

Cosmic Frontier Experimental Program

DOE/HEP report to the AAAC
September 18, 2023

Kathy Turner, Bryan J. Field, and Christopher Jackson (detailer)
U.S. Department of Energy
Office of High-Energy Physics



U.S. DEPARTMENT OF
ENERGY

Office of
Science



Outline

- HEP Program Intro: Mission, Planning, Guidance
- Budget
- Cosmic Frontier Program
- Astro2020 Recommendations, Responses



The Vera C. Rubin Observatory. El Peñón peak of Cerro Pachón, in the Coquimbo Region of northern Chile



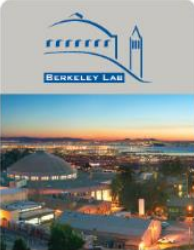
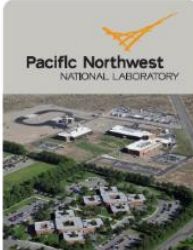
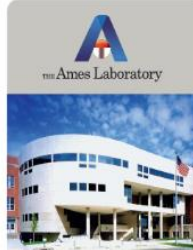

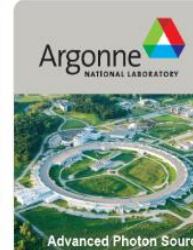
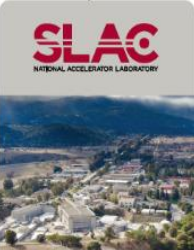
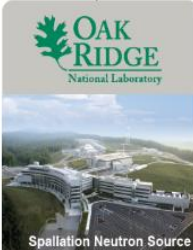


U.S. DEPARTMENT OF
ENERGY

Office of
Science

HEP Program Intro: Mission, Planning, Guidance

Mission – DOE and Office of Science

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

 <p>Berkeley Lab Berkeley, California 202 acres and 97 buildings 3,396 FTEs 950 students & postdocs 9,320 facility users www.lbl.gov</p>	 <p>Pacific Northwest National Laboratory Richland, Washington 346 acres and 12 buildings 4,344 FTEs 550 students & postdocs 1,733 facility users www.pnnl.gov</p>	 <p>Ames Laboratory Ames, Iowa 8 acres and 12 buildings 308 FTEs 158 students & postdocs www.ameslab.gov</p>	 <p>Fermilab Batavia, Illinois 6,800 acres and 354 buildings 1,720 FTEs 55 students & postdocs 2,097 facility users www.fnal.gov</p>	 <p>Argonne National Laboratory Argonne, Illinois 1,517 acres and 100 buildings 3,460 FTEs 1,054 students & postdocs 6,547 facility users www.anl.gov</p>
 <p>SLAC National Accelerator Laboratory Menlo Park, California 426 acres and 151 buildings 1,596 FTEs 213 students & postdocs 4,474 facility users www.slac.stanford.edu</p>	 <p>Oak Ridge National Laboratory Oak Ridge, Tennessee 4,421 acres and 194 buildings 4,686 FTEs 1,080 students & postdocs 3,215 facility users www.ornl.gov</p>	 <p>Jefferson Lab Newport News, Virginia 169 acres and 72 buildings 729 FTEs 60 students & postdocs 1,261 facility users www.jlab.org</p>	 <p>PPPL Princeton Plasma Physics Laboratory Princeton, New Jersey 89 acres and 34 buildings 429 FTEs 54 students & postdocs 290 facility users www.pppl.gov</p>	 <p>BROOKHAVEN NATIONAL LABORATORY Upton, New York 5,322 acres and 310 buildings 2,882 FTEs 642 students & postdocs 4,134 facility users www.bnl.gov</p>

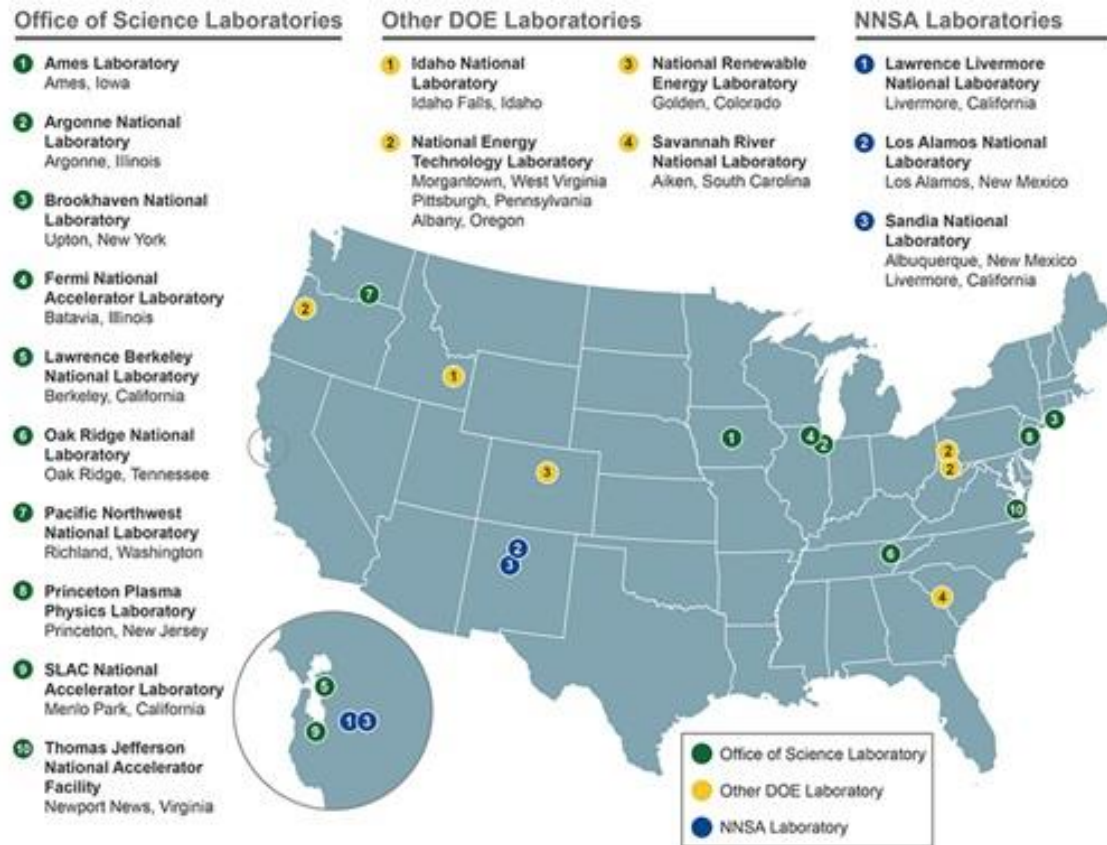
FY 2017 28 user facilities

U.S. DEPARTMENT OF ENERGY
Office of Science

DOE National Labs – Our Crown Jewels

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



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

The laboratories:

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

Office of Science by the Numbers (2022)

OFFICE OF SCIENCE BY THE NUMBERS

Delivering scientific discoveries and major scientific tools to transform our understanding of nature and advance the energy, economic, and national security of the United States

FY22

6 CORE SCIENCE PROGRAMS

- Advanced Scientific Computing Research
- Basic Energy Sciences
- Biological and Environmental Research
- Fusion Energy Sciences
- High Energy Physics
- Nuclear Physics

3 ENGINEERING AND TECHNOLOGY OFFICES

- Accelerator Research and Development and Production
- Isotope Research and Development and Production
- Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)

5 NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS

ACROSS ITS 10 NATIONAL LABS, OFFICE OF SCIENCE MAINTAINS APPROXIMATELY

24 MILLION
SQUARE FEET OF SPACE

1,600
BUILDINGS

38,000
ACRES OF
LAND OWNED

SUPPORTS RESEARCH SPANNING

16
DOE
NATIONAL LABS

50
STATES, PUERTO RICO,
AND WASHINGTON, D.C.

>340

UNIVERSITIES AND
HIGHER-LEARNING
INSTITUTIONS

4

BIOENERGY
RESEARCH
CENTERS

2

ENERGY
INNOVATION
HUB
PROGRAMS

51

ENERGY
FRONTIER
RESEARCH
CENTERS

STEWARDS

10

DOE NATIONAL
LABORATORIES

ESTIMATED
RESEARCHERS
SUPPORTED

10,300 Permanent PhDs

3,200 Postdoctoral
Associates

4,900 Graduate Students

9,000 Other Scientific
Personnel

OVER
38,500

USERS AT

28

OFFICE OF SCIENCE
FACILITIES

10

SITE OFFICES

1

CONSOLIDATED
SERVICE CENTER

OVER

100

NOBEL
PRIZES

\$7.5 BILLION

OVERALL
OFFICE OF
SCIENCE BUDGET

\$857 MILLION

USER
FACILITY
CONSTRUCTION

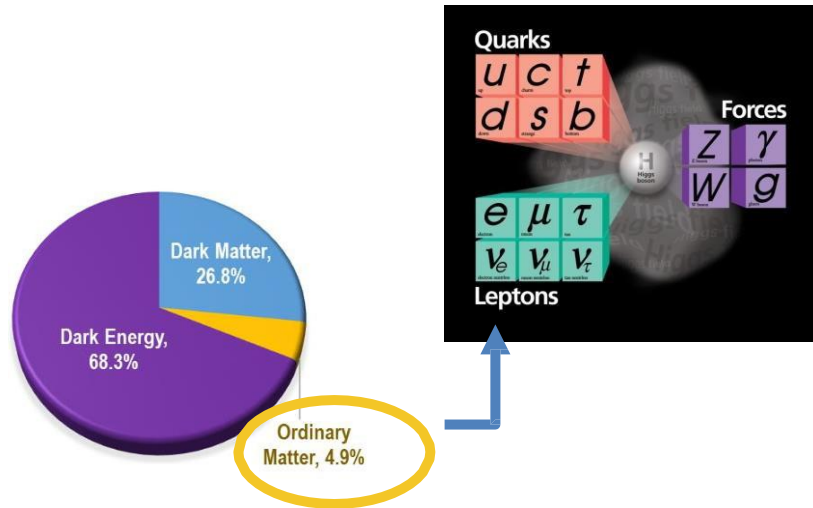
\$291 MILLION

SCIENCE
LABORATORY
INFRASTRUCTURE

Mission – DOE/SC Office of High Energy Physics (HEP)

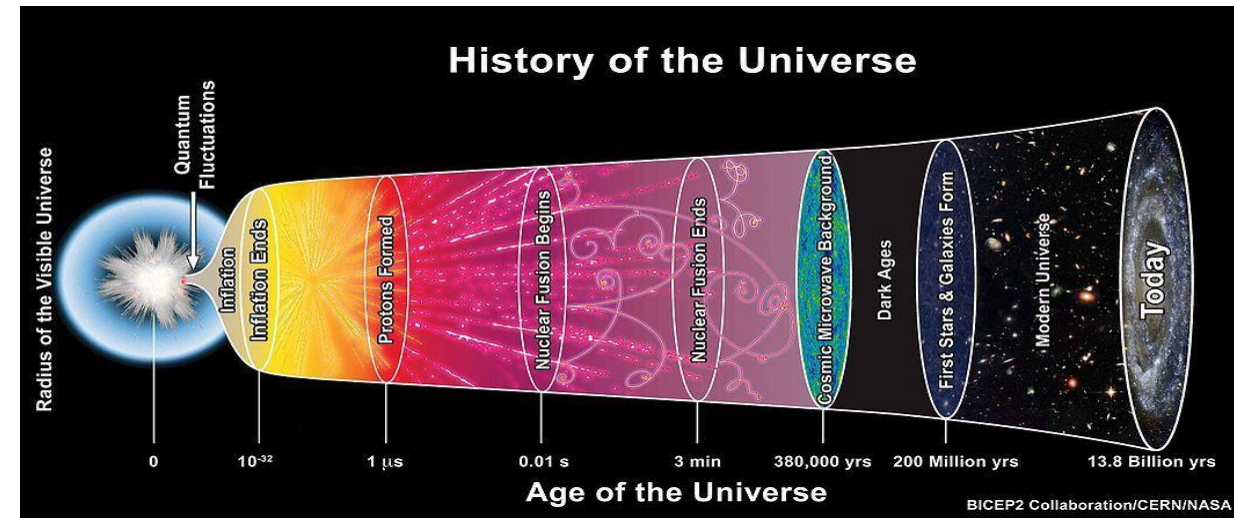
HEP's mission is to understand the universe at the most fundamental level:

- ▶ **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.

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



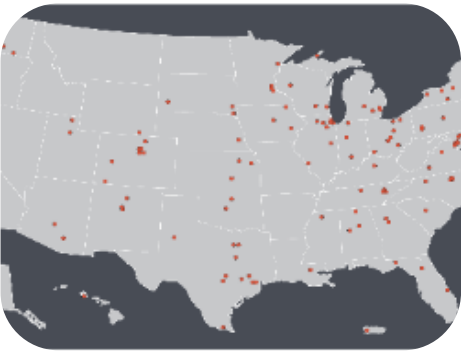
How the Universe evolves

- Beginning... Hot/dense primordial mass-energy
- Expansion... Passing through mass-energy phases
- Universe as we observe it now... Large scale structure evident – function of mass-energy constituents and dynamics as it evolved

HEP at a Glance – FY2023 (FY2023 Budget \$1.166B; FY2024 Request \$1.226B)



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



Funding at >160 Institutions, including 12 DOE Labs



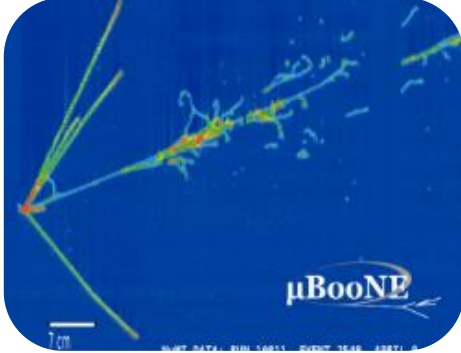
Over 1,175 Ph.D. Scientists and 525 Grad Students Supported



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

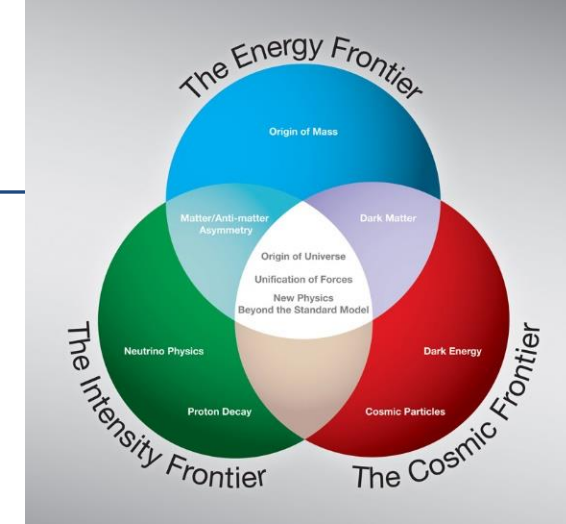
DOE supports ~ 85% of the U.S. high energy/particle physics effort (in \$) at Universities + National Labs

HEP Program Layout

HEP is carried out along 3 experimental Frontiers: Advancements in all 3 frontiers is needed to achieve the long-term goals of the field.

→ HEP is primarily a Particle Accelerator based program:

Energy & Intensity Frontiers



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

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

Crosscutting HEP subprograms:

- Theoretical research for all Frontiers, High Performance Computing & Computational HEP, AI/ML, Accelerator and Detector R&D, Quantum Information Science

HEP – Carrying out the Mission

Program Model: Science Mission-driven

Develop 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
 - Support R&D for the future including detector technologies, QIS, etc.
 - Theoretical efforts provide the vision and the mathematical framework for understanding and extending our knowledge of fundamental matter & energy.
- Form mutually beneficial **partnerships** with other agencies (e.g., NASA, NSF, international) to help deliver our mission
- HEP works proactively with labs & university community to carry out the 2014 P5 strategic plan portfolio of facilities, projects & experiments.

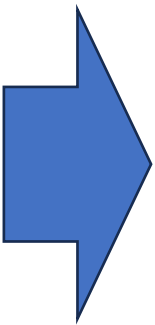
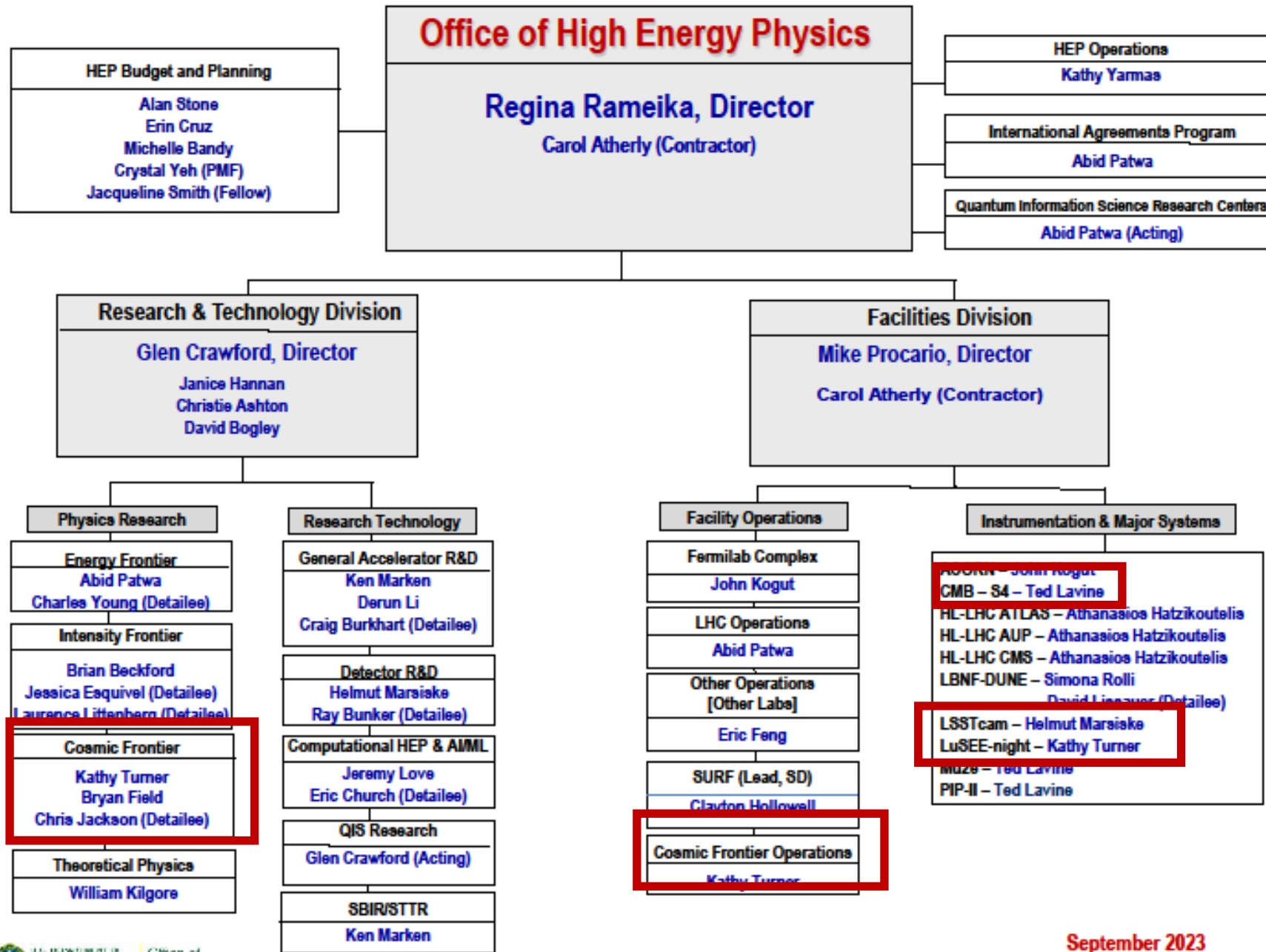
HEP – Program Model

HEP strength is our Science Collaboration Model & Scientist Participation in all Phases & Activities

- Support scientists as part of 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 Scientific 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 Organization



September 2023





U.S. DEPARTMENT OF
ENERGY

Office of
Science

Program Guidance, Planning

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) – Developed Prioritization Criteria
 - 2014 Particle Physics Project Prioritization Panel (“P5”): **Our current 10-year Strategic Plan**
 - Next P5 strategic plan is expected ~ end 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 (**EPP2024**) study is ongoing – looking at big science questions
- Board on Physics & Astronomy, Committee on Astronomy & Astrophysics

Other Input & Coordination

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

HEPAP/PASAG (2009) Developed Program Prioritization Criteria

- **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.

Cosmic Frontier – Guidance used to Develop Program

PASAG (2009) – gave criteria we use to determine HEP roles & responsibilities

Astro2010 recommended DOE/NSF partnership on LSST (Rubin)

P5 (2014) strategic plan recommended science & project priorities aligned with the P5 science drivers -- in Dark Energy, Dark Matter, CMB projects + small projects.



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

- **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
- **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)

Future Planning: Snowmass 2022, P5 2023, EPP2024

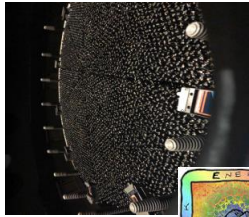


Cosmic Frontier Program Objectives:

We use the 2009 HEPAP/PASAG Criteria to determine priorities in selecting and supporting roles & responsibilities on projects or experiments

- HEP carries out select, high impact experiments and projects that make significant leaps in science, aligned with the P5 science drivers and as recommended by the P5 strategic plan.
- Carry out Roles & Responsibilities that make significant, coherent, contributions
 - aligned with HEP program and priorities, responsibilities and science and
 - 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

Cosmic Frontier: Current Program Based on 2014 P5 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 ~ mid-2025) with **DESC** (planning)
- Peer into era of **Inflation** with **SPT-3G** (operating), **CMB-S4** (concept design)

Dark Matter:

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

Small Projects: Search for the **Dark Ages** signal using **LuSEE-Night** pathfinder

Neutrino properties constrained using dark energy & CMB measurements

Exploring the Unknown - Always interested in New Physics!

Black: HEP support ended

Green: support continues

Recommended by 2014 P5

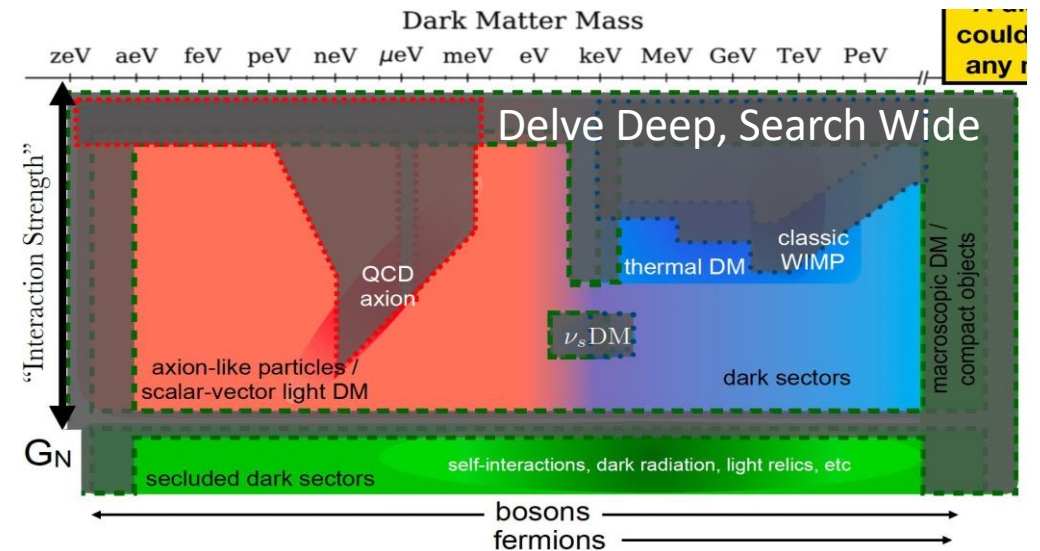
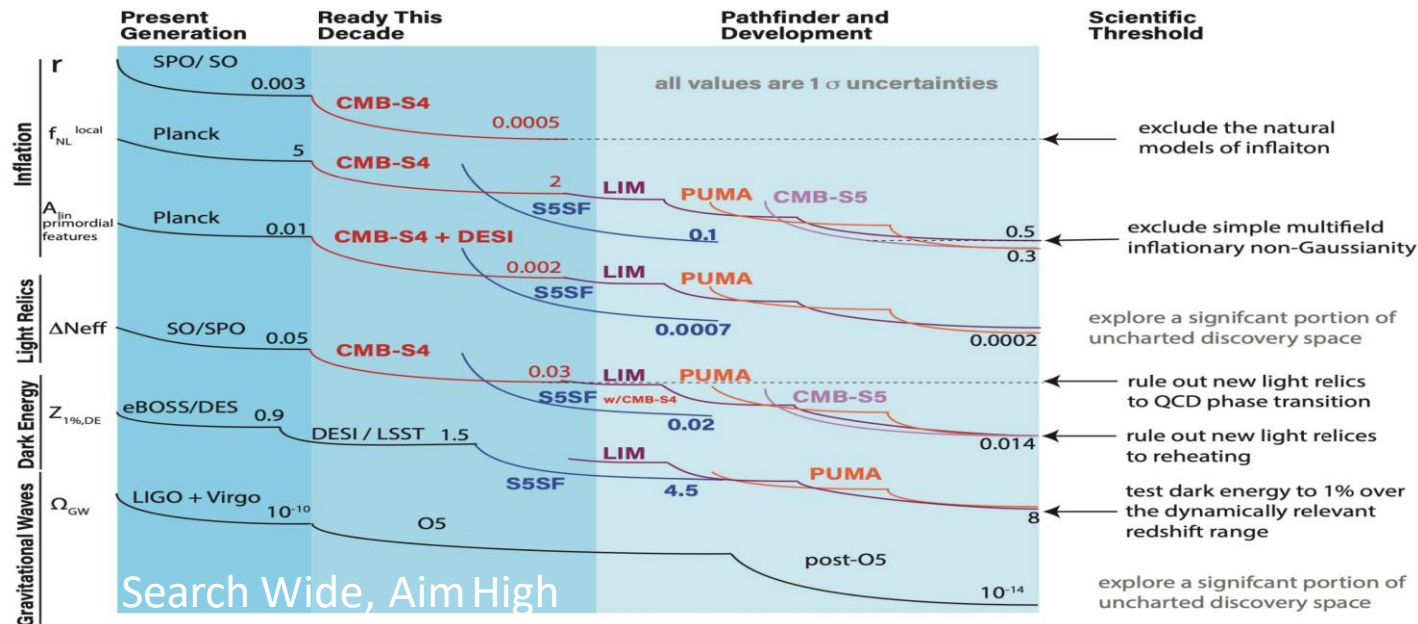
Future Planning: SNOWMASS Community Process (2022) → feeds into P5 (2023)

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

- Identify key science questions and directions & options to address them
- See <https://www.slac.stanford.edu/econf/C210711> and <https://www.slac.stanford.edu/econf/C210711/SnowmassBook.pdf>

Snowmass report:

- 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 of 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





U.S. DEPARTMENT OF
ENERGY

Office of
Science

BUDGET

- **Process**
- **HEP**
- **Cosmic Frontier**

Three Phases of Federal Budget Process – for specific FY budget

- **Formulation:** Executive branch prepares the President's Budget Request
 - White House Office of Management and Budget (OMB) controls this process, providing guidance to Executive branch agencies; this is submitted to Congress
- **Congressional:** Enacts laws that control spending and receipts
 - Congress considers the President's Budget proposals (pass “marks” for each side’s vision), they eventually agree (“reconciliation”), pass a budget resolution, and enact the regular appropriations acts and other laws that control spending and receipts.
 - President signs the budget and it becomes law
- **Execution:** Executive branch agencies carry out program
 - OMB apportions funds to Executive Branch agencies, which obligate and disperse funding to carry out their programs, projects, and activities



FY 20XX Budget	DOE Internal Planning with OMB and OSTP Guidance												OMB Review			Budget Release	Congressional Budget and Appropriations									Spend the Fiscal Year Budget											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	CY(XX-3)			Calendar Year (20XX-2)						Calendar Year (20XX-1)									Calendar Year 20XX																		

If this process is not completed by the end of a fiscal year, Congress may pass a “continuing resolution”, or without any action, U.S. Government can [partially] “shutdown”



Budget Formulation Process



- **OMB provides policy guidance for Executive branch agency budget requests**
 - Absent more specific guidance, agencies start with outyear estimates from previous budget
- **OMB works with agencies**
 - Identify major issues, develop plans for fall review, plan analysis of issues that will require decisions
- **OMB provides detailed instructions for submitting budget material**
- **Agencies submit budgets to OMB [before Labor Day]**
- **OMB reviews budget proposals**
 - Considers Presidential priorities, program performance, budget constraints
- **OMB provides recommended budget proposal to President and provides pass back to agencies [after Thanksgiving]**
- **Agencies may appeal to OMB and the President**
- **Agencies prepare and OMB reviews final congressional budget justification materials [early January]**
- **February: President transmits budget to Congress**



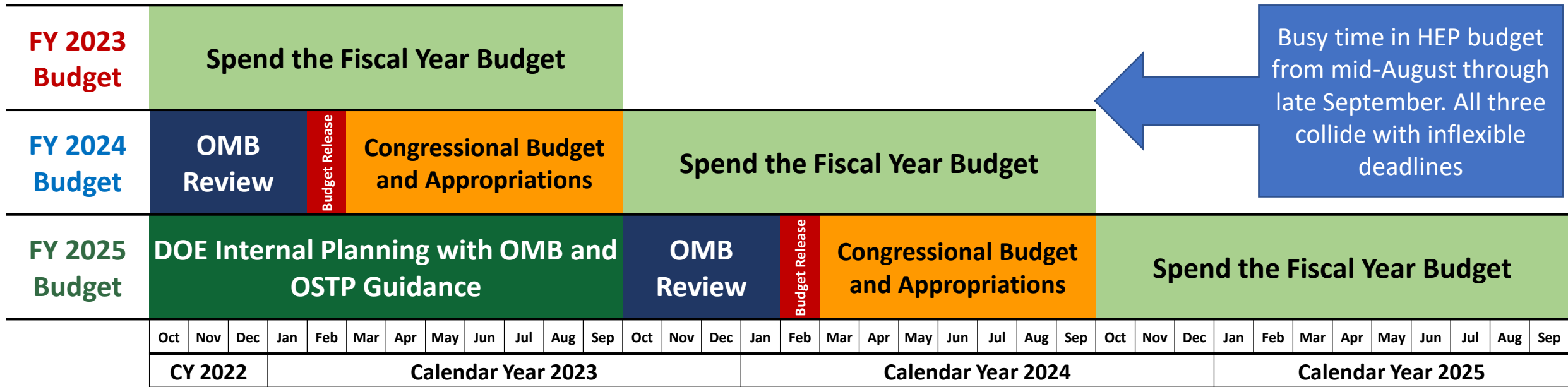
Process is the same for all agencies.

...

The U.S. Federal Budget Cycle – at a specific time

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

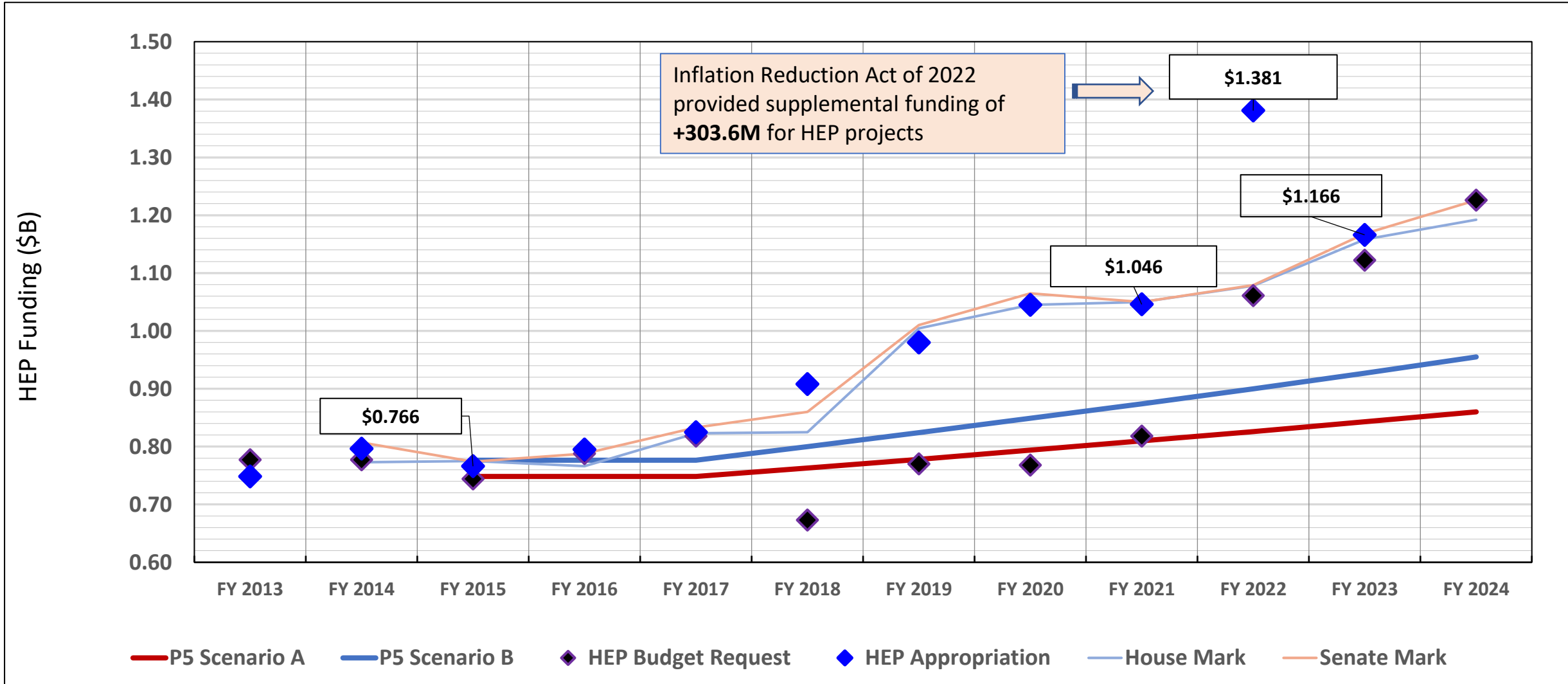
- Executing current Fiscal Year (FY; October 1 – September 30).
 - Aggregating final FY 2023 End of Year requests to determine final distributions of reserves
- OMB review and Congressional Appropriation for upcoming FY.
 - Preparing FY 2024 Initial Funding Plan for DOE Labs and Program Managers annual budgets assuming a 3-month CR
- Agency internal planning for the second FY from now
 - Submitting the FY 2025 HEP narrative draft to SC budget and DOE CFO for review before it goes to OMB for review



↑ We are here



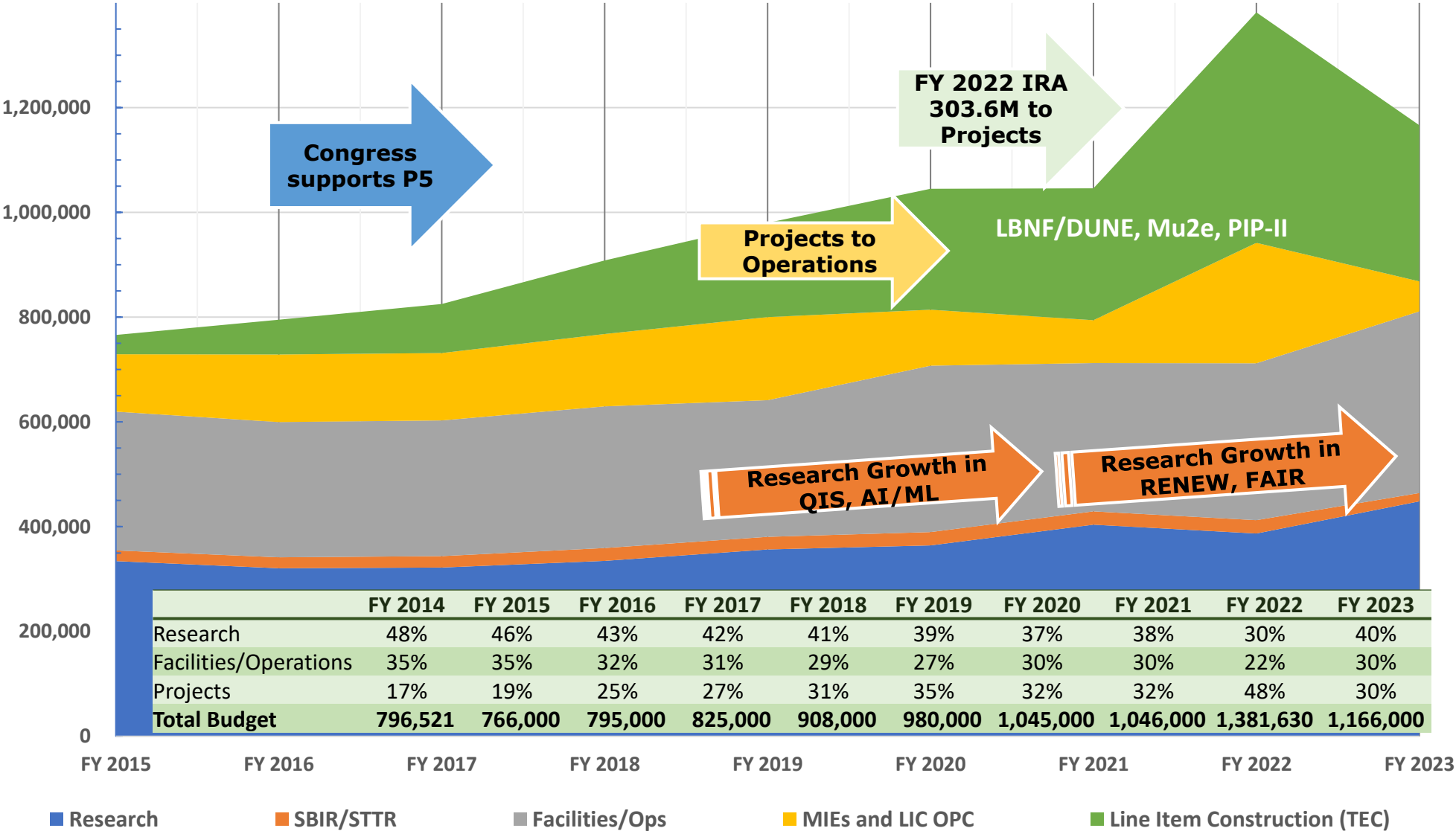
HEP Budget History 2013 to Present



- U.S. Congress continues to show strong support for executing the 2014 P5 strategy, and for accelerating the pace of projects

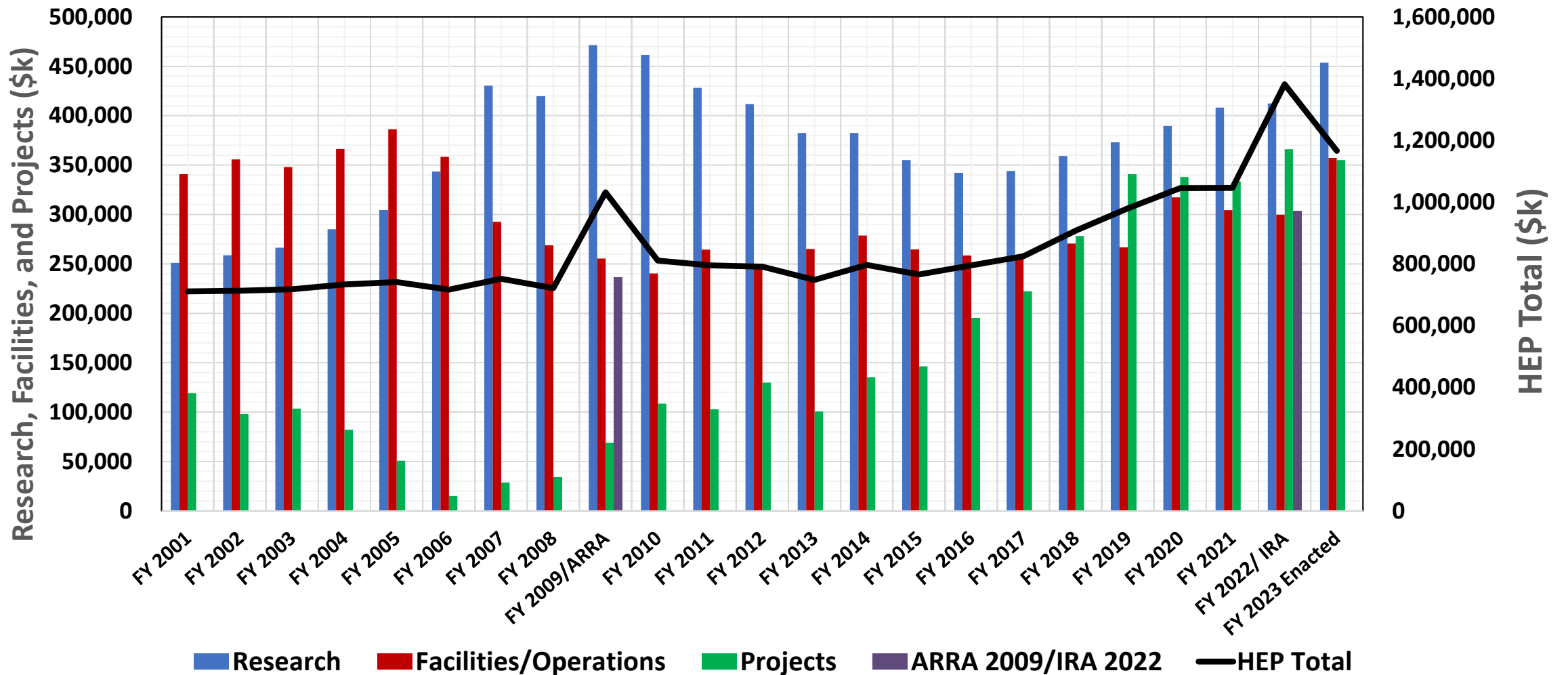


HEP Budget (\$K): Research, Facilities/ExpOps, Projects (MIE & LIC) FY 2014 – FY 2023



HEP Budget (\$K): Research, Facilities/ExpOps, Projects

FY 2001 – FY 2023



ARRA 2009 funds supported Research, Facilities, and Projects
 IRA 2022 funds supported Projects only



HEP FY 2024 President's Request - Research Initiatives

HEP budget (in \$K)	FY20 Enacted	FY21 Enacted	FY22 Enacted	FY23 Enacted	FY24 Request
Reaching a New Energy Sciences Workforce (RENEW)	0	0	4	8	11.5
Funding for Accelerated, Inclusive Research (FAIR)				2	4
Artificial Intelligence & Machine Learning (AI/ML)	15	33.5	35.8	40	40
Advanced Computing (was Integrated Computational & Data Infrastructure)			4.1	5.1	5.1
Microelectronics		5	7	7	7
Quantum Information Science (QIS)	23.5	20.1	26.6	25.6	25.6
Quantum Center	15	25	25	25	25
Accelerate [Accelerate Innovations in Emerging Technologies]				4	4
Accelerator Science and Technology Initiative (ASTI) [formerly SATI]		6.3	17.4	10	10
Traineeships (GARD, Computing, Detector R&D)	4	4	5	6	
TOTAL	57.5	93.9	124.9	132.7	132.2

- ▶ **RENEW (\$11.5M):** Expands targeted efforts to increase participation and retention of individuals from underrepresented groups in SC research activities. <https://science.osti.gov/Initiatives/RENEW>
- ▶ **FAIR (\$4.0M):** Improve capability of HBCUs and MSIs to perform and propose competitive research and build beneficial relationships between these institutions and DOE national laboratories and facilities. <https://science.osti.gov/Initiatives/FAIR>



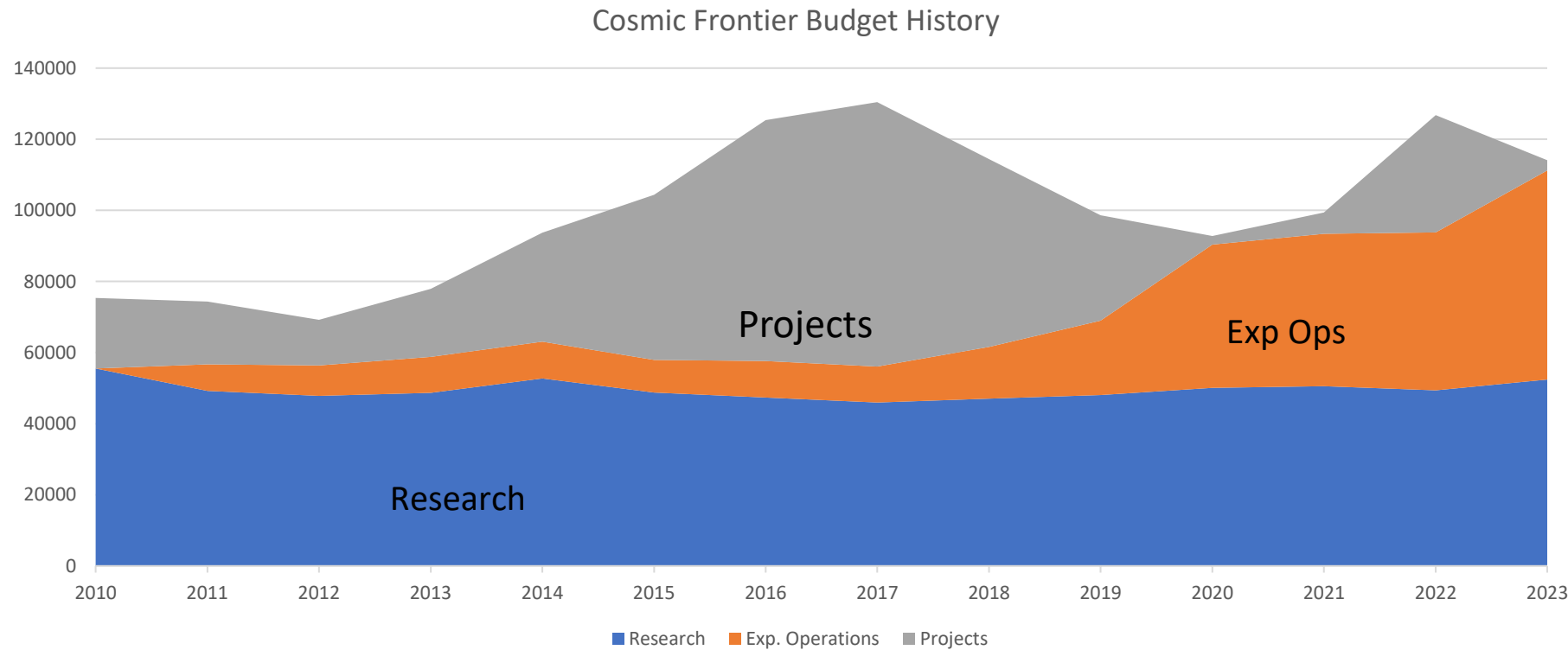
Cosmic Frontier Budget – FY2021 – FY2024

Cosmic Frontier (\$K)	FY2021 Actual	FY2022 Actual	FY2022 Inflation Reduction Act	FY2023 Actual	FY2024 Request
Research	50,521	49,395		52,417	48,048
Research (Univ+Lab)	43,901	42,513		45,698	
Future R&D	1,700	1,475		1,979	
AI/ML Research	4,920	5,407		4,740	
Exp. Ops.	42,880	44,350		58,810	61,830
Projects: CMB-S4, LuSEE-Night (FY22)	6,000	23,000	11,893	1,000	9,000
Total	99,401	116,745	11,893	108,227	120,342

NOTES:

- The amounts shown in the table do not include workforce costs or SBIR/STTR funds.
- FY 23 Request was \$92.9M

Cosmic Frontier Budget History



FY22 Project includes funds from the Inflation Reduction Act

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 (all funds in FY22); SuperCDMS completed in FY23

Future opportunities: Compelling Cosmic Frontier Projects will be considered and supported within available overall HEP project funds.



U.S. DEPARTMENT OF
ENERGY

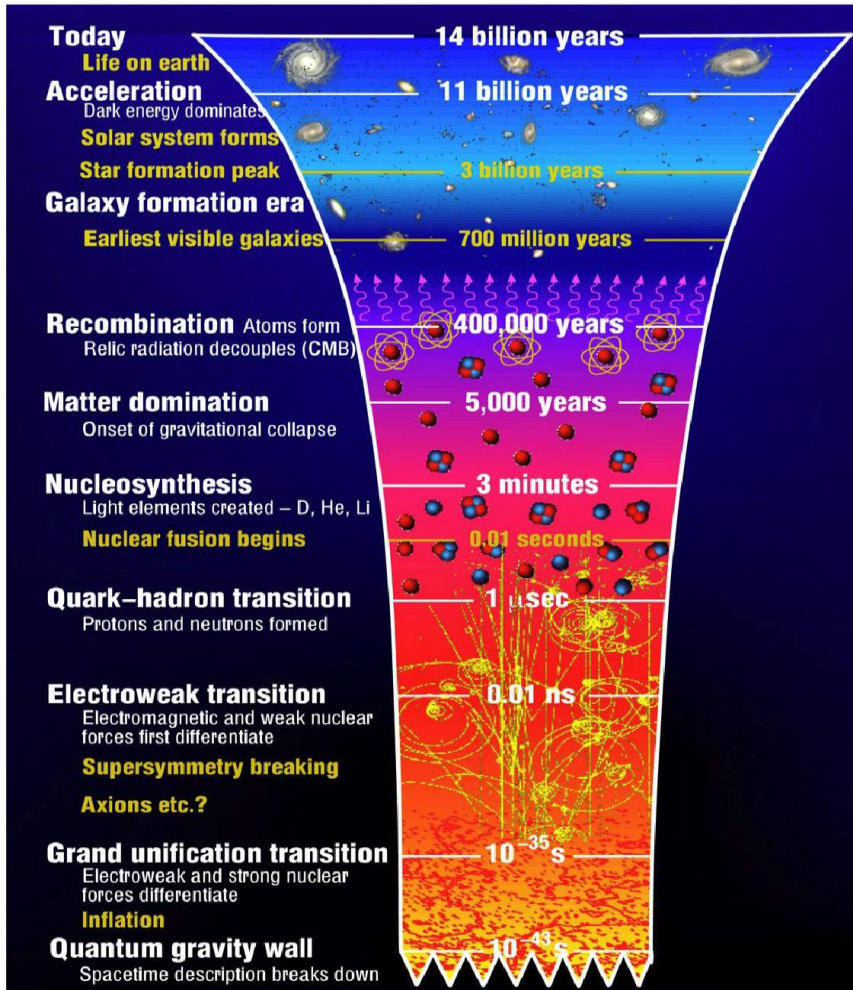
Office of
Science

Cosmic Frontier

- **Program - Detailed Status**

Cosmic Frontier – Experimental Program

Cosmic Frontier: 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 specific projects recommended by the 2014 P5 strategic plan.**

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

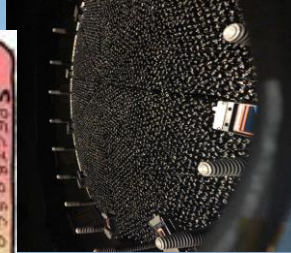
DOE/HEP joint efforts with NASA, NSF

Experiments no longer supported by DOE are in grey.

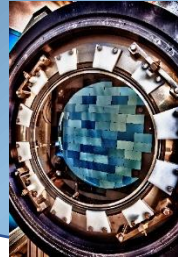
		DOE Project	DOE Operations	Oversight	Status
DES	NSF/AST	DECam	yes	JOG	survey completed; data processing & analysis operating
DESI	NSF/AST	Instrument, data management, telescope upgrades	full support of the Mayall	MOU for Mayall	
Rubin, LSST, DESC	NSF/AST	LSSTCam	50/50 split	MOU; JOG	project, commissioning, 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

HEP Cosmic Frontier: Cosmic Acceleration

Dark Energy



Pinhole camera 3.2Gpixel image of Vera C. Rubin



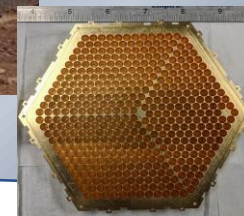
CMB



SPT-3G



CMB-S4
Next Generation CMB Experiment

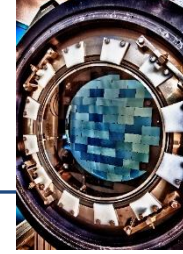


Dark Ages



LuSEE-Night

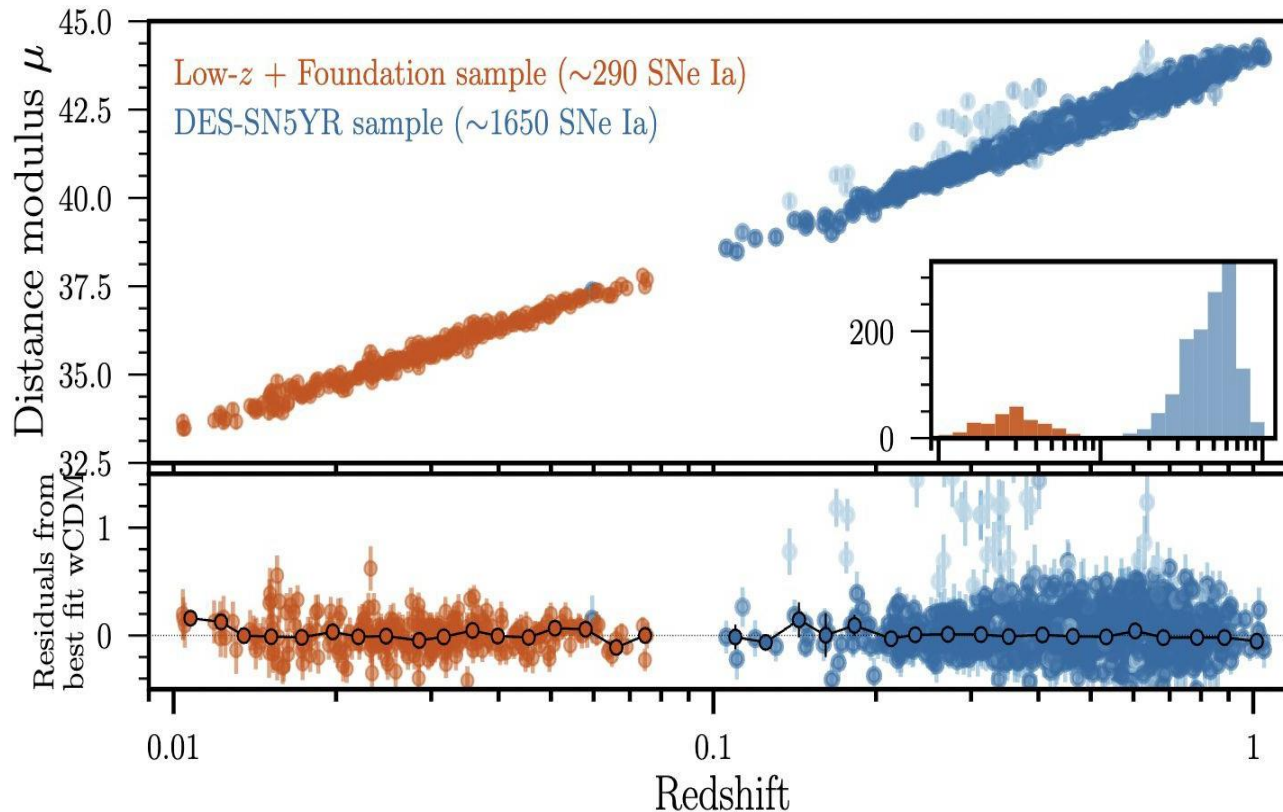
Dark Energy Survey (DES), Dark Energy Camera (DECam)



DARK ENERGY
SURVEY

DOE and NSF partnership

- Fermilab led fabrication of 570Mpix DECam; NSF led telescope upgrades, data management 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; >438 publications; >100 PhD's*



NEWS:

The 5 year DES SN sample: the **largest and deepest** SN sample from a **single telescope ever compiled**

~1700 SNe Ia

- Well defined sample selection
- Spectroscopic redshifts from OzDES
- SN classification using the most advanced machine learning techniques
- Final Type I SN cosmology results from DES have been unblinded and results will be coming out soon.

Cosmic Acceleration: Dark Energy

→ Dark Energy Spectroscopic Instrument (DESI)

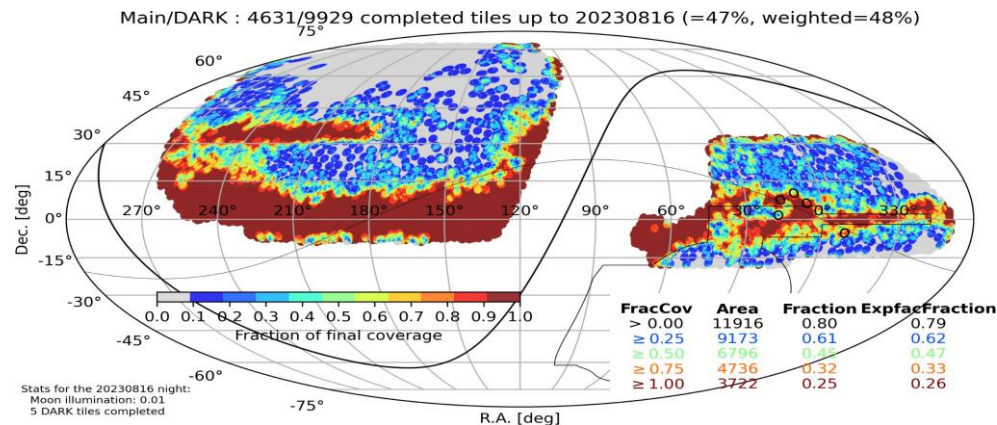


World's first Stage IV dark energy project → Will measure spectra of > 40 million galaxies to trace the universe's history. DESI is the world's premier multi-object spectrograph w/5,000 fibers, positioned robotically

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

Operations: DOE provides full support ("leases") for the Mayall telescope at Kitt Peak.

- Survey operations started May 2021. DESI was down June 2022 to Sept 2022 due to Contreras fire.
 - Kitt Peak utilities restored; road access still restricted.
- Summer 2023 shutdown → Along with other planned maintenance, the primary mirror was re-aluminized due to loss of reflectivity from fire-borne particulates. Data-taking restarted early August.



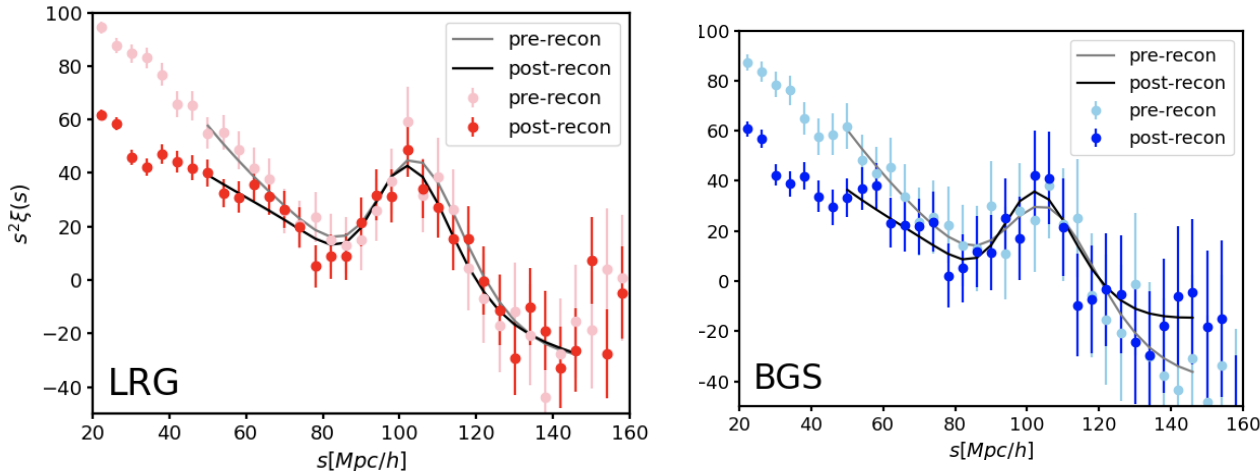
As of mid-August, DESI is running ~ 2.5 months ahead of schedule with over 23 million extra-galactic redshifts recorded (more than all other surveys combined). The dark time coverage is shown in the figure above.



DESI – Data & Science Results



Feb. 2023: First year data released to the collaboration

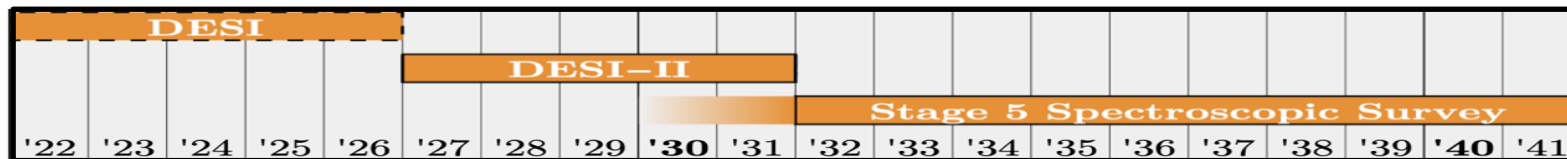


April 2023: Paper submitted on first detection of the baryon acoustic oscillation signal from the first two months of main survey submitted, using all 4 object types to study large-scale structure evolution. Two methods are shown here at 5σ and 2.5σ .

June 2023: Early Data Release was made publicly available and contains all the data from the Commissioning and Survey Validation phases. Data are available for download at <https://data.desi.lbl.gov>.

- Collaboration released 2 “Key papers” describing the data, and 14 science and technical papers simultaneously.

Future planning:



Future: Collaboration is planning an upgrade to DESI-II and has proposed a stage 5 project to P5.



Vera C. Rubin Observatory



- A next-generation, ground-based facility, providing repeated imaging of faint and time-variable astronomical objects across the entire southern sky every few nights for ten years

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

→ **DOE's science interests are led by the Dark Energy Science Collaboration**

Construction Project:

NSF responsibilities – observatory, telescope, data management, education/outreach, commissioning

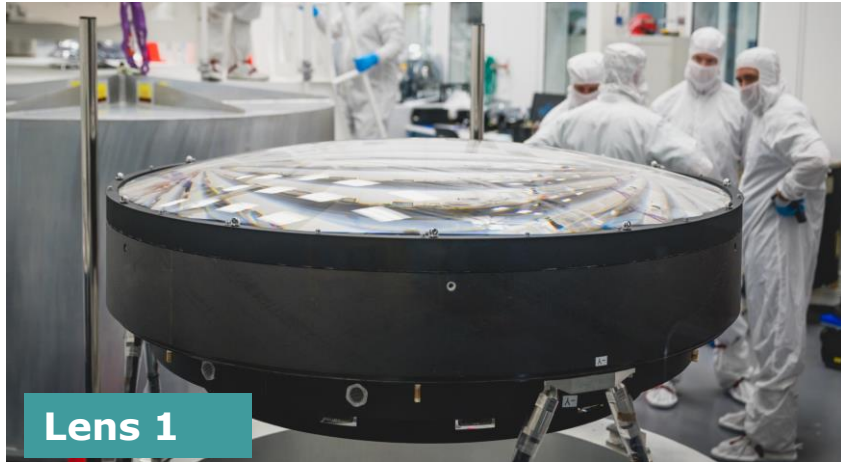
DOE responsibilities:

- **LSST Camera fabrication** was 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; also overall Project roles

• **Project construction completion forecast ~early/mid-2025.**



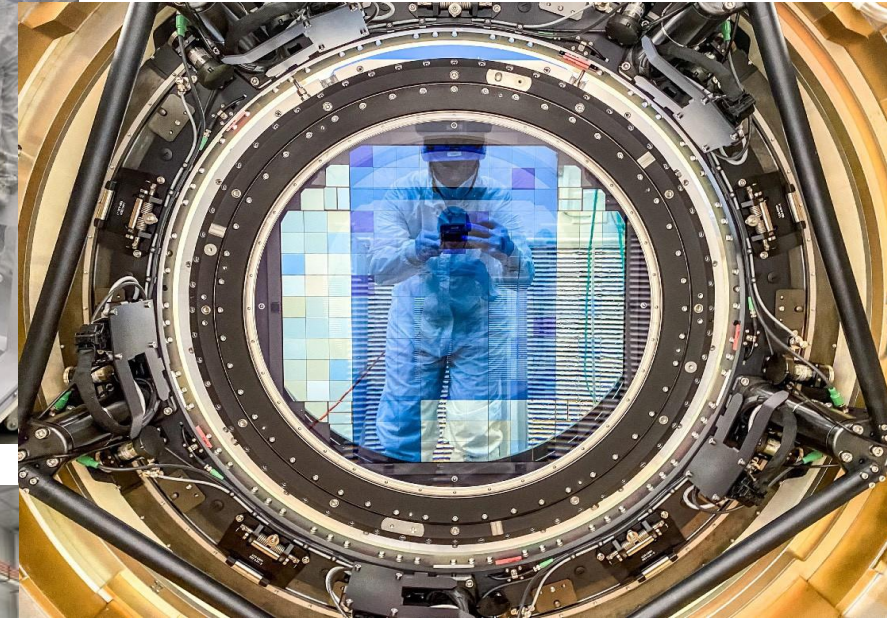
Commissioning



Lens 1



Filters



Focal plane



Camera on the test stand



- LSST Camera is undergoing integration & test at SLAC.
- Shipment to Chile is planned for November

Rubin Observatory: Facility Operations Planning

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 - DOE/NSF ~50/50 split

- DOE (SLAC) - primarily responsible for the US Data Facility (USDF), Camera maintenance and operations, as well as overall management roles and data quality studies
- Pre-Operations activities have started; planning continues for full operations with survey start ~ mid-FY2025
- Carrying out Data Previews

US Data Facility is at SLAC Shared Science Data Facility (s3df)

- Will carry out the full data facility efforts and deliver data to all researchers and collaborations
 - Rubin is data expected to be 30 Pbytes per year
- International in-kind contributions have been developed in exchange for early access to data; Data Rights Agreements are in process



SLAC US Data Facility

S3df/SRCF → Modern datacenter: 6 MW capacity

Rubin's USDF:

- **6k cores, 15 PB storage in hand**
 - +4k cores, 17 PB on site awaiting installation
 - Ultimately 80-100k cores, 200 PB by 10 yrs
- Hybrid model with hardware and initial services at SLAC.
- Rubin has a multi-site processing model → SLAC plus annual catalog processing also in the UK and France; transfers of test data demonstrated
- Rubin Science Platform (user access) is in the Google Cloud
- **Being used for LSST Camera testing and have demonstrated the automatic transfer of Auxiliary Telescope (AuxTel) data**
- **Using AuxTel as pathfinder:**
 - Auto deliver data from summit to USDF and do prompt processing
 - Reanalysis routinely happening
 - ~350 Rubin staff using RSP
- **Preparing for multi-site processing using HSC precursor data**
 - Using LHC tools for workflow (PanDA) and data mgmt (Rucio)
- **Planning Data Previews in 2024 and 2025**

S3df/SRCF: SLAC Shared Science Data Facility (s3df)
–Stanford Research Computing Facility



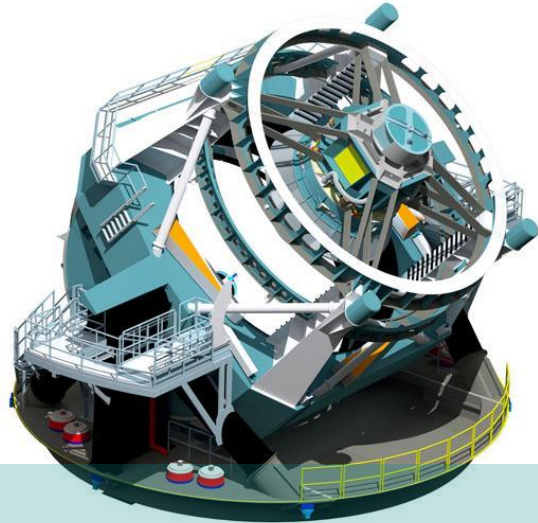
Rubin - Data Production System Vision

Raw Data: 20TB/night



Sequential 30s images covering the entire visible sky every few days

7 seconds to deliver visit to USDF

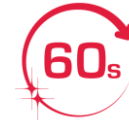


Prompt Data Products

Alerts: up to 10 million per night

Results of Difference Image Analysis (DIA): transient and variable sources

Solar System Objects: ~ 6 million



via nightly alert streams



via Prompt Products Database

Data Release Data Products

Final 10yr Data Release:

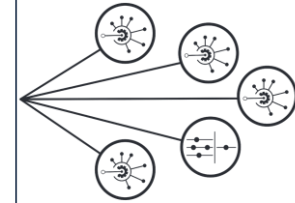
- Images: 5.5 million x 3.2 Gpx
- Catalog: 15PB, 37 billion objects



via Data Releases

All data archived at USDF

USDF



Community Brokers

Alert Filtering Service

Rubin DACs (DFs & Chile)

Independent DACs (iDACs)

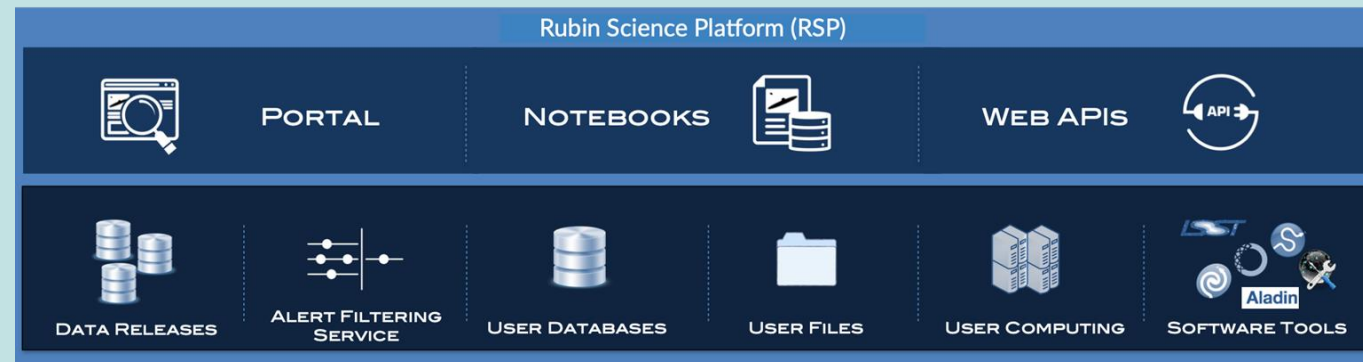
Annual reprocessings split among US, UK, French Facilities

Access to proprietary data and the Science Platform require Rubin data rights

Rubin Science Platform

Provides access to Rubin Data Products and services for all science users and project staff

5-10k Science users hosted in Google cloud - data source: USDF



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

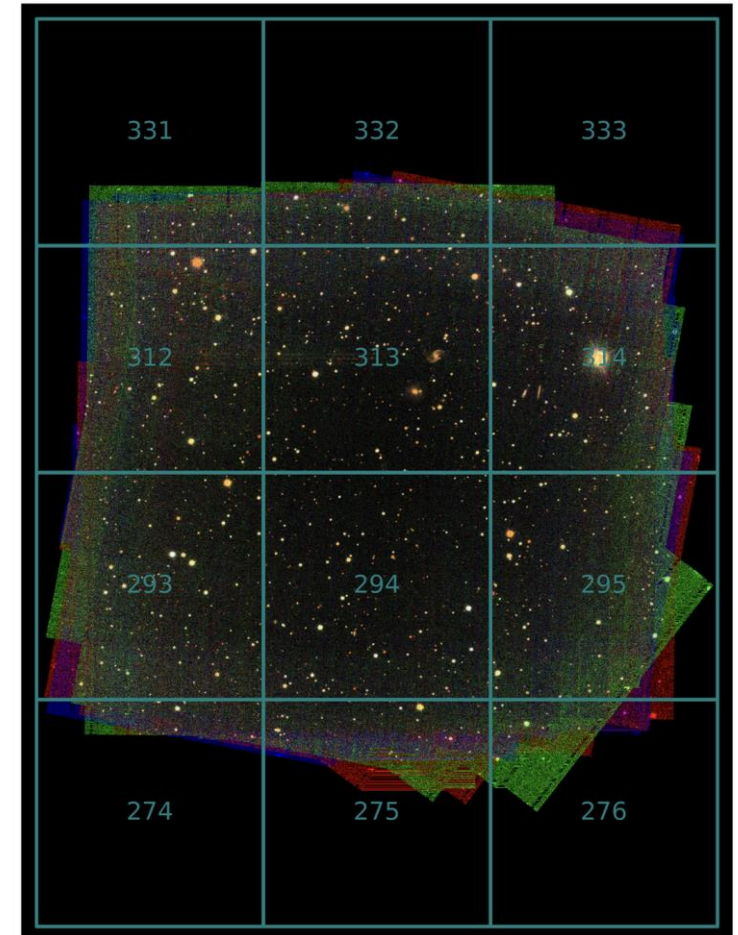


Scientific Research - Both NSF and DOE will support community efforts for LSST analyses

• **DOE's research efforts are organized through DESC**; planning and readiness activities are continuing.

- Rubin Data will yield constraints on the nature of **Dark Energy at 10x the current experiments**
- Rubin Data will constrain **modifications to GR, neutrino mass**, nature of **dark matter** – lots of scope for **cross-correlation** of DESC products with other cosmology surveys.

LATISS_runs_AUXTEL_DRP_IMAGING_2023-05A_w_2023_19_PREOPS-3444:
coadd GRI tract = 5615 (vMin=0.2, dataRange=3, Q=2)



Collaboration has 1250+ members and growing – 244 full members; from 20+ countries.

63 publications overall, 14 already in 2023, 9 submitted

Preparing for commissioning & data arrival with simulated and precursor data

- Planning, pipeline building, and readiness activities are continuing
- Simulations, image coaddition and deblending efforts
- Fruitful collaboration between DESC and Rubin on many fronts
- DESC simulations used for Rubin Data Preview 0.1 and 0.2

Connections with Rubin Observatory

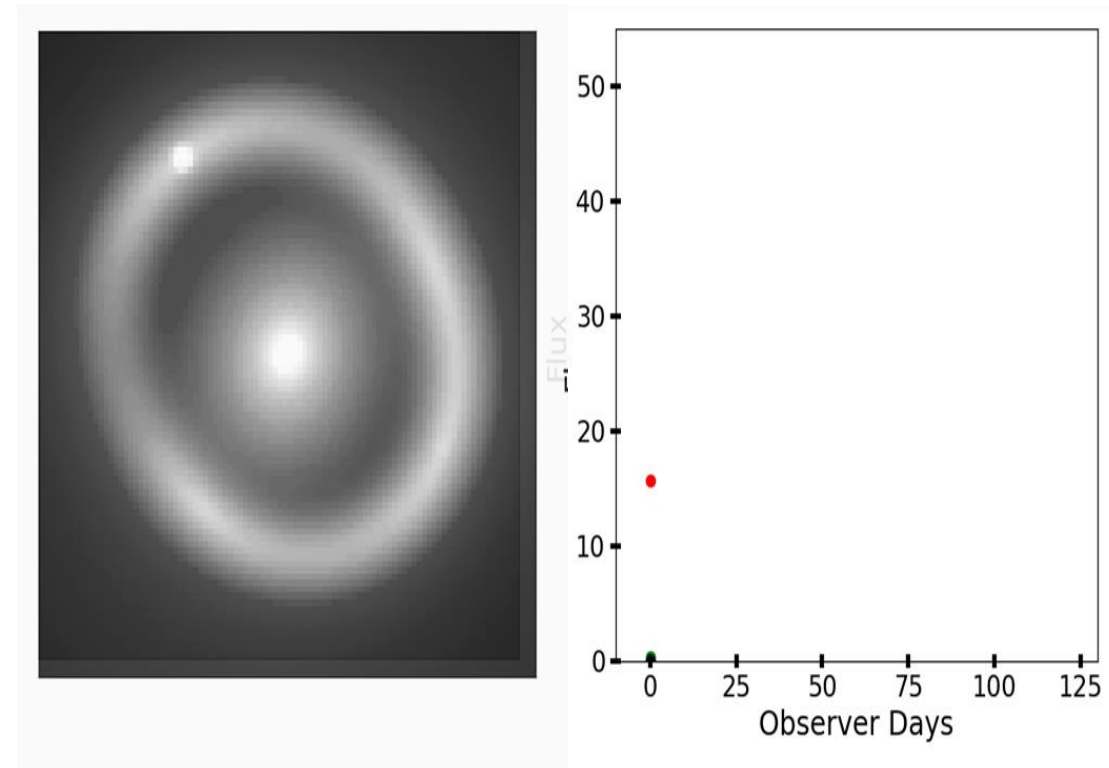
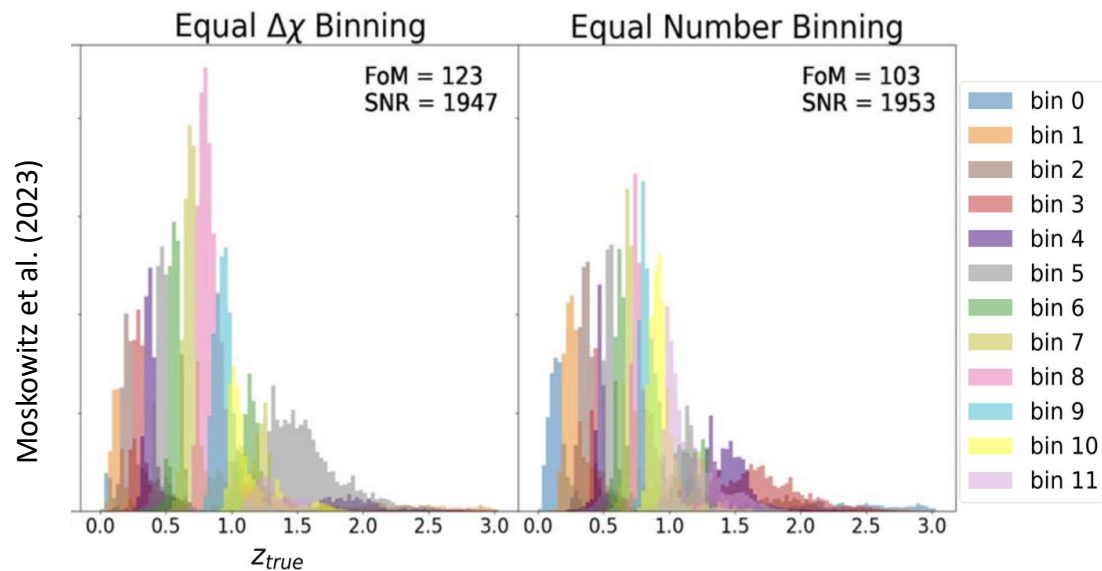
- More than 100 DESC members are involved in Rubin commissioning, including international in-kind contributions



Static cosmology probes: 3x2pt

Time domain probe: Strongly lensed SN

Irene Moskowitz (PhD student, Rutgers) is investigating the optimal redshift binning strategy for our '3x2pt' weak lensing signal using a CNN. This work is part of the STatic Analysis Roundtable (STAR) which brings together all 'static science' probes in DESC.



Justin Pierel (Einstein Fellow, STScI) combined simulations of images and Rubin observing strategy to simulate light curves of strongly-lensed SNe from Rubin

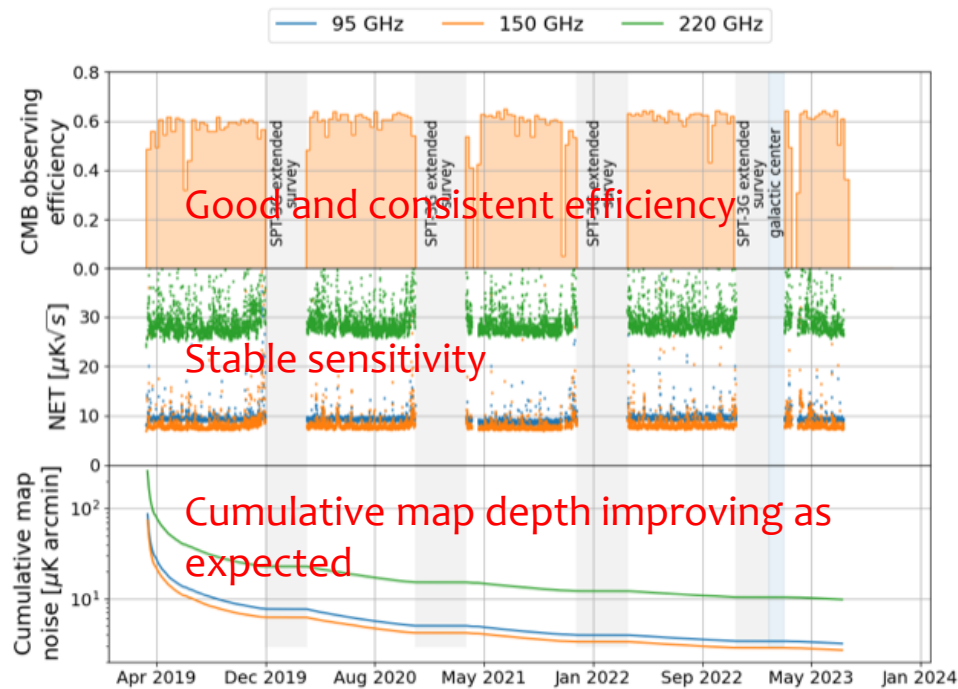
CMB & South Pole Telescope (SPT-3G)

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

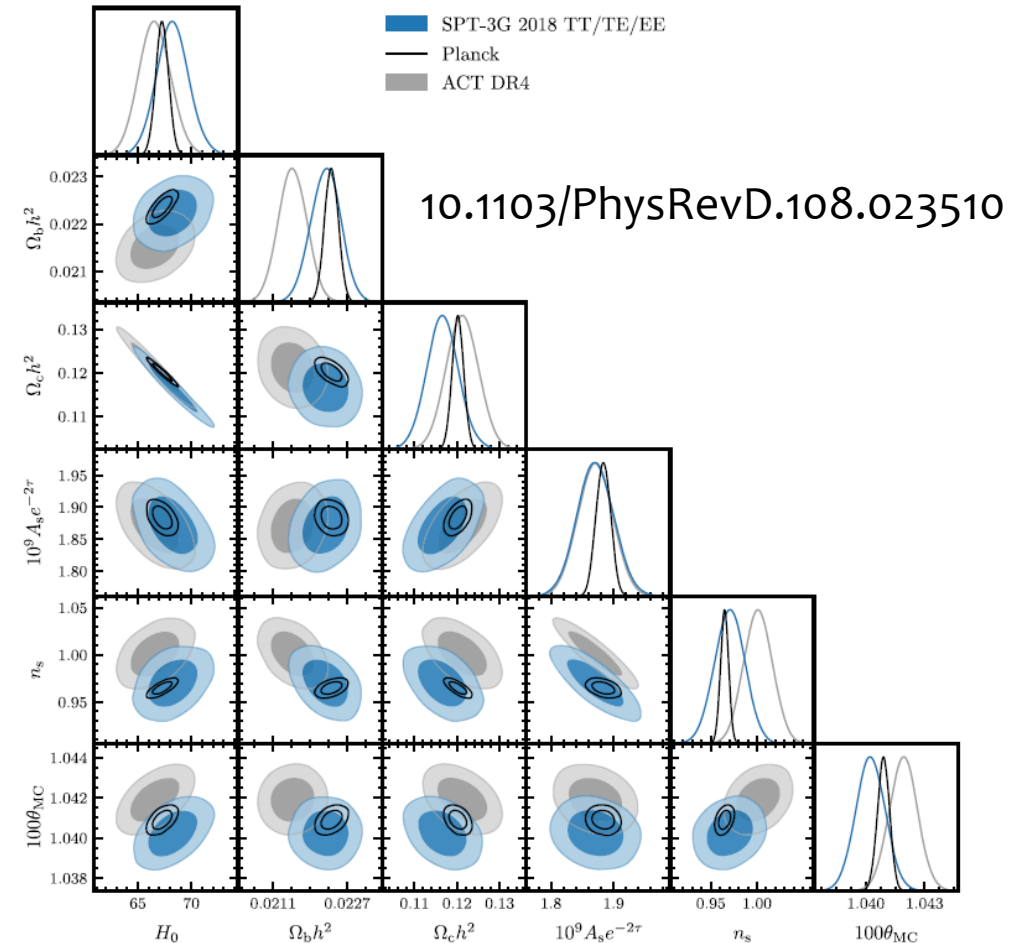
➤ P5 recommended DOE should support CMB experiments in the core program.

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; Cosmology Results from SPT-3G data (first half of 2018) using joint TT, TE and EE power spectrum measurements published July 2023



The constraints derived from the SPT-3G (blue) TT, TE and EE data are in excellent agreement with the Planck (black) constraints, including for H_0 and with ACT (gray) data.



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

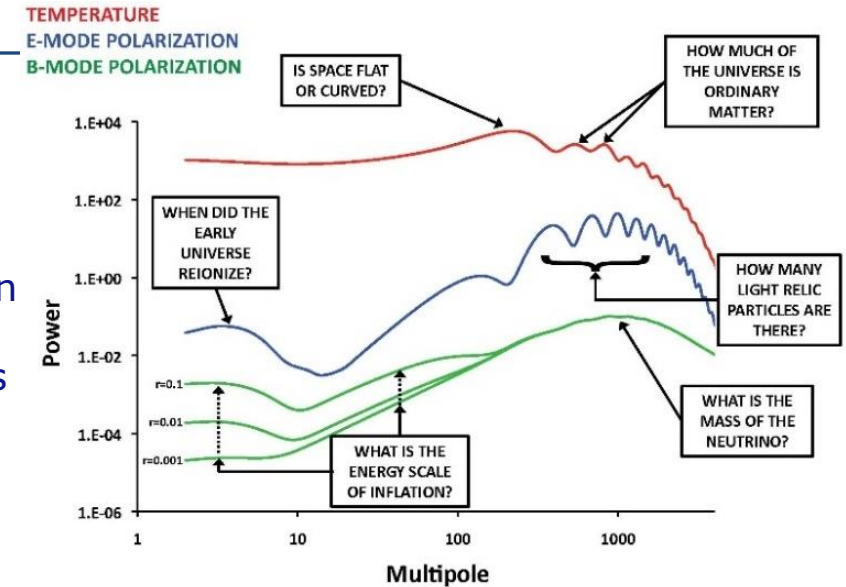
“An important requirement for our strong endorsement is that the project broadly engage astronomers beyond the traditional CMB community.”

Cosmic Microwave Background Stage 4 (CMB-S4) Project

CMB-S4 builds on the foundation of decades of CMB measurements to take a major leap in CMB science.

- Array of small and large telescopes in Chile and the South Pole
 - ▶ 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 time domain science; neutrino properties, relic particles

Goal: cross critical science thresholds, including definitive tests of Inflation
→ World leading science!



Science	Stage 2	Stage 3	Stage 4	Top Level goal for CMB-S4
Inflation "r"	≤0.1	≤0.01	≤0.001	Detect/rule out classes of inflationary models
s(Neff)	0.14	0.06	0.03	Detect/rule out light relic particles w/ spin
s(Mass of neutrinos)	0.15eV	0.06eV	0.02eV	3sigma detection
# detectors	~1000	~10,000	~500,000	Deployed on multiple telescopes
Sensitivity (μK ⁻²)	10 ⁵	10 ⁶	10⁸	2° to 1' angular scales

- DOE History:** decades of involvement in CMB technology & experiments, starting with George Smoot (LBNL) on NASA's COBE.
- NERSC has done a large fraction of the international CMB computing for decades, including NASA/ESA's Planck.
 - Technology development and fabrication by DOE labs - to most of the ground-based experiments, many as work for others.
 - HEP is supporting science-only efforts on BICEP and PolarBear/Simons.
 - HEP contributed to sensor fabrication for SPTpol and built the 16,000-detector focal plan for SPT-3G; now operating

Cosmic Acceleration

CMB-S4 (Cosmic Microwave Background Stage 4)



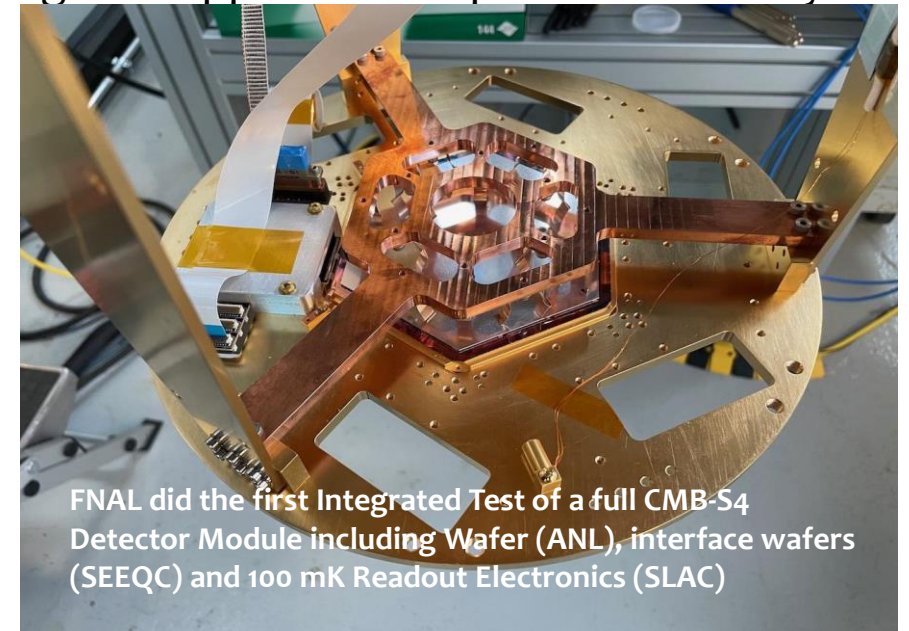
- 2014 P5 recommended CMB-S4 as a joint DOE/NSF, **planned to be the next flagship HEP project following Rubin**
- CD-0 in 2019; MIE project approved FY2021
- Astro2020 recommended CMB-S4 as 2nd priority for ground-based astronomy/astrophysics
- DOE/HEP has been working with NSF to move CMB-S4 forward.
 - Technology, computing, & project roles are well matched to DOE expertise & capabilities
- In December 2022, the Project reported an alternative design that will address South Pole infrastructure and logistics constraints made clear in early 2022 and will **still meet all the science goals**.
 - Now working on this design, including renewable energy & energy storage to supplement SP power availability

CMB-S4 is being considered by P5.

The South Pole is critical to Inflation measurements, HEP's primary science interest.

Status – from the Project Office

- Recently awarded funding from NSF to support continued development on planned NSF scope (led by U.Chicago)
- Anticipating entry into NSF Major Facilities design stage pool, enabling detailed planning with NSF OPP and an NSF conceptual design review.



FNAL did the first Integrated Test of a full CMB-S4 Detector Module including Wafer (ANL), interface wafers (SEEQC) and 100 mK Readout Electronics (SLAC)

Astro2020: Science Panel on Cosmology → Dark Ages

The Panel on Cosmology identified 4 Questions:

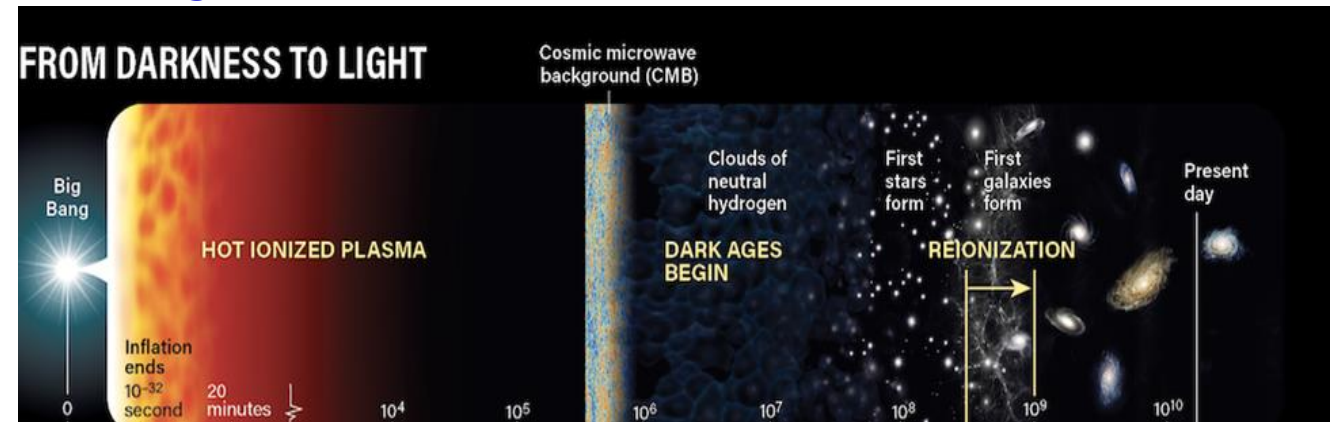
- What set the hot Big Bang in motion?
- What are the properties of dark matter and the dark sector?
- What physics drives the cosmic expansion & large-scale evolution of the universe?
- How will measurements of gravitational waves reshape our cosmological view?

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 & 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

→ The DOE/NASA partnership on **LuSEE-Night** is a high level, strategic initiative & an opportunity for great science.

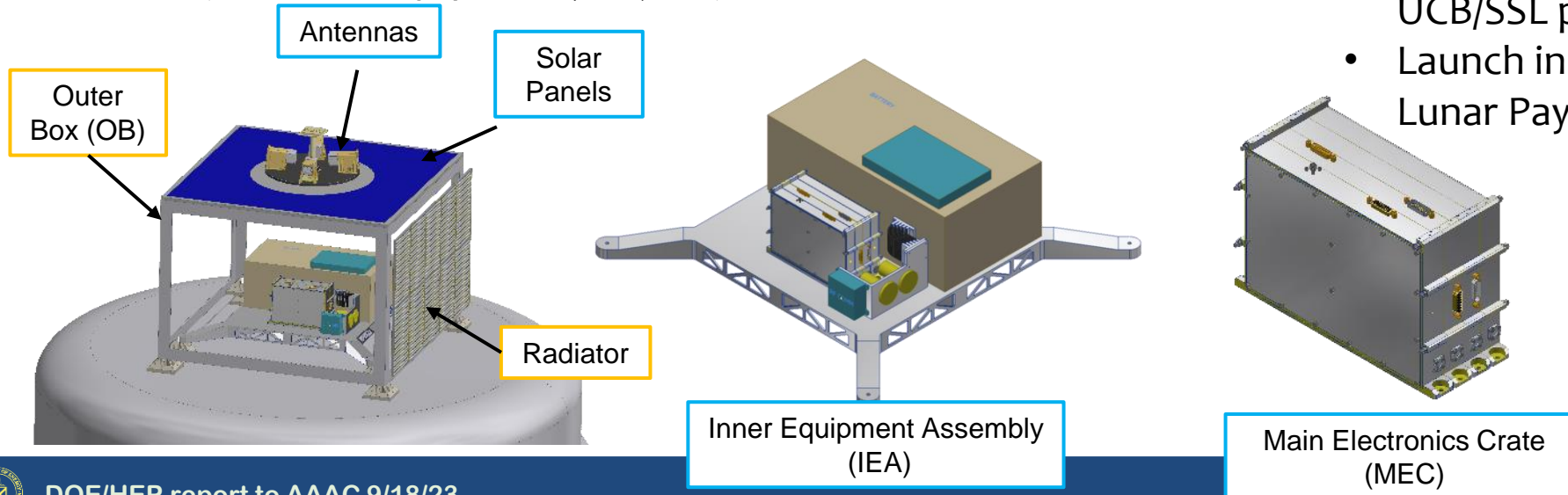
- Pathfinder mission to place the most sensitive constraints to date on the **Dark Ages signal** & potentially discover the Dark Ages signal.
- Capability to measure the radio environment and observe the long-wavelength radio signal through the lunar night (launch early 2025).



Milestones/Schedule

- Nov. 2021: DOE approval of Critical Decision 0; DOE lead is Brookhaven Lab
 - BNL is also leading the Science Collaboration
- DOE Major Item of Equipment (MIE) Project started in FY2022

- Project Decision 3 review at the end of August - successful
- DOE MIE hardware will be delivered to the UCB/SSL project office by mid-2024
- Launch in late 2025 by NASA's Commercial Lunar Payload Service (CLPS) mission.



HEP Cosmic Frontier: Dark Matter

Dark Matter Generation 3



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



WIMP search at SURF (SD); started FY22

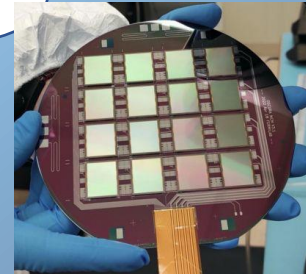


WIMP search at SNOLAB (Canada); Ops starts 2025

Dark Matter New Initiatives

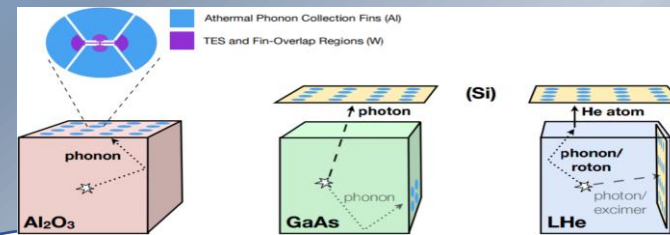


Axion search 2-4 GHz



OSCURA

TESSERACT



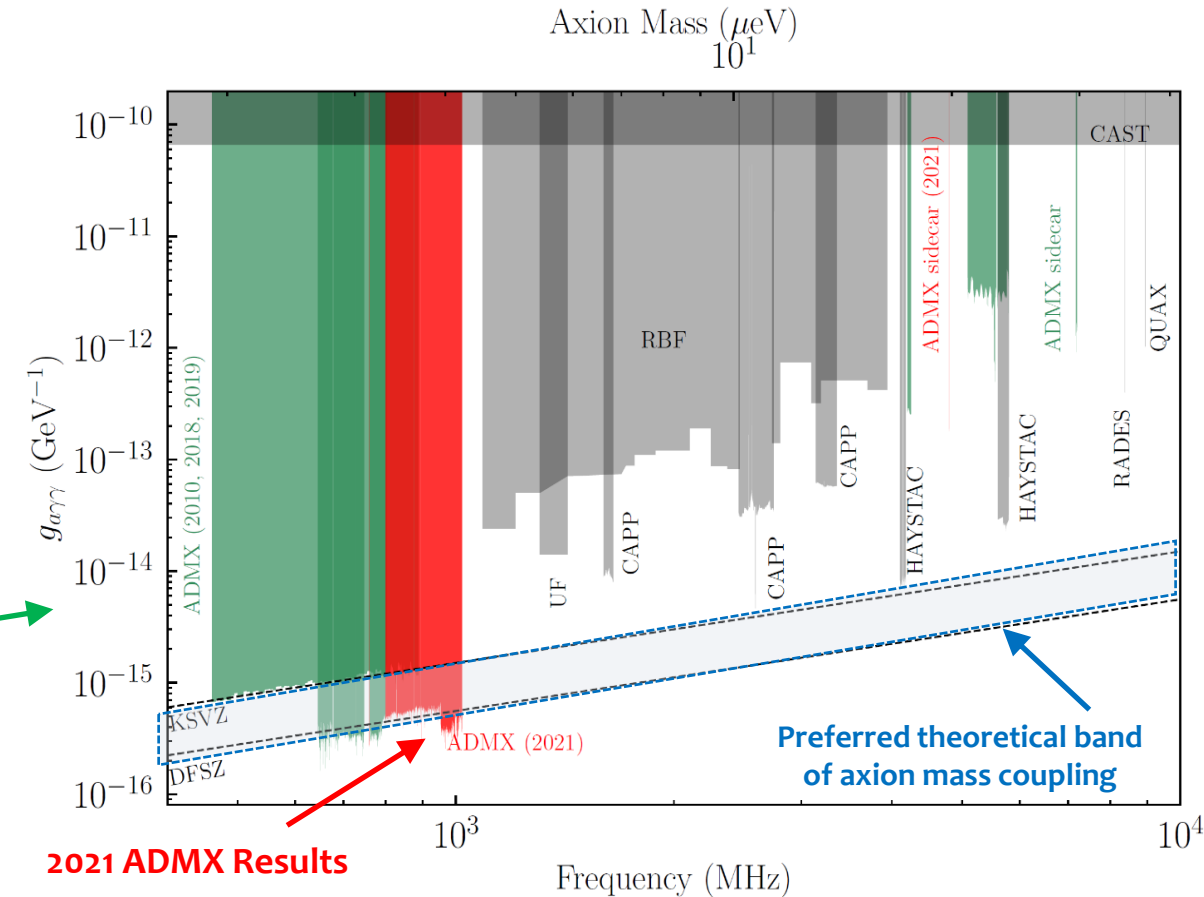
Direct Detection Dark Matter 2nd Generation (DM-G2): ADMX-G2

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

Future: Collaboration is planning the ADMX-Extended Frequency Range as a new initiative concept.

Previous ADMX limits

Other experiment results in grey



ADMX-G2 continues operations at U. Washington

- 2021 results (shown) are 5-orders of magnitude better than previous limits, ruling out axion DM hypothesis in this mass-coupling range
- Continues operations and planned upgrades to search next mass range: Run 1C & 1D (through FY24), Run 2A starts mid-FY25

DM-G2: LZ – First Results



Gen-2 Direct Detection WIMP Dark Matter search ~10-1000 GeV mass

- 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
- **First Results: July 2022 – with only its first 60 days of data, already had the world’s most sensitive dark matter results; published in PRL in July 2023 (1000 days planned)**
- June 2023 – Science Run 3 started

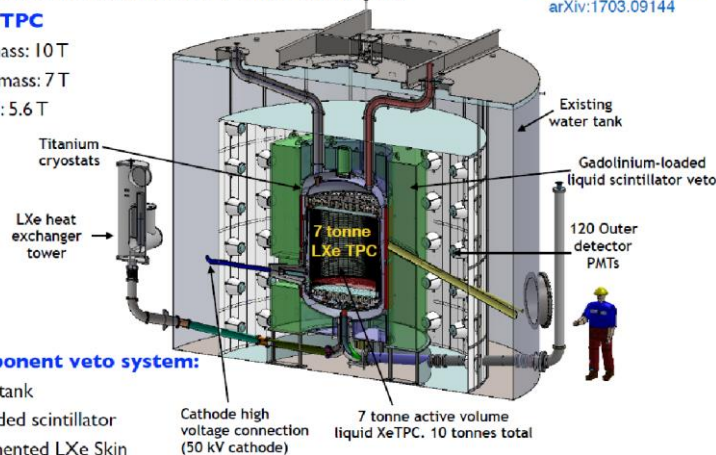


• LZ experiment at SURF, in Lead SD (~1 mile underground)

• Xenon TPC

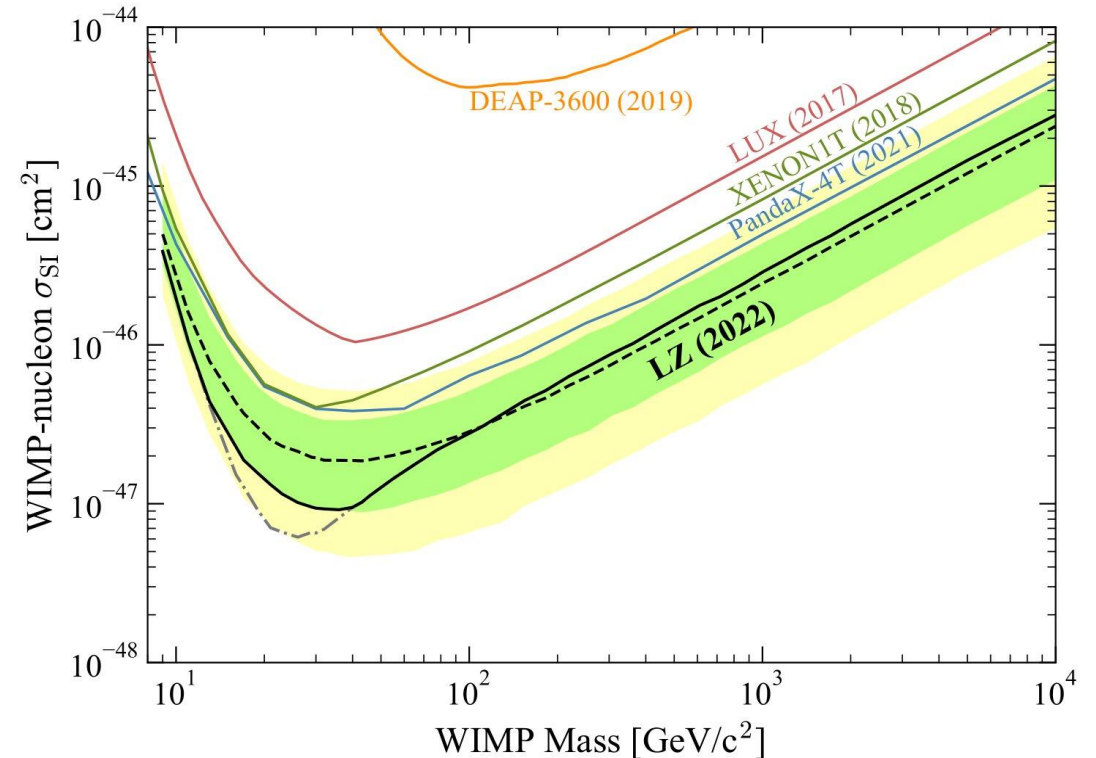
- Total mass: 10 T
- Active mass: 7 T
- Fiducial: 5.6 T

Technical Design Report:
arXiv:1703.09144



• 3-component veto system:

- Water tank
- Gd-loaded scintillator
- Instrumented LXe Skin

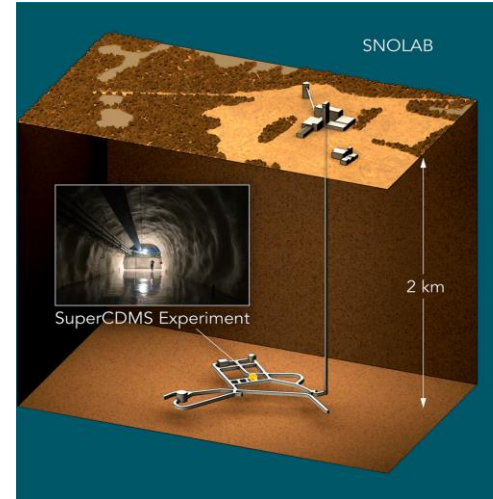


10.1103/PhysRevLett.131.041002

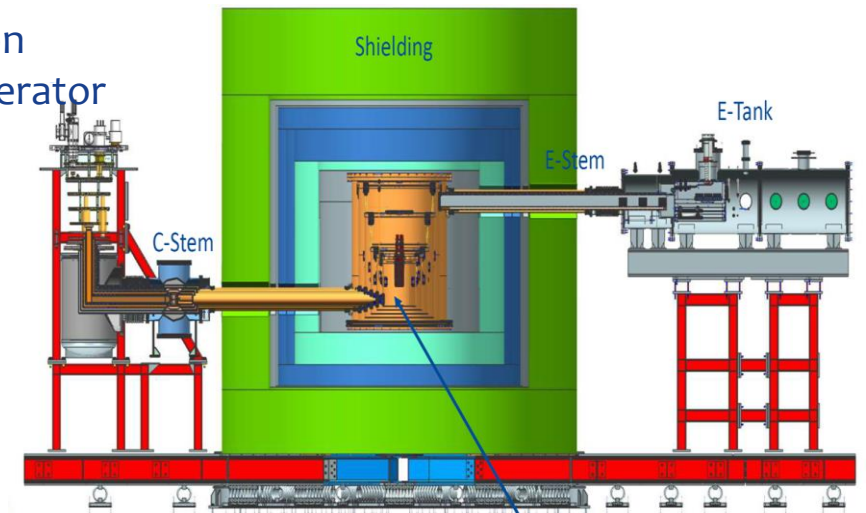
DM-G2: SuperCDMS SNOLAB

Gen-2 Direct Detection WIMP Dark Matter search ~1-10 GeV mass
- at Creighton Nickel Mine in Sudbury Canada

- Cryogenic solid-state crystal detectors
 - Construction Project completed with CD-4 in April 2023
 - Integrations, Installation and Commissioning activities & planning are underway
 - Operations testing with pre-production detectors started in FY 2022
 - First 2 production towers delivered to SNOLAB
 - Testing with production towers starts in FY 2024; operations starts in FY 2025



Dilution Refrigerator



Dark Matter New Initiatives (DMNI) for small projects

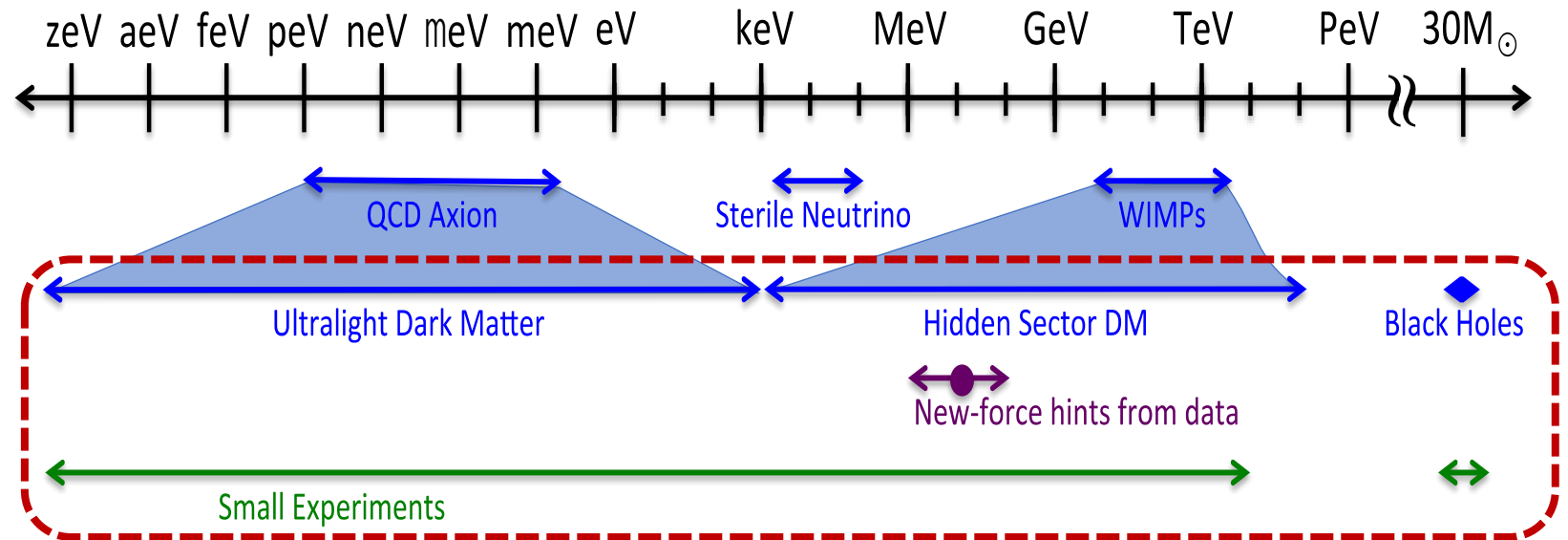
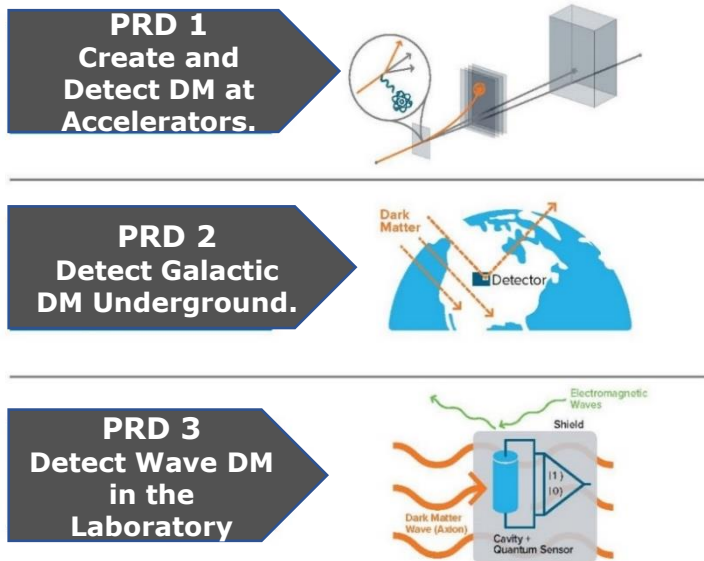
P5 recommended the search for Dark Matter particles as a high priority & also that the program should include small projects

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

- **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/>

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



Dark Matter New Initiatives (DMNI) – Concept Studies

→ HEP continues support for the selected concept teams to carry out near-term technology R&D and develop design and execution plans that could lead to new, small projects that address the 2019 BRN study, searching for DM in new areas of phase space and with new technologies.

- The concepts are developing plans that can be reviewed and considered for advancing to a small project fabrication phase.

Cosmic Frontier:

- **ADMX Extended** (axions 2-4GHz), 9-17 μeV
- **OSCURA** (low noise “Skipper” CCD detector) 1MeV-1GeV
- **DM-Radio** (axion search), $<\mu\text{eV}$
- **TESSERACT** (Multiple detectors, w/TES readout), $>10\text{ MeV}$

Intensity Frontier (accelerator based)

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

Status review of the DMNI concepts was held June 2022 and HEP briefings in summer 2023.

→ Most expect to have their design complete in 2024.

Exploring the Unknown

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

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

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



AMS (w/NASA)

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



HAWC (w/NSF)

Gamma rays and cosmic rays between 100 GeV and 100 TeV
- HEP operations support completed early FY2021.

New results!
10.1103/PhysRevLett.131.051201

HAWC Full Operating Array



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

Black: HEP support ended
Green: funding continues



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Astro2020 recommendations, responses & related info - versions to use

- DEI, Harassment
- Demographics, Metrics
- Data Management
- Climate Change, Energy Usage
- AI/ML
- Community Engagement

Diversity, Equity & Inclusion (DEI), Harassment, Demographics – at the Federal Government Level

A significant number of efforts at the cross-agency level of the federal government have been going on in the last few years regarding these issues. WH Executive Orders and OSTP memos provide higher-level guidance and recommendations than those of specific agencies, scientific fields, etc.

- Cross-agency task forces are in progress; details available when completed.

2021

Jan. 2021, Biden White House [Executive Order \(WH-EO\) 13985 on “Advancing Racial Equity and Support for Underserved Communities”](#)

Jan. 2021, Biden memo, Restoring Trust in Government Through Scientific Integrity and Evidence-Based Policy Making.

<https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/memorandum-on-restoring-trust-in-government-through-scientific-integrity-and-evidence-based-policymaking/>

June 2021, WH-EO 14035 – Diversity, Equity, Inclusion and Accessibility

<https://www.whitehouse.gov/briefing-room/presidential-actions/2021/06/25/executive-order-on-diversity-equity-inclusion-and-accessibility-in-the-federal-workforce/>

DOE is a member of task forces set up in response - to review policies and identify solutions

<https://www.whitehouse.gov/ostp/ostps-teams/nstc/scientific-integrity-task-force/>

<https://www.whitehouse.gov/wp-content/uploads/2021/09/091621-Best-Practices-for-Diversity-Inclusion-in-STEM.pdf>

Diversity, Equity & Inclusion (DEI), Harassment, Demographics – at the Federal Government Level

2022

- 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).
 - https://www.whitehouse.gov/wp-content/uploads/2022/01/01-22-Protecting_the_Integrity_of_Government_Science.pdf
- In March 2022, OSTP issued a memo calling upon the agencies to respond to the recommendations.
 - <https://www.whitehouse.gov/wp-content/uploads/2022/03/03-2022-Next-Steps-for-Protecting-Scientific-Integrity.pdf>

2023

- Feb 2023, WH-EO 14091 – Updated order for Advancing Racial Equity
 - <https://www.whitehouse.gov/briefing-room/presidential-actions/2023/02/16/executive-order-on-further-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/>
 - DOE has launched a new task force in response

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

DOE efforts in DEI and related issues – History, Status

➔ Along with government-wide efforts, DOE has been carrying out internal efforts

DOE/SC 2019-2020 internal review of business practices led to recommendations and setup of DEI Working Group to move forward

DOE has investigated advancing DEI in business practices and at the national laboratories; learn more at:

- [Advancing DEI in SC Business Practices](#), and
- [Advancing DEI at the SC DOE National Laboratories](#).

April 2022 –DOE released our plan on the Roadmap to Equity – Implementing Racial Equity and Support for Underserved Communities

- <https://www.energy.gov/articles/doe-releases-new-equity-action-plan-unveils-investments-strengthen-hbcu-opportunities>
- <https://www.energy.gov/diversity/articles/roadmap-equity-implementing-racial-equity-and-support-underserved-communities>

See full plan at:

- https://www.energy.gov/sites/default/files/2022-04/DOE%20Equity%20Action%20Plan_Letterhead.pdf

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.

- https://www.energy.gov/sites/default/files/2022-09/DOEDEIAStrategicPlan_1.pdf

DOE efforts in DEI and related issues - Actions

Oct. 2022 “Everyone has a role to play”

SC is committed to advancing belonging, accessibility, justice, equity, diversity, and inclusion (**BAJEDI**) across the portfolio of activities we sponsor. <https://www.energy.gov/science/articles/everyone-has-role-play-making-science-more-equitable-and-inclusive>

See DOE’s Statement of Commitment – including links to info on harassment, preventing discrimination, reporting issues and actions: <https://science.osti.gov/SW-DEI/SC-Statement-of-Commitment>
...and the associated statement on consequences of unprofessional behavior: <https://science.osti.gov/SW-DEI/SC-Statement-of-Commitment/Potential-Consequences>

DOE/SC already has efforts aligned with these issues and we continue to further develop plans for the future.

➔ One stop shop for info at Office of Scientific Workforce Diversity Equity & Inclusion:

<https://science.osti.gov/SW-DEI>

Also see Office of Economic Impact and Diversity: <https://www.energy.gov/diversity/office-economic-impact-and-diversity>

DOE/SC Statement of Commitment (Oct. 2022)

- “The DOE Office of Science (SC) is **fully and unconditionally committed to fostering safe, diverse, equitable, inclusive, and accessible work, research, and funding environments** that value mutual respect and personal integrity.... SC’s effective stewardship and 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 is foundational to delivering on our mission. We are **committed to promoting people from all backgrounds**, including individuals and communities that were historically underrepresented and minoritized in STEM fields and the activities we sponsor in recognition of our responsibility to serve the public...
- Discrimination and harassment undermine SC’s ability to achieve its mission by reducing productivity, discouraging or inhibiting talent recruitment, retention, and career advancement, and weakening the integrity of the SC enterprise overall. **SC does not tolerate discrimination or harassment of any kind...**
- Beyond issues that may rise to the level of legal action, 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...**”

SC Statement of Commitment: <https://science.osti.gov/SW-DEI/SC-Statement-of-Commitment>

DOE/SC: DEI policies & procedures

DOE/SC does not tolerate discrimination or harassment of any kind, including [sexual or non-sexual harassment](#), bullying, intimidation, violence, threats of violence, retaliation, or other disruptive behavior in the federal workplace, including DOE field site offices, or at national laboratories, scientific user facilities, academic institutions, other institutions that we fund, or other locations where activities that we support are carried out.

The DOE has long-standing [policies and procedures](#) for the prevention of discrimination and harassment. SC has established this site to make those policies and procedures more accessible to the scientific community and the institutions that receive DOE SC funding, as well as to clearly communicate [SC's commitment](#) to diversity, equity, and inclusion.

- As SC continues to identify opportunities to improve our policies, practices, and communications to advance diversity, equity, and inclusion in furtherance of our core values and mission, updated policies, procedures, and resources will be posted here on an ongoing basis.

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

DOE efforts in DEI and related issues – initiatives and activities

Over the last few years, SC has initiated activities to adhere to our principles via business processes and removing barriers to research.

- Starting FY 2023, all SC Funding Opportunity Announcements require a Promoting Inclusive and Equitable Research (PIER) plan, with an associated merit review metric.
- Starting in FY2023, there are new SC-hosted/funded **conference requirements**, including a code-of-conduct (with consequences if not followed) recruitment, and accessibility.
- HEP specifically considers diversity on **review panels** for proposals and projects, experimental operations & facilities.
- DOE currently collects **demographics** as required/allowed by OMB.
 - We are working to improve data collection and reporting capabilities . Starting in FY2023, we updated requirements in PAMS to require a response to by all key applicants, awardees and reviewers (can always “not wish to respond”).
 - 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.
- New Funding Initiatives: **RENEW (FY2022), FAIR (FY2023) and other Funding**

DOE/SC: Promoting Inclusive and Equitable Research (PIER) Plans

Beginning in FY 2023, Office of Science solicitations require applicants to submit a plan for Promoting Inclusive and Equitable Research, or PIER Plan, along with their research proposals.

- **PIER Plans should describe the activities and strategies that investigators and research personnel will incorporate to promote diversity, equity, inclusion, and accessibility in their research projects.**
 - The complexity and detail of a PIER Plan is expected to increase with the size of the research team and the number of personnel to be supported.
 - **The PIER Plans will be evaluated under a new merit review criterion as part of the peer review process.**
- PIER is not meant to be a general-purpose exercise in Diversity, Equity, and Inclusion (DEI), nor does it ask for participation in unrelated outreach efforts. PIER is **Promoting Inclusive and Equitable Research**, and a PIER Plan should describe how inclusivity and equity are to be expressed in the research being proposed, and how senior investigators on the proposal are involved in the effort.
- A PIER Plan can leverage institutional DEI plans and resources, but it is not enough to simply describe those programs and resources; the PIER Plan must discuss how they are to be implemented in the proposed research.

Additional information and FAQs: <https://science.osti.gov/grants/Applicant-and-Awardee-Resources/PIER-Plans>

DOE/SC Conference Requirements (starting FY2023)

<https://science.osti.gov/grants/Applicant-and-Awardee-Resources/Applicant-FAQs#conference>

<https://science.osti.gov/SW-DEI/SC-Statement-of-Commitment/Potential-Consequences>

SC does not tolerate discrimination or harassment of any kind, including sexual or non-sexual harassment, bullying, intimidation, violence, threats of violence, retaliation, or other disruptive behavior at institutions receiving SC funding or other locations where activities funded by SC are carried out. Further, SC is committed to advancing BAJEDI across the portfolio of activities it sponsors.

For applications requesting SC funds for the purpose of supporting (hosting) a **conference, symposium, or workshop, the meeting must have a policy or code of conduct in place that addresses discrimination and harassment**, including sexual harassment, other forms of harassment, and sexual assault, and that includes **processes for reporting complaints and addressing complaints**. The policy or code-of-conduct must be shared with all participants prior to the conference, symposium, or workshop (hereinafter the ‘meeting’) and made easily available. Applications must include:

- A link to the current code of conduct of the host organization for the meeting
- A recruitment and accessibility plan for speakers and attendees that includes discussion of recruitment of individuals from groups underrepresented in the research/professional community associated with the technical focus of the meeting, and discussion on plans to address possible barriers for attendees, including but not limited to physical barriers.

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. If a participant does not adhere to such expectations, SC reserves the right to take appropriate action. Such action may include:

- 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.

DOE/SC: Reaching a New Energy Sciences Workforce for High-Energy Physics (RENEW-HEP)

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.
 - <https://science.osti.gov/Initiatives/RENEW>
- The HEP RENEW FOA (\$4M in FY2022, \$8M in FY2023, \$10M requested for FY2024) is to support training and research experiences in particle physics for members of underserved communities, with the goals of supporting investigators and building research infrastructure at institutions which have not traditionally been part of the portfolio and encouraging underrepresented populations to pursue STEM careers.
 - \$50K - \$500K per year; 3-year awards

https://science.osti.gov/hep/Funding-Opportunities/-/media/grants/pdf/foas/2023/SC_FOA_0002949.pdf



This is the FY2023 FOA. There will certainly be changes for FY2024.

SC's FY2023 RENEW awards announcement (Aug. 2023):

Official announcement: <https://www.energy.gov/articles/doe-announces-70-million-research-training-opportunities-students-and-faculty-historically>

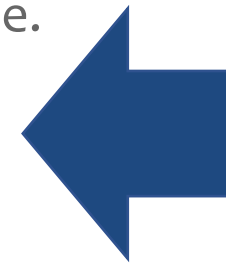
List of awards: https://science.osti.gov/-/media/Initiatives/pdf/renew/RENEW_Public_Abstracts-FY23.pdf

DOE/SC: Funding for Accelerated, Inclusive Research (FAIR)

FAIR initiative – started 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.
 - <https://science.osti.gov/Initiatives/FAIR>
- Funding for Accelerated, Inclusive Research (FAIR) aims to build research capacity, infrastructure, and expertise at institutions historically underrepresented in the Office of Science portfolio, including minority serving institutions (MSIs) and emerging research institutions (ERIs).
- FAIR supports mutually beneficial relationships between MSIs and ERIs with partnering institutions to perform basic research in fields supported by the Office of Science.

https://science.osti.gov/hep/Funding-Opportunities/-/media/grants/pdf/foas/2023/SC_FOA_0002931.pdf



This is the FY2023 FOA. There will certainly be changes for FY2024.

SC's FY2023 FAIR awards announcement (Aug. 2023):

\$37 million in funding for 52 projects to 44 institutions

See: <https://www.energy.gov/articles/us-department-energy-announces-37-million-build-research-capacity-historically>

List of awards: https://science.osti.gov/Initiatives/FAIR?utm_medium=email&utm_source=govdelivery

Other DOE Research, Workforce or Career Development Opportunities

- **Workforce Development (WDTS) programs:** <https://science.osti.gov/wdts>
 - **Office of Science Graduate Student Research fellowships (SCSGR)**
 - Supports grad student research at a DOE lab, 3 to 12 months
 - Two calls per year, usually Feb/Aug
 - Applications typically due May/Nov for following Fall or Summer start
 - **Science Undergraduate Laboratory Internships (SULI)**
 - Supports undergraduate research at a DOE lab, 10 to 16 weeks
 - Three calls per year, for following Spring/Summer/Fall terms
 - **Visiting Faculty Program**
 - Summer research support for faculty/students from historically underrepresented institutions
 - One call per year, usually in Oct. Applications due in Jan.
 - **Community College Internships (CCI)**
 - Provides technical training for community college students at DOE laboratories; 10 weeks
 - Three separate internship terms: Summer, Fall, Spring
- **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; to work at DOE or a DOE national lab - <https://www.energy.gov/diversity/minority-educational-institution-student-partnership-program-meispp-internships>

Available funds have
been increasing!

DOE Data Policy

(Astro2020 recommendations were about coordinating archive centers & using standard formats in archives.)

Data, Science

- SC has a data policy
- Data Management Plans (DMP) are required in proposals and reviewed in the merit review process
- HEP is participating in the Future of Astrophysical Research Infrastructure workshop and related efforts.
- All survey projects (DES, DESI, Rubin Observatory) are making data public after a proprietary period.

History:

2013 OSTP Public Access Memo (Dr. Holdren) “Increasing Access to the Results of Federally Funded Scientific Research”

The Administration is committed to ensuring that, to the greatest extent and with the fewest constraints possible and consistent with law and the objectives set out below, the direct results of federally funded scientific research are made available to and useful for the public, industry, and the scientific community. Such results include peer-reviewed publications and digital data.

Requirements include:

- Applied to agencies with over \$100M in annual R&D
- Free public access to federally-funded scholarly publications with a 12-month embargo period
- Required recipients of federal grants and contracts to develop “data management plans” (DMPs)
- Implementation required “within the existing agency budget”

→ Led to development of [2014 DOE Public Access Plan](#)

Full DOE policy: <https://www.energy.gov/datamanagement/doe-policy-digital-research-data-management>

Full SC policy: <https://science.osti.gov/Funding-Opportunities/Digital-Data-Management>



DOE Data Policy

2022 OSTP Public Access memo (Dr. Nelson), “Ensuring Free, Immediate, and Equitable Access to Federally Funded Research”

-- expands on the 2013 memo

A federal public access policy consistent with our values of equal opportunity must allow for broad and expeditious sharing of federally funded research—and must allow all Americans to benefit from the returns on our research and development investments without delay.

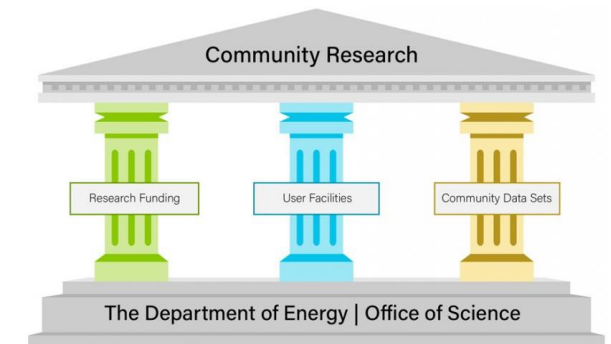
Requirements include:

- Removes 12-month embargo on access to scholarly publications – immediate access upon publication
- Requires immediate access to data underlying publications and increased access to other data
- Requires the use of persistent identifiers (PIDs) for research outputs (e.g., publications, data, software), researchers, and awards
- Submission of most agencies’ new public access plans to OSTP by Feb. 21, 2023

The National Science and Technology Council (NSTC) Subcommittee on Open Science (SOS) provides a forum for interagency coordination in response to the 2022 OSTP Public Access memo

- NSF, NASA, DOE and many other agencies subject to the OSTP guidance participate
- SOS being chaired by DHHS, NSF, NASA
- DOE co-chairs three SOS working groups

See <https://www.whitehouse.gov/wp-content/uploads/2022/08/08-2022-OSTP-Public-Access-Memo.pdf> and <https://www.whitehouse.gov/wp-content/uploads/2022/08/08-2022-SOS-NSTC-CHARTER.pdf>



DOE Data Policy

2022 OSTP Public Access Memo Section Descriptions

Section 3: Publications & Data

Section 4: PIDs – Research & Scientific Integrity

Section 5: Interagency Coordination

Aug 25, 2022

Feb 21, 2023

Dec 31, 2024

Dec 31, 2025

Dec 31, 2026

Dec 31, 2027

OSTP Public Access Policy Guidance released

Section 3: DOE Public Access Plan due to OSTP/OMB

Section 3: Last date to publish related DOE policies

Section 3: Last date for related policies to be effective

DOE plan released 6/30/23

Section 4: Last date to provide optional DOE Public Access Plan update to OSTP/OMB

Section 4: Last date to publish related DOE policies

Section 4: Last date for related policies to be effective

- Elimination of any embargo period before free public access to journal articles or final accepted manuscripts resulting from federal funding
- Immediate access to scientific data displayed in or underlying publications
- Expanded access to scientific data not displayed in Publications
- Broad adoption of persistent identifiers (PIDs) for research outputs, organizations, awards and contracts, and people.

Requirements and guidance will be in place by the end of 2024 with implementation by the end of 2025.

See <https://www.energy.gov/doe-public-access-plan>

2023 is a Year of Open Science - multi-agency initiative:

→ <https://open.science.gov/>

DOE Office of Scientific and Technical Information (OSTI) is happy to receive your comments at comments@osti.gov

More info on processes and policies available at: <https://www.osti.gov/pids/> and <https://science.osti.gov/Initiatives/PuRe-Data>

Climate Change, 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. Efforts include industry and academic partnerships.
- DOE has partnerships with other agencies, e.g. https://www.nsf.gov/news/news_summ.jsp?cntn_id=305100&org=ENG

BNL's Northeast Solar Energy Research Center



- DOE Initiatives; DOE Office of Sustainability, e.g.
 - DOE Net Zero Labs Pilot Initiative
 - Energy Earthshots Research Centers (EERC) Initiative
 - Climate Resilience Centers (CRCs)
- 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
- Development for specific experiments, e.g. ANL, in collaboration with NREL, is studying deployment of renewable energy and energy storage at unique remote sites to support HEP Cosmic Frontier experiments, e.g. for CMB-S4.
- Many of our experiments now have partial remote data-taking (in Cosmic Frontier e.g. DESI, the underground dark matter experiments, etc. including plans for Rubin and CMB-S4). Most workshops and meetings now have zoom participation.

Efforts aligned with Astro2020 Recommendations on AI/ML, Community Engagement

AI/ML techniques are vitally important for advancing the field of HEP as well as across SC. HEP funding has increased from \$20M (FY20) to \$40M (FY24 Request). In FY22, HEP made 16 awards to universities for AI/ML efforts, including for cosmology. Cosmic Frontier has AI/ML efforts at labs, universities & has recent Early Career awards.

Community Engagement - HEP labs work with local communities- employment opportunities and outreach efforts.



U.S. DEPARTMENT OF
ENERGY

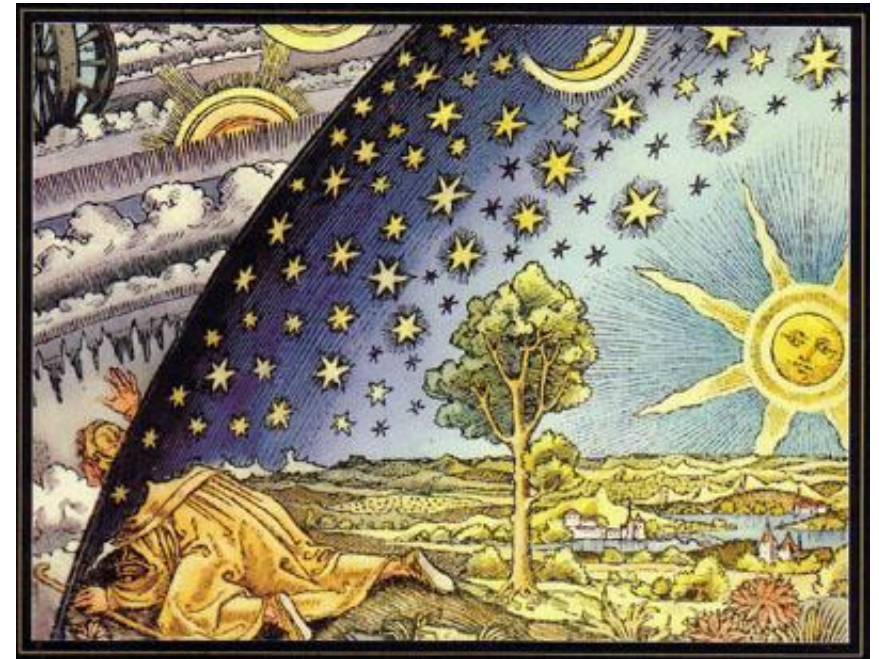
Office of
Science

Summary

HEP Cosmic Frontier

Summary & Future Planning

- HEP continues to carry out the 2014 P5 strategic plan:
 - Delivering results – DESI, LZ, ADMX-G2
 - Nearing completion – SuperCDMS SNOLAB, Rubin Observatory
 - Working on developing CMB-S4
- Completed execution of the FY 2023 budget
 - Planning for FY 2024
 - Developing FY 2025
- Future Planning: 2023 P5
 - New Projects & Directions!





U.S. DEPARTMENT OF
ENERGY

Office of
Science