DOE Office of Science (SC), Office of High Energy Physics (HEP) Cosmic Frontier report

to the

Astronomy & Astrophysics Advisory Committee January 26, 2023

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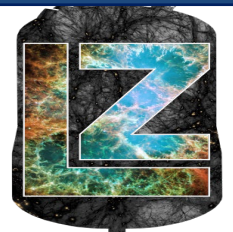
U.S. DEPARTMENT OF ENERGY | Office of Science

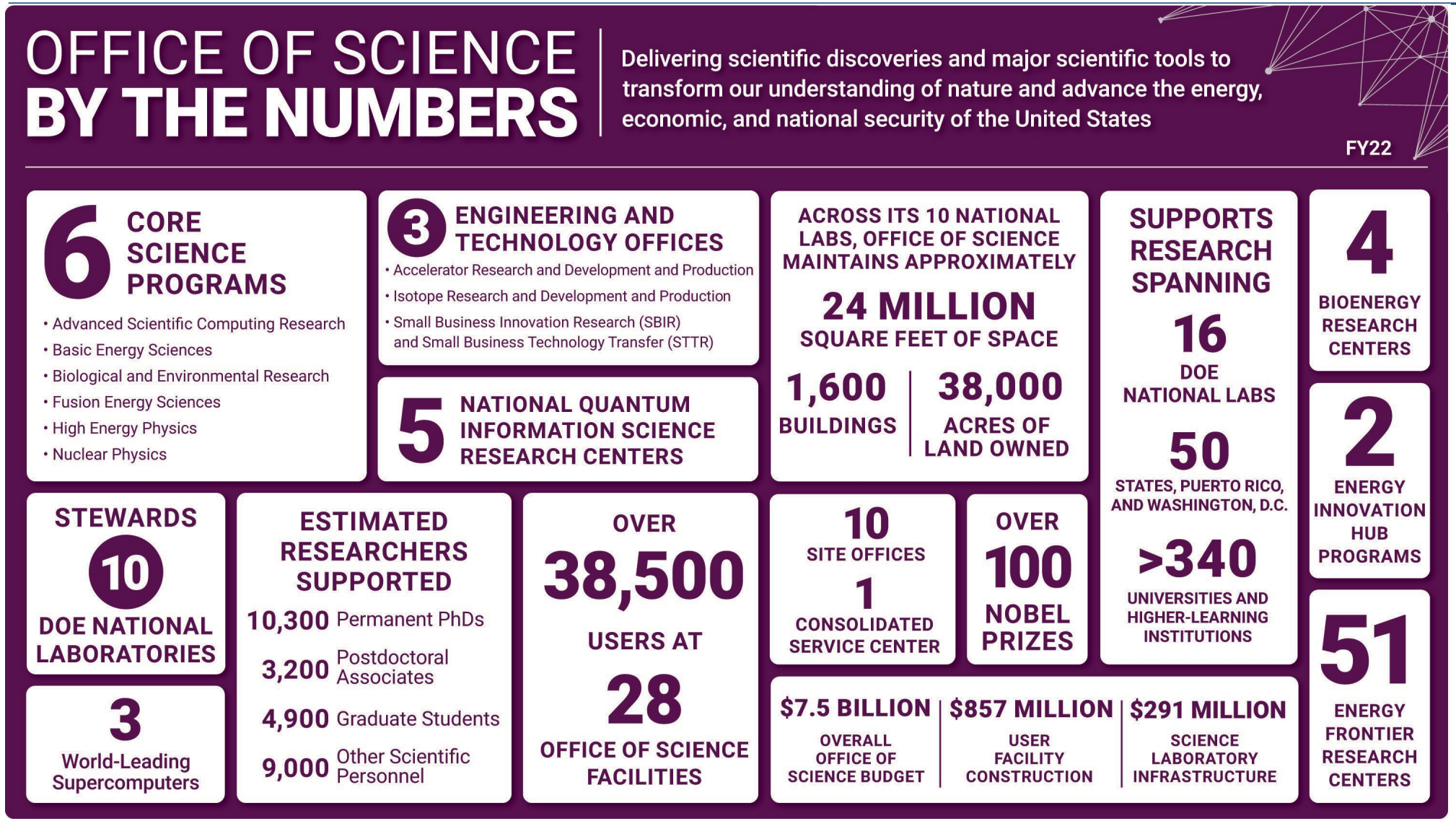
VERA C. RUBIN OBSERVATORY

ADMX AXION DARK MATTER EXPERIMENT



SUPER CDMS Cryogenic Dark Matter Search

Office of Science by the Numbers (2022)



HEP at a Glance (FY2023 Enacted Budget $1.166B)

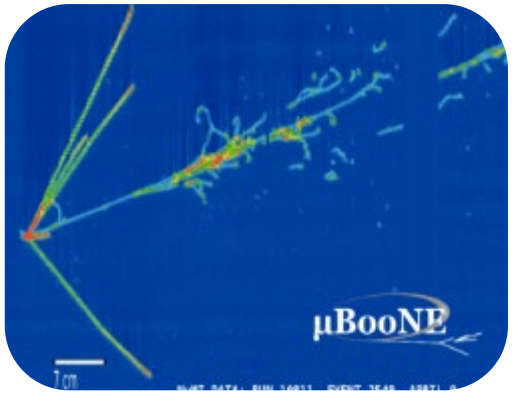
Largest Supporter (**~85%**) of Particle Physics in the U.S.

Funding at **>160** Institutions, including **12** DOE Labs

Over **1,175** Ph.D. Scientists and **525** Grad Students Supported

Over **2,325** Users at **2** SC Scientific Facilities

~30% of Research to Universities



Research:

39.8%, $464.4M

Facility Operations:

29.7%, $346.6M

Projects:

30.4%, $355M

OUTLINE

Report on the HEP Cosmic Frontier Program

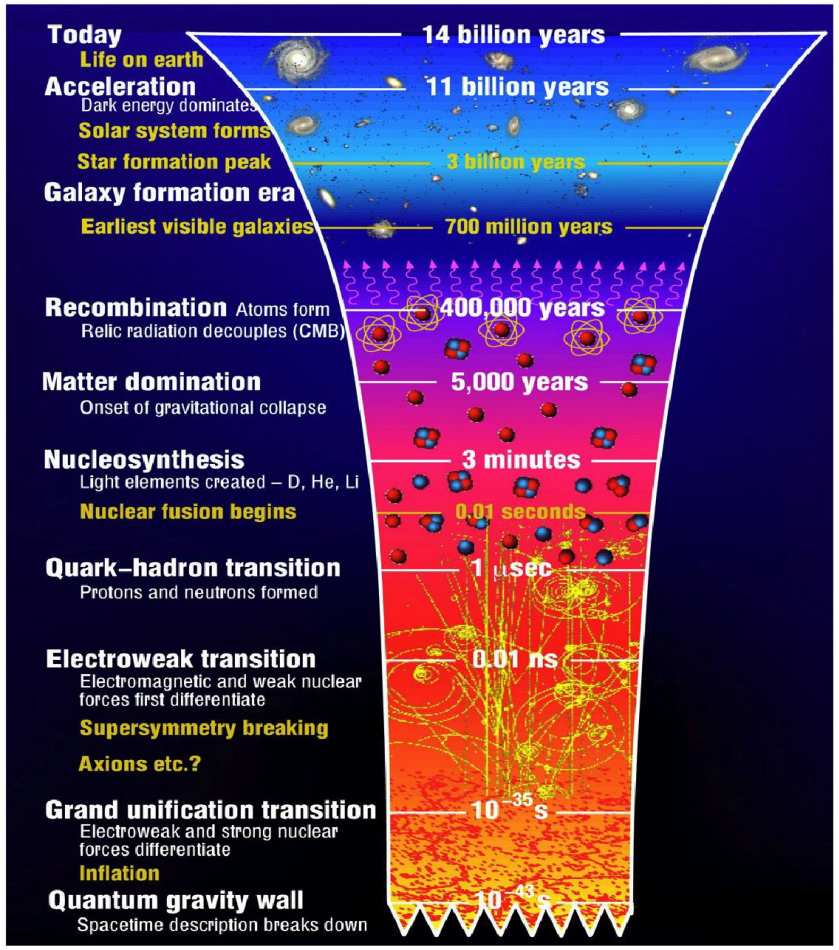
- Cosmic Frontier Program Status
- Budget
- (Other) Astro2020 recommendations
- Planning for the Future

Cosmic Frontier – Current Program

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 – Partnerships

HEP forms partnerships to help deliver our mission.

➔In Cosmic Frontier, we have significant partnerships with w/NSF (PHY, AST, OPP) NASA (AST, ISS, CLPS), and International (France, UK, etc).

US Agency MOU's:

Oct. 2022 → DOE and NASA signed a high-level Memorandum of Understanding (MOU) to continue partnerships - in Cosmic Frontier this led to **partnership** on Lunar Surface Electromagnetics Experiment at Night (LuSEE-Night)

Jan. 25, 2023 → DOE and the NSF signed a MOU that will continue a longstanding collaboration on scientific and engineering research and enable increased partnership to address the most important challenges of the 21st century.

> "This MOU will allow us to strengthen the partnership between DOE and NSF. It will expand the capabilities of each and allow us to continue to grow U.S. leadership in science and technology," said Asmeret Asefaw Berhe, DOE's director of the Office of Science. "These kinds of partnerships are key to meeting current and future scientific challenges."

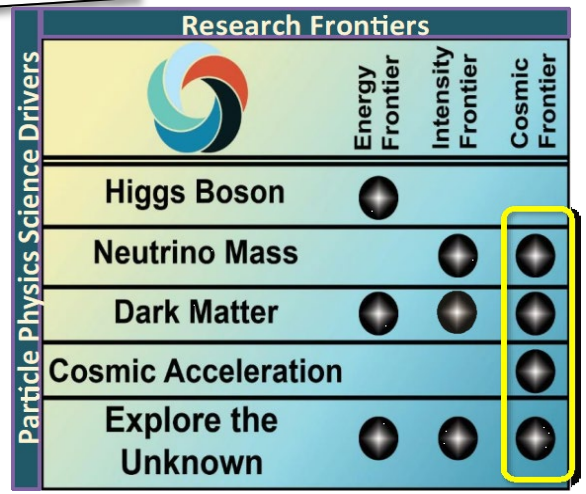
https://beta.nsf.gov/news/nsf-and-doe-announce-expanded-collaboration

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; Maintain a portfolio of small projects



- **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 Ages**: **LuSEE-Night** pathfinder
- **Dark Matter:** suite of "generation 2" direct detection experiments to detect DM particles; Dark Matter New Initiatives (DMNI) concept development for small projects
- **Neutrino Mass** – survey experiments provide information on neutrino properties
- **Explore the Unknown** – always of interest!

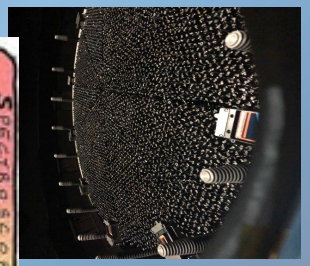
Astro2020 recommended:

- **DOE/NSF partnership on CMB-S4**
- **Dark Ages** identified as Discovery Area → cosmological probe with great potential
- Efforts on diversity, equity, inclusion, demographics, data, etc. (joint with NSF & NASA)

HEP Cosmic Frontier: Cosmic Acceleration

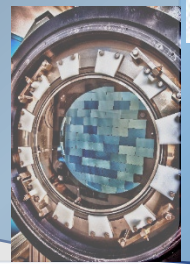
Dark Energy

DARK ENERGY SURVEY

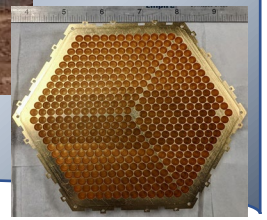


VERA C. RUBIN OBSERVATORY

Pinhole camera 3.2Gpixel image of Vera C. Rubin



CMB



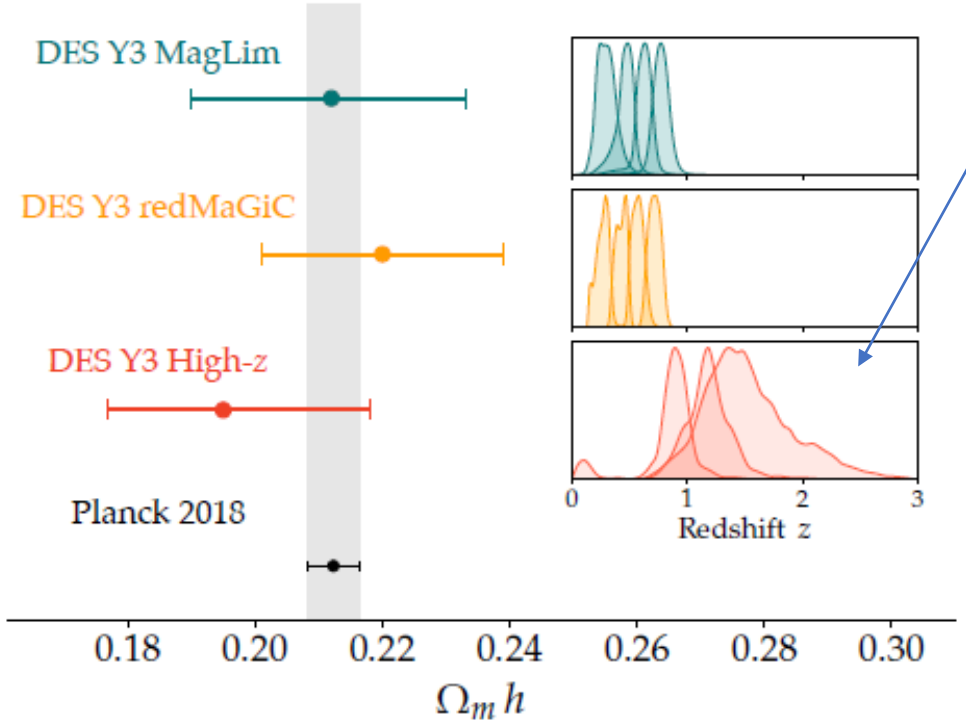
Dark Ages

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;* >416 publications; >100 PhD's



A recent result:

- Year 3 High-z galaxy-galaxy correlation cosmology paper submitted.
- It greatly extends the redshift range compared to the Y3 Key Project results (which were called MagLim and redMaGiC).
- Plot shows constraints on W_M h for the three lens samples https://arxiv.org/abs/2211.16593

- **DES Collaboration Meeting** in Portsmouth UK was very well-attended (90 in-person + 45 remote attendees).
- It focused on producing final cosmology results for all Key Projects.

Coming very soon:

- Cosmology from 1650 photometrically-typed SNIa that have spectroscopic redshifts of host galaxies. Better than all previous SN cosmology results combined
- Cosmology from Y6 BAO measurement
- And the combination!

Dark Energy Spectroscopic Instrument (DESI) Experiment

DOE's DESI is in its 2nd year of operations (since May 2022).

- 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).

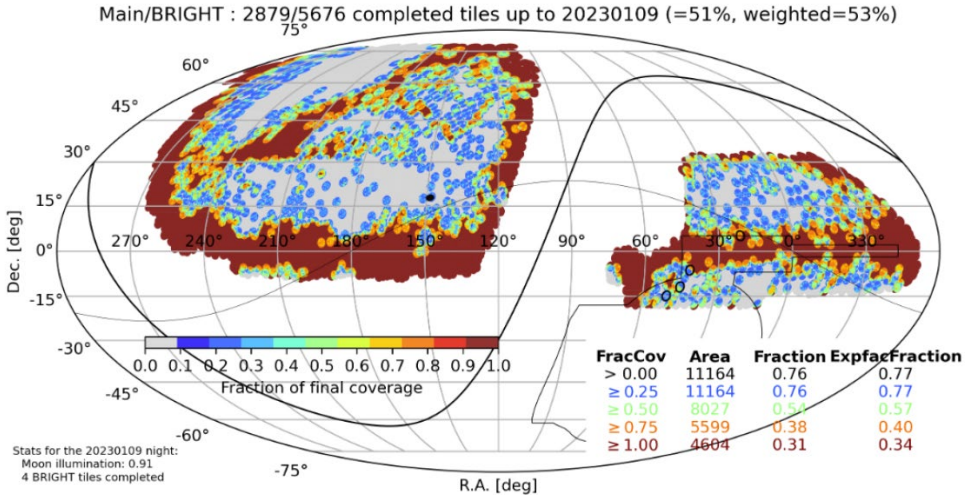
Operations: DOE provides full support for NSF's Mayall telescope.

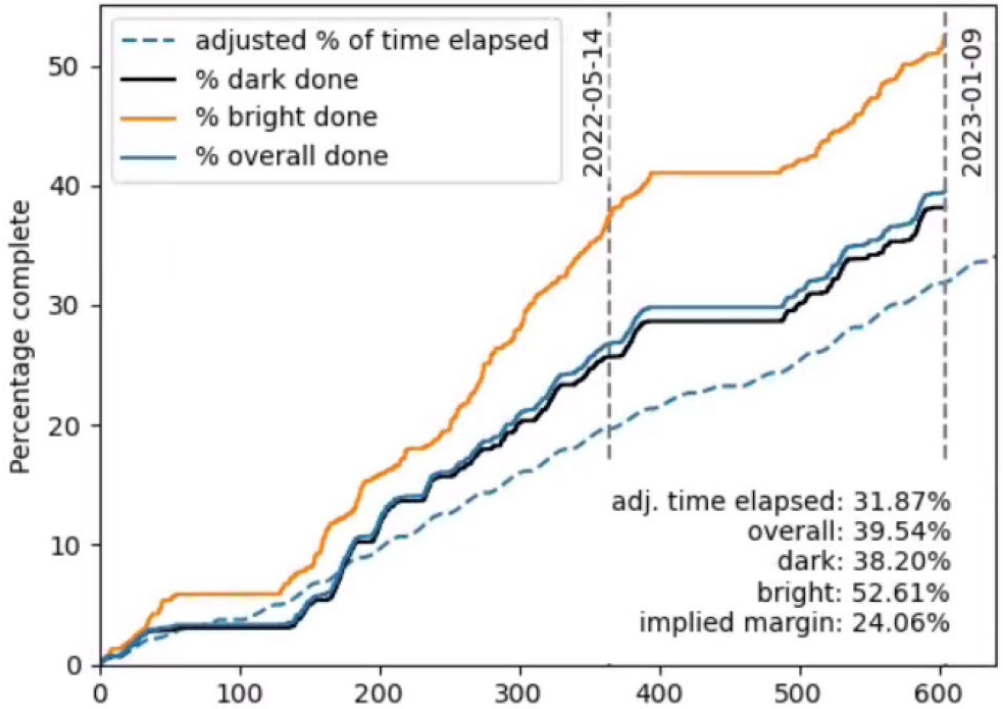
Bright-time survey > 50% complete

Dark-time survey almost 40% complete

Through early January 2023 – DESI is running ahead of schedule

Successful data-taking: ~ 17 Million extra-galactic redshifts recorded (more than all other surveys combined)

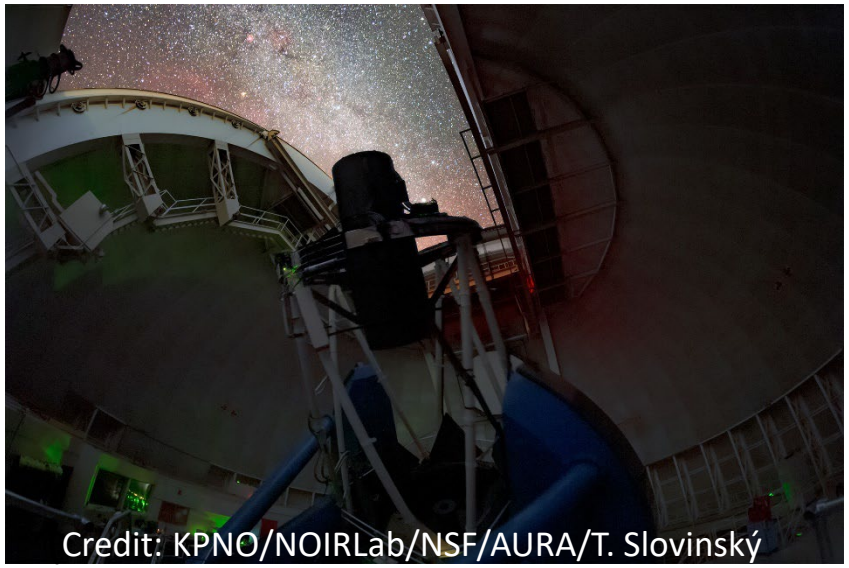




DESI - status

2022 June Contreras Fire

- NEWS ➔ DESI is back on-sky as of Sept. 16
- As of now, main-line power and fiber internet are restored
- Road access to KPNO continues to be restricted.
- Still assessing whether the Mayall aluminum coating may have a loss of reflectivity due to fire-borne particulates.


Credit: KPNO/NOIRLab/NSF/AURA/T. Slovinský

Collaboration efforts:

Seminal paper on Instrumentation - published

37 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

- Internal release of first year data is imminent

Public data release of SV data plus 2 months of main survey data coming up soon.

Vera C. Rubin Observatory

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

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

→Project completion planned for end of 2024.

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 the 9-CCD Commissioning Camera (ComCam); data quality and verification studies

News – LSST Camera:

- Vincent Riot LSST Camera Project Manager since 2016, leaving LSST & Rubin
- Martin Nordby, currently LSST Camera System Engineer & Head Mechanical Engineer, will assume the position of Project Manager
- Travis Lange, currently a Mechanical Engineer on the LSST Camera, will become Deputy Project Manager

DOE people at Rubin, Sept 2022

Facility Operations

Pre-Operations activities have started; Full operations planning continues; Joint DOE/NSF review is scheduled for late February

Camera Integration, Test & Commissioning – at SLAC

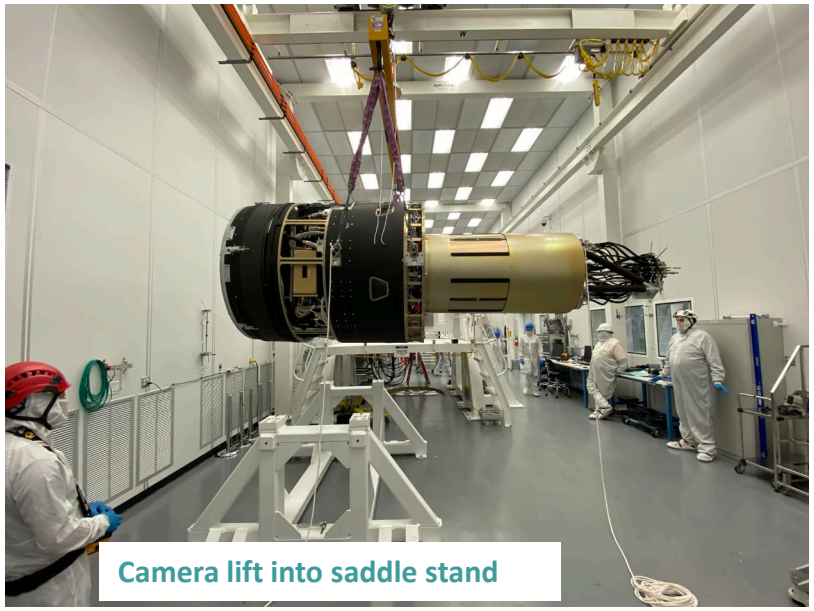
Camera now fully assembled; See video of Filter operation
https://drive.google.com/file/d/19uQ14LRCP3RvCDzjgKjOAkVETWtAp_YC/view?usp=share_link)

Modifications for new Cold Refrigeration system are complete
- Camera moved to enable refrigeration modification

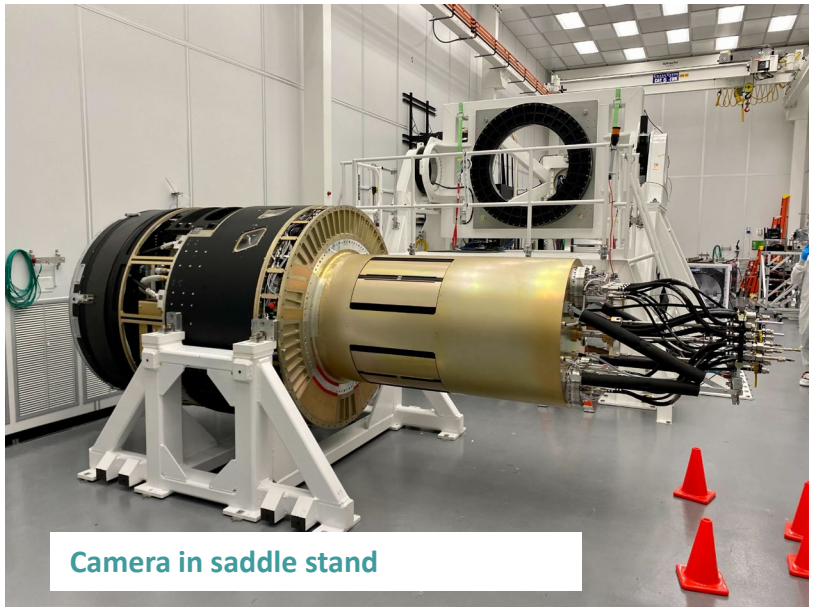
- Preparing for final Verification testing at SLAC this spring
- Current schedule has shipment to Chile in May/June
- ComCam mounted on Telescope, images collected to exercise observatory systemswith it to date)

Refrigeration system modification to install pumped coolant manifold

Camera lift out of integration stand



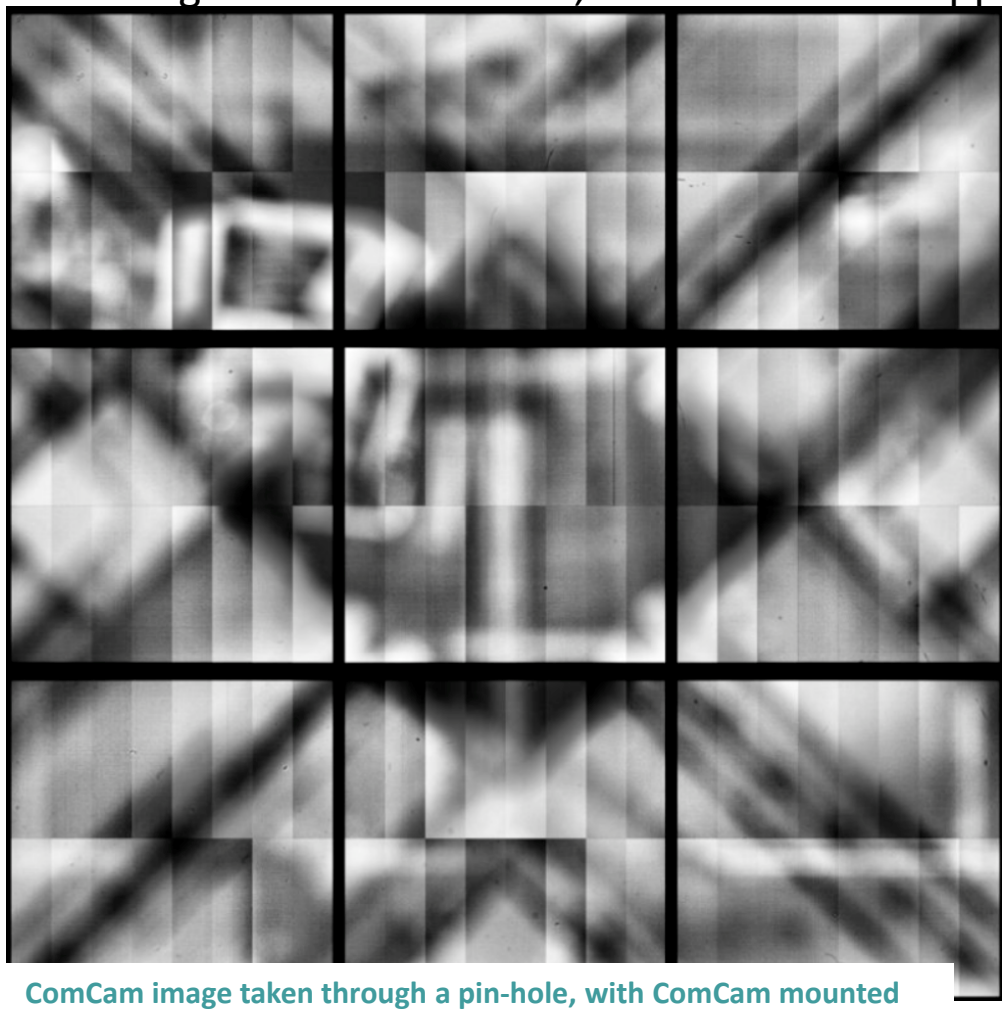
Camera lift into saddle stand



Camera in saddle stand

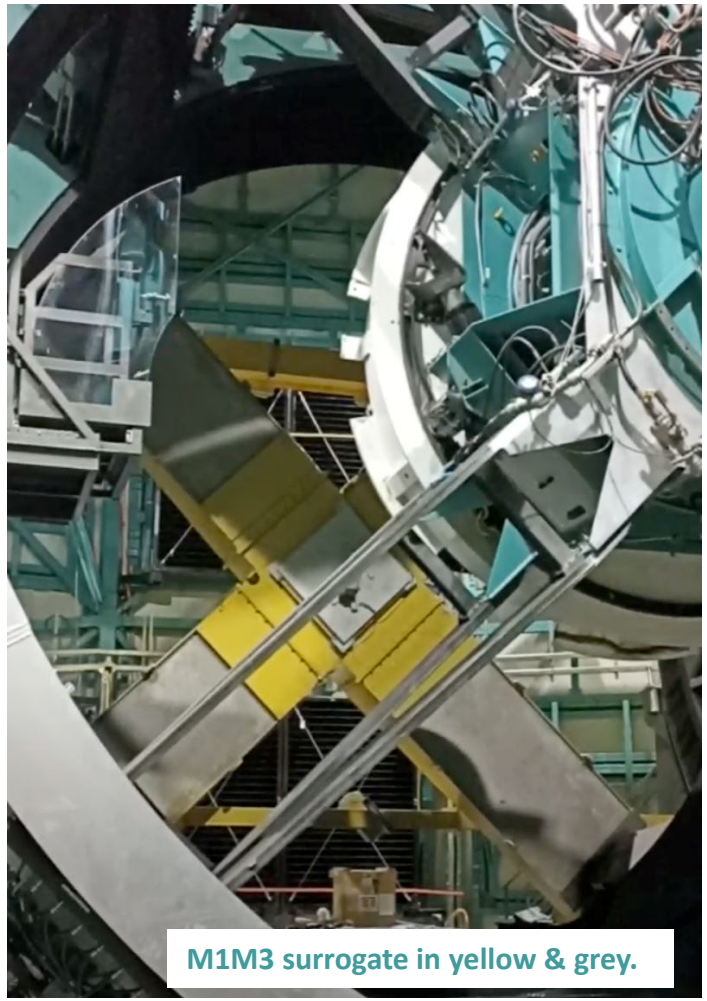
Commissioning in Chile

ComCam is mounted on the Telescope; being used to exercise observatory systems. The commissioning team is working on the Star Tracker, includes 3 DOE-supported people from BNL, Duke, Santa Cruz.



ComCam image taken through a pin-hole, with ComCam mounted on the Telescope. Structures are the M1M3 surrogate.

ComCam and the white M2 surrogate.

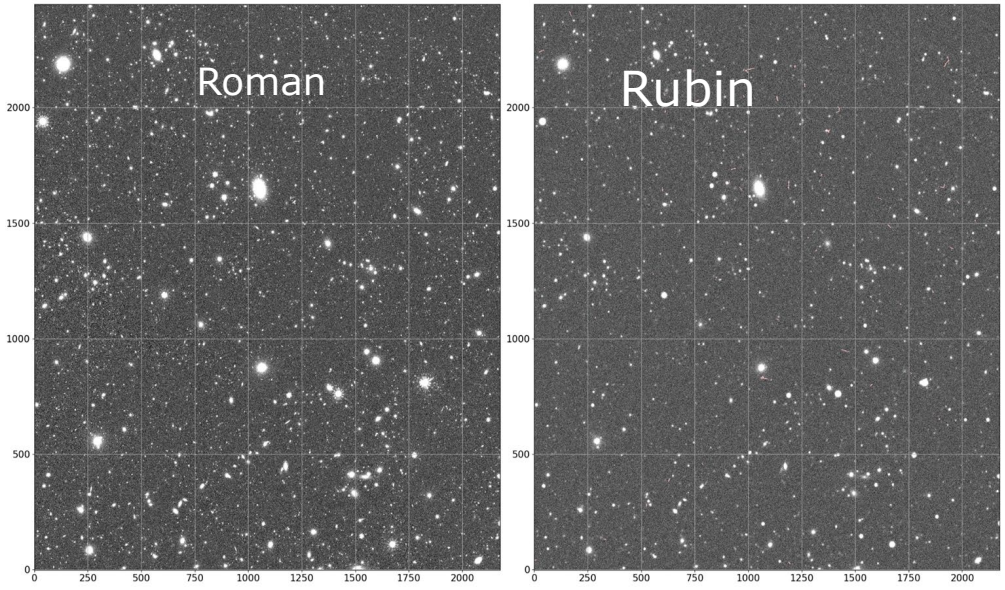


M1M3 surrogate in yellow & grey.

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.
- Fruitful collaboration between **DESC and Rubin** on many fronts, including simulations, image coaddition and deblending, and commissioning



Simulations of the same patch of sky as seen by NASA's Roman mission and Rubin, based on DESC DC2, arXiv:2209.06829, Image credit: Sanchez, Troxel

Study of the nature of Dark Energy via complementary probes: SNe, Strong and weak Lensing, Large-scale Structure, 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 ~ 1150 members;

- 238 full members; from 20+ countries
- Since 2018, 52 journal publications + 16 papers under review

Astro2020 Science Theme:
New Messengers and New Physics ➔ CMB-S4

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

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_{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

CMB-S4 goal: cross critical science thresholds, including definitive tests of Inflation

Early FY2022 – Project's expectations for Antarctic infrastructure & logistics (AI&L) isn't sufficient for the original concept.

➔At agencies' request, Project begins development of alternative concept(s) that fit within I&L constraints AND still delivers the full science goals.

July 2022 – new, permanent DOE Project Director on board – Dr. Jim Strait (formerly FNAL, w/extensive project experience)

CMB-S4 Analysis of Alternatives → Path Forward

Dec. 2022 – Project briefed agencies on the results of their Analysis of Alternatives study to identify a configuration that reduces the required logistics support at the South Pole and achieves all of its science goals.

The CMB-S4 Project has selected the following configuration (Alternative 1), which will be developed into a complete conceptual design for an NSF CDR and a DOE CD-1 Review. Development will continue to provide the best design within constraints.

- South Pole: 3 Small-Aperture Telescopes (9 optics tubes) and 1 Large-Aperture Telescope
- Chile: 2 Large Aperture Telescopes
- Renewable energy and energy storage on an independent grid to supplement the power available to CMB-S4 at the South Pole

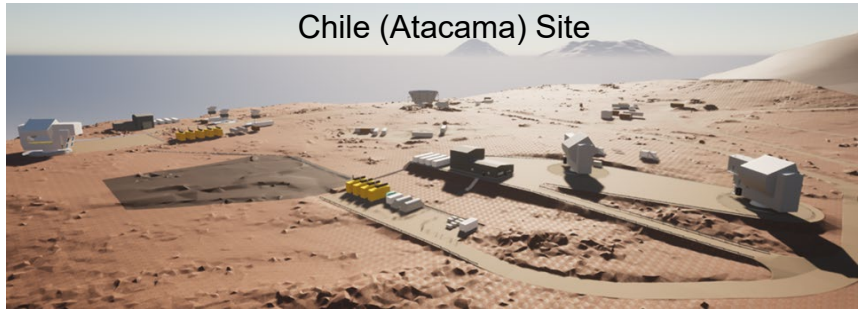
This configuration is selected because:

- **It i**s scientifically superior and has lowest risk scientific risk
- **It requires the least observing time to reach the science goals**
- Its construction and lifecycle costs are the lowest

Alternative	South Pole Scope	Chile (Atacama) Scope
Previous Project Baseline	6 Small-Aperture Telescopes 1 Large-Aperture Telescope	2 Large-Aperture Telescopes
Alternative 1: SATs & LAT at South Pole	3 Small-Aperture Telescopes 1 Large-Aperture Telescope	2 Large-Aperture Telescopes
Alternative 2: Only SATs at South Pole	4 Small-Aperture Telescopes	3 to 5 Large-Aperture Telescopes
Alternative 3: Nothing at South Pole		≥9 Small-Aperture Telescopes ≥3 Large-Aperture Telescopes

South Pole Site

Chile (Atacama) Site



CMB-S4 status, planning

DOE embraces the Astro2020 recommendation and is working with NSF divisions 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

DOE/HEP is supportive of the Project moving forward on developing Alternative 1

- ✓ **assessed as meeting science goals, in particular having precision and systematic error checks needed for Inflation**
- ✓ **cost effective**
- ✓ **close to Project's estimate of I&L availability**

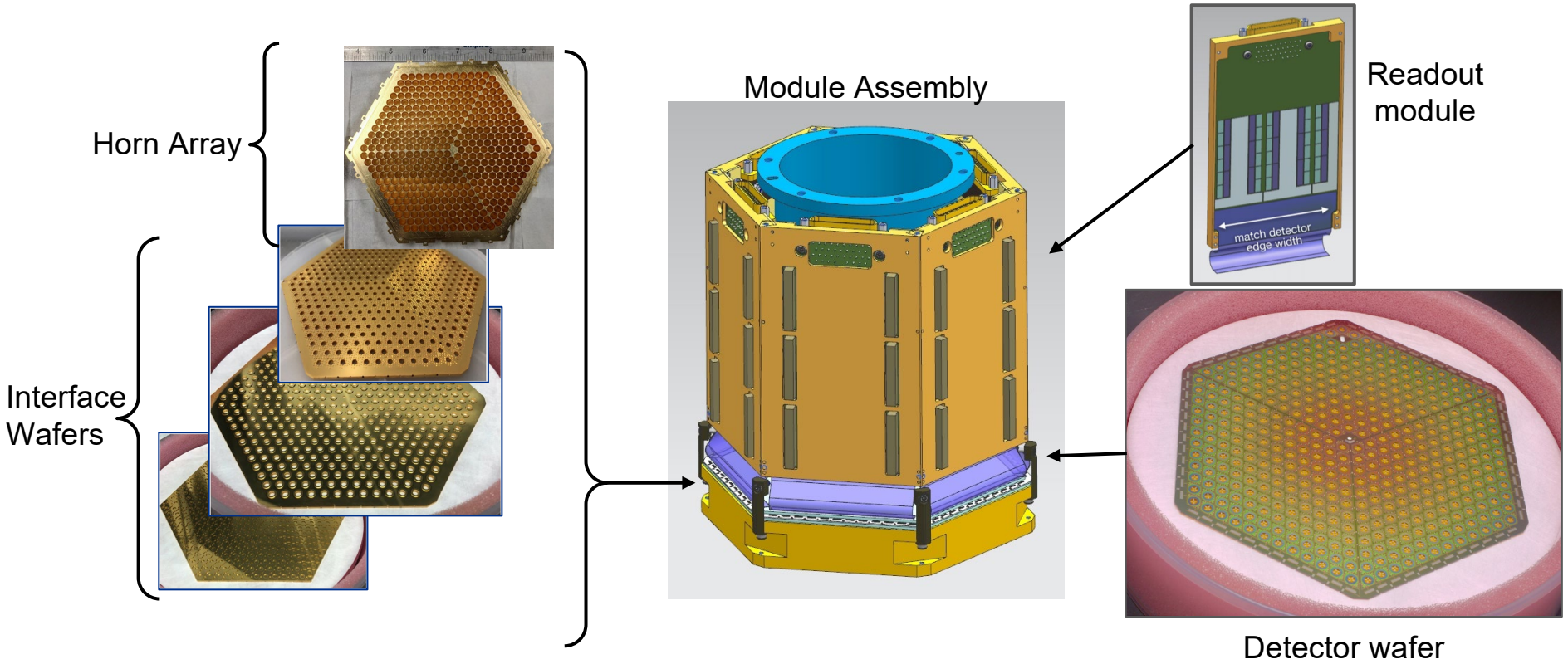
DOE Funding:

- FY22 $8M + FY22 IRA $10M
- FY23 $1M
- Expect to be able to provide funds sufficient to move them forward to a conceptual design and Critical Decision 1 (CD-1) review by end of FY24.

CMB-S4 Development continues

DOE/HEP labs have done CMB technology R&D and instrumentation for decades.
- sensor and readout electronics technologies, packing, testing 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.



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

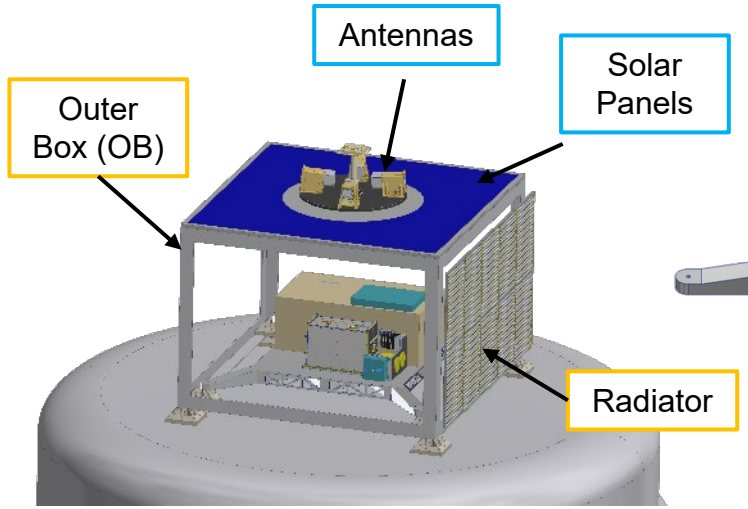
The **Panel on Cosmology** identified as a **Discovery Area** using the **Dark Ages as a cosmological probe with great potential.**
"The panel sees 21 cm and molecular line intensity mapping of the Dark Ages and reionization era as both the discovery area for the next decade and as the likely future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

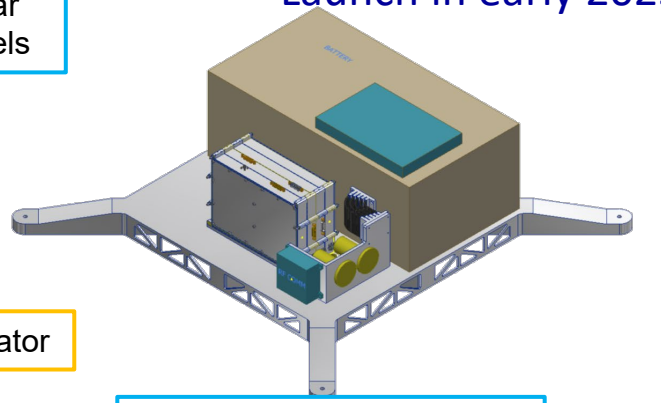
➔**The Dark Ages signal has never been observed. A first discovery would be a significant step in understanding this phase after CMB and when stars & galaxies form.**

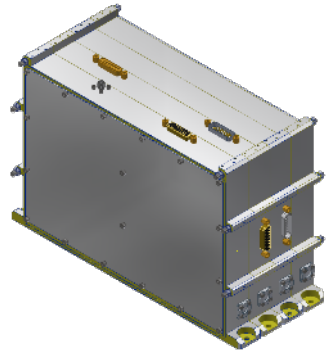
- LuSEE-Night is a pathfinder mission to place the most sensitive constraints to date on the **Dark Ages signal**
- Capability to measure the radio environment and observe the long-wavelength radio signal through the lunar night (launch early 2025).

UCB/SSL is overall lead (for **LuSEE-Night** & **LuSEE-Light)**
DOE LuSEE-Night Project started in FY 2022 (all funds provided)

- deliver to the UCB/SSL project office by early 2024
- Launch in early 2025 by NASA's Commercial Lunar Payload Service.




Inner Equipment Assembly (IEA)


Main Electronics Crate (MEC)

HEP Cosmic Frontier: Dark Matter

Dark Matter Generation 3

ADMX AXION DARK MATTER EXPERIMENT

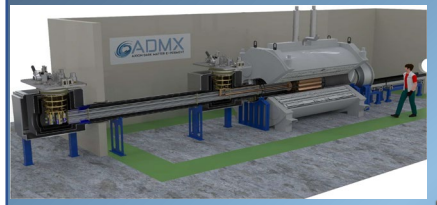
Axion search .6-2MHz at U.Wash; started 2017

WIMP search at SURF (SD); started FY22

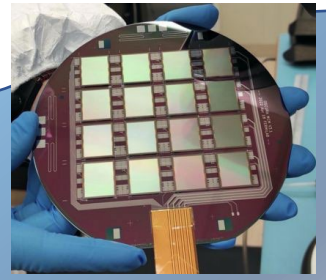
SUPER CDMS Cryogenic Dark Matter Search

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

Dark Matter New Initiatives



Axion search 2-4 GHz



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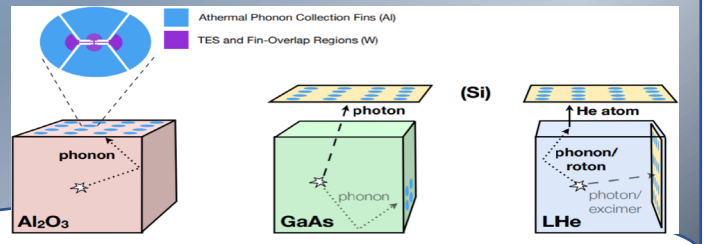


The National Energy Research Scientific Computing Center (NERSC)

NERSC is the primary scientific computing facility for the DOE Office of Science.
- HEP allocations follow the programmatic priorities established by P5.

HEP SubProgram	AY22 CPU	AY23 CPU	AY23 GPU
Energy	1,159k	710k	127k
Theory	1,090k	430k	430k
Cosmic	906k	878k	293k
GARD	354k	242k	59k
Intensity	222k	167k	152k
Comp+QIS+ Other	65k	151k	51k
Total	**3,795k**	**2,487k**	**1,112k**

Cosmic Frontier allocations include the efforts for LZ, DES, DESI and DESC. The majority of Cosmic Frontier proposals received their requested allocations in full.

Budget News

Budget Notes

Office of Science

Late FY2022 → $1.55B boost through the Inflation Reduction Act to advance portfolio of major projects

FY2023 → Budget increased 8% to $8.1B (significantly exceeds $7.8B request)

HEP

Late FY2022 → $303.6M boost through the Inflation Reduction Act to advance portfolio of major projects

FY2023 → Budget increased 8.2% to $1.166B (significantly exceeds $1.121B request)

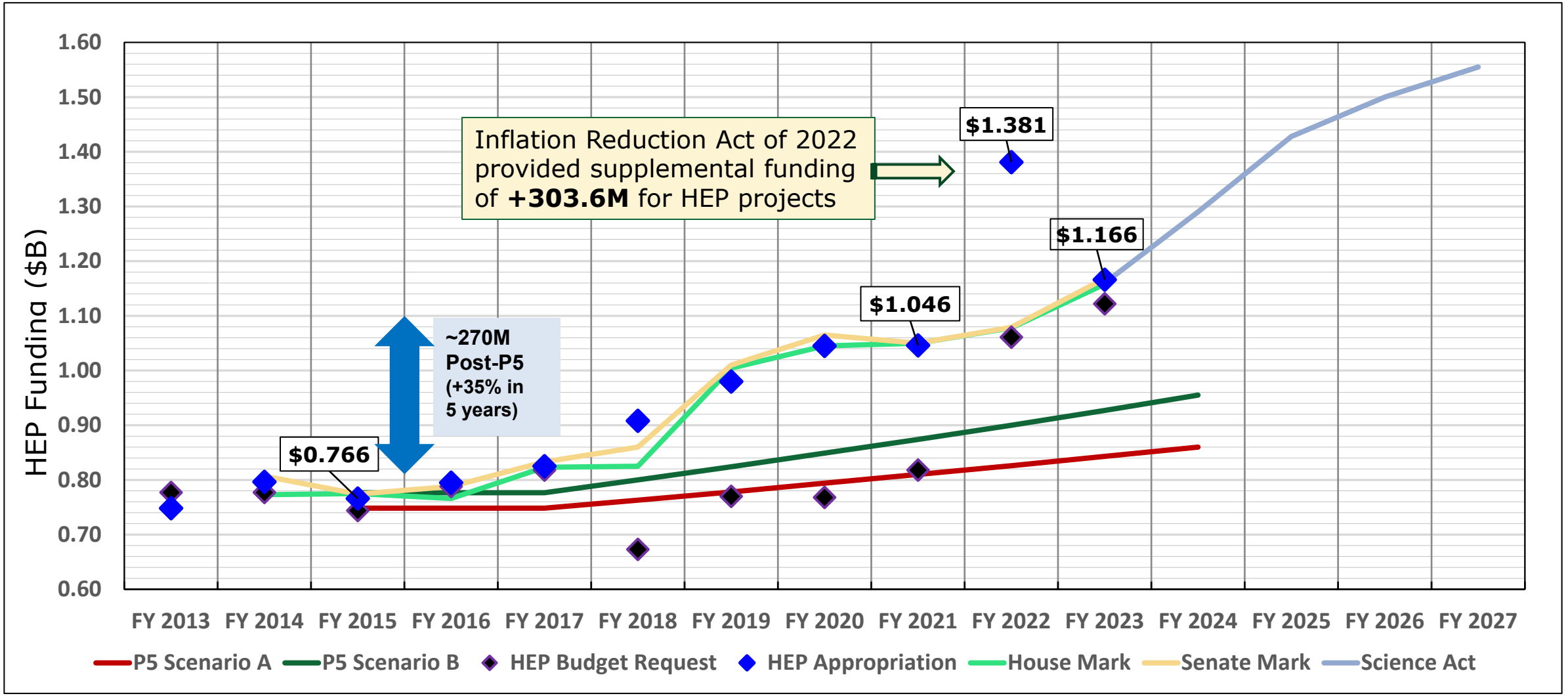
- **U.S. Congress continues to show strong support for executing the P5 strategy, and for accelerating the pace of projects**

HEP Funding Category ($K)	FY 2020 Actual	FY 2021 Actual	FY2022 Enacted	FY2023 Request	FY2023 Enacted
Research	389,646	408,163	416,605	418,646	464,373
Facilities, Exp. Operations	317,310	304,337	290,395	313,374	346,627
Projects	338,044	333,500	371,000	390,000	355,000
Total	**1,045,000**	**1,046,000**	**1,078,000**	**1,122,020**	**1,166,000**

Congressional direction at the SC level propagated down to HEP:
AI/ML $38.5M, QIS & QIS Center $48.9M, RENEW/FAIR $9.9M

July 2022: The CHIPS and Science Act 2022 is an Authorization bill (DOE ~ $67B over 5 years), a prerequisite under House and Senate rules for the Congress to appropriate budget authority for programs.

HEP Budget History 2013 to Present



Initiatives (HEP budget)

HEP budget (in $K)	FY20 Enacted	FY21 Enacted	FY22 Enacted	FY23 Enacted
BE: Reaching a New Energy Sciences Workforce (RENEW)	0.0	0.0	4.0	8.0
BE: Funding for Accelerated, Inclusive Research (FAIR)				1.9
BE: EPSCOR				1.9
Artificial Intelligence & Machine Learning (AI/ML)	15.0	33.5	35.8	38.5
Traineeships (GARD, Computing, Detector R&D)	4.0	4.0	5.0	6.0
Advanced Computing (was Integrated Computational & Data Infrastructure)			4.1	5.0
Microelectronics		5.0	7.0	6.7
Quantum Information Science (QIS)	23.5	20.1	26.6	24.5
Quantum Center	15.0	25.0	25.0	24.4
Accelerate [Accformerlyelerate Innovations in Emerging Technologies]				3.8
Accelerator Science and Technology Initiative (ASTI) [formerly SATI]		6.3	17.4	9.6

SC efforts:

- **RENEW**: SC selections from the FY 2022 ($32M); in FY 2023, SC has committed to nearly doubling the funding to $56M
- **FAIR**: SC announced the FY 2023 FAIR solicitation, **committing $35M** to support research capacity at MSIs and non-R1 institutions.
- See details at https://science.osti.gov/Initiatives/RENEW and https://science.osti.gov/Initiatives/FAIR.

Cosmic Frontier Budget

Cosmic Frontier ($K)	FY2019 Actual	FY2020 Actual	FY2021 Actual	FY2022 Actual	FY2022 IRA	FY2023 Enacted
Research (Univ+Lab)	*48,053*	*44,264*	*43,901*	*42,513*		*44,237*
Future R&D	*3,265*	*2,480*	*1,700*	*1,475*		*1800*
AI/ML Research for CF		3,351	4,920	5,407		4,640
Experimental Ops.	20,957	40,235	42,880	44,350		56,550
Projects	26,350	2,450	6,000	23,000	10,000	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*	*10,000*	*1,000*
LuSEE-Night				*15,000*		
Total	**98,625**	**92,780**	**99,401**	**116,745**	**10,000**	**108,227**

Astro2020: Other Recommendations & Current Status

Astro2020/AAAC – Diversity, Equity, Inclusion, Harassment, Discrimination, Demographics, Metrics

Diversity, Equity, Inclusion, Harassment, Discrimination, Demographics

Astro2020 p.3-14, 3-22, 3-23, 3-27, 3-30

- **Increase incentives for improving diversity** among the college/university faculty
- **Reinvest in professional workforce diversity programs**
- **Implement undergraduate and graduate "traineeship" funding**
- **Include diversity**—of project teams and participants—**in the evaluation of funding awards**
- **Scientific integrity policies** address harassment and discrimination

➔ ***DOE and Office of Science are moving forward on these issues within the context of government efforts.***

Demographics, Proposal Metrics & Reviews

Astro2020 p.3-29, 4-3, AAAC 12-5

- Establish a consistent format and policy for collecting, evaluating, and publicly reporting **demographic data across agencies**
- **Release data on proposal success rates** annually; Track metrics to determine what's being supported.
- Continue expansion of **dual anonymous reviews** within NASA; Request that NSF and DOE develop and adopt similar reviews or other practices to show sufficient evidence of bias mitigation in their review processes.

In Jan. 2021, the Biden Administration issued a memo, *Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policy Making.* DOE is a member of the **Task Force** set up to review existing agency policies and identify effective solutions. A **Jan. 2022** report recommended all agencies update their scientific integrity policies and effective practices, addressing diversity, equity, inclusion, and accessibility; promoting safe, equitable workplaces free from harassment and discrimination; protection of research security; responding to research misconduct; open science; emerging models of science (citizen science, community-engaged research); and new technologies (e.g. AI/ML). OSTP issued a memo **in March 2022** calling upon the agencies to respond to the recommendations.

SC Efforts in Making Science More Equitable and Inclusive

➔**As a steward of public funding, the Office of Science has a responsibility to ensure that we are serving the public.**

SC is deeply committed to (see SC Statement of Commitment: https://science.osti.gov/SW-DEI/SC- Statement-of-Commitment)

- Supporting diverse, equitable, inclusive, and accessible work, research, and funding environments that value mutual respect and personal integrity;
- Promoting people of all backgrounds, including individuals from groups and communities historically underrepresented in STEM fields;
- Advancing scientific discovery by harnessing a diverse range of views, expertise, and experiences to drive scientific and technological innovation.

SC does not tolerate discrimination or harassment of any kind…

See The Roadmap to Equity and Justice at the Department of Energy | Department of Energy

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.

In Sept. 2022, DOE released our first-ever Diversity, Equity, Inclusion, and Accessibility (DEIA) Strategic Plan, which outlines actions to strengthen 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 details on SC efforts at: https://www.energy.gov/science/diversity-equity-inclusion

SC Efforts in Broadening Participation – Promoting Inclusive and Equitable Research (PIER) plans

The FY 2023 new proposal requirements are a reflection of this responsibility and of this commitment. "Everyone has a Role to Play in Making Science More Equitable and Inclusive"

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

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."

PIER plans will be evaluated as part of the merit review process which considers:

- Scientific and/or Technical Merit of the Project;
- Appropriateness of the Proposed Method or Approach;
- Competency of Applicant's Personnel and Adequacy of Proposed Resources;
- Reasonableness and Appropriateness of the Proposed Budget; and
- **Quality and Efficacy of the Plan for Promoting Inclusive and Equitable Research.**

SC Efforts in Broadening Participation – Events, Conferences

SC expects the scientific community, particularly those engaging in SC-sponsored activities, to always conduct themselves in a manner that is respectful, ethical, professional, and inclusive. **SC reserves the right to take appropriate action at SC-hosted events** should participants not adhere to these expectations for responsible workplace behavior. **SC also strongly encourages recipient and partner institutions to adopt and implement their own codes of conduct**…"

By attending such events, participants agree to conduct themselves according to these expectations. If a participant does not adhere to such expectations, SC reserves the right to take appropriate action, e.g.

- A verbal reprimand and reminder of the expectations,
- Being asked to leave the event,
- Removal by security personnel,
- Temporary or permanent suspension from receiving invitations to future non-public SC events, and,
- Reporting of individual(s) responsible for exclusionary and/or disruptive workplace behavior through appropriate channels.

→ **Inappropriate behavior can be reported by an attendee to the senior most SC federal manager present at the event or the senior federal manager of the SC host office for the event.**

SC has new conference proposal requirements:

- Have a **code-of-conduct** that addresses
  - Discrimination and harassment of all kinds,
  - Defines how issues can be reported and how complaints will be addressed,
  - Describes how all attendees will be informed of the policies and procedures.
- Have a **recruitment and accessibility plan** that describes plan for recruiting speakers and attendees, including discussion of recruitment of individuals from groups underrepresented in the research/professional community associated with the technical focus.

SC Efforts in Broadening Participation – Initiatives & Programs

RENEW initiative – started in FY2022

Reaching a New Energy Sciences Workforce (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.

FAIR initiative – starts in FY2023

Funding for Accelerated and Inclusive Research (FAIR) is aimed at undergraduate students and faculty to address place-inspired R&D and loss points of personnel in the field.

Workforce Development programs see https://science.osti.gov/wdts

- Programs to work at a DOE lab: Community College Internships (CCI); Science Undergraduate Laboratory Internships (SULI); SC Graduate Student Research fellowships (SCSGR); Visiting Faculty Program; Albert Einstein Distinguished Educator Program (K-12)
- DOE Scholars Program https://orise.orau.gov/doescholars/ - work at DOE or a lab

HEP traineeships

HEP **traineeship** FOA's in Instrumentation, Accelerator R&D, and Computing – to address critical, targeted workforce development in areas of interest to our mission.

Lab Programs

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

SC Efforts – Demographics, Metrics, Reviews

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

- 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.

➔ Have hired a Data Scientist

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

- DOE issued the DOE Equity Action Plan in April 2022 which includes actions on overcoming institutional barriers for demographic data collection.
- Note that the CHIPS and Science Act includes as provision for OSTP to establish consistent guidelines across the Federal agencies for collecting data on applicants/awardees. OSTP is in the early planning stages of the working group that will coordinate this. SC would follow the federal wide guidelines.

➢ 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 – AI/ML

AAAC 12-4: Continue 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 and the Offices have been ramping up efforts in this area.

- FY2023 Congressional Direction to SC for AI/ML → not less than $135M

HEP $K for AI/ML

FY20 Enacted	FY21 Enacted	FY22 Enacted	FY23 Enacted
15	33.5	35.8	38.5

→AI/ML techniques in high energy physics are vitally important for advancing the field.
HEP had a FOA for university AI/ML efforts and in November 2022 announced $4.3 million in funding for 16 projects in AI/ML research. The awards support the SC initiative to use AI techniques to deliver scientific discoveries that would not otherwise be possible, and to broaden participation in high energy physics research. A similar announcement was made for team awards to DOE labs.

- Projects include constructing models to increase the speed of simulations for cosmology and particle physics; use of deep learning to develop governing theories; and ML techniques to efficiently and thoroughly search the parameter spaces of likely new theories of particle physics that have their origins at the highest energy scales. These investments also include development of new methods for machine learning in real-time (known as edge computing) for data collection and efforts toward performing robust data analysis with self-consistent ML measurement techniques

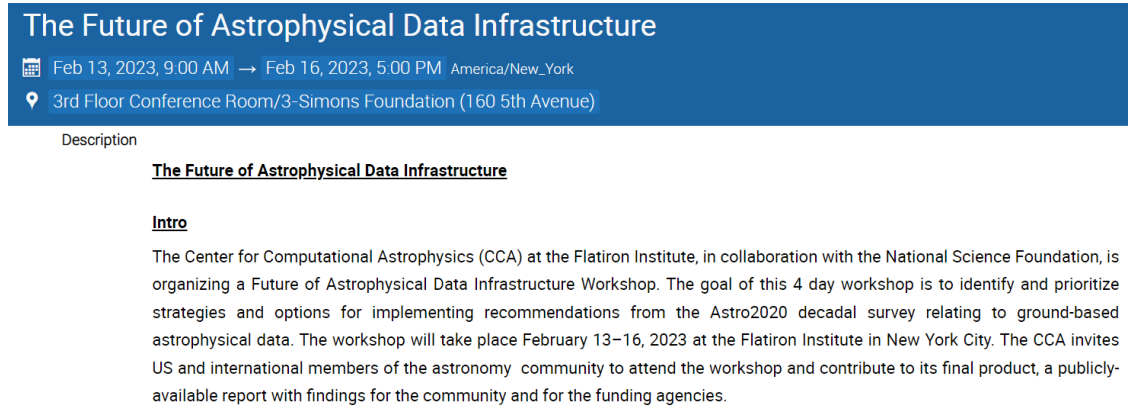
Cosmic Frontier has efforts at labs, universities & has recent Early Career awards (Andrew Hearin – ANL; Brian Nord - FNAL)

Astro2020/AAAC – Data, Science

Astro2020 p.4-20, 4-21, AAAC 13-8

- Improve coordination among U.S. archive centers and to create a centralized nexus for interacting with the international archive communities
- Planning to design, build, deploy, and sustain, and archive pipelines for producing science-ready data with a standard format for eventual public use.
- Maximize the scientific yields of the Vera C. Rubin Observatory and Nancy Grace Roman Space Telescope, e.g. by survey designs

➢ DOE/HEP is Participating in the workshop


The Future of Astrophysical Data Infrastructure

Feb 13, 2023, 9:00 AM → Feb 16, 2023, 5:00 PM America/New_York

3rd Floor Conference Room/3-Simons Foundation (160 5th Avenue)

Description

The Future of Astrophysical Data Infrastructure

Intro

The Center for Computational Astrophysics (CCA) at the Flatiron Institute, in collaboration with the National Science Foundation, is organizing a Future of Astrophysical Data Infrastructure Workshop. The goal of this 4 day workshop is to identify and prioritize strategies and options for implementing recommendations from the Astro2020 decadal survey relating to ground-based astrophysical data. The workshop will take place February 13–16, 2023 at the Flatiron Institute in New York City. The CCA invites US and international members of the astronomy community to attend the workshop and contribute to its final product, a publicly-available report with findings for the community and for the funding agencies.

➢All survey projects (DES, eBOSS, DESI, Rubin Observatory, CMB-S4) are making data public after a proprietary period.

➢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. We will continue this via our Three Agency Group (TAG).

DOE SC Data Management Overview

SC data management principles		
Enable discovery	Share, preserve, validate	Cost management

Data Management Plan (DMP) requirements			
Share, preserve, validate	Make data associated with publications accessible	Availability of data management resources	Privacy, security, confidentiality

- **DMPs are reviewed as part of the overall SC research proposal merit review process**
  - Additional requirements and review criteria for the DMP may be identified in a solicitation

Complete information available at: https://science.osti.gov/Funding-Opportunities/Digital-Data-Management

Astro2020/AAAC – Climate Change, Energy Usage

Astro2020 p.3-42, AAAC 8-5, AAAC 10-6

- Increase the use of remote observing, hybrid conferences, and remote conferences
- Agency cooperation on education & public engagement, reducing emissions, assess impacts
- Report on energy usage

Climate change and energy issues are of great importance to the Department of **Energy**. DOE has significant ongoing programs to address climate change, reduce energy usage, enhance energy resiliency and efficiencies, consider energy justice and develop new energy sources and technologies
- include industry and academic partnerships

- DOE Initiatives; DOE Office of Sustainability
- DOE Labs have significant research in this area and are upgrading facilities to ensure energy efficiency.
  - Lab Programs, Sustainability plans
  - Emphasis is on technology development including renewable energy, energy storage

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).


BNL's Northeast Solar Energy Research Center

Astro2020/AAAC – Climate Change, Energy Usage - DOE Initiatives (Examples, not exhaustive!)

DOE Net Zero Labs Pilot Initiative – net-zero emissions and energy resilient operations; see e.g. https://www.pnnl.gov/net-zero

Energy Earthshots Research Centers (EERC) Initiative ($200M) calls for innovation and collaboration to tackle barriers to deploying emerging clean energy technologies & accelerate breakthroughs towards more abundant, affordable, and reliable clean energy solutions. Six energy "shots" have been announced: Hydrogen, Long Duration Storage, Carbon Negative, Enhanced Geothermal, Floating Offshore Wind and Industrial Heat.

AI4ESP

Building a New Scientific Community

- combining Climate Research, Artificial Intelligence, Applied Math and Supercomputing

See Accelerating and Improving Smart Use of Big Data to Predict Earth System Processes | Department of Energy

Climate Resilience Centers (CRCs)

Biological and Environmental Research (BER) FOA #0002915 to improve the availability and utility of BER research, data, models, and capabilities to address climate resiliency, particularly by underrepresented or vulnerable communities.

March 2022: DOE Office of Energy Efficiency and Renewable Energy (EERE) and NSF signed an MOU to continue our longstanding partnership for collaboration on scientific and engineering research to bolster national energy policy. See https://www.nsf.gov/news/news_summ.jsp?cntn_id=305100&org=ENG

Astro2020/AAAC – Climate Change, Energy Usage - DOE Lab Programs (Examples, not exhaustive!)

Lab Programs – mostly funded by SC Basic Energy Sciences (BES) or Basic Energy Research (BER)

LBNL: Energy Technologies Area, https://eta.lbl.gov/

- Research areas in energy storage, resilience, integrated energy systems, the water-energy nexus, and science of manufacturing
- Developing strategies to fight the Climate Crisis to fixing our nation's infrastructure to addressing inequity through energy justice

LBNL: Earth and Environmental Sciences Area, https://eesa.lbl.gov/program-domains/

- Tackling pressing environmental and energy challenges to enable sustainable stewardship of our environmental systems and judicious use of the Earth's subsurface energy resources

LLNL: Extensive array of climate change and energy security research programs supported by SC as well as NNSA and other stakeholders.

SLAC: Applied Energy Division, including industry partners and Stanford Univ partners; Research on energy alternatives

Astro2020/AAAC – Climate Change, Energy Usage - Lab Sustainability Plans & Efforts (Examples, not exhaustive!)

BNL: large solar farm on site to produce electricity

LBNL: Energy efficiency in high performance computing (HPC) data centers https://www.nersc.gov/news-publications/nersc-news/nersc-center-news/2020/less-is-more-lbnl-breaks-new-ground-in-data-center-optimization/

LBNL: Efforts to reduce waste, energy consumption, water usage etc. on site. See https://sbl.lbl.gov/

LLNL:

- Identify way to innovate towards more energy and water-efficient solutions, and incorporating these into ongoing facilities
- Pursuing renewable energy generation
- Examples are installation of a 3.3 megawatt solar farm on the LLNL site, meeting the FY21 requirement to replace 75% of the fossil fuel, light duty vehicles with alternative fuel vehicles (currently now accounting for 80% of vehicles), and adding to the currently 79 charging stations and plugs for electric vehicles.

PNNL: Project to develop opportunities at the buildings–grid nexus for improved reliability, consumer benefits, and energy efficiency… first of its kind to test demand-side transactive controls at a scale involving multiple commercial buildings and devices.

- https://www.pnnl.gov/projects/clean-energy-and-transactive-campus

SLAC: Have a number of registered Energy Savings buildings on campus, as well as other energy efficiency efforts.

Astro2020/AAAC – Climate Change, Energy Usage - Technology R&D (Examples, not exhaustive!)

ANL: In collaboration with NREL, looking at deployment of renewable energy and energy storage at unique remote sites to support **HEP Cosmic Frontier experiments**.

- New technologies for clean energy storage devices, Scientists enhance stability of new material for solar cells | Argonne National Laboratory (anl.gov)

BNL:

- Grid Modernization: Grid modeling and simulation; Data analytics and machine learning applications; Probabilistic risk assessment; Methods and tools for dynamic assessment and control design
- Energy Efficiency: Alternative fuels including biofuels and hydrogen; Emissions measurement &analysis; Geothermal materials
- Energy Storage: Batteries for electric vehicles – fast charge, higher capacity materials' Battery systems suitable for large scale applications; EFRC – science of scalable batteries
- Developing cloud chambers to study various climate effects.
- Carbon chemistry - Developing useful products from waste methane and carbon dioxide, Novel Chemical Reaction Supports Carbon-Neutral Industrial Processes | BNL Newsroom

LLNL

- Climate science research using high-performance computing and expertise in fundamental sciences such as meteorology, climatology, applied mathematics and computational science to the problem of understanding and predicting how the Earth's systems evolve. https://climate.llnl.gov/
- Developing the energy systems of the future including Fusion Energy (as highlighted by the recent demonstration of fusion net power output or ignition at the NIF laser facility) to battery, solar, wind and nuclear power research. https://www.llnl.gov/missions/energy

DOE – Other News related to Energy Usage & Climate Change -- in the last 2 weeks at https://www.energy.gov/newsroom

DOE and FEMA Release One-Year Progress Report on Joint Effort to Modernize Puerto Rico's Grid With 100% Clean Energy
https://www.energy.gov/articles/doe-and-fema-release-one-year-progress-report-joint-effort-modernize-puerto-ricos-grid-100

DOE Launches $10 Million Prize to Accelerate Community Solar in Underrepresented Communities
https://www.energy.gov/articles/doe-launches-10-million-prize-accelerate-community-solar-underrepresented-communities

Biden-Harris Administration Announces Funding For Community-Centered Clean Energy Programs Across the U.S. And $9 Billion For Home Rebates
https://www.energy.gov/articles/biden-harris-administration-announces-funding-community-centered-clean-energy-programs

DOE Launches New $50 Million Program to Help Communities Meet Their Clean Energy Goals
https://www.energy.gov/articles/doe-launches-new-50-million-program-help-communities-meet-their-clean-energy-goals

DOE Announces $42 Million to Develop More Affordable and Efficient Advanced Electric Vehicle Batteries in America
https://www.energy.gov/articles/doe-announces-42-million-develop-more-affordable-and-efficient-advanced-electric-vehicle

Biden-Harris Administration Releases First-Ever Blueprint to Decarbonize America's Transportation Sector
https://www.energy.gov/articles/biden-harris-administration-releases-first-ever-blueprint-decarbonize-americas

Astro2020/AAAC – Budgets, Community Engagement Tracking Progress

AAAC 10-7, 12-1

- Identify budgetary options that would permit the recommended funding increases in the individual investigator research grants and in technology development.

Astro2020 p.3-35

Define a **Community Astronomy model of engagement** that advances scientific research while respecting, empowering and benefiting local communities.

- Astronomy community should work through AAS, other professional societies, other disciplines, and representatives from local communities.

NOTE: HEP labs work with their local communities to provide employment opportunities and outreach efforts.

AAAC 4-1

Living document between NASA, DOE & NSF that links each agency's effort

➔The agencies have started development of this document.

Future Planning

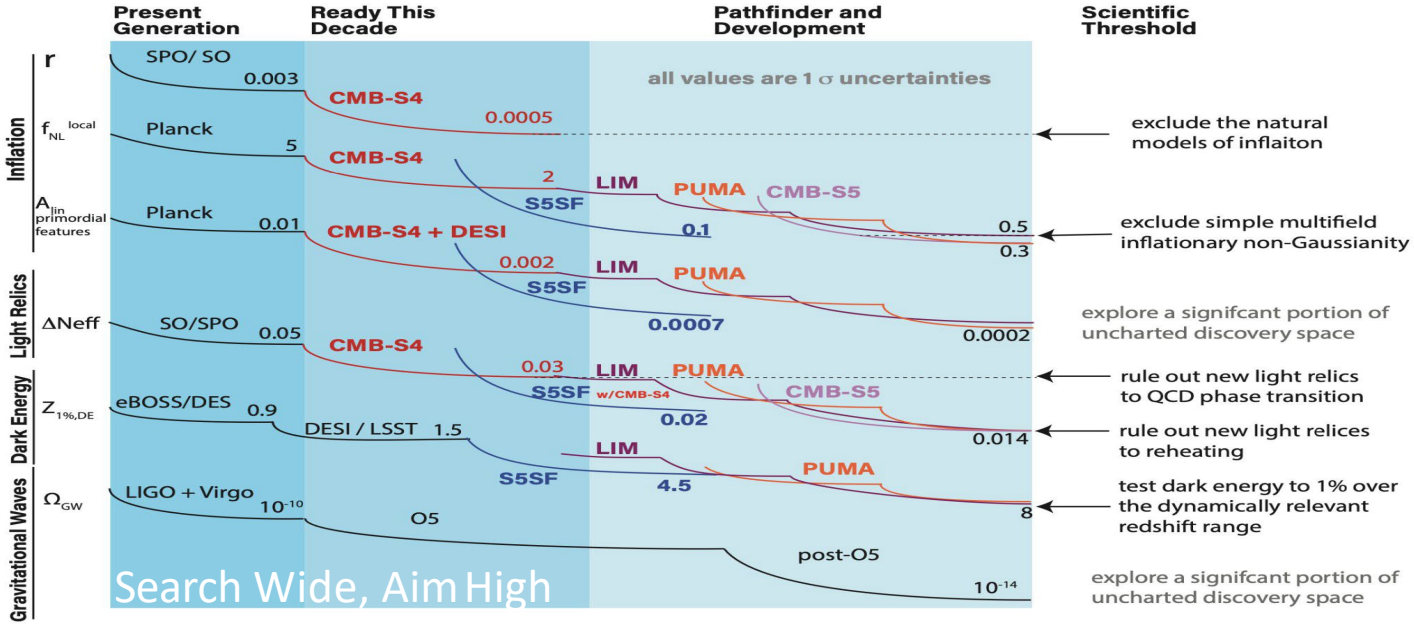
HEP - Strategic Planning Timeline ➔ SNOWMASS

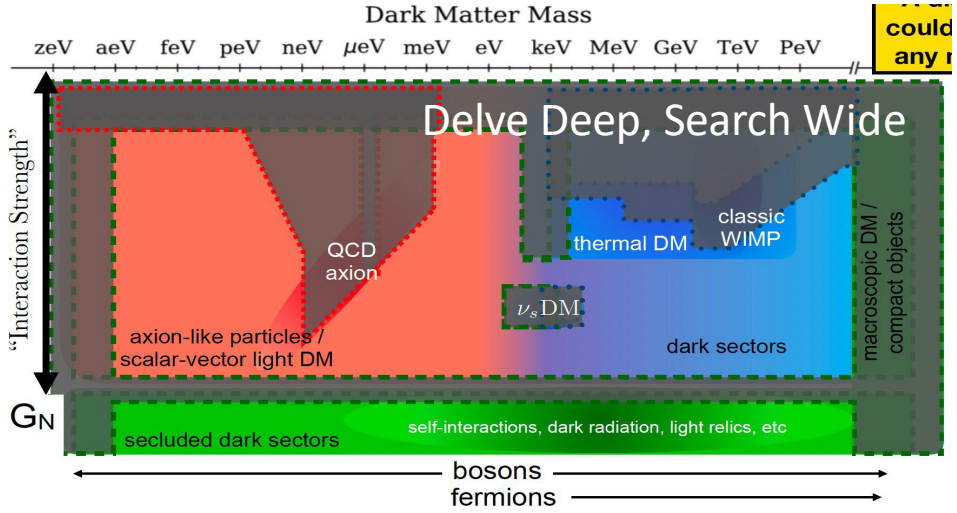
HEP community-wide "Snowmass" study process organized by the American Physical Society (APS) Division of Particles and Fields (DPF) & Division of Particles and Beams held July 2022. https://snowmass21.org/start

- Identify key science questions and directions & options to address them
- Draft Summary report at: **[2301.06581] Report of the 2021 U.S. Community Study on the Future of Particle Physics (Snowmass 2021) Summary Chapter (arxiv.org)**

"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".

➔ **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





HEP - Strategic Planning Timeline → P5

DOE/NSF HEPAP P5 subpanel convened in December 2022
- 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.

Preliminary P5 website (Charge letter, Membership, and dates of in-person and virtual town halls) can be found here: http://hitoshi.berkeley.edu/P5/.

→ **Cosmic Frontier Town Hall at LBNL on Feb. 22-23.**

Other studies:

- HEPAP International Benchmarking subpanel (reports ~ end of 2023)

- https://science.osti.gov/-/media/hep/hepap/pdf/202203/HEPAP_202203_Charge_G_Crawford.pdf

- National Academy of Sciences (NAS) Elementary Particle Physics (EPP) Decadal Survey

- running concurrently with and complementary to the P5 process.

HEP Cosmic Frontier – Summary & Future Planning

Continue World-Leading Program aligned with 2014 P5

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

➔**Planning**

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

The Future's Bright!

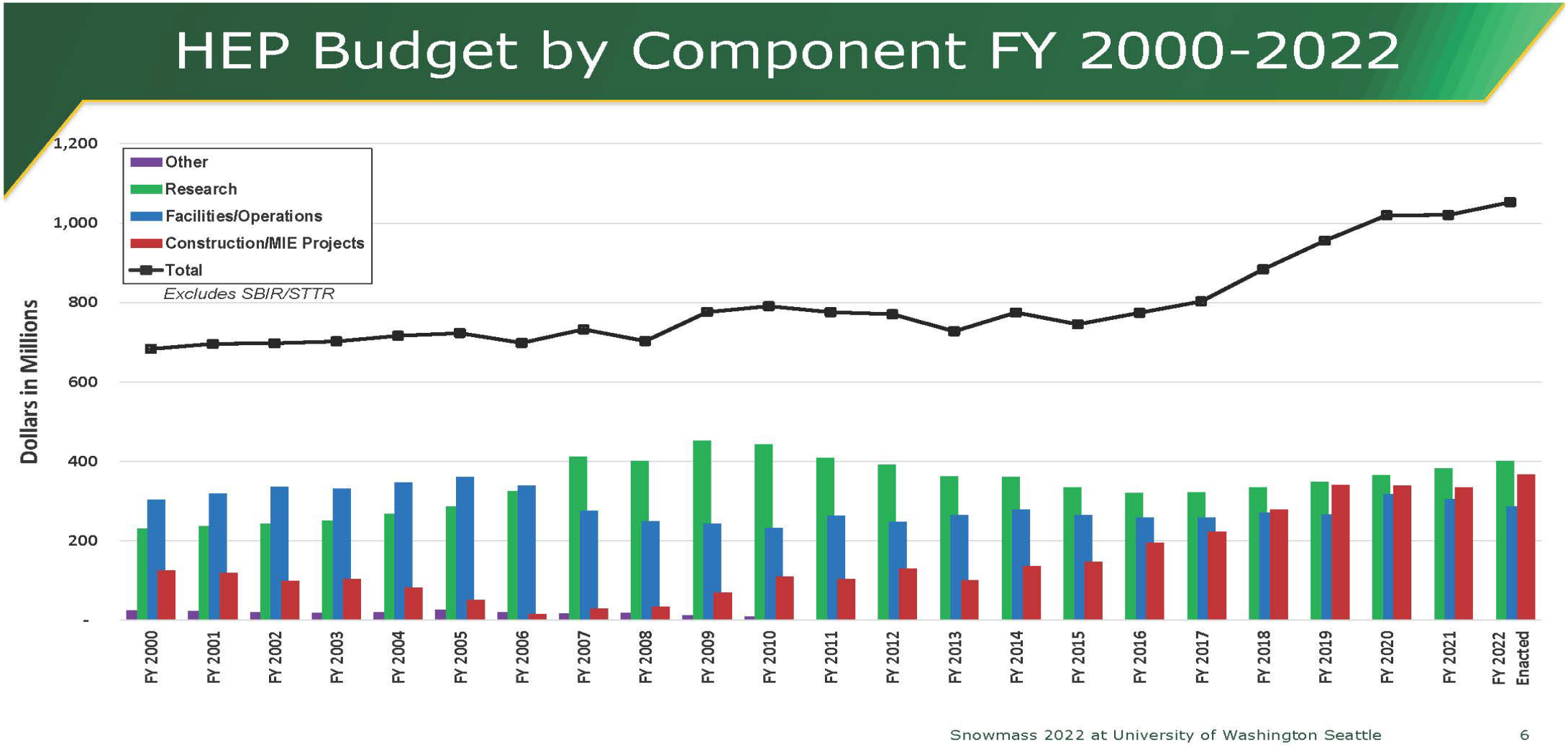
U.S. DEPARTMENT OF
ENERGY

Office of
Science

2022-2023 P5 Panel Charge (DOE + NSF)

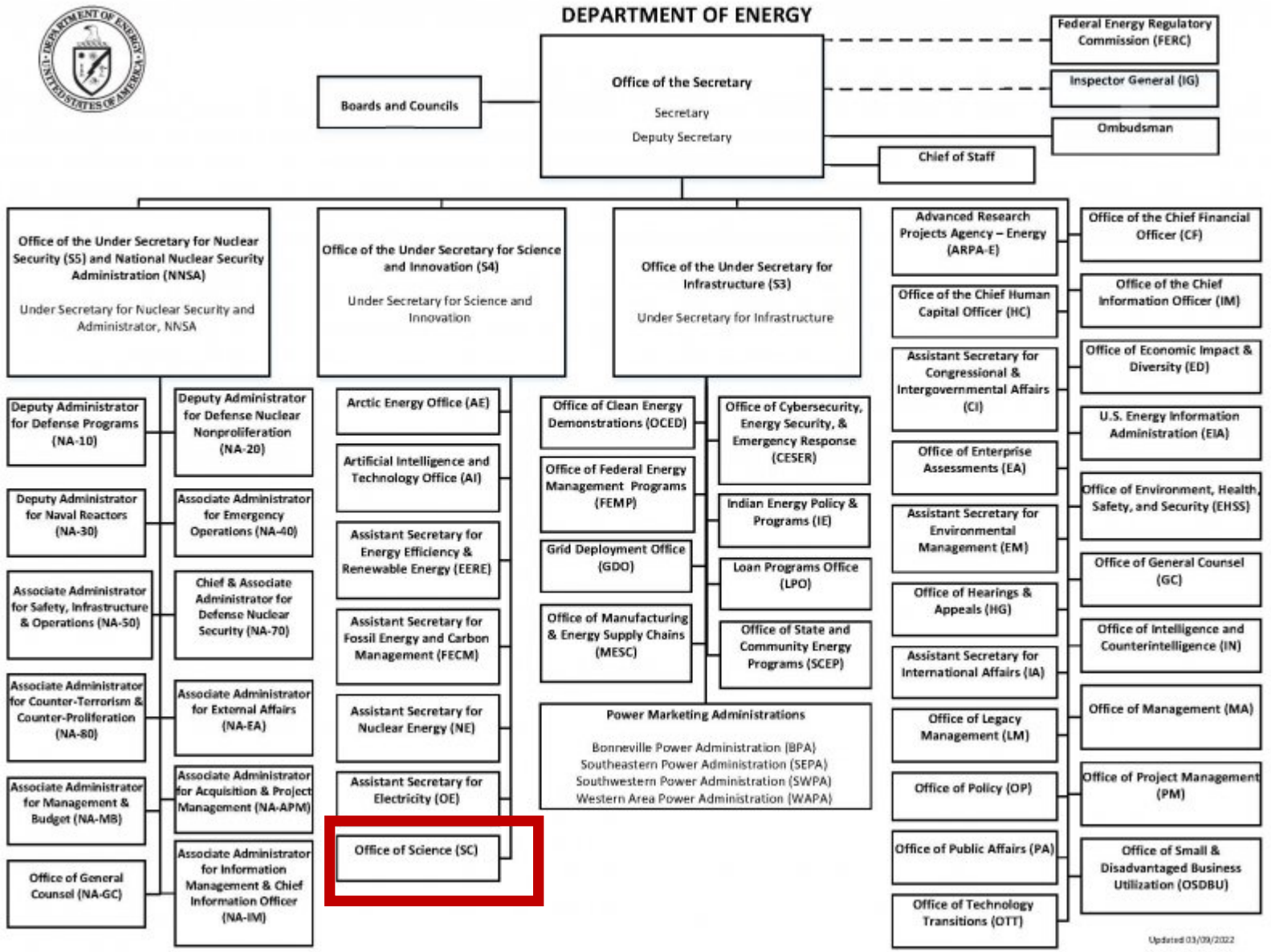
- Remember HEP is a global field
- Support decisions to retain US leadership as a global partner
- Preserve essential roles of Universities and National Labs
- Assess science case for on-going projects
- Assess infrastructure upgrades that create new science capabilities
- Remember costs of R&D, commissioning, and operations for future projects
- Remember that a balanced core research budget is paramount to producing science from current projects and developing ideas for new ones
- Remember that a diverse workforce results in improved science
- Address synergies with broad national initiatives

HEP Budget History – by Component



Snowmass 2022 at University of Washington Seattle 6

DOE Organization



Office of Science Organization