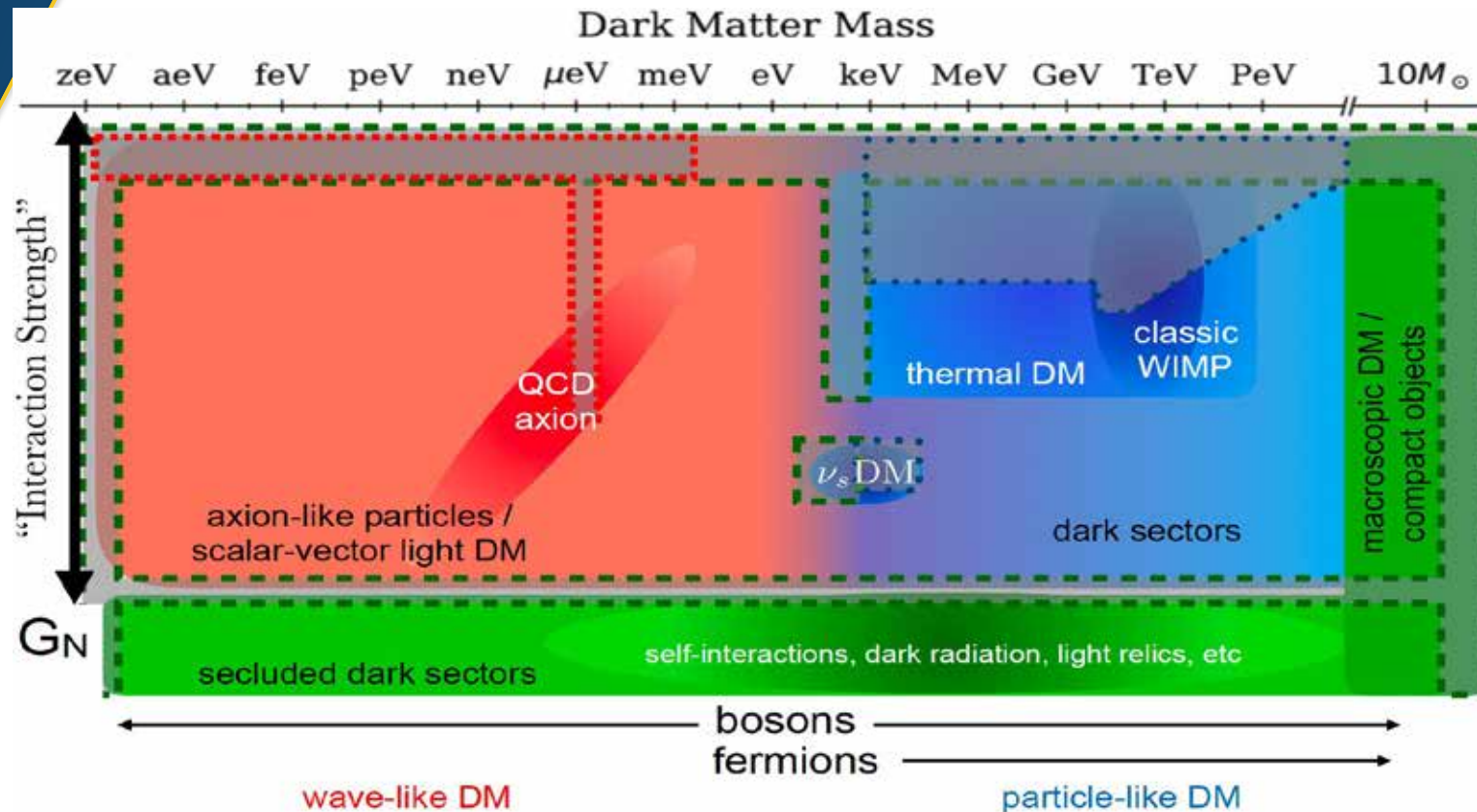


**Near term:** DESI survey; complete Rubin & LSST; construct CMB-S4

**Longer term roadmap** to a future Stage V Spectroscopic Facility, and small projects & pathfinders toward new opportunities such as gravitational waves, 21cm, and Line-Intensity Mapping.



# Snowmass Cosmic Frontier Summary – Dark Matter



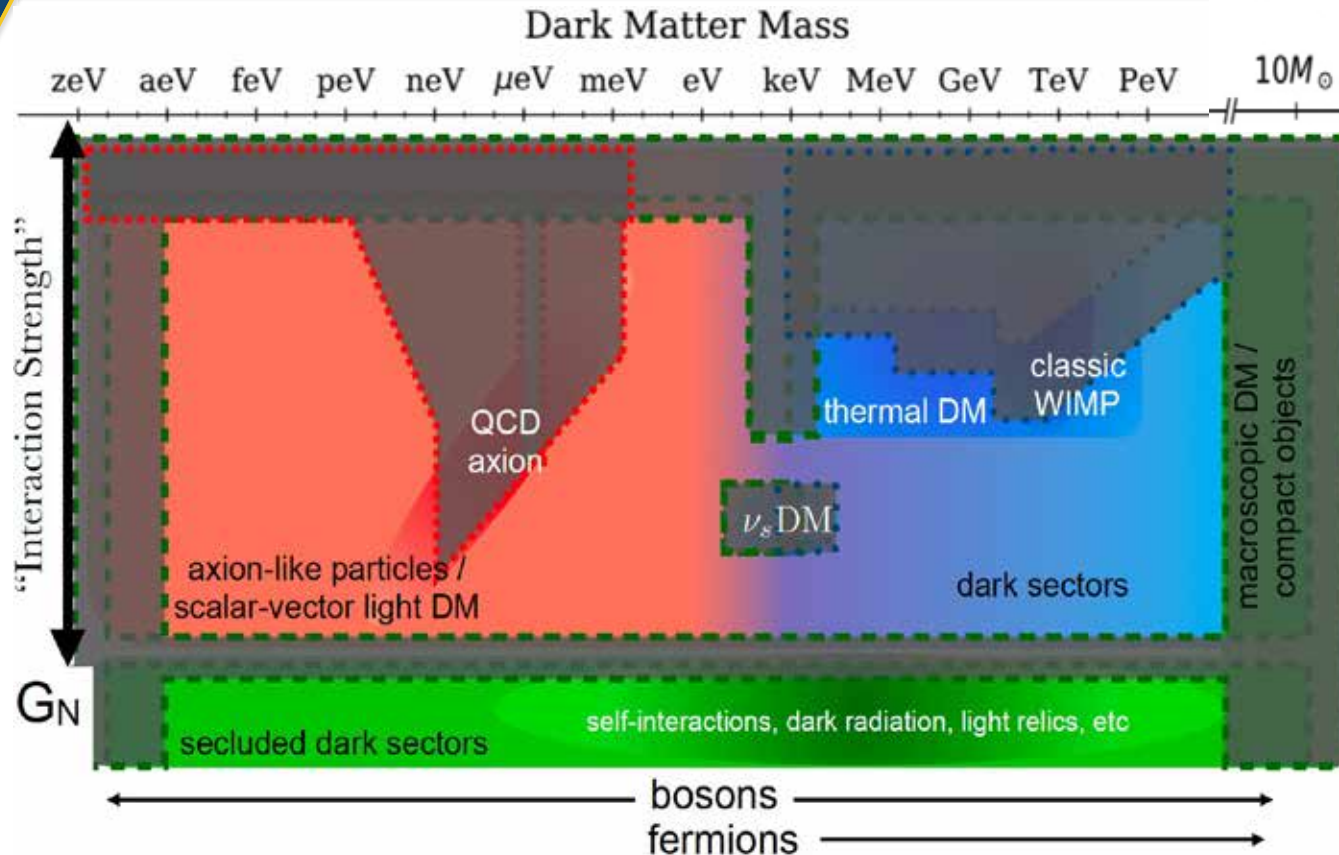
## Next 10 years à leave no stone unturned

- range of direct searches for WIMPs interacting with targets on Earth
- indirect searches for annihilation products
- cosmic probes based on structure



# Snowmass Cosmic Frontier Summary – Dark Matter

## Delve Deep, Search Wide



Deep coverage of high priority remaining **axion**, **WIMP** parameter space.

Significant inroads will be made into vastly expanded parameter space including new dark sector models.

Enabled by a versatile, wide-ranging program of complementary terrestrial, indirect, and cosmic probes

In the next 10 years, including future Gen-3 direct searches for WIMPs and axions, combined with future indirect observatories, a program of smaller scale searches, and key inputs from cosmic probes, results in broad coverage.

# HEP Cosmic Frontier – Summary & Future Planning

## Continue World-Leading Program aligned with 2014 P5

- **DESI, LZ, ADMX** continue operations; **SuperCDMS** Ops starting
- **Rubin** construction à commissioning; ops planning
- **CMB-S4** planning continues
- **LuSEE-Night** in fabrication phase

## è Planning

- Astro2020 + Snowmass workshop July 2022 + other plans à Input to next P5
  - Lots of amazing new ideas and directions to consider!

**The Future's Bright!**





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