U.S. DEPARTMENT OF ENERGY | Office of Science

Office of High Energy Physics (HEP) Cosmic Frontier

Astronomy & Astrophysics Advisory Committee

Sept. 26, 2022

Kathy Turner

Experimental Research at the Cosmic Frontier
Office of High Energy Physics

OUTLINE

- HEP Program: Intro, Guidance, Budget
- Cosmic Frontier Program Details
- Astro2020 & AAAC Recommendation

  → DOE comments
- Future planning

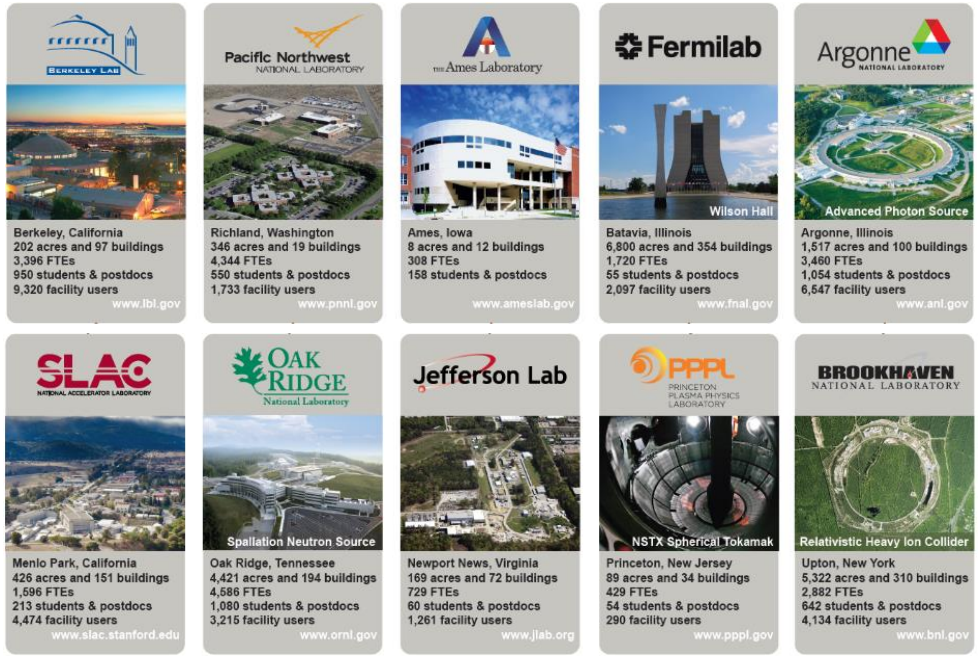
U.S. DEPARTMENT OF
ENERGY | Office of Science

HEP Program:
Intro, Guidance

Mission -DOE & Office of Science (SC)

DOE 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.

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

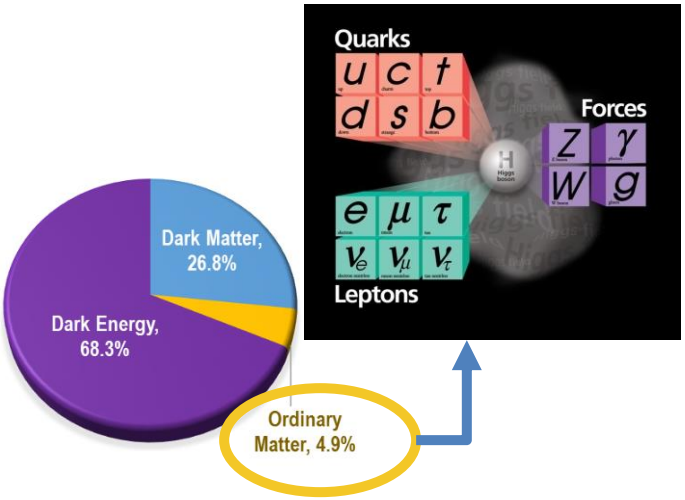


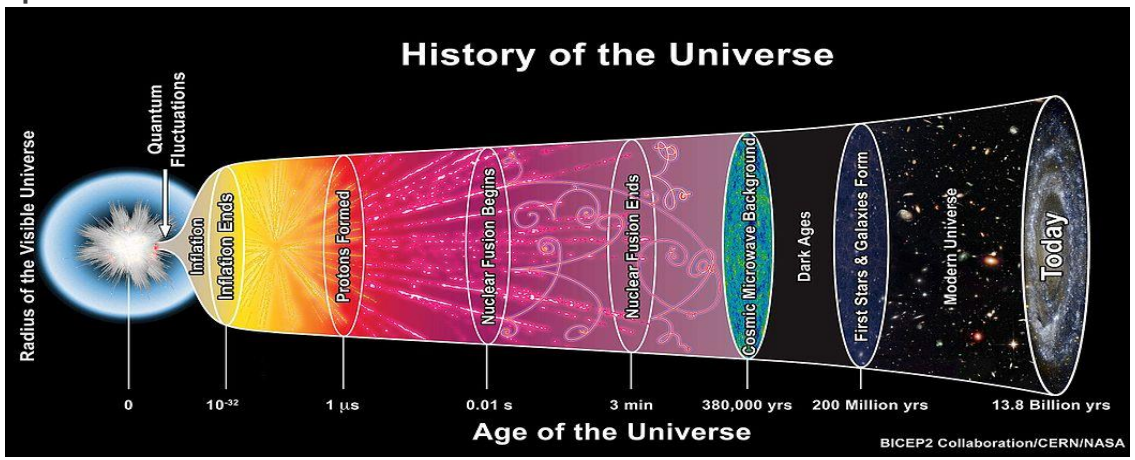
The Office of High Energy Physics (HEP) Program Mission

DOE is a mission-oriented agency → 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





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

DOE supports ~ 85% of the U.S. HEP effort (in $) at Universities + National Labs

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

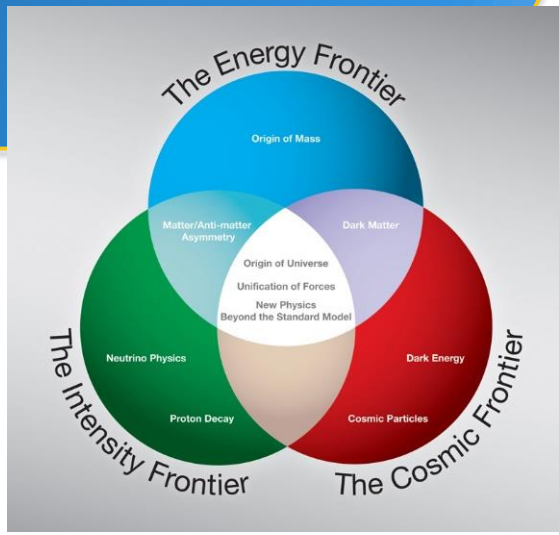
HEP carries out the DOE mission and objectives through a balanced portfolio to work at the cutting edge of science

- 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
- Development of **key technologies** and **trained personnel** needed to work at the cutting edge of science.
  - R&D for detectors, accelerators, QIS, AI/ML
- Theoretical efforts provide the vision and the mathematical framework for understanding and extending our knowledge of fundamental matter & energy.

Form **partnerships** (*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 Layout



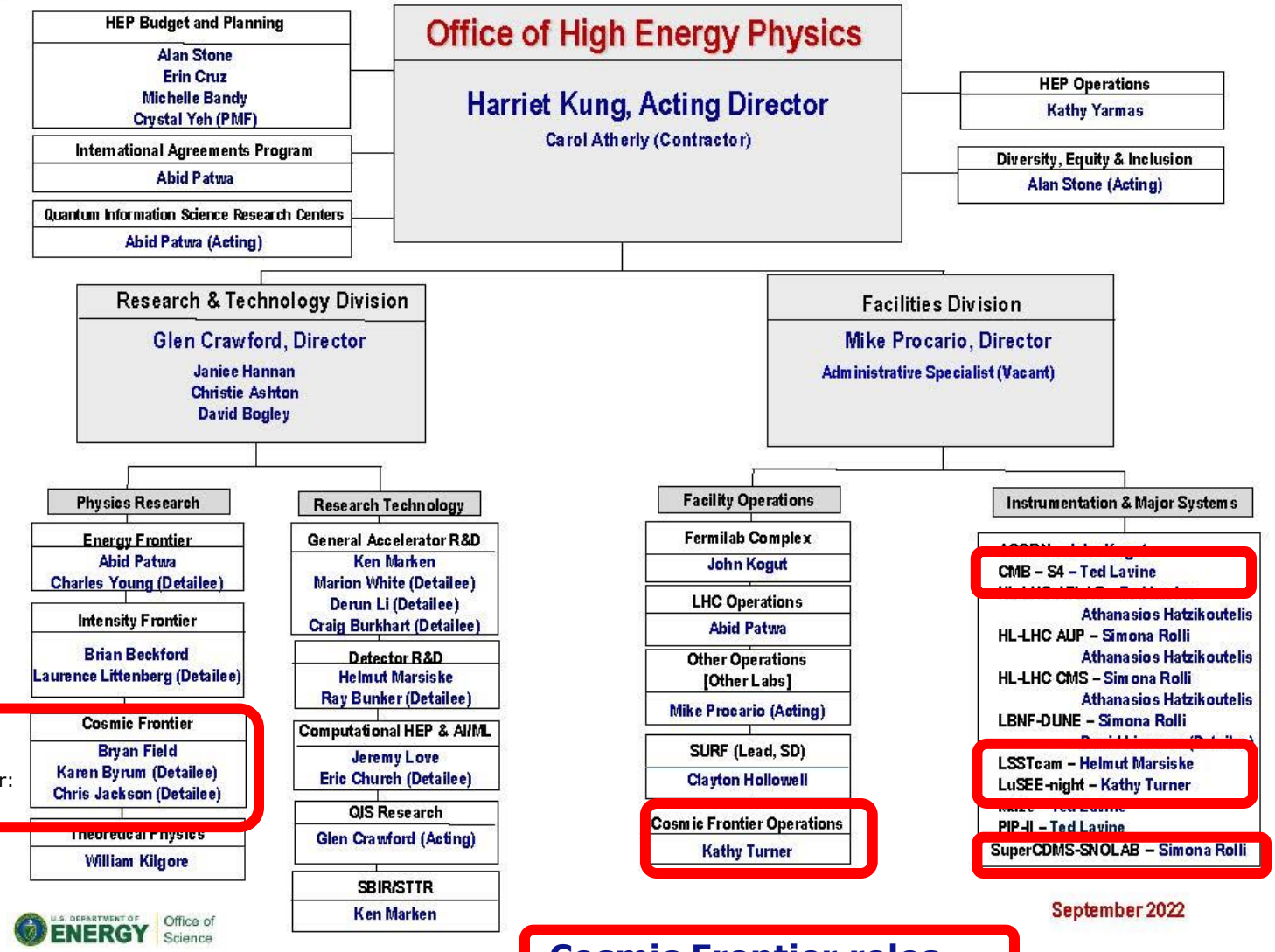
HEP is carried out along 3 Frontiers:
Advancements at all 3 frontiers are needed to achieve the long-term goals of the field.
→HEP is primarily a Particle Accelerator based program: **Energy & Intensity Frontiers**

→Cosmic Frontier uses naturally occurring data to study 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.**

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

DOE Office of HEP



DOE Scholar Intern, in Cosmic Frontier: **Elgin Leary**

Cosmic Frontier roles

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 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

HEP Program Execution - Collaboration Model

HEP strength is our Science Collaboration Model!

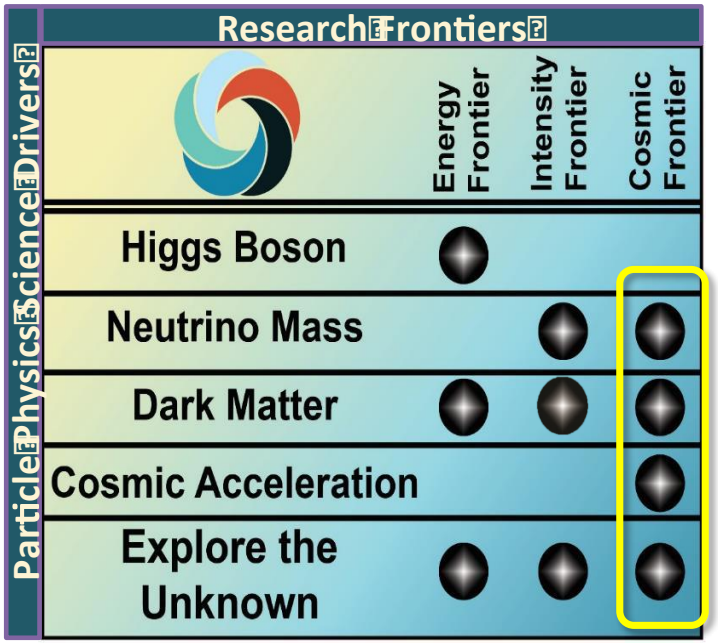
- Support structured science collaborations that participate in all stages, leading to the best possible results from state-of-the art projects.
- Scientists are intimately involved & have roles & responsibilities in project design & fabrication (hardware, software), commissioning, experimental operations, 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**

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.

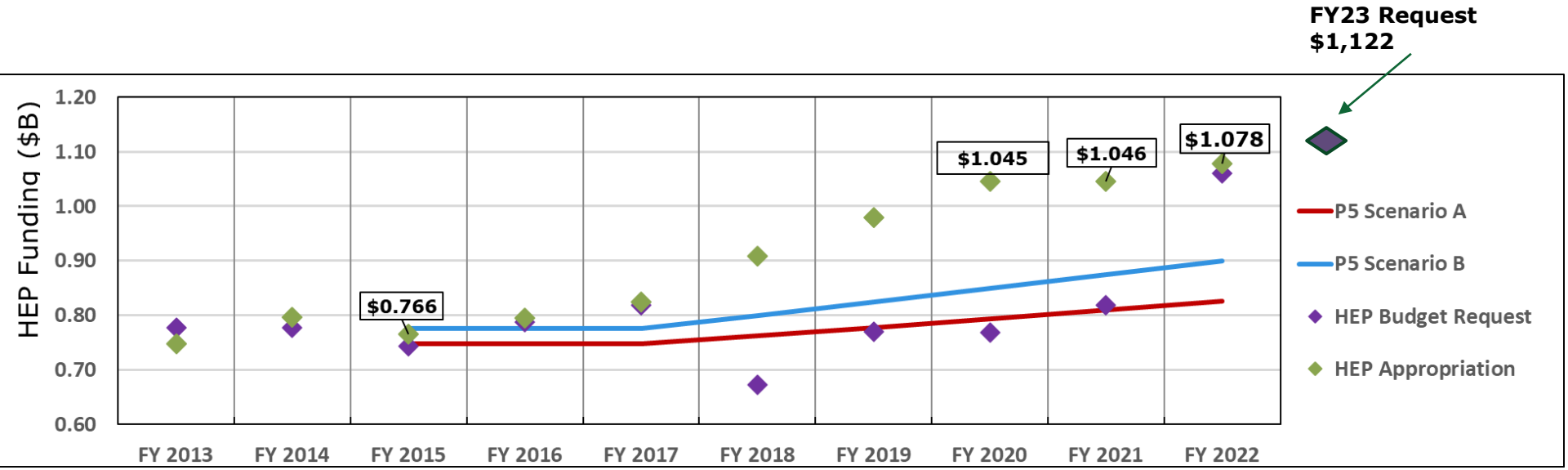
HEP Community support of this process is a critical element of its success

U.S. DEPARTMENT OF
ENERGY | Office of Science

HEP Budget

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: 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

FY 2023 HEP Budget Request Highlights

FY 2023 Request for ~$1,122M focuses resources on the highest priorities in fundamental research, operation and maintenance of scientific user facilities, facility upgrades, and projects identified in the 2014 Particle Physics Project Prioritization Panel (P5) report.

High priority areas for **core HEP research: 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**:

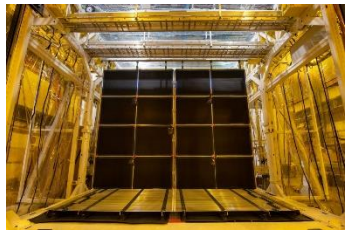
- QIS, AI/ML, Microelectronics, Integrated Computational and Data Infrastructure, Accelerator Science and Technology, Reaching a New Energy Sciences Workforce (RENEW), Accelerate Innovations in Emerging Technologies (Accelerate), and Funding for Accelerated, Inclusive Research (FAIR)

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**. LuSEE-Night** continues with all funds provided in FY22.

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

Main Injector at the Fermilab Accelerator Complex



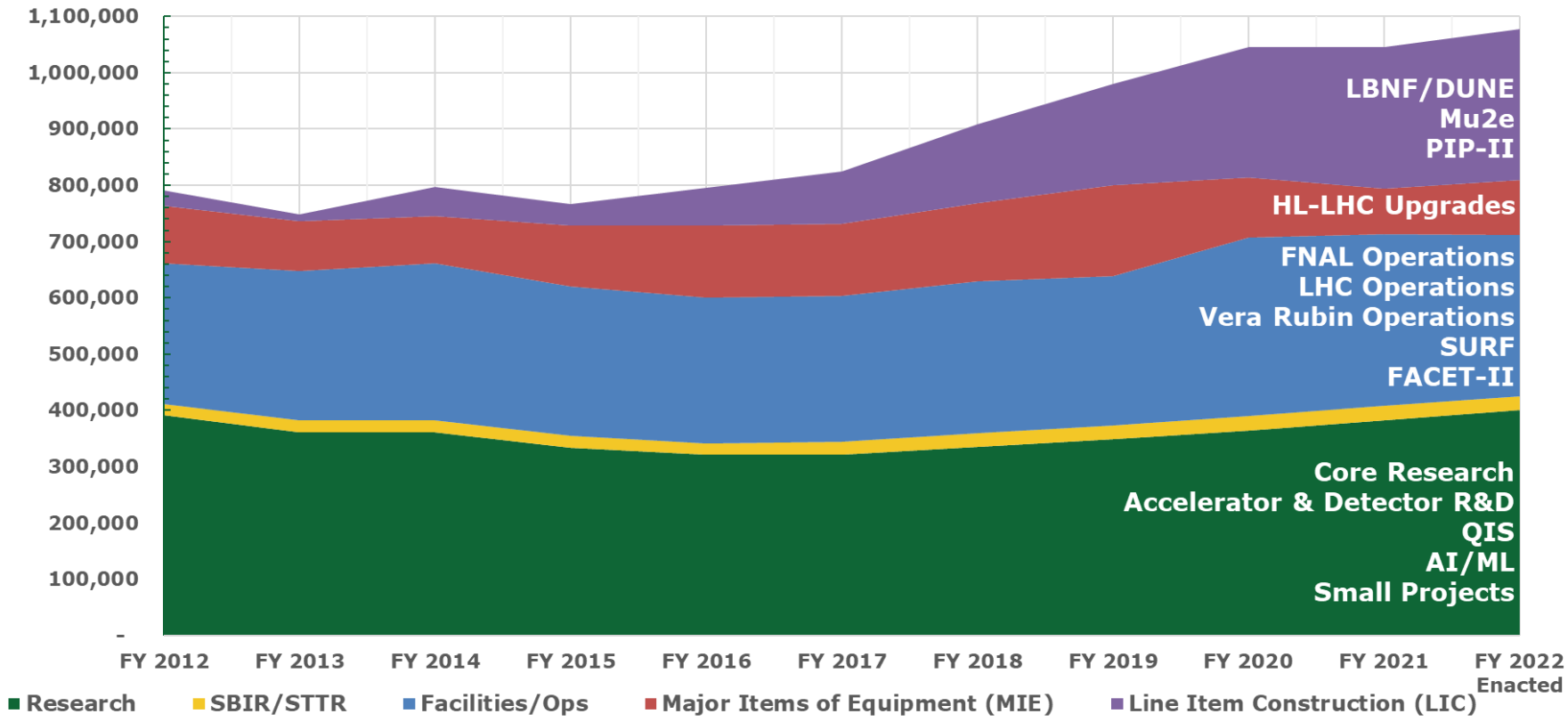
Short-Baseline Neutrino Detector at Fermilab

LZ direct dark matter search experiment at SURF

CMS Detector at LHC in CERN

HEP Budget ($K) – history (Research, Experimental Operations, Projects)

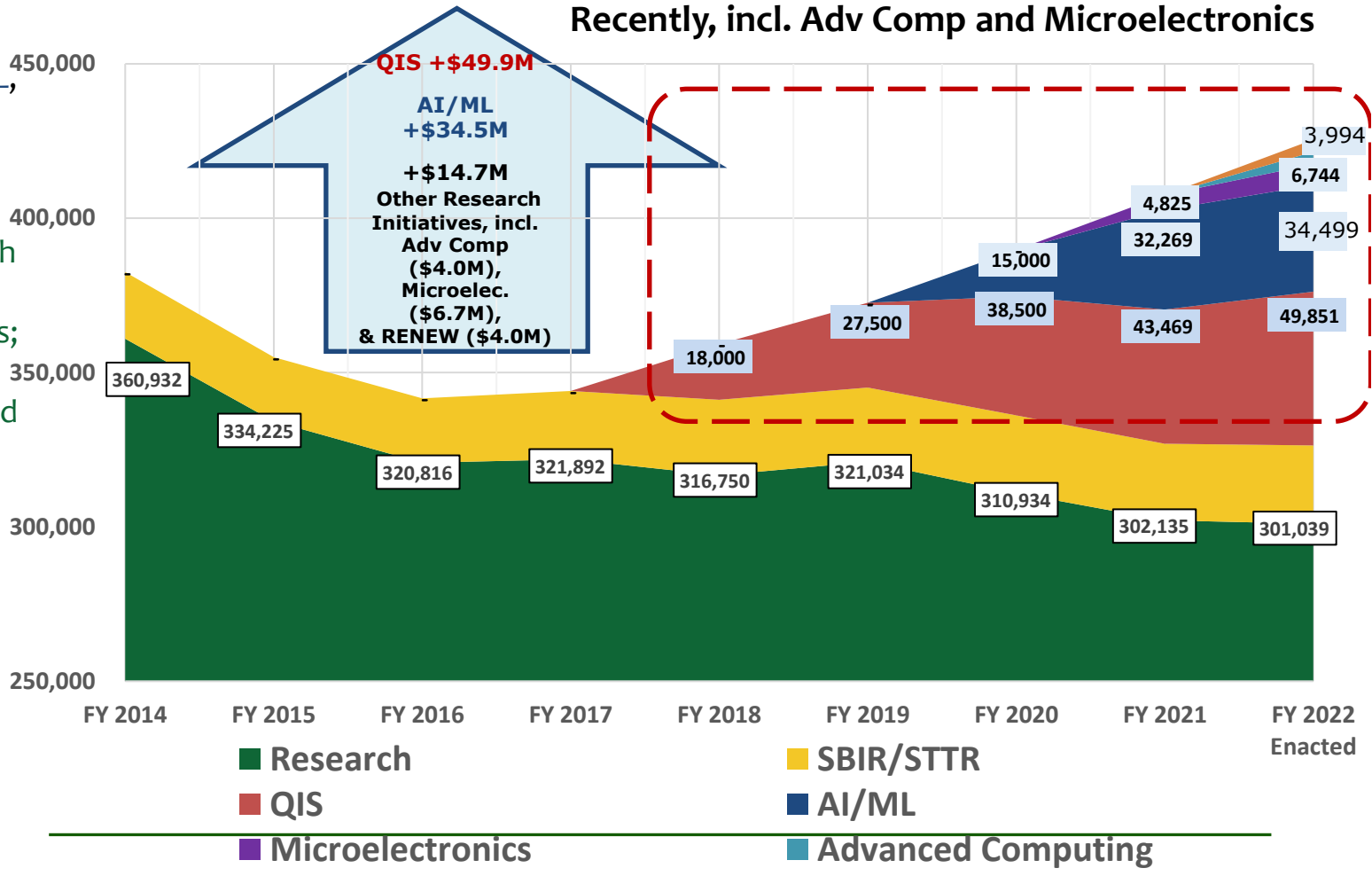
HEP Funding *($ in k)*	FY 2017 Actual	FY 2018 Actual	FY 2019 Actual	FY 2020 Actual	FY 2021 Actual	FY 2022 Enacted	FY 2023 President's Request *(for Reference)*	FY 2023 House Mark *(for Reference)*	FY 2023 House Mark *(for Reference)*
TOTAL	**825,000**	**908,000**	**980,000**	**1,045,000**	**1,046,000**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



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



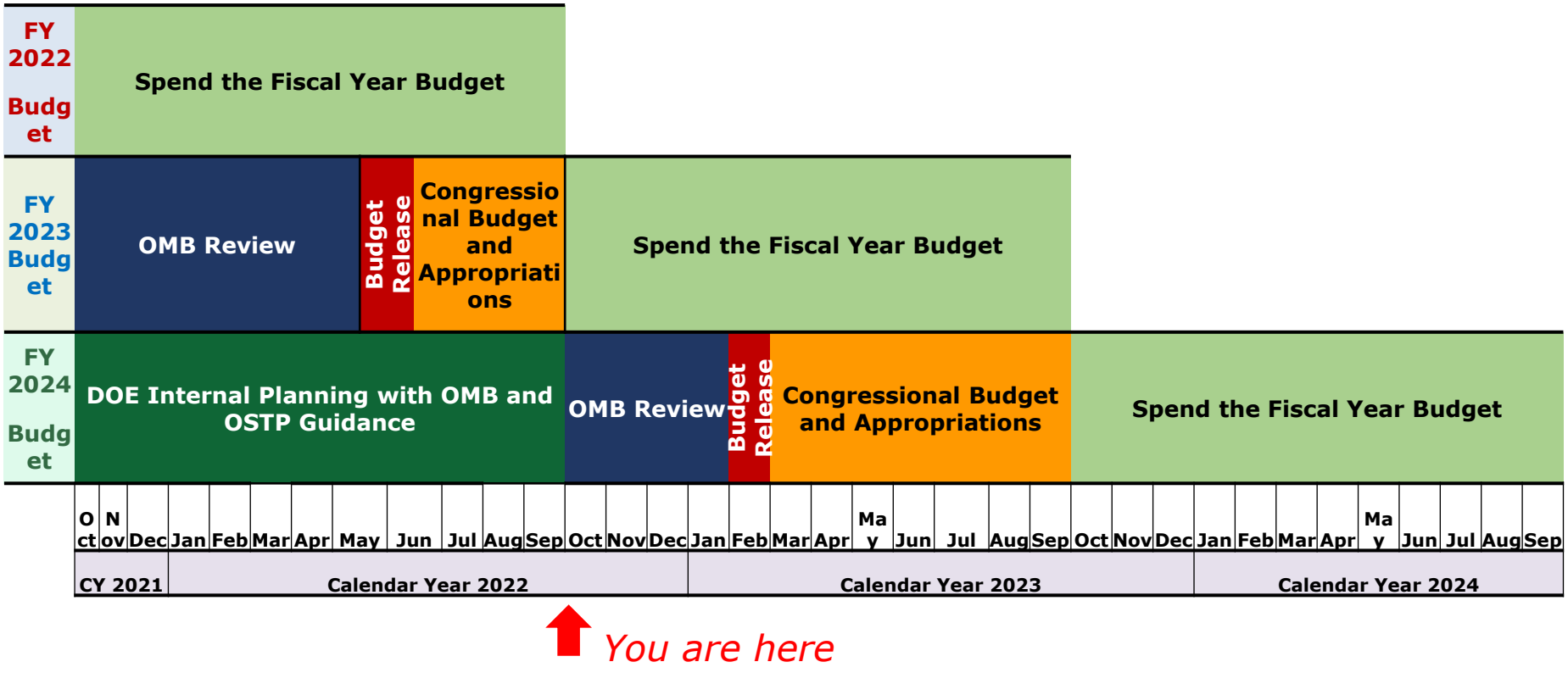
Office of Science & HEP
-- [New] Initiatives in Research funding

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

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



The U.S. Federal Budget Cycle

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

- The President submits a Budget Request (PBR) to Congress
- 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 ("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
- *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"*

Iterative process in budget development:

- SC & HEP get guidance from OMB; HEP works with SC to prepare a budget; iterations with HEP -- SC -- OMB
- HEP amounts go into Presidential Request, which breaks out research, operations and projects by Frontier.
- At the start of the FY, each Frontier gets a "control total" to work to; if we're in a CR it's based on the prior FY; updated when the budget is passed and then funds are adjusted throughout the year.

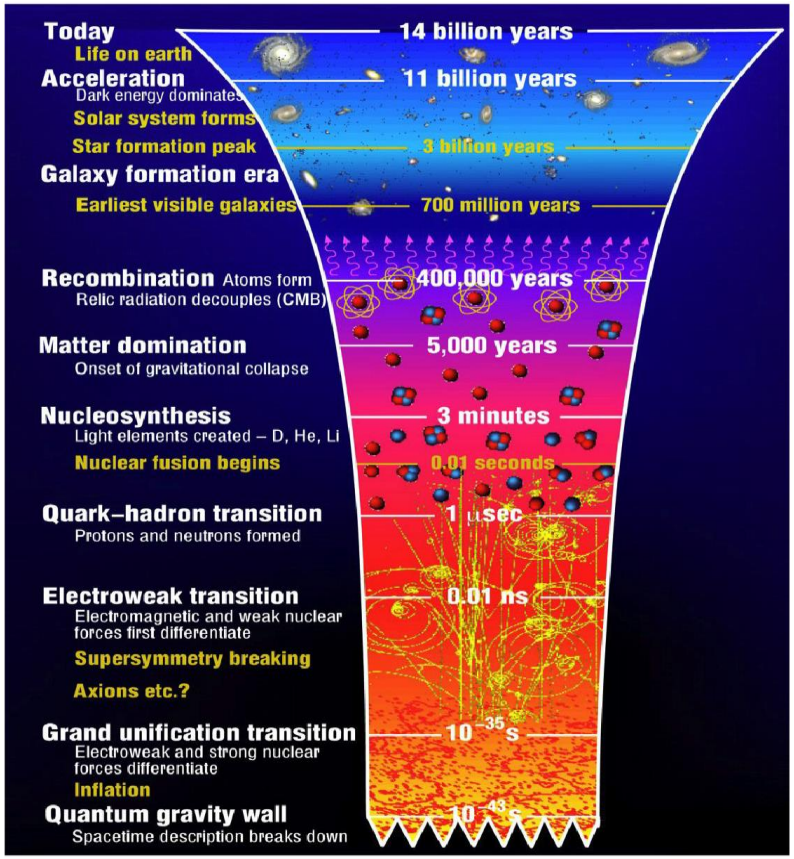
U.S. DEPARTMENT OF ENERGY | Office of Science

Cosmic Frontier - Intro, status, budget, planning

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.



Experiments to reveal the nature of **dark energy** and search for **dark matter** particles, 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

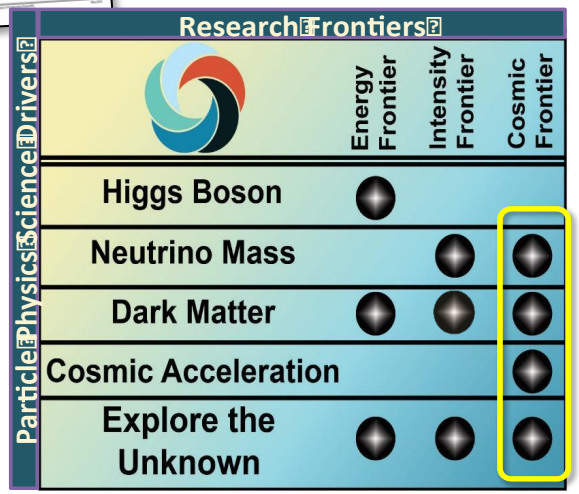
- Partnerships w/NSF (PHY, AST, OPP) NASA (AST, ISS, CLPS), and/or International.
- Significant contributions & support from other HEP areas (e.g. Theory, Advanced Detector Development, Computational HEP, QIS, AI/ML) and other SC areas (e.g. ASCR Supercomputing)

Cosmic Frontier – 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:

- **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

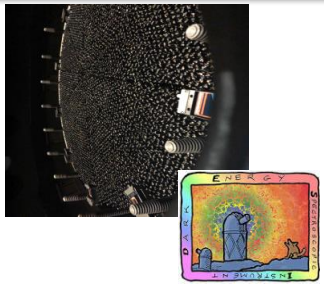
Dark Matter: suite of "generation 2" direct detection experiments to detect DM particles

→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 – Program is aligned with the P5 Science Drivers & Project Recommendations



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

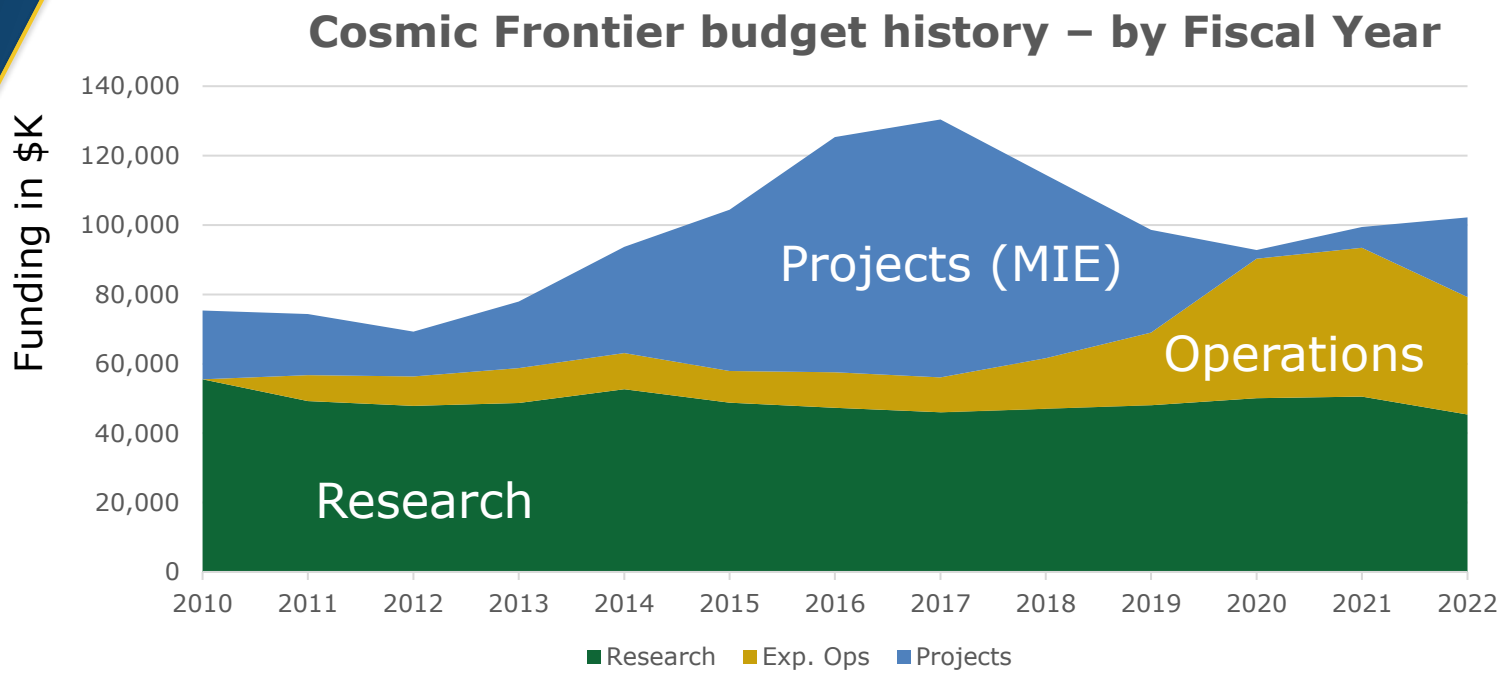
Neutrino properties constrained using dark energy & CMB measurements

Exploring the Unknown - Always interested in New Physics!

Small project

Black: HEP support ended
Green: funding continues

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 Budget

Cosmic Frontier ($K)	FY2019 Actual	FY2020 Actual	FY2021 Actual	FY2022 Enacted	FY2022 Actual	FY2023 Request
Research (Univ+Lab)	*48,053*	*44,264*	*43,901*	*38,552*	*42,513*	*42,213*
Future R&D	*3,265*	*2,480*	*1,700*	*1,926*	*1,475*	*0*
AI/ML Research for CF		3,351	4,920	4,920	5,407	4,817
Experimental Ops.	20,957	40,235	42,880	33,829	44,350	45,851
Projects	26,350	2,450	6,000	23,000	23,000	1,000
DESI	*9,350*	*0*	*0*			*0*
LZ	*14,450*	*0*	*0*			*0*
SuperCDMS	*2,550*	*0*	*0*			*0*
CMB-S4	*-*	*2,450*	*6,000*	*8,000*	*8,000*	*1,000*
LuSEE-Night				*15,000*	*15,000*	
Total	**98,625**	**92,780**	**99,401**	**102,227**	**116,745**	**93,881**

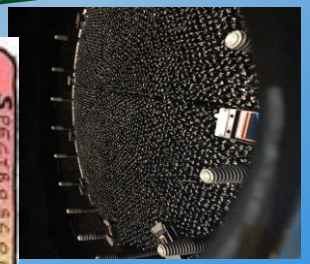
- Research: Scientist support for world-leading efforts in design and optimization in their planning, fabrication, commissioning, operations and data production, analysis.
- **Operations:** Commissioning and facility operations planning for LSST/Rubin; operations of FGST/LAT, SPT-3G, ADMX-G2, DESI, LZ; pre-operations activities for SuperCDMS-SNOLAB.
- **Projects:** CMB-S4, LuSEE-Night

HEP Cosmic Frontier: Cosmic Acceleration

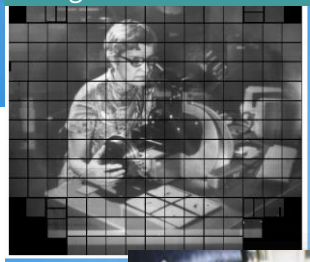
Pinhole camera 3.2Gpixel image of Vera C. Rubin

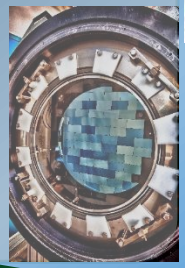
Dark Energy

DARK ENERGY SURVEY

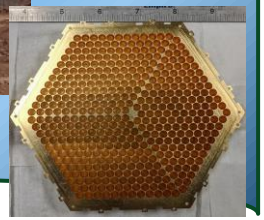


VERA C. RUBIN OBSERVATORY





CMB



Dark Ages

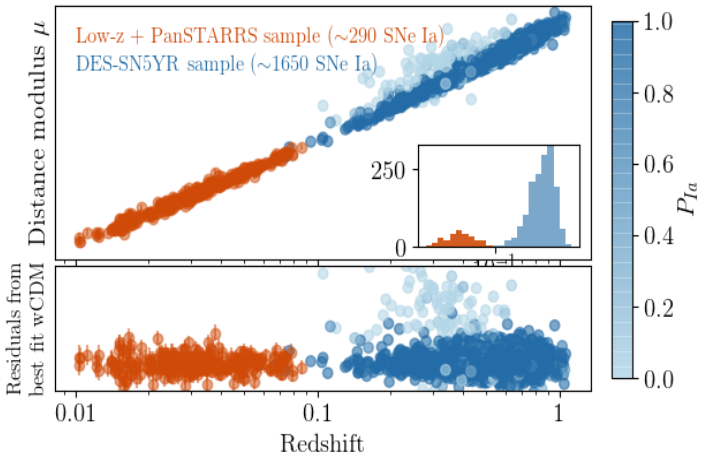
Dark Energy Survey (DES) - Dark Energy Camera (DECam)

DARK ENERGY SURVEY

DOE and NSF partnership

- Fermilab led fabrication of 570Mpix DECam; NSF led telescope upgrades, data man. system
- Both agencies supported operations on NSF's Blanco telescope at CTIO in Chile. 6-year imaging survey of 5100 sq-deg completed Jan. 2019
- *Collaboration > 400 scientists; 25 institutions in 7 countries;* >410 publications; >100 PhD's

		DES 3x2pt	All External	All data
wCDM	w_0	$-0.94^{+0.31}_{-0.18}$	$-1.04^{+0.03}_{-0.03}$	$-1.03^{+0.03}_{-0.03}$
w_0-w_a	w_0	≥ -1.40	$-0.94^{+0.08}_{-0.08}$	$-0.95^{+0.08}_{-0.08}$
	w_a	$-0.94^{+1.15}_{-1.15}$	$-0.45^{+0.36}_{-0.28}$	$-0.38^{+0.36}_{-0.28}$
	w_p	$-0.99^{+0.28}_{-0.17}$	$-1.04^{+0.04}_{-0.03}$	$-1.03^{+0.04}_{-0.03}$
Ω_k	$10^2\Omega_k$	≥ -16	$0.08^{+0.18}_{-0.18}$	$0.09^{+0.17}_{-0.17}$
$N_{\rm eff}$	$N_{\rm eff}$	≤ 7.84	$3.10^{+0.16}_{-0.17}$	$3.10^{+0.15}_{-0.16}$
$\Delta N_{\rm eff} > 0.047$	$\Delta N_{\rm eff}$	-	≤ 0.36	≤ 0.34
	$m_{\rm eff}$ [eV]	-	≤ 0.18	≤ 0.14
$m_{\rm th} < 10$eV	$\Delta N_{\rm eff}$	-	≤ 0.23	≤ 0.28
	$m_{\rm eff}$ [eV]	-	≤ 0.42	≤ 0.20
Σ_0-μ_0	Σ_0	$0.56^{+0.37}_{-0.48}$	$0.37^{+0.12}_{-0.09}$	$0.04^{+0.05}_{-0.05}$
	μ_0	-	$0.20^{+0.22}_{-0.22}$	$0.08^{+0.21}_{-0.19}$



Y5 SN Ia cosmology (final) results expected in fall. 1650 photometrically-typed SNIa whose host galaxies have precision (spectroscopic) redshifts. Better than all previous SN cosmology results combined

- Year 3 "Key Project" Extended cosmology paper submitted.
- Uses DES Y3 3x2pt and the otherwise most powerful external data sets including BAO, SNIa, RSD, and CMB
- No significant deviations from LCDM

https://arxiv.org/abs/2207.05766

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

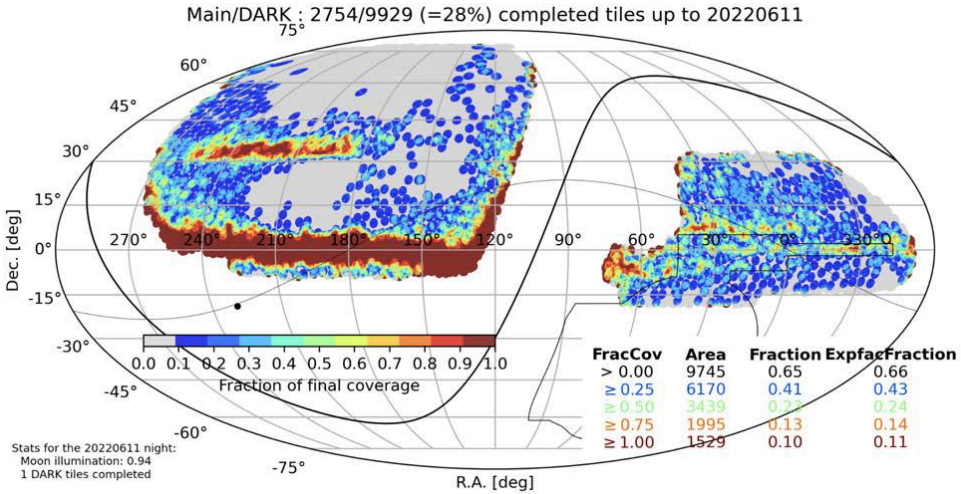
First **Stage IV dark energy;** Will measure spectra of > 40 million galaxies

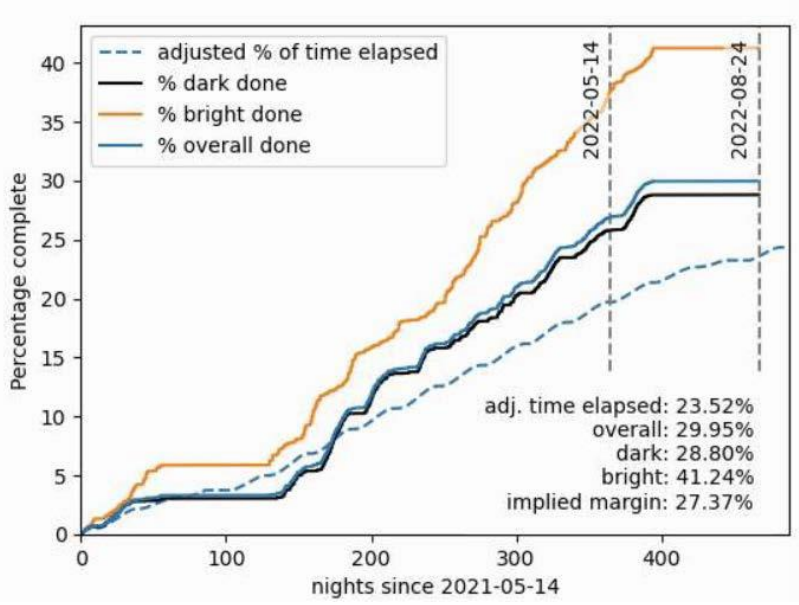
DOE/LBNL Project: Instrumentation, Data Management System, & Upgrades of NSF's Kitt Peak Mayall telescope (including MOSAIC camera).

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

Through mid-June 2022 -- DESI was running ahead of project schedule

Successful data-taking: ~ 18 Million extra-galactic redshifts recorded (more than all other surveys combined)





DESI - status

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.

NEWS ➔ DESI is back on-sky as of Sept. 16

- still assessing any degradation in performance

Thank you to fire fighters and the other agencies that protected the site and are now carrying out recovery services. There's still a ways to go: …no internet, generator power, problems with the roads, etc.

DESI Science & Collaboration

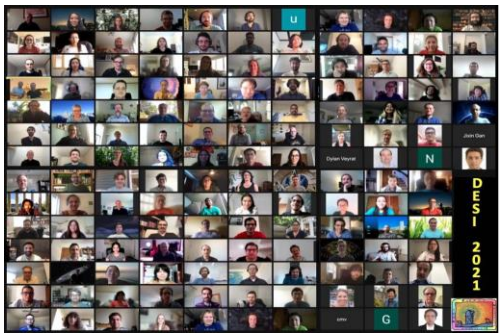
DESI Collaboration results →
Seminal paper on Instrumentation - in publication
33 refereed and published papers so far

Survey Validation (SV) results: 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)

DESI DEI committee formed in 2020 & already has successes, e.g. Mentoring, climate surveys. See www.desi.lbl.gov/diversity



DESI Collaboration ~1000 members from 74 institutions

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.

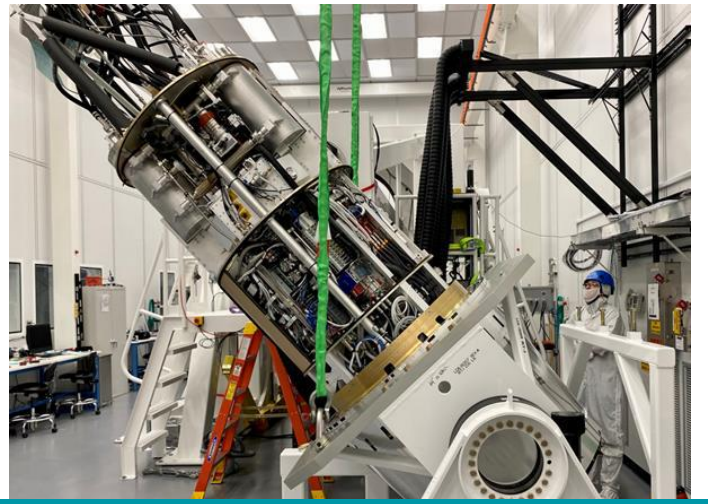
NSF (AURA) & DOE (SLAC) partnership, with private, international contributions

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

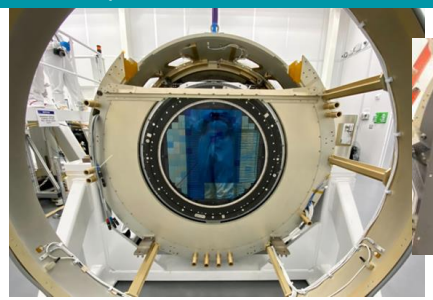
Facility Operations: 50/50 DOE & NSF split; DOE responsible primarily for camera maintenance and operations, US Data Facility

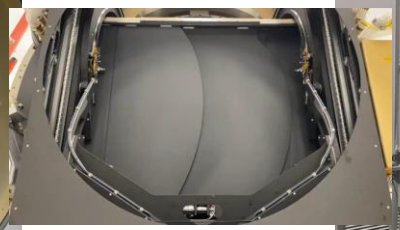
Camera Commissioning - status

- Carrying out assembly and verification at SLAC + preparations in Chile
- Ready to ship to Chile (~ Spring 2023); installation ~ end 2023.
- Cold refrigeration system (for electronics) being replaced due to instabilities



Cryostat, utility trunk,L3 mated to camera; Shutters



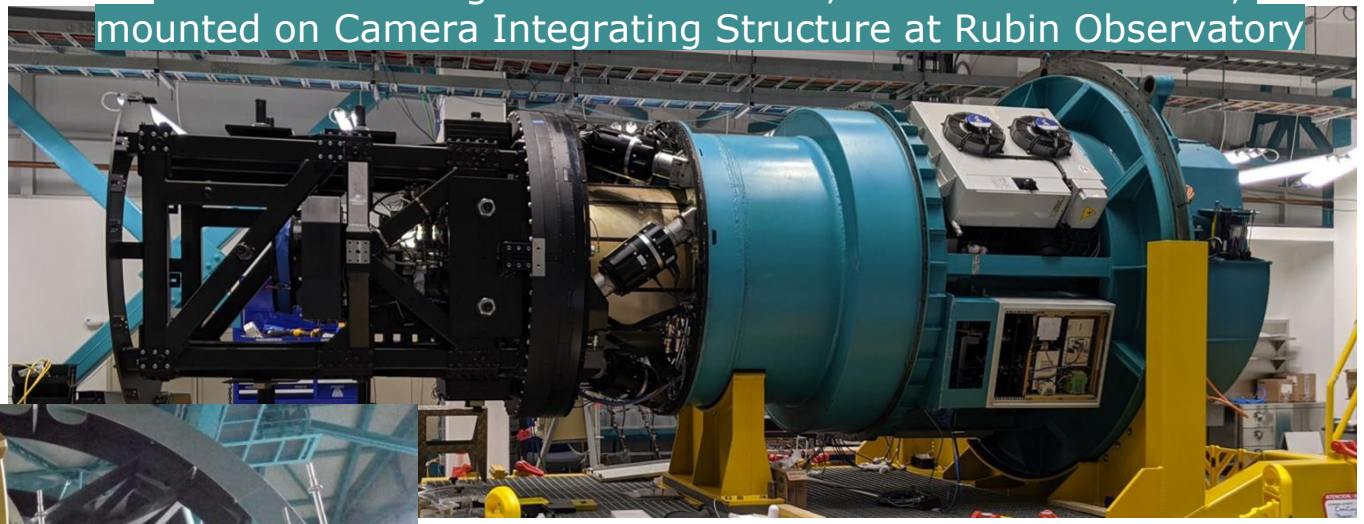


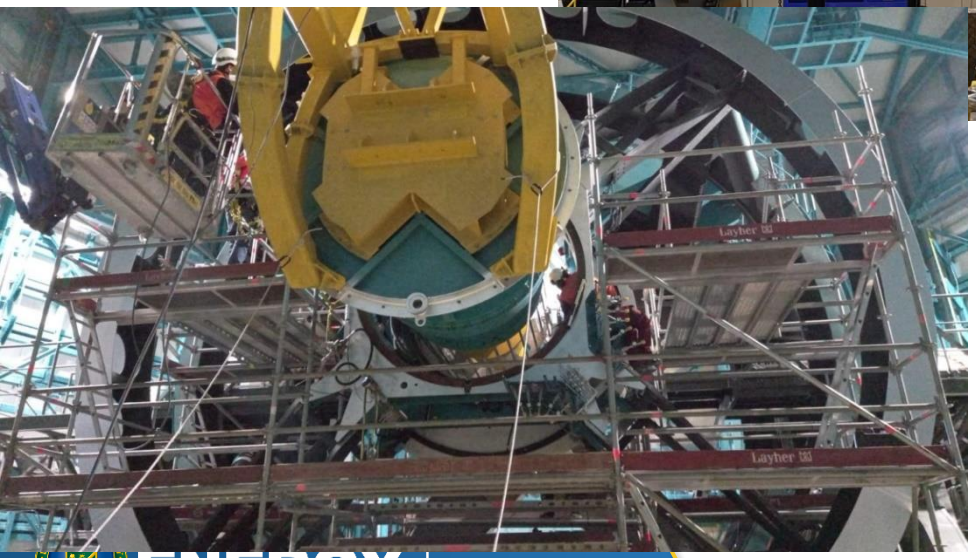
9/7/22 – Camera fully assembled at SLAC

Commissioning in Chile

- Camera Off-Telescope Components have been fabricated and verified. Cryo refrigeration system ground unit already on the summit.
- DOE camera team participates in Commissioning Camera (ComCam).

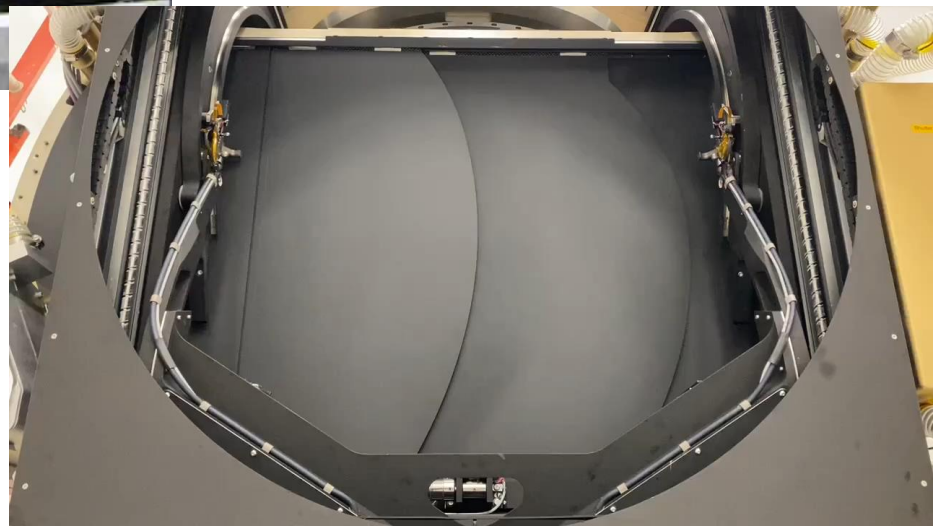
ComCam & Refrigeration Pathfinder, with mass simulator, mounted on Camera Integrating Structure at Rubin Observatory





ComCam mounted on telescope mount assembly

Camera assembly



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

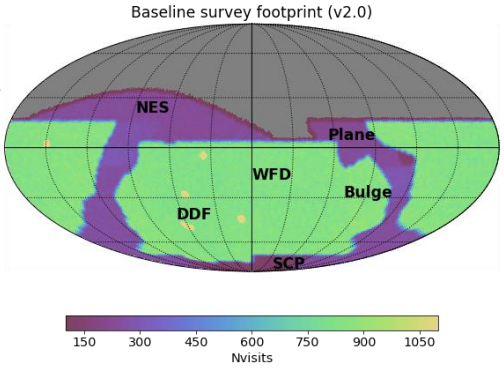
Facility Operations: 50/50 DOE & NSF split; Planning underway
DOE responsible primarily for camera maintenance and operations, US Data Facility

- 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
- 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

Full LSST survey data-taking starts ~ Oct. 2024.

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

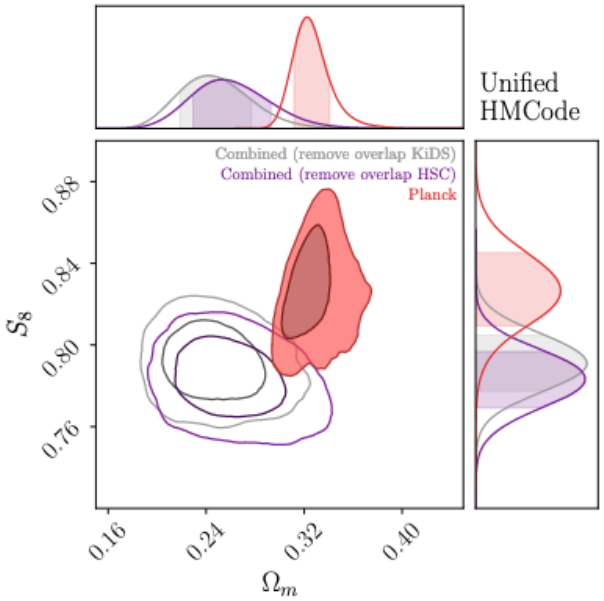


AAS meeting, Pasadena, June 2022

Dark Energy Science Collaboration (DESC) will use the Rubin Observatory's Legacy Survey of Space and Time

Scientific Research - Both NSF and DOE will support community efforts

- **DOE's research efforts are organized through DESC**; planning, pipeline building and readiness activities are continuing.



Constraints on total matter density today and normalization of the matter fluctuations from combined surveys, compared to Planck results.

Longley et al., arXiv:2208.07179
submitted to MNRAS

Rubin data enable Dark Energy studies via complementary probes: SNe, BAO, Weak and Strong Lensing, Galaxy Clusters

These probes also provide constraints on the nature of inflation, modifications to GR, the masses of neutrinos, the nature of dark matter.

Collaboration ~ 1170 members; 237 full members; from 20+ countries
Since 2018, 49 publications (+ 9 under review)

Science Highlight (left): Reanalysis of three cosmic shear datasets: DES-Y1, KiDS-1000, HSC-Y1 w/LSST DESC-developed pipelines

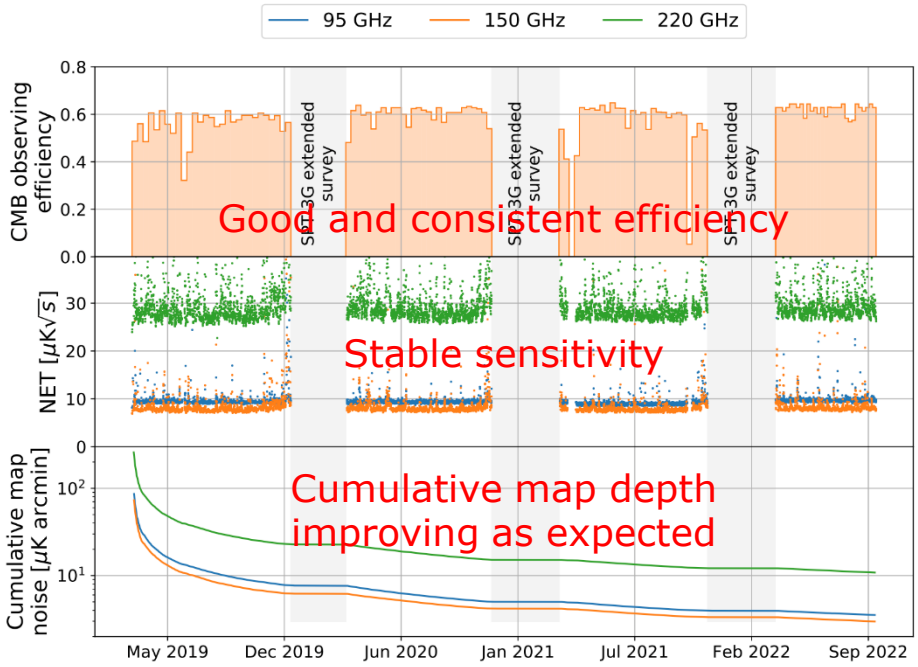
- Unified analysis allows for
  - Rigorous consistency tests across surveys
  - Robustness tests for different small-scale modeling approaches and DESC pipelines
  - Tests of varying choices for priors

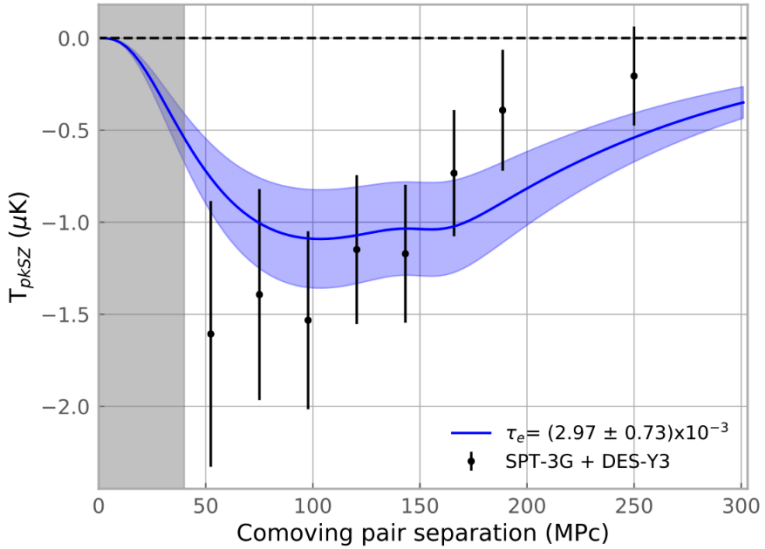
CMB & South Pole Telescope (SPT-3G)

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

SPT-3G: NSF & DOE partnership

- HEP supported major upgrade: fabrication of the 16,000-detector focal plane, greatly increasing sensitivity
- Survey started 2018; continues to operate smoothly with high observing efficiency; First Results out
- Collaboration > 80 members, 21 institutions in 5 countries; ~20 postdocs & 30 grad students





SPT-3G science publication

- Measurement of pair-wise kinematic Sunyaev-Zel'dovich effect (pkSZ)
  - Uses SPT-3G temperature maps at location of Y3 DES clusters
  - Probe of large-scale structure and test of GR
  - First result using full set of 2019+2020 survey data
- Schiappucci et al., 2022, submitted to PRD: http://arxiv.org/abs/2207.11937

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

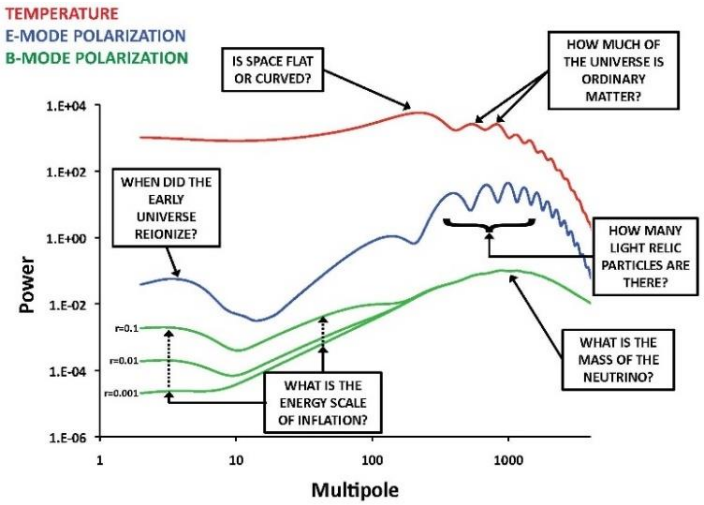
"An important requirement for our strong endorsement is that the project broadly engage astronomers beyond the traditional CMB community.

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



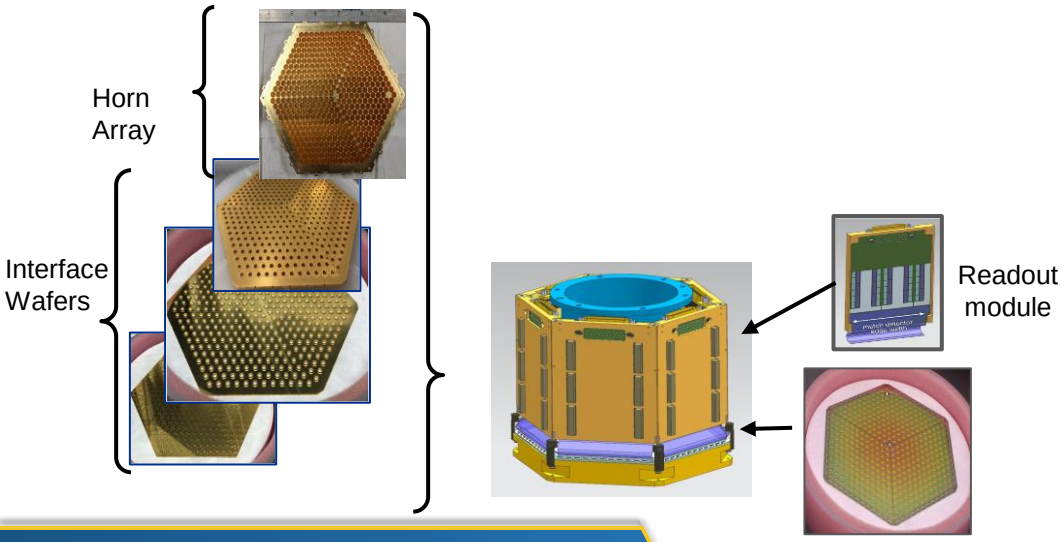
2014 HEPAP/P5 strategic plan recommended CMB-S4 as a joint DOE/NSF project
2016-2017 AAAC subpanel: CMB-S4 Concept Definition Taskforce study
2019 – DOE approved CD-0
2020 – LBNL chosen as DOE's lead lab

2019-2020 – Plan to Astro2020
- 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 > 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
July 2022 – new Project Director on board -- Jim Strait

DOE & NSF have been meeting regularly for a few years. Following Astro2020, meetings are being held to consider potential paths forward.

- 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.**



- Alternatives reviewed by Collaboration and going to external panel in ~ month
- Will present to the Agencies to support moving forward in planning & conceptual design

Astro2020: Science Panel on Cosmology → Dark Ages

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

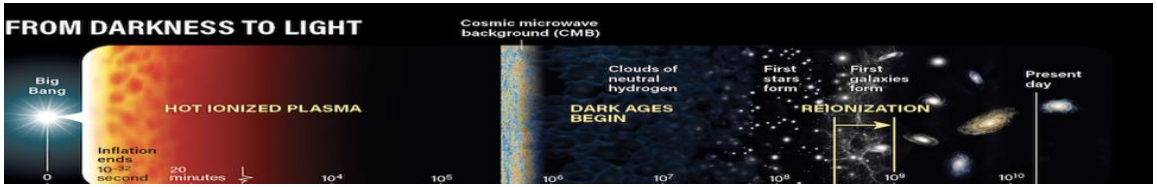
- What set the hot Big Bang in motion?
- What are the properties of dark matter and the dark sector?
- What physics drives the cosmic expansion & large-scale evolution of the universe?
- How will measurements of gravitational waves reshape our cosmological view?

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 after CMB and 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 (<50MHz) radio sky are sensitive to 21cm emission from neutral hydrogen at high redshift (z>30)"



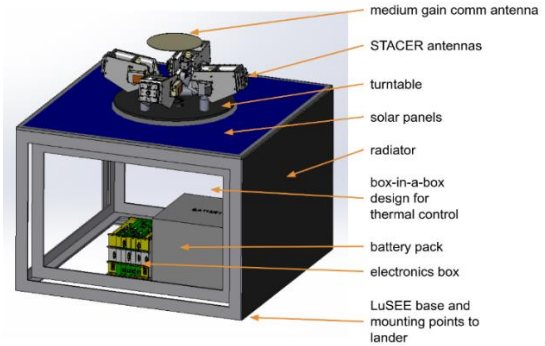
DOE/NASA Partnership on LuSEE-Night → Pathfinder to the Dark Ages

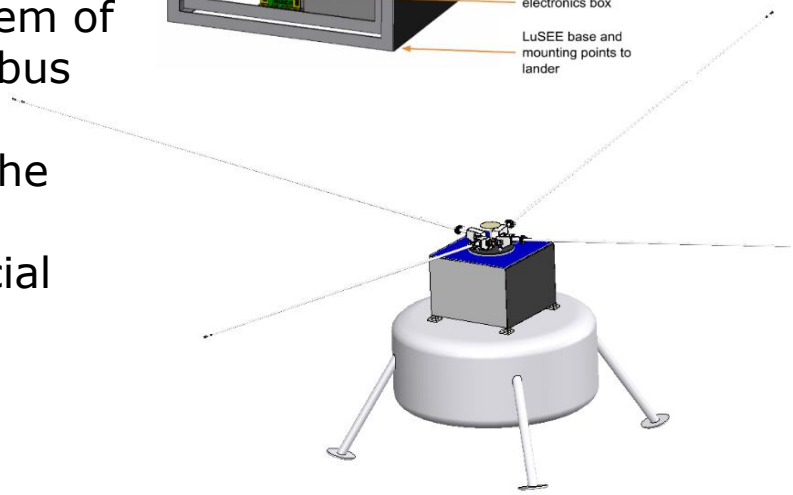
DOE/NASA high level MOU to continue partnerships signed in Oct. 2020, led to: **partnership** on Lunar Surface Electromagnetics Experiment at Night (LuSEE-Night)

- 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
  - Project Manager: Sven Herrmann
  - Project Scientist: Anze Slosar
- **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) mission.





Reviews: PD-1 May 2022; PD-2/3a Sept. 2022
Agencies are developing an MOU.

HEP Cosmic Frontier: Dark Matter

Dark Matter Generation 3

ADMX AXION DARK MATTER EXPERIMENT

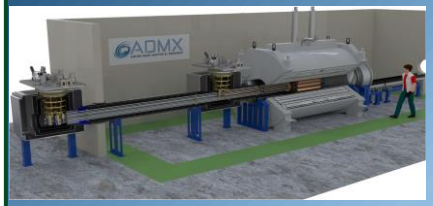
Axion search .6-2MHz at U.Wash; started 2017

WIMP search at SURF (SD); started FY22

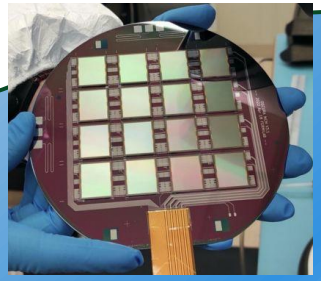
SUPER CDMS Cryogenic Dark Matter Search

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

Dark Matter New Initiatives

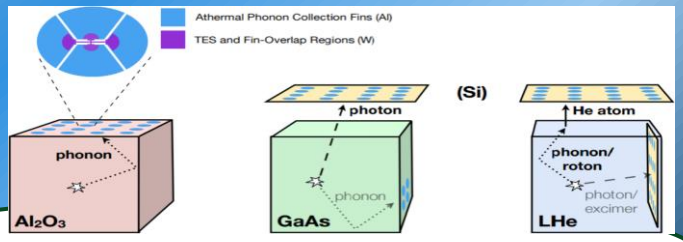


Axion search 2-4 GHz



OSCURA

TESSERACT



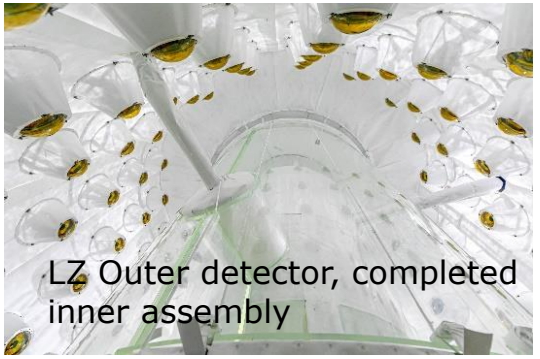
Direct Detection of Dark Matter

Staged suite of complementary direct detection experiments with multiple technologies to search for dark matter particles

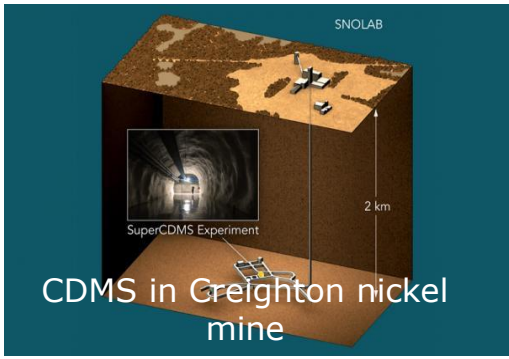
3 Dark Matter 2nd Generation (DM-G2) projects

ADMX-G2
- Axion search 2-8 μeV; currently operating at UWashington
- Started 2017; Planned upgrades to step through frequencies

LZ at Homestake Mine in South Dakota
- Dual phase liquid Xe WIMP search; ~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


LZ Outer detector, completed inner assembly

SuperCDMS-SNOLab in Canada (HEP+NSF partnership)
- Cryogenic solid-state crystal WIMP search; ~1-10 GeV mass
- Expect full fabrication completion early FY2022
- Full operations start in 2024; partial detector ops in 2023



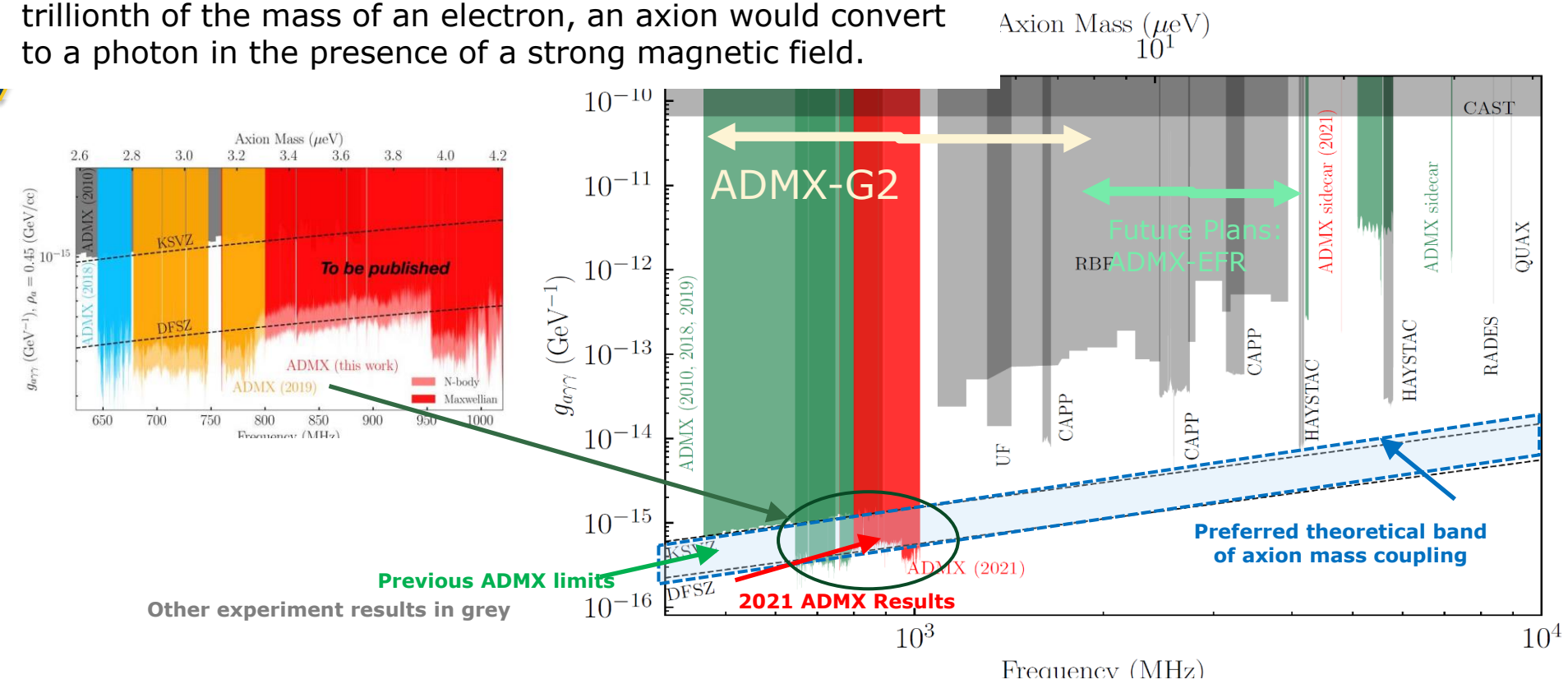
CDMS in Creighton nickel mine

Dark Matter New Initiatives (DMNI) – concept studies ongoing to develop small projects (4 in Cosmic Frontier; 2 in Intensity Frontier) to search in new areas of phase space, with new technologies

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

ADMX
AXION DARK MATTER EXPERIMENT

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.



ADMX-G2 operating at U. Washington; searches for axions 0.6 to 2 MHz

- 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 continue searching
- Collaboration designing a new initiative concept for 2-4 MHz (ADMX-EFR)

DM-G2: LZ – First Results

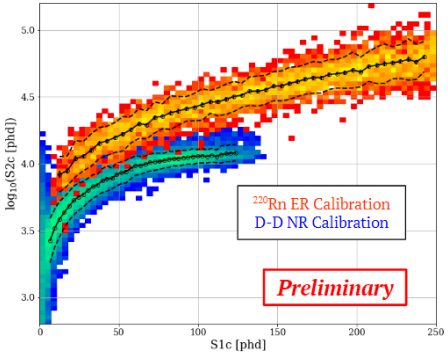
Gen-2 Direct Detection WIMP Dark Matter search

- 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

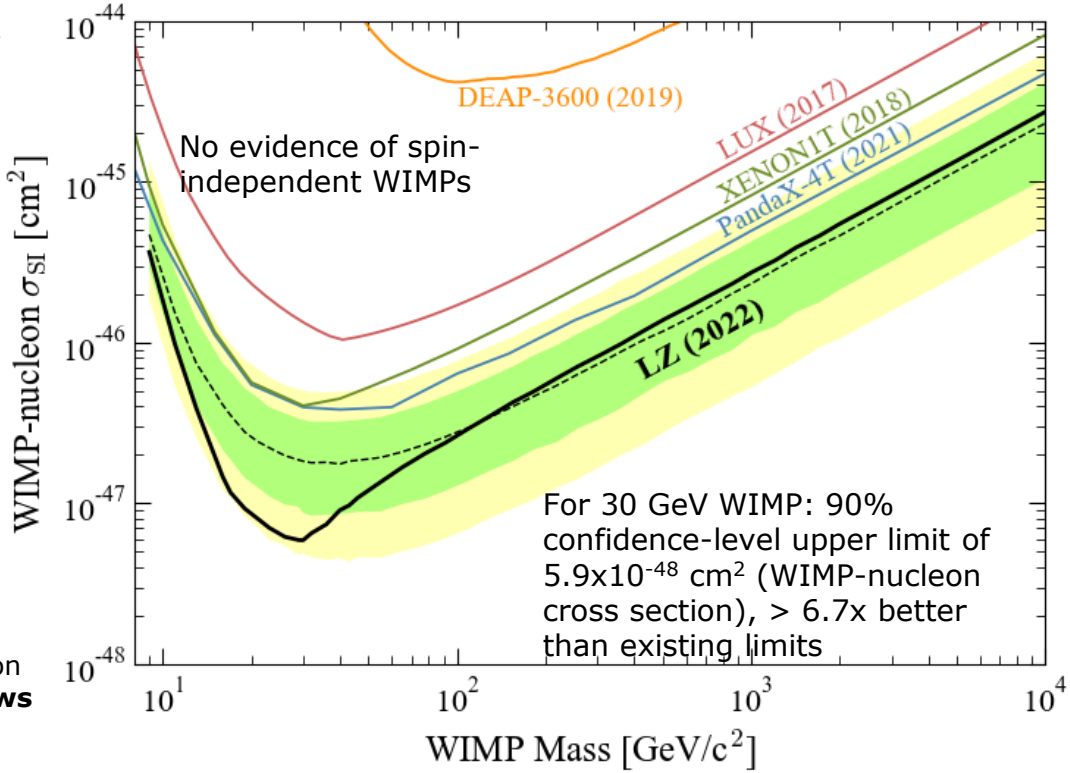
Collaboration ~ 250 people
DEI committee started in 2018

➔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**.

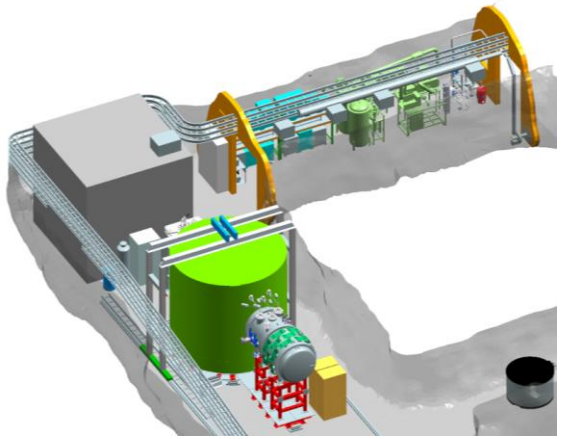


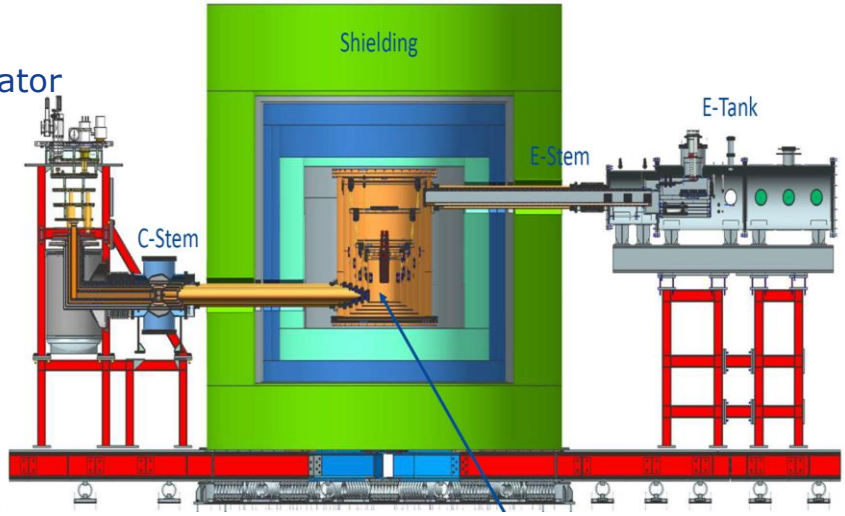
DM-G2: SuperCDMS SNOLAB

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.



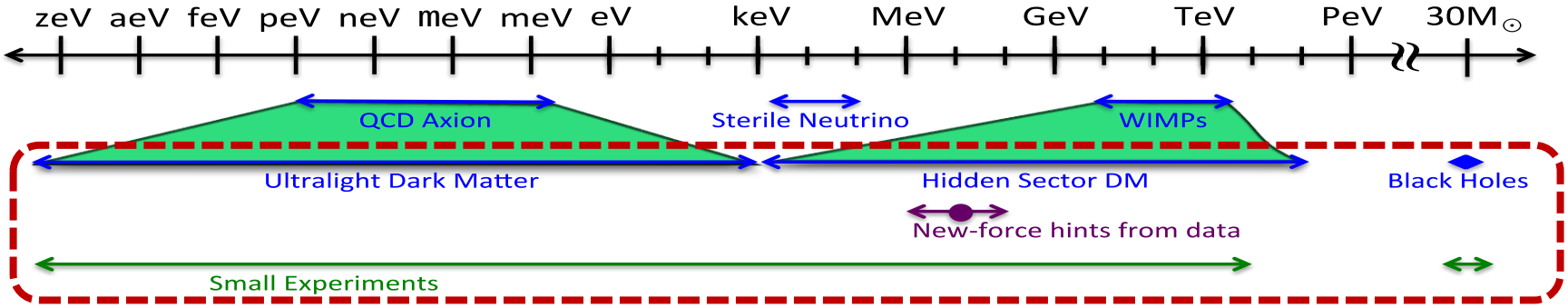


- Expect full fabrication completion in early FY2023
- Full science operations start in 2024; Start operating with partial detector beforehand.

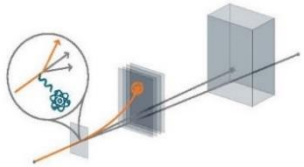
Dark Matter New Initiatives (DMNI) for small projects

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

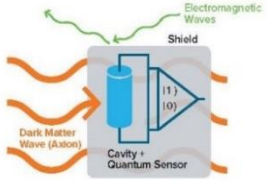


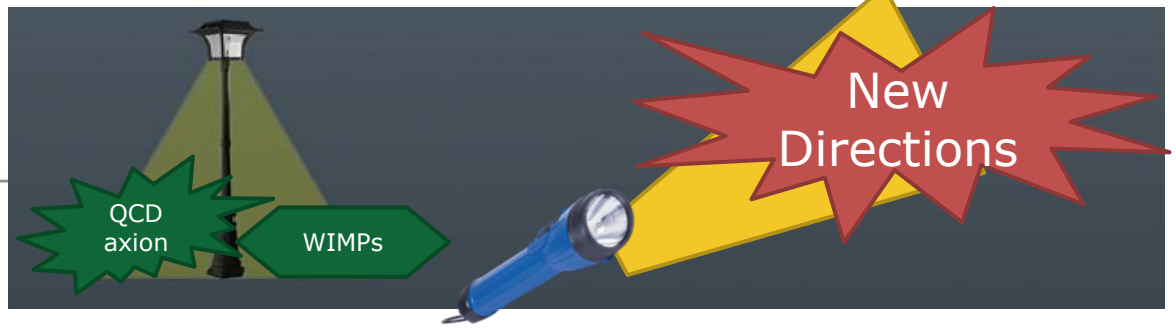
PRD 1
Create and Detect DM at Accelerators.



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)

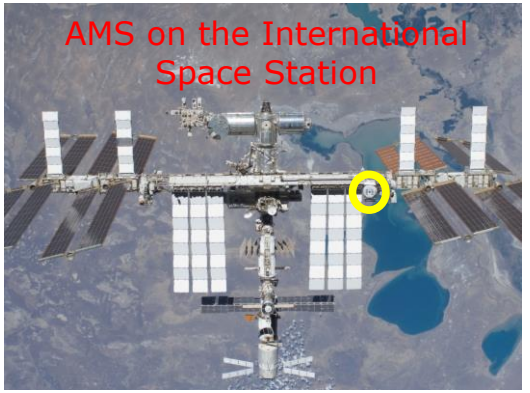
Annual status review of the DMNI concepts held June 2022.

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
- 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.

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

Black: HEP support ended

Green: funding continues

DOE joint efforts with NASA, NSF

		DOE Project	DOE Operations	oversight	status
DES	NSF/AST	DECam	yes	JOG	survey completed; data processing & analysis
DESI	NSF/AST	Instrument, data management, telescope upgrades	full support of the Mayall	MOU for Mayall	operating
Rubin, LSST, DESC	NSF/AST	LSSTCam	50/50 split	MOU; JOG	project, operations in planning
CMB-S4	NSF	yes	yes	JOG	DOE CD-0; in planning; agencies considering
SuperCDMS	NSF/PHY	yes	yes	JOG	fabrication completing 2023; operations 2024
SPT-3G	NSF	instrument upgrade	yes		
FGST/LAT	NASA/AST	LAT fabrication	yes	Int. Fin. Comm.	LAT Science Ops for 10 yrs; now critical efforts only
AMS	NASA ISS	yes	yes	MOU; meetings	support AMS PI and group
LuSEE-Night	NASA CLPS	yes	yes	MOU; meetings	fabrication started 2022
Planck	NASA/AST	no	no*	MOU; meetings	supported data processing at NERSC
HAWC	NSF	yes	yes	MOU; meetings	DOE support completed
VERITAS	NSF	yes	yes		DOE support completed
Pierre Auger	NSF	yes	yes		DOE support completed

SC Research Programs -- Funding Opportunity Announcements (FOA)

HEP University Research FOA; expected release in early FY 2023

- New Merit Criterion introduced starting in the FY 2022 review process: Quality and Efficacy of Recruitment and Mentoring Plan
- Proposed research reviews best if closely aligned with the DOE/HEP mission, its program, and P5 strategy
- Reviews best if there's close engagement within the experimental collaborations; priority to scientists with significant/leadership/major/key roles responsibilities

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

- training and research experiences to support historically underrepresented groups
- Proposals were due mid-August; review in the fall
- 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).

U.S. DEPARTMENT OF ENERGY | Office of Science

Response to AAAC, Astro2020 recommendations

AAAC Recommendations: Tracking Agency Responses to 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.

The agencies have started development of this document.

DEMOGRAPHICS: AAAC & Astro2020 - The Profession & its Societal Impacts

AAAC 5-1: 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.

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.

Note: There currently exists a living document where NASA, the NSF, and the DOE have shared and are updating processes regarding recommendation 5-1. This was presented to the AAAC in the June meeting.

DEMOGRAPHICS: AAAC & Astro2020 - The Profession & its Societal Impacts

PAMS == Portfolio Analysis And Management System

AAAC 7-6: 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.

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.

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.

- *When a person sets up their profile in PAMS, they're asked for their name and address, specialty and degree(s) and institution(s) – e.g. High Energy Physics, PhD, 1988, University X). They are also required to answer the demographic questions, but they still have the option to select "Do Not Wish to Provide" as a possible response.*

SC Notes:
Increasing project personnel data collection is something SC is working on, but there isn't a short-term solution.

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.

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.

AAAC 7-7 (Astro2020 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.

SC has added language to its FOA's to remind the community of **prohibition of harassment & discrimination** by awardees and recipient institutions.
→ DOE has a www site describing how to report discrimination or harassment. See link.

Most of the HEP Cosmic Frontier projects and collaborations have developed **Codes-of-Conduct** and have an **Ombudsperson**. This is a promising practice within the community.

Labs have also stated values about their environments and cultures. See here for SLAC's mission values of Excellence, Integrity, Collaboration, Respect, and Creativity.

The scope of DOE's scientific integrity policy covers the definition of scientific integrity that was established by OSTP in 2010, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/scientific-integrity-memo-12172010.pdf. This did not include the topic of harassment.

DOE last updated its scientific integrity policy in January 2017, which expanded the policy to DOE laboratory contract staff and put other measures in place. Link:
https://www.energy.gov/sites/default/files/2017/01/f34/DOE%20Scientific%20Integrity%20Policy%2001112017.PDF

AAAC 7-7 (Astro2020 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.

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, instances in which the policies were not followed or enforced, and identify effective solutions for strengthening scientific integrity in specific areas. DOE has been a member of this Task Force. The Task Force released its report in January 2022, *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 further 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 its scientific integrity policy.

The Profession & its Societal Impacts Recommendations - Relating to Diversity, Equity, Inclusion & Workforce Development

The DOE **Office of Science (SC)** is fully committed to fostering safe, diverse, equitable, and inclusive work, research, and funding environments that value mutual respect and personal integrity.
https://www.energy.gov/science/diversity-equity-inclusion

In 2018, SC Senior Management charged a SC Working Group to ▪ Assess what SC is currently doing to improve diversity, equity, and inclusion (DEI) in its awards management and related business processes. ▪ Identify opportunities for SC to advance DEI in its business practices and demonstrate that DEI is foundational to SC business practices.

See report to Nov. 2021 HEPAP by Dr. Julie Carruthers, head of DOE SC Office of Diversity, Inclusion & Research Integrity.
https://science.osti.gov/-/media/hep/hepap/pdf/202111/SC_DEI_Initiatives-Carruthers_HEPAP_202111.pdf

A lot of DEI-related efforts are in the works and will be rolled out in the coming months.

AAAC 4-1B (Astro2020 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.

AAAC 6-3 (Astro2020 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.

AAAC 6-4 (Astro2020 3-22): 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.

AAAC 6-2 (Astro2020 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.

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.

In FY 2022, SC is piloting the requirement to submit a ***Recruitment and Inclusion Plan*** as part of the proposal narrative for all applications submitted to the six FOAs for the Reaching a New Energy Sciences Workforce (RENEW) initiative. SC is planning to expand this type of requirement in FY 2023.

SC is incorporating **environmental justice language** into requests for information and FOA's providing educational opportunities for minority serving institutions and minority education institutions which has been shared in outreach events since January 2022.

SC **Early Career Program** continues to promote diversity of PI's & Institutions and supports over 80 PI's/year. The 2022 FOA strengthened review criteria consideration of promotion of diversity of PI's and Institutions.

In early FY 2023, SC will be announcing additional new DEI-related policies on extramural research programs.

HEP-specific efforts:

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

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

- 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

Available funds for these programs have been increasing!

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/

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

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

RENEW initiative

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.

→See Reaching a New Energy Sciences W... | U.S. DOE Office of Science(SC) (osti.gov)

The REACHING A NEW ENERGY SCIENCES WORKFORCE for HIGH ENERGY PHYSICS (HEP-RENEW) FOA ($4M) 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.

- The HEP FOA can be found **here**.
- Proposals were due August 15, 2022 at 11:59 PM ET and reviews and decisions are planned for the fall.

FAIR initiative

The FY 2023 President's Request includes $1M 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.

Investment in the Larger Ecosystem - DOE Efforts/Comments on Community Outreach, Engagement, and Inclusivity

AAAC 7-1 (Astro2020 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.

Our labs have active efforts on community outreach and workforce development, e.g.

- We have local efforts by labs and experiments, e.g. DESI participates in efforts at Kitt Peak
- The Sanford Underground Research Lab (SURF) in S. Dakota has an extensive outreach program, with a focus on the Lakota community. They regularly organize events and activities around the native heritage. e.g.: Sacred Circle Garden

Other efforts:

Fermilab Cultural Events
Public Events | Events at Fermilab (fnal.gov)

Oak Ridge
Community Engagement | ORNL

Pacific Northwest Cultural Resources
Cultural Resources | PNNL

AAAC: Recommendations on Development of New Technologies

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

- DOE realizes the importance of technology and instrumentation development and is working to ensure adequate funding is made available. The HEP FOA has a specific subprograms in Accelerator R&D, and Advanced Detector R&D. DOE labs have specific laboratory-directed R&D (LDRD) competitive programs to develop new technologies.

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.

- DOE realizes the importance of AI/ML across many areas of science and related fields. https://www.energy.gov/science/initiatives/artificial-intelligence-and-machine-learning
- HEP has recently hired a program manager in AI/ML and is committed to supporting AI/ML development in high energy physics and astrophysics. Proposals to the recent AI/ML FOA are currently in the review process.

AAAC: Recommendation on data archives

AAAC 10-9: The agencies should improve coordination among U.S. archive centers, including a plan for standardized pipeline development and data formats.

HEP recently funded a SciDAC-HEP (DOE program, Scientific Discovery through Advanced Computing) award that will create simulations of large galaxy catalogs with more accurate modeling and will make these publicly accessible for the next generation of astrophysics experiments.

The DOE is working with NASA and the AMS Collaboration to ensure the program's scientific data is stored in a publicly accessible archive, in a timely manner, in order to maximize the scientific return to the greater science community.

Most of the astrophysical survey data sets that are processed by our collaborations (e.g. DES, eBOSS, DESI) are being made publicly available.

AAAC Recommendations: Interagency Cooperation for 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.

Rubin and Euclid are discussing implementation strategies to support joint data products. Rubin, Roman and Euclid US leadership are working with key stakeholder institutions (incl. NOIRLab, SLAC, STScI, and IPAC) on the development of joint processing activities.

There is a Three Agency Group (TAG) that meets periodically to consider how to maximize the scientific synergies between these facilities. Efforts discussed have been sharing simulations, joint data processing, cross-project data analyses, and survey strategies.

Note that each individual observatory has a specific design and extensive planning for its primary survey strategy that follows that design and carries out the maximum science for the community. There are many considerations in developing the survey strategy, including considerations of overlapping areas from many other observatories and data sets.

AAAC Recommendations: Interagency Efforts and Cooperation on Climate and Energy Usage

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.

DOE is working within the guidance of the recently released Executive Order on Federal Sustainability. See: FACT SHEET: President Biden Signs Executive Order Catalyzing America's Clean Energy Economy Through Federal Sustainability - The White House.

Note there is extensive effort going on in DOE related to energy efficiency. See: EERE Initiatives and Projects | Department of Energy

1. education and public engagement

2. reducing emissions
   - Most of the HEP projects and experiments have greatly increased virtual meetings and conferences and off-site monitoring and operating of experiments over the last decade, and especially during the last few years.
   - DOE labs have taken initiative in investing in an increasing amount of power from green energy sources while increasing the efficiency of infrastructure.

AAAC: Recommendations Regarding Grant Funding

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

HEP is fully committed to support a balanced program of project construction and experimental operations, along with the necessary research efforts to prepare for and carry out the resulting data analyses. HEP community advice (e.g. from HEPAP) and input from reviews of research proposals and programs address the required funding and priorities such that the scientific yields of the program is maximized. We are working to increase research funding in the coming years.

AAAC: Recommendations Regarding Dual Anonymous Reviews

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.

Due to stage of data collection and analysis currently, there is no basis to determine whether double-blind proposal reviews for research applications will make a difference.
Further, it would require a regulations rule-making process to change SC's required merit review criteria.

Note that HEP's research grants support scientists that have roles on projects, experimental operations and data analysis, all on the same award. There may also be multiple faculty scientists on the award. This model looks at a PI's entire program and minimizes the number of different proposals and review processes a PI must go through.

Some DOE scientific user facilities are piloting double-blind peer reviews for proposals. This may prove to be fruitful for facilities in which a PI is given a certain allocation of time to carry out their experiment and is independent of the requirements of building or operating that facility.

U.S. DEPARTMENT OF
ENERGY | Office of Science

Planning for the Future

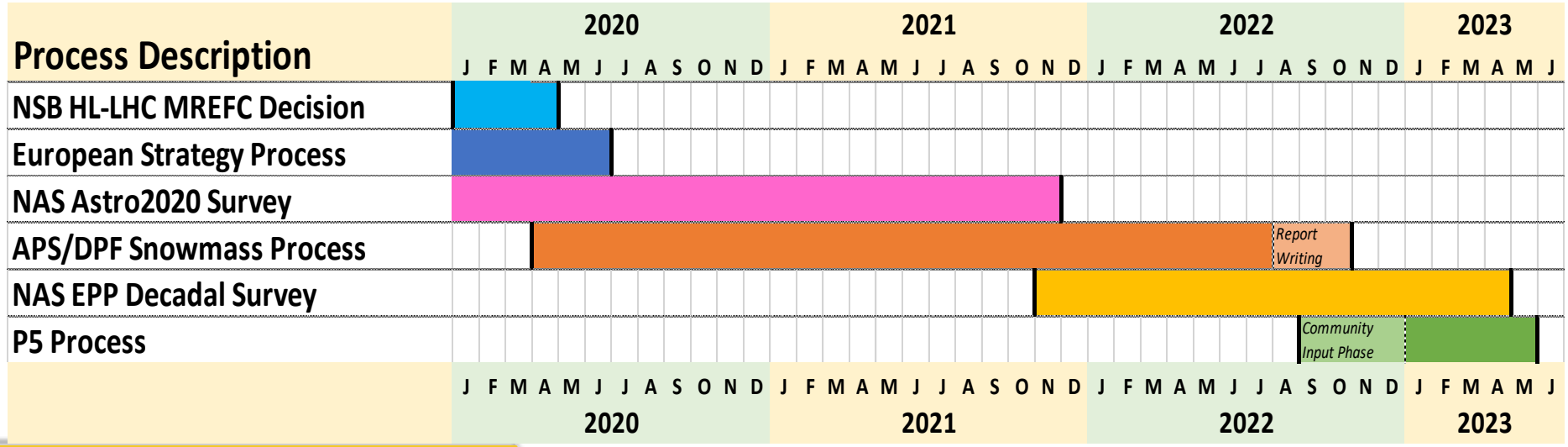
HEP - Strategic Planning Timeline

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 science questions & directions & options to address these for the coming decade.

National Academy of Sciences (NAS) Elementary Particle Physics (EPP) Decadal Survey will run concurrently with and complement the P5 process.

Next P5 process to lay out strategic plan begins fall 2022.
- Inputs - Astro2020, Snowmass, European strategy, Japanese planning etc.
- P5 report by ~ May 2023 will inform FY 2024 Congressional actions & FY 2025 U.S. budget formulation



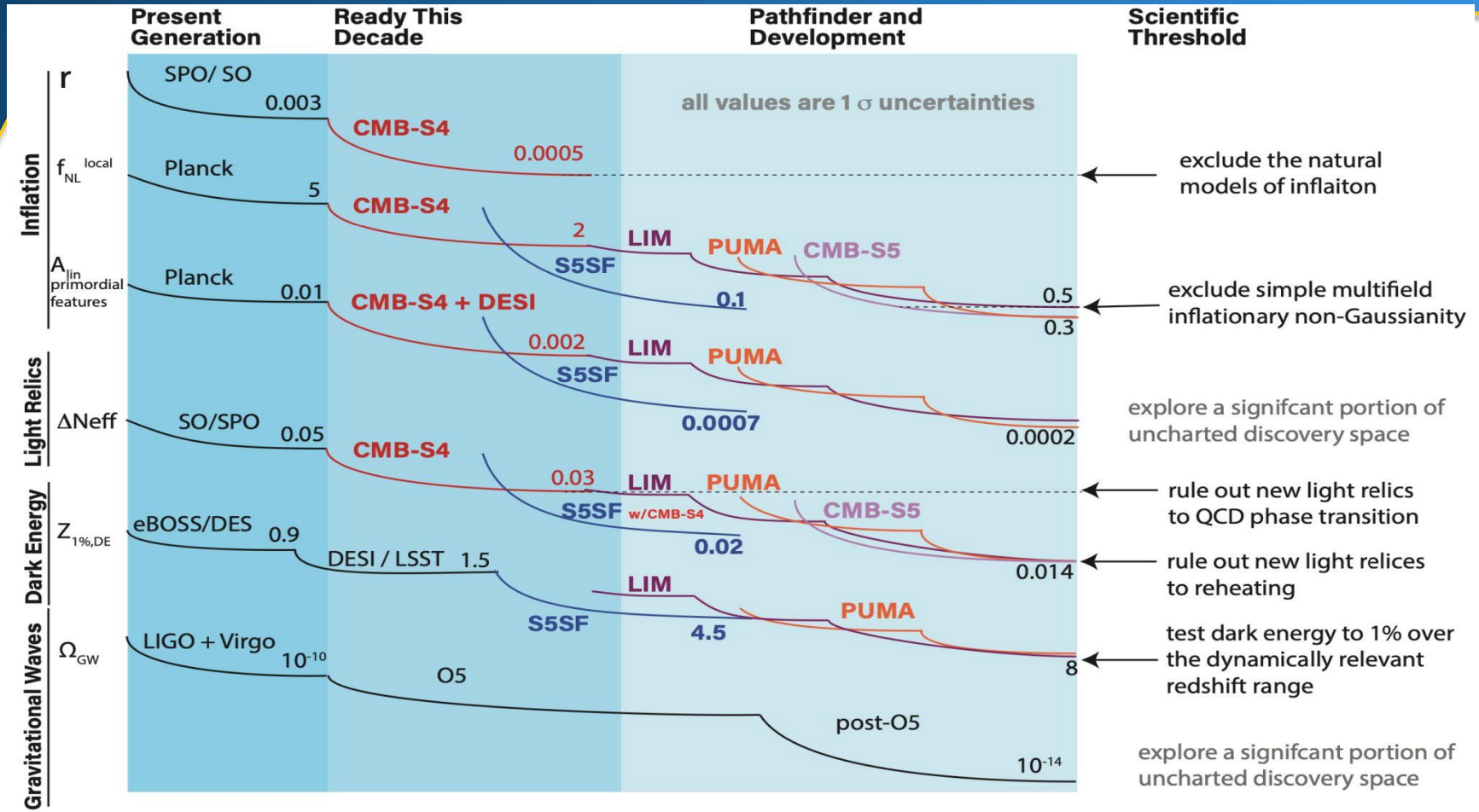
Snowmass workshop held at Univ of Washington, July 2022 (followed 2 years of community study)

→ **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

"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".

Snowmass Cosmic Frontier Summary - Cosmology

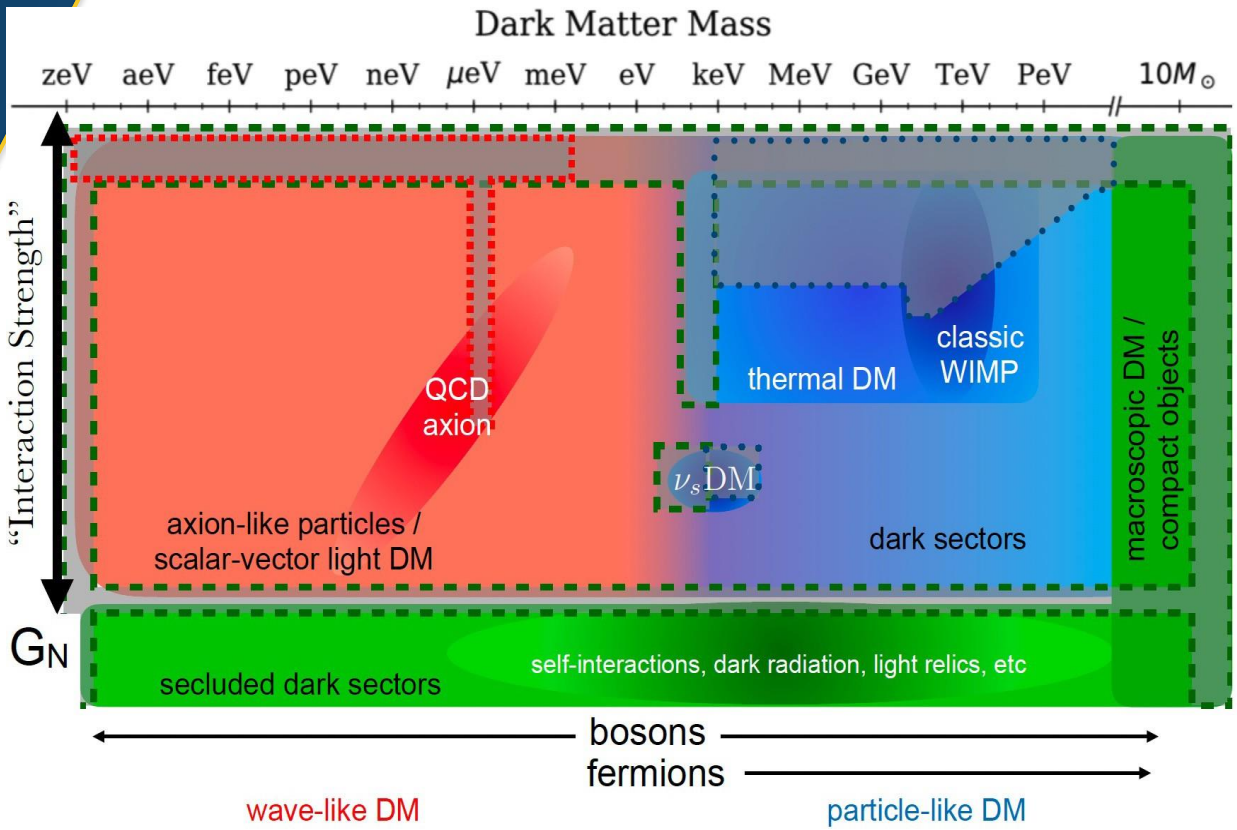
Search Wide, Aim High



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
Delve Deep, Search Wide



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.

→ **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

HEP Cosmic Frontier – Summary & Future Planning

➢ Program:

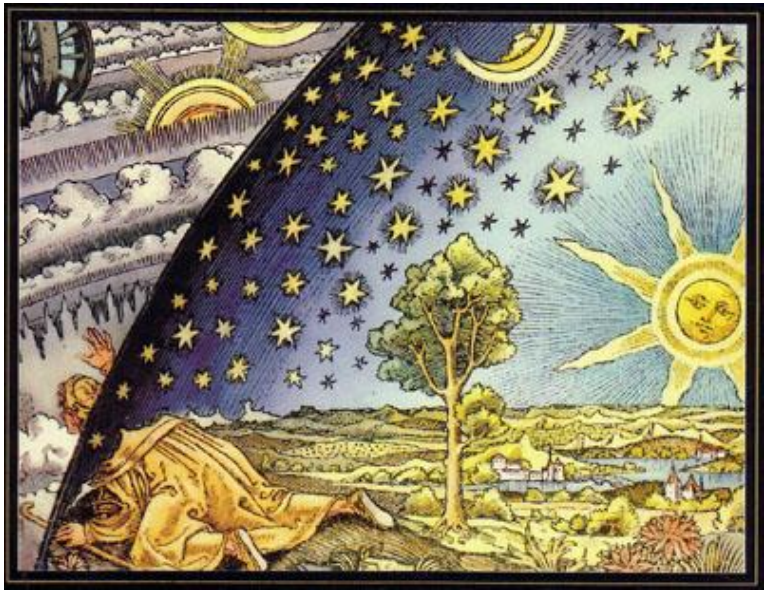
- DESI, LZ continue operations
- Rubin Observatory construction → commissioning; ops planning
- CMB-S4 planning continues

➢ Planning

- HEP continues to carry out the 2014 P5 strategic plan
- Snowmass workshop July 2022
- Starting the next P5 – inputs from Astro2020, Snowmass, Europe, Japan, etc.

➢ Budgets:

- Completed FY2022
- Initial Planning for FY2023
- Develop FY2024



U.S. DEPARTMENT OF
ENERGY

Office of
Science

CMB-S4 - details

- 2 large aperture (6m) in **Chile;** Deep & wide N_{eff} & Legacy Survey ~60% of sky

Project plan sent to Astro2020

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

- 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

2019-2020 – Plan to Astro2020

- 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 > x10 from all stage 3.

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

2020 – LBNL chosen as DOE's lead lab

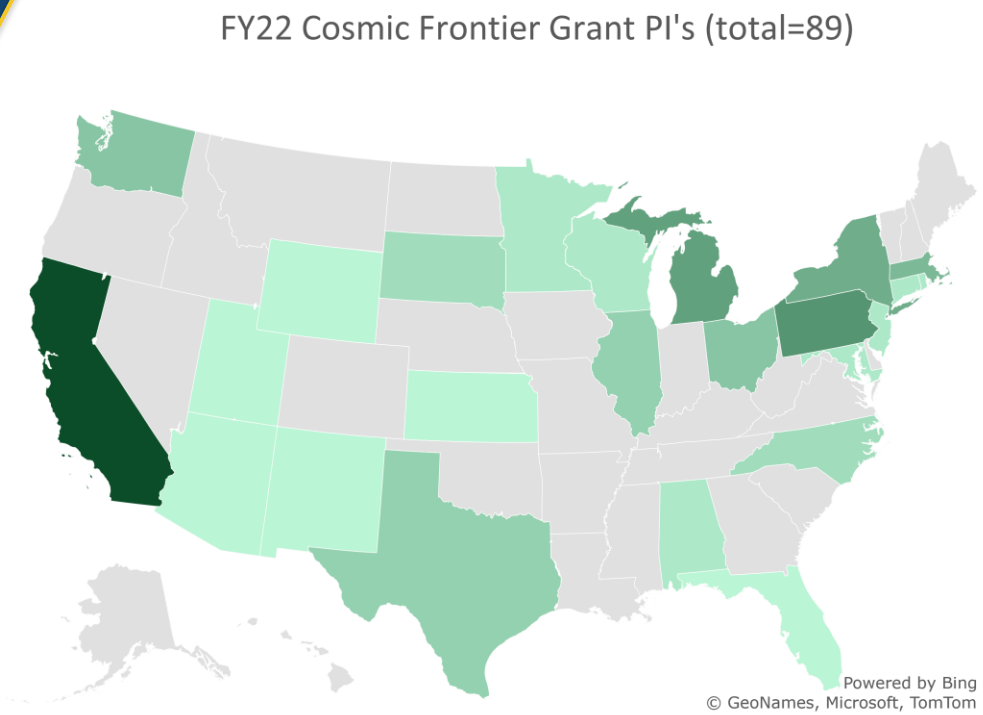
FY2021 - Congress approved DOE **Major Item of Equipment "project start"**

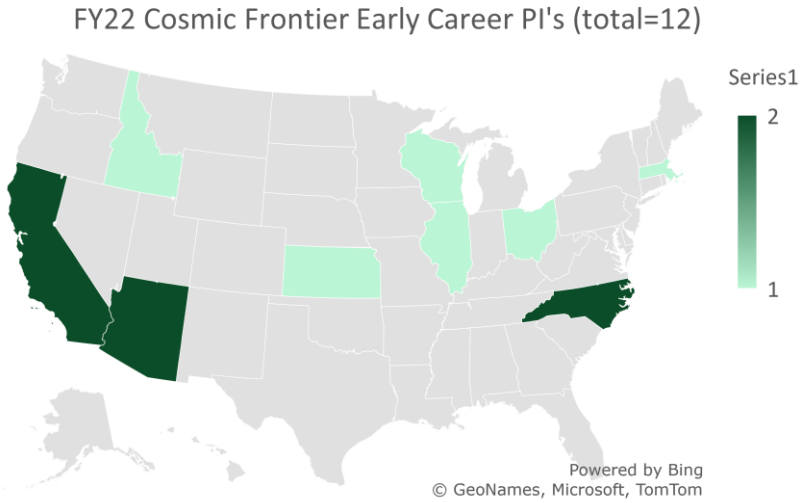
Nov. 2021 - **Astro2020 recommended DOE/NSF partnership** on CMB-S4

July 2022 – new Project Director on board -- Jim Strait

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

FY2022 Cosmic Frontier Grant Faculty & Research Scientists





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

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.

85

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.