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

to the

Committee on Astronomy & Astrophysics

March 30, 2023

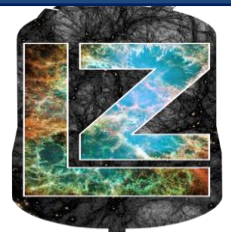
Kathy Turner

Cosmic Frontier Program Managers: Karen Byrum, Bryan Field, Chris Jackson, Kathy Turner

U.S. DEPARTMENT OF ENERGY | Office of Science

VERA C. RUBIN OBSERVATORY

ADMX AXION DARK MATTER EXPERIMENT



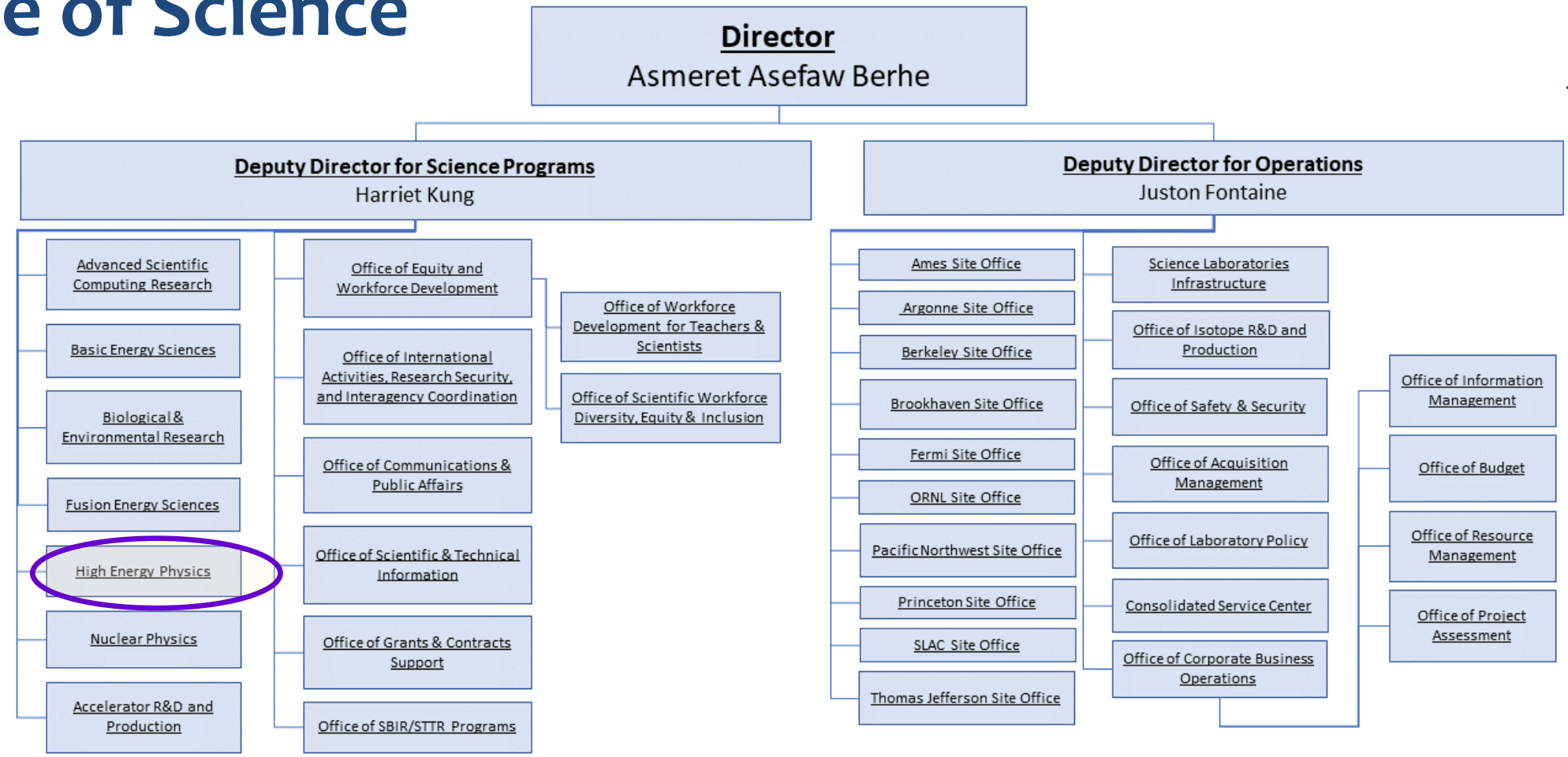
SUPER CDMS Cryogenic Dark Matter Search

OUTLINE

Report on the HEP Cosmic Frontier Program

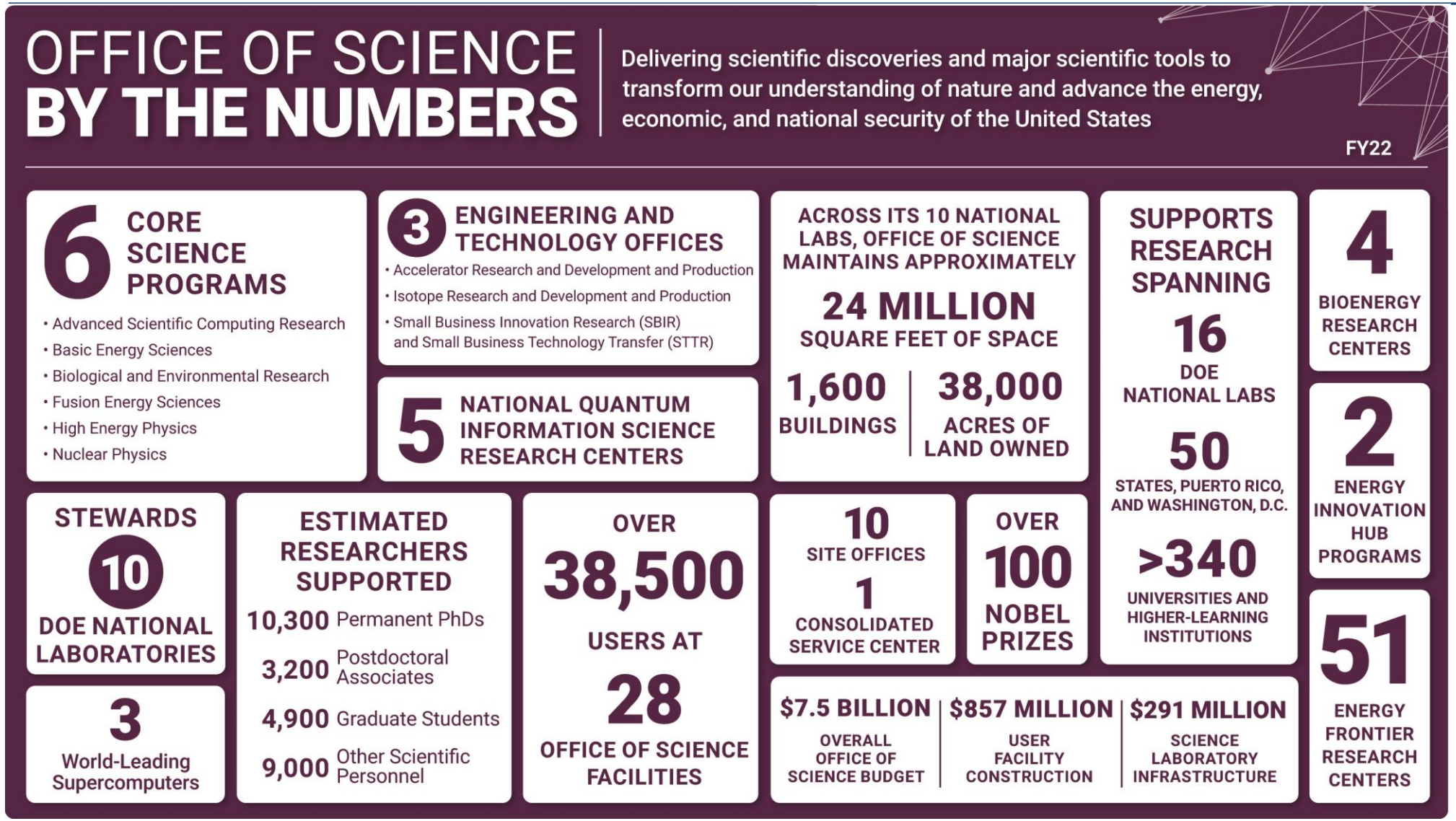
- Organization and News
- Cosmic Frontier Program Status
- Budget
- (Other) Astro2020 recommendations
- Planning for the Future

DOE Office of Science

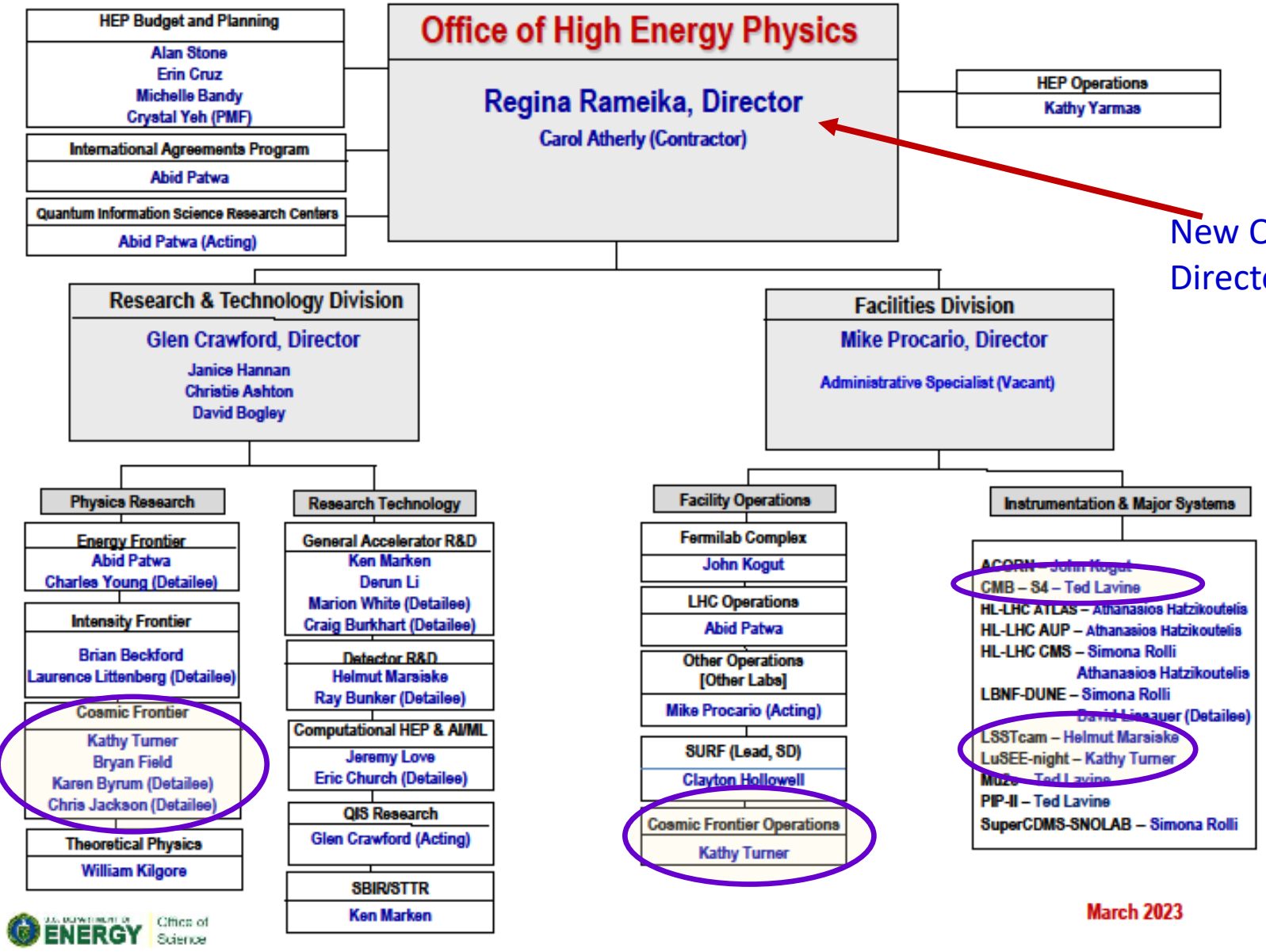


- **DOE Mission includes maintaining a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity, with clear leadership in strategic areas.**
- SC Mission is to deliver the scientific discoveries and major scientific tools that transform our understanding of nature and advance the energy, economic, and national security of the United States

Office of Science by the Numbers (2022)

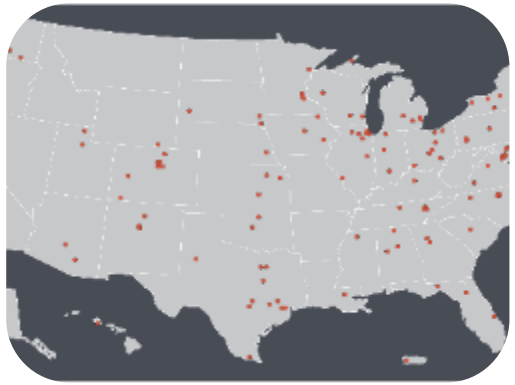


DOE Office of High Energy Physics Organization



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

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

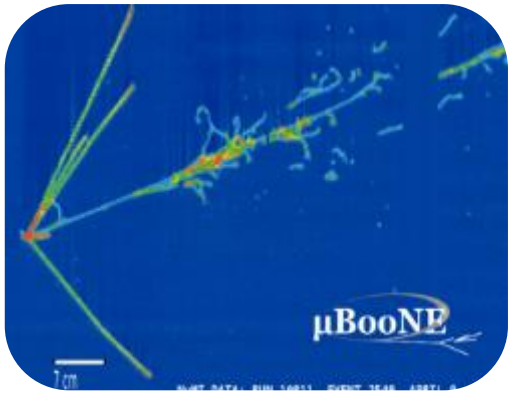


Funding at **>160** Institutions, including **12** DOE Labs

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

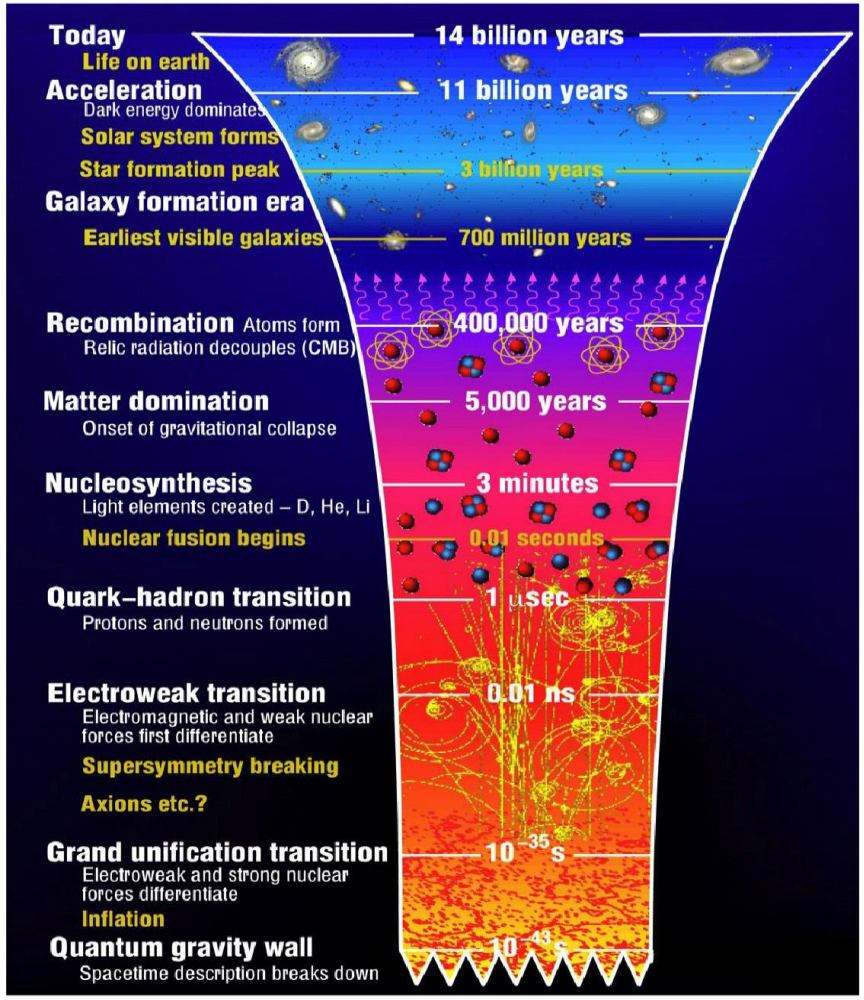
Projects:

30.4%, $355M

Cosmic Frontier – Program 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.**

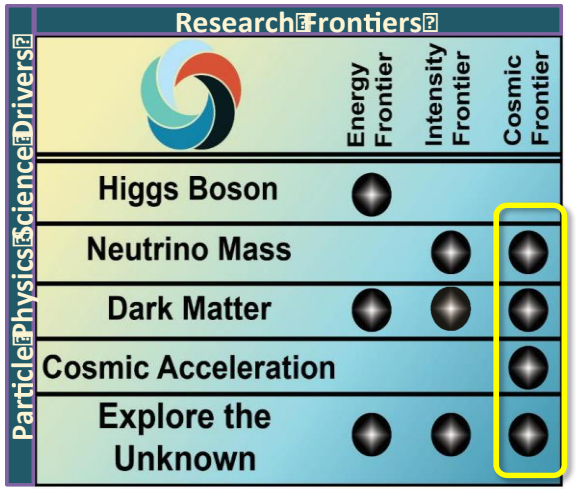
- Partnerships w/NSF (PHY, AST, OPP) NASA (AST, ISS, CLPS), and/or International.
- Overlap with other HEP areas (e.g. Theory, Advanced Detector Development, Computational HEP, QIS, AI/ML) and other SC areas (e.g. ASCR Supercomputing)

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 science & project priorities aligned with the P5 science drivers -- in Dark Energy, Dark Matter (direct detection) & CMB projects, maintain a portfolio of small projects.

This is the program we are executing now!



- **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) small project concepts
- **Neutrino Mass** – survey experiments provide information on neutrino properties
- **Explore the Unknown** – always of interest!

Astro2020 recommended:

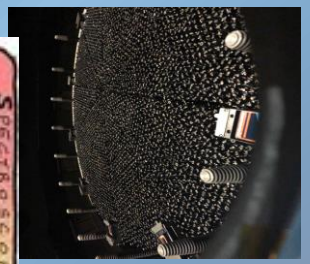
- **DOE/NSF partnership on CMB-S4**
- **Dark Ages** identified as Discovery Area → cosmological probe with great potential
- Efforts on diversity, equity, inclusion, demographics, data, etc. (joint with NSF & NASA)

Future: Snowmass 2022, P5 2023

HEP Cosmic Frontier: Cosmic Acceleration

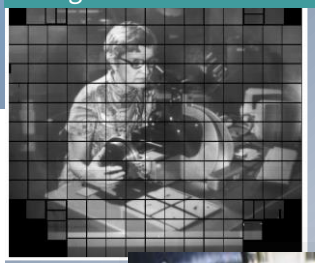
Dark Energy

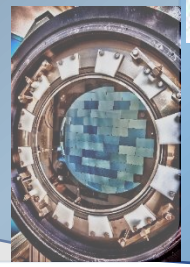
DARK ENERGY SURVEY



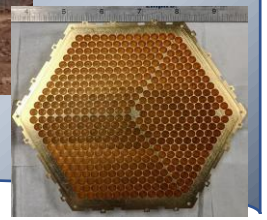
VERA C. RUBIN OBSERVATORY

Pinhole camera 3.2Gpixel image of Vera C. Rubin





CMB



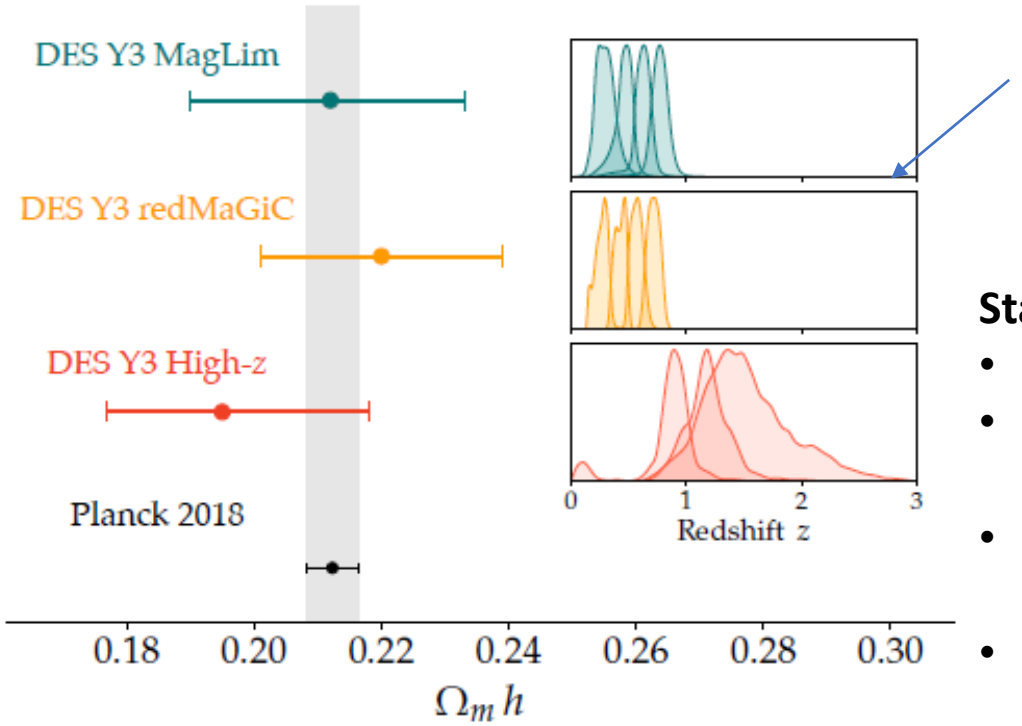
Dark Ages

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

Status

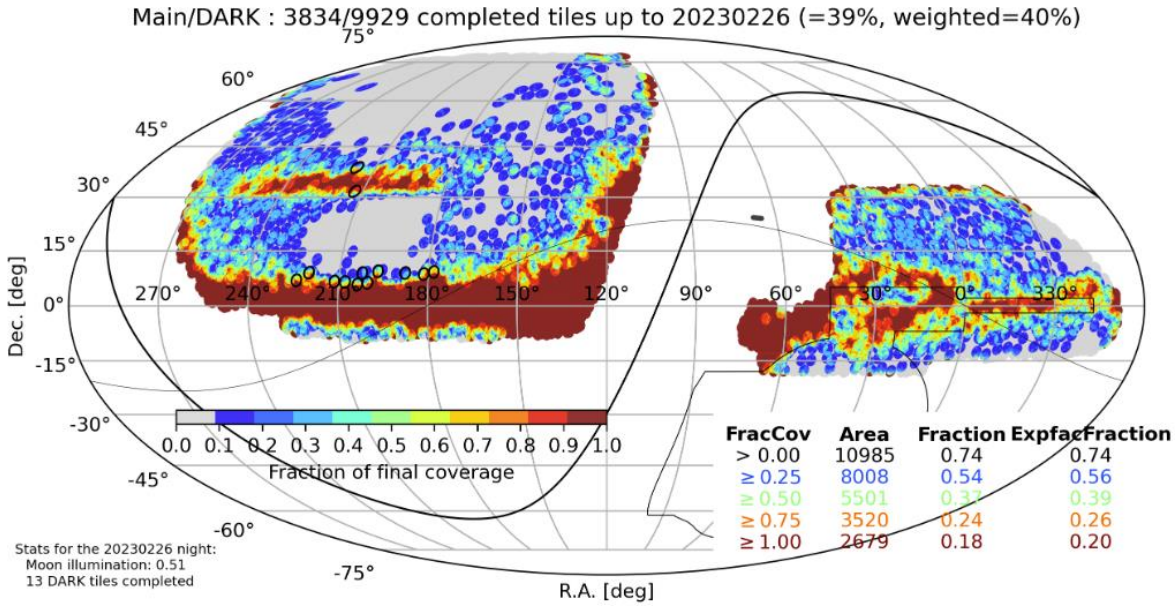
- Year 3 value-added cosmology catalog was made public in March 2022.
- Year 6A2 "Gold" catalog has been released to the collaboration and they are working on cosmology analyses.
- As of end of 2022, 416 papers submitted, 386 accepted or published, 22,780 citations.
- Working on cosmology from 1650 photo-z typed SN1a, with spectroscopic z's of host galaxies and cosmology from the Y6 BAO measurements.

Dark Energy Spectroscopic Instrument (DESI) Experiment – operating since May 2022

Survey Status

- DESI is back on-sky as of Sept. 16, 2022 – following the June 2022 Contreras fire
- Main-line power and fiber internet are restored; Road access to KPNO continues to be restricted.

- Appears the Mayall telescope primary mirror has some loss of reflectivity due to fire-borne particulates. Re-aluminization of the mirror may be required at the next opportunity.



DESI is running ahead of schedule with > 19 Million extra-galactic redshifts recorded (more than all other surveys combined)

Data

- Early data (commissioning + science verification) will be public ~ May 2023
- First year data released to the collaboration in Feb. 2023 - includes all data up until the June 2022 fire. The finished processed data with calibrations, subtractions, Q/A, and catalogs, with over 14 Million main survey extra-galactic redshifts; including 6.4M BGS, 2.9M LRG, 4.0M ELG, and 1.4M QSO main survey target spectra and redshifts.

Grad student Claire Lamman led "5000 eyes" Planetarium show released at end of Feb.

https://www.desi.lbl.gov/education-outreach/planetarium-show/

Collaboration proposed a phased plan to the February P5 meeting: continue with DESI-II; future Spec-S5 facility

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 construction complete expected ~ end 2024.

Construction Project:

DOE responsibilities

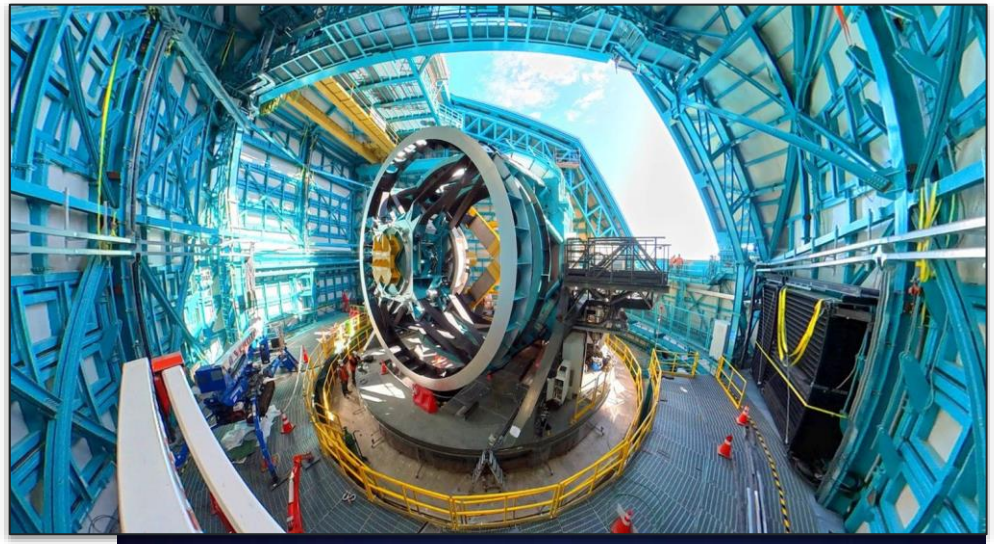
- **LSST Camera** MIE fabrication completed Sept. 2021
- **Commissioning roles -** LSST Camera assembly, test, shipment, integration; effort on the 9-CCD Commissioning Camera (ComCam); data quality and verification studies

Facility Operations

Pre-Operations activities have started; Full operations planning continues; **Joint DOE/NSF review was held late February**

DOE-supported operations efforts are primarily:

- Camera maintenance and operations
- US Data Facility → SLAC is managing organization
- Has a multi-site processing model; hardware and initial services at SLAC; will have a hybrid model with Rubin Science Platform (user access) in cloud; will carry out the full data facility efforts and deliver data to all researchers and collaborations

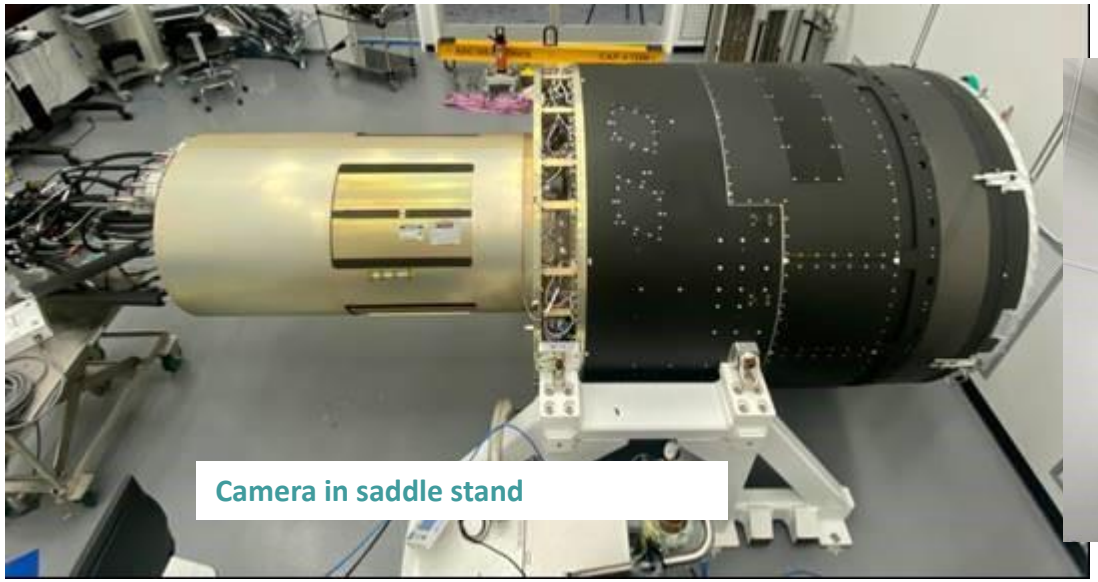


Rubin Observatory at night under full moon
(Photo: Peter Ferguson)

Integration, Test & Commissioning

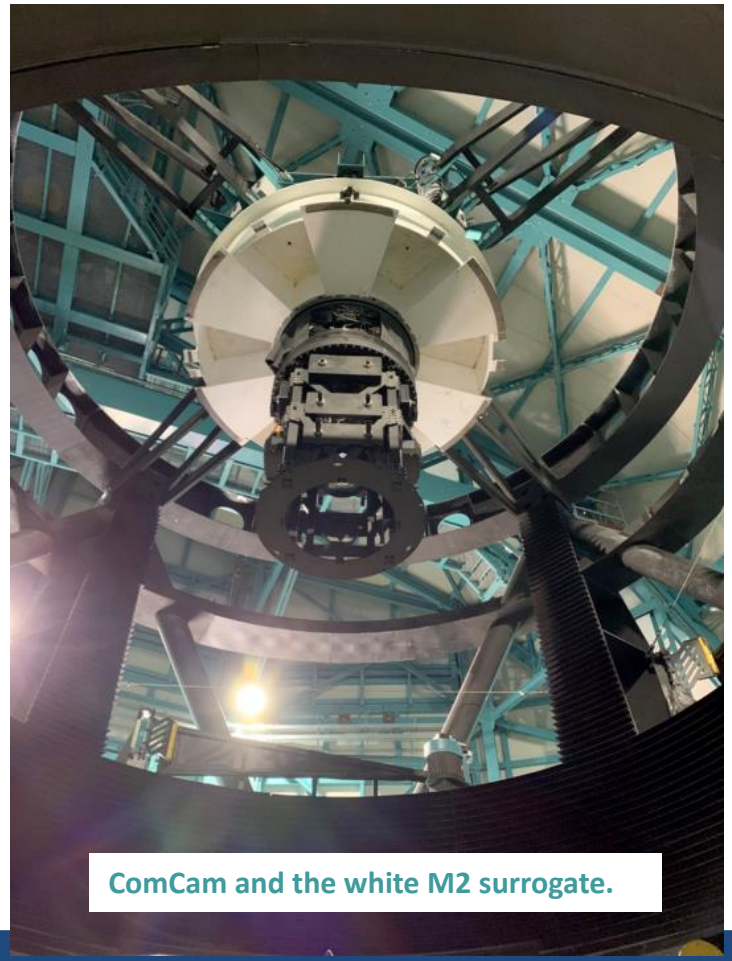
At SLAC: Camera now fully assembled; See video of Filter operation (https://drive.google.com/file/d/19uQ14LRCP3RvCDzjgKjOAkVETWtAp_YC/view?usp=share_link)

- Camera Cold Refrigeration system needed was replaced due to instabilities; the new pumped-coolant system modifications are now complete & being commissioned
- Preparing for final verification testing at SLAC this spring
- Current schedule has shipment to Chile in late summer 2023



Camera in saddle stand

Camera in test stand



ComCam and the white M2 surrogate.

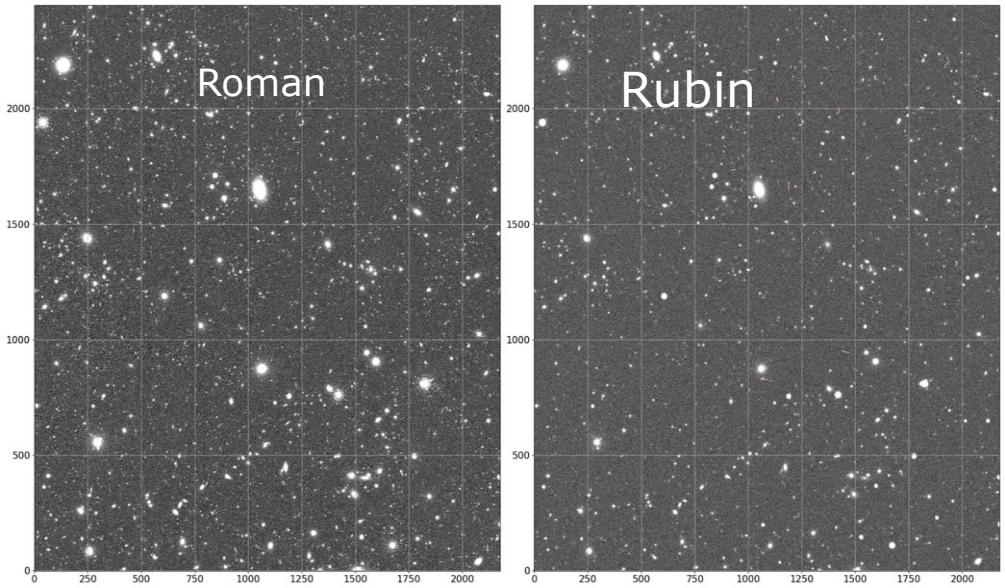
In Chile:

- Installing all equipment needed for camera, e.g. refrigeration line integration, chillers
- ComCam mounted on Telescope, being used to exercise observatory systems

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

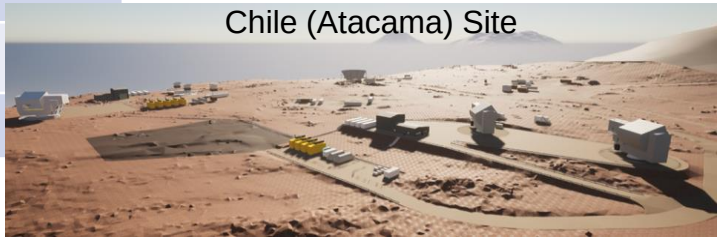
NSF & DOE should jointly pursue the design & implementation of the next generation ground-based cosmic microwave background experiment. "An important requirement for our strong endorsement is that the project broadly engage astronomers beyond the traditional CMB community.

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

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(Mn)	0.15eV	0.06eV	**0.02eV**	3s detection
# detectors	~1000	~10,000	**~500,000**	Deployed on multiple telescopes
Sensitivity (mK^{-2})	10^5	10^8	**10^8**	2° to 1' angular scales

South Pole Site

Chile (Atacama) Site



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

- Well aligned with P5 science drivers. **HEP's primary interest is Inflation**
- Technology, high performance computing needs, and project roles well matched to DOE lab expertise & capabilities

➔DOE & NSF continue regular meetings on CMB-S4; now every 2 weeks

CMB-S4 status, planning

- **2019**: DOE approved Critical Decision 0 (CD-0)
- **FY2021** - Congress approved DOE **Major Item of Equipment "project start"**
- **Early FY2022** – Project's expectations for Antarctic infrastructure & logistics (I&L) aren't sufficient for the original concept.
- **Dec. 2022** – Project briefed agencies on the results of their study to develop updated design
  - South Pole: 3 Small-Aperture Telescopes and 1 Large-Aperture Telescope
  - Chile: 2 Large Aperture Telescopes
  - Renewable energy and energy storage on an independent grid to supplement the power available at the South Pole

DOE/HEP is supportive of Project moving forward to development this updated design

✓ assessed as meeting science goals, with precision & systematic error checks needed for Inflation
✓ cost effective; construction and lifecycle costs are the lowest
✓ close to Project's estimate of I&L availability

- DOE expects to be able to provide funds sufficient to move them forward to a conceptual design in early 2025.
- Project is continuing planning & technology studies.

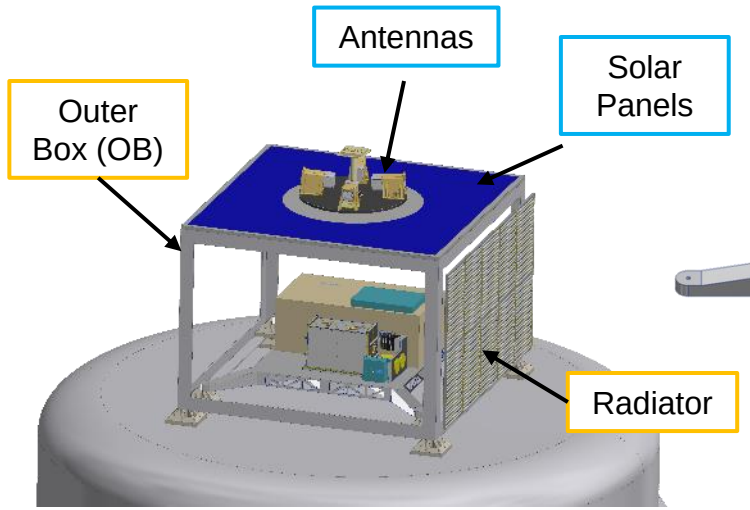
DOE/NASA Partnership on LuSEE-Night → Pathfinder to the Dark Ages

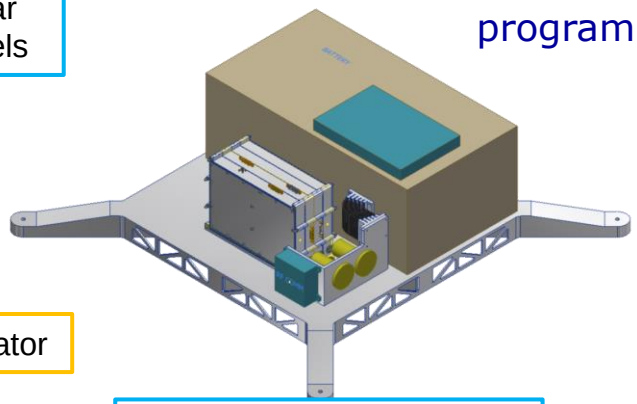
The **Panel on Cosmology** identified as a **Discovery Area** using the **Dark Ages as a cosmological probe with great potential.**
"The panel sees 21 cm and molecular line intensity mapping of the Dark Ages and reionization era as both the discovery area for the next decade and as the likely future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

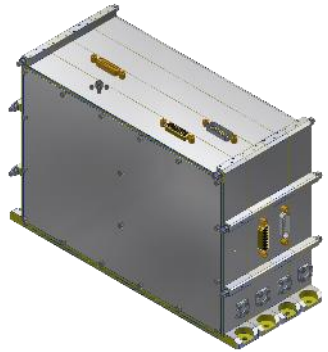
- UCB/SSL is overall lead (for LuSEE-Night & LuSEE-Light)
- DOE/HEP → LuSEE-Night Major Item of Equipment Project (led by BNL) started in FY 2022 (all funds provided); Project Decision 2 (Baselining) was signed this week. Planned to deliver to SSL April 2024.




Inner Equipment Assembly (IEA)

➔See NASA's Press Release (3.14.23) – Firefly Aerospace was selected as part of their Commercial Lunar Payload Service program; launch end of 2025.

https://www.nasa.gov/press-release/nasa-picks-firefly-aerospace-for-robotic-delivery-to-far-side-of-moon


Main Electronics Crate (MEC)

BNL is also leading the Science Collaboration

HEP Cosmic Frontier: Dark Matter

Dark Matter Generation 3

ADMX AXION DARK MATTER EXPERIMENT

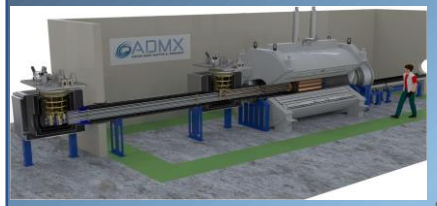
Axion search .6-2MHz at U.Wash; started 2017

WIMP search at SURF (SD); started FY22

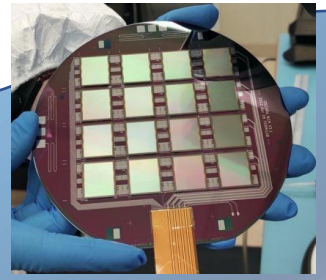
SUPER CDMS Cryogenic Dark Matter Search

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

Dark Matter New Initiatives



Axion search 2-4 GHz



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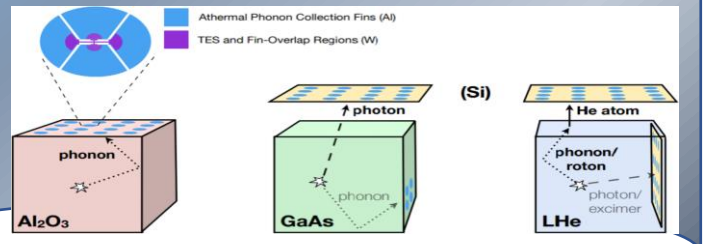
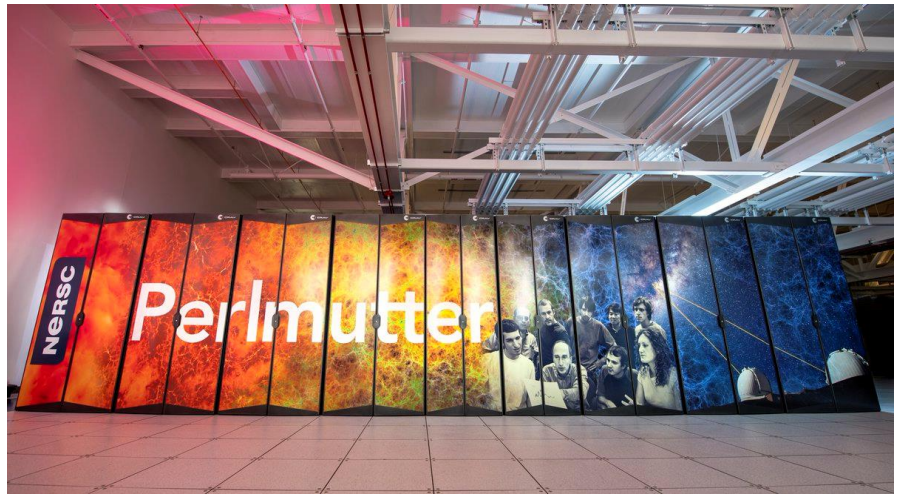


The National Energy Research Scientific Computing Center (NERSC)

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



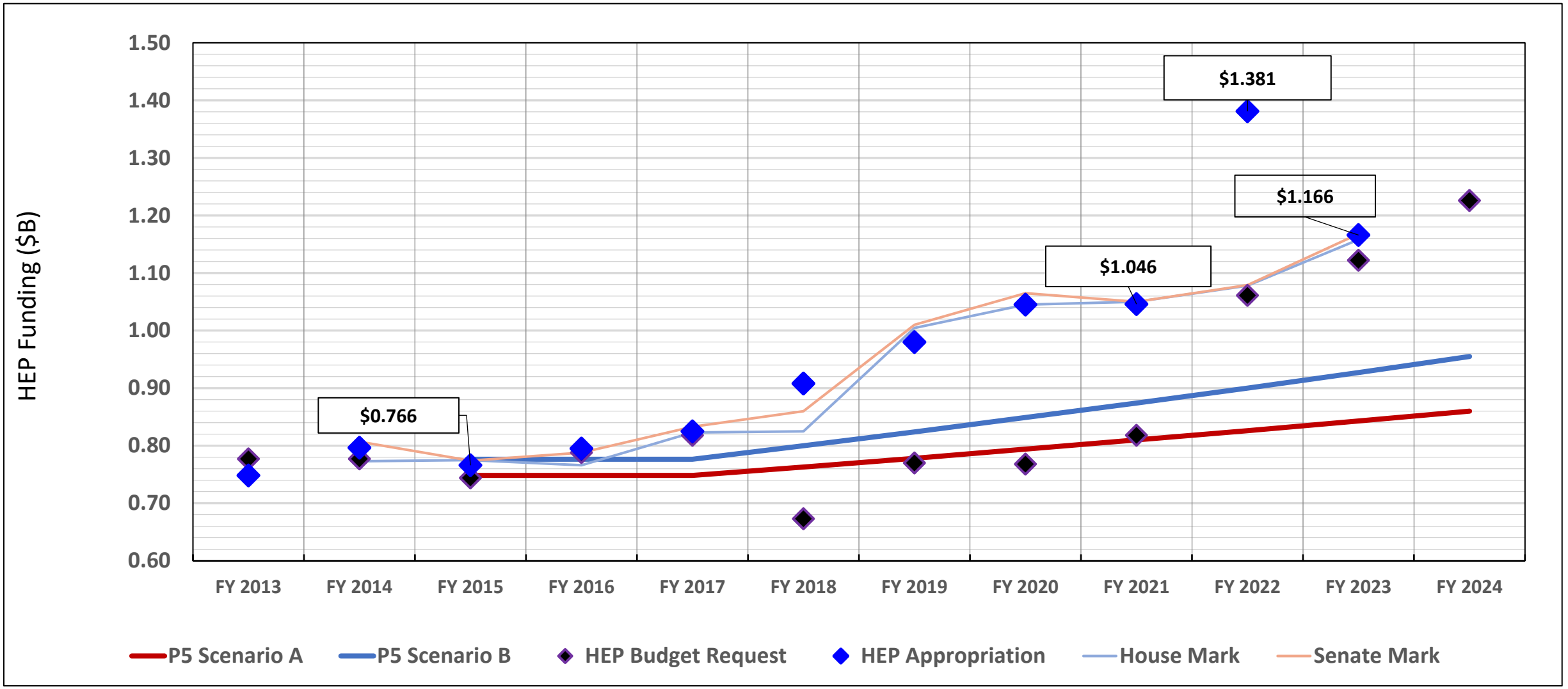
HEP SubProgram	AY22 CPU	AY23 CPU	AY23 GPU
Energy	1,159k	710k	127k
Theory	1,090k	430k	430k
Cosmic	906k	878k	293k
GARD	354k	242k	59k
Intensity	222k	167k	152k
Comp+QIS+ Other	65k	151k	51k
Total	**3,795k**	**2,487k**	**1,112k**

HEP/ Cosmic Frontier allocations include the efforts for LZ, DES, DESI and DESC as a priority since they're dependent on it.

- **NERSC** has done a large fraction of the international CMB computing for decades, including Planck.

Budget

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 FY 2024 President's Request - Research Initiatives

(dollars in thousands)

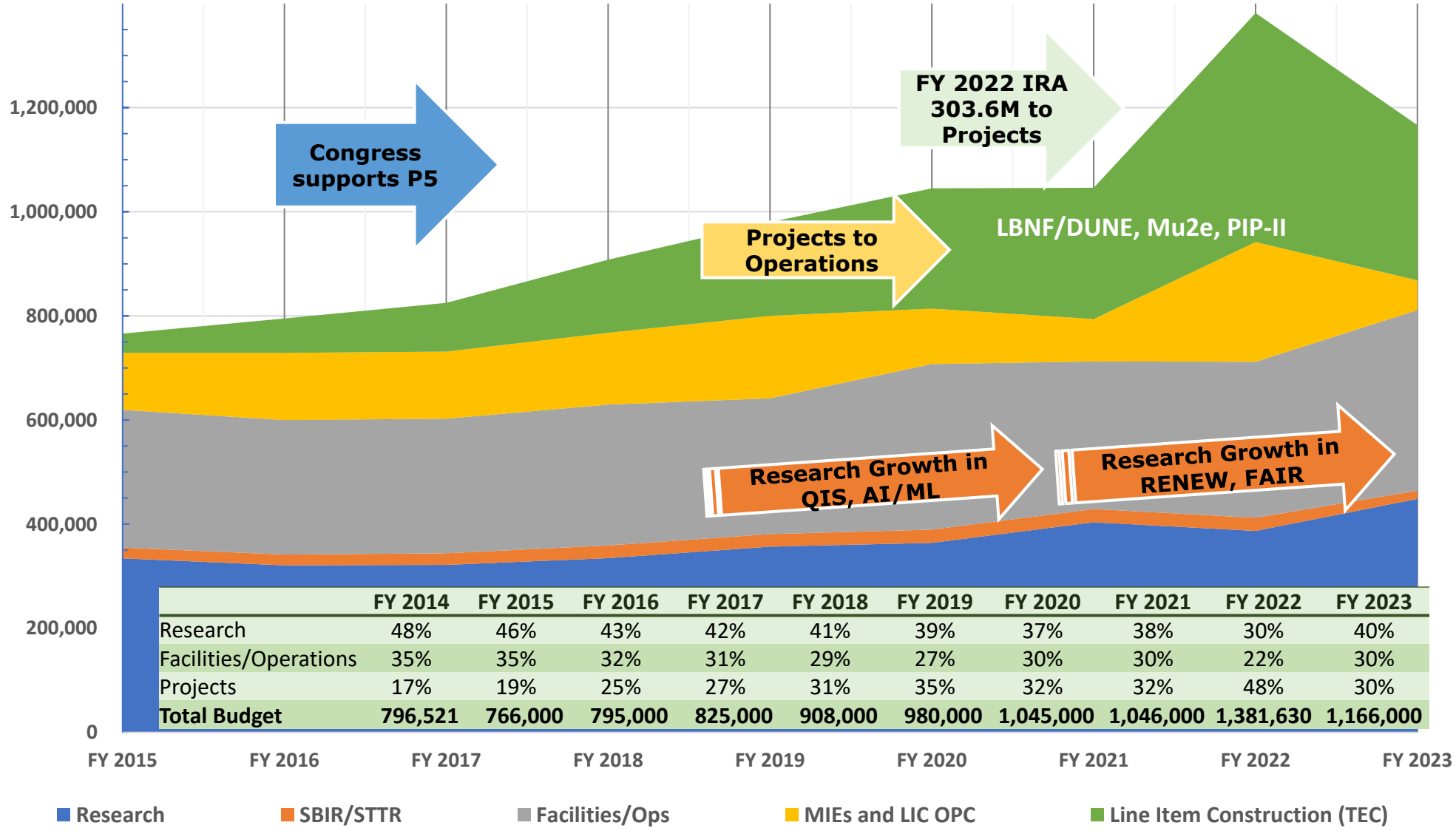
	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted		FY 2024 Request vs FY 2022 Enacted	
High Energy Physics (HEP)							
Accelerate Innovations in Emerging Technologies	–	4,000	4,000	–	–	+4,000	–
Accelerator Science and Technology Initiative	17,432	10,000	10,000	–	–	-7,432	-42.63%
Advanced Computing	–	5,146	5,146	–	–	+5,146	–
Artificial Intelligence and Machine Learning	35,806	40,000	40,000	–	–	+4,194	+11.71%
Funding for Accelerated, Inclusive Research (FAIR)	–	2,000	4,000	+2,000	+100.00%	+4,000	–
Integrated Computational & Data Infrastructure	4,146	–	–	–	–	-4,146	-100.00%
Microelectronics	7,000	7,000	7,000	–	–	–	–
Quantum Information Science	51,566	50,566	50,566	–	–	-1,000	-1.94%
Reaching a New Energy Sciences Workforce (RENEW)	4,000	8,000	11,500	+3,500	+43.75%	+7,500	+187.50%
Total, Research Initiatives	**119,950**	**126,712**	**132,212**	**+5,500**	**+4.34%**	**+12,262**	**+10.22%**

- **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

- HEP RENEW FY 2023 FOA closes 3/31/23. SC-wide FAIR FOA closes 4/11/23. Proposal decisions expected in summer.

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

FY 2014 – FY 2023



	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023
Research	48%	46%	43%	42%	41%	39%	37%	38%	30%	40%
Facilities/Operations	35%	35%	32%	31%	29%	27%	30%	30%	22%	30%
Projects	17%	19%	25%	27%	31%	35%	32%	32%	48%	30%
Total Budget	**796,521**	**766,000**	**795,000**	**825,000**	**908,000**	**980,000**	**1,045,000**	**1,046,000**	**1,381,630**	**1,166,000**

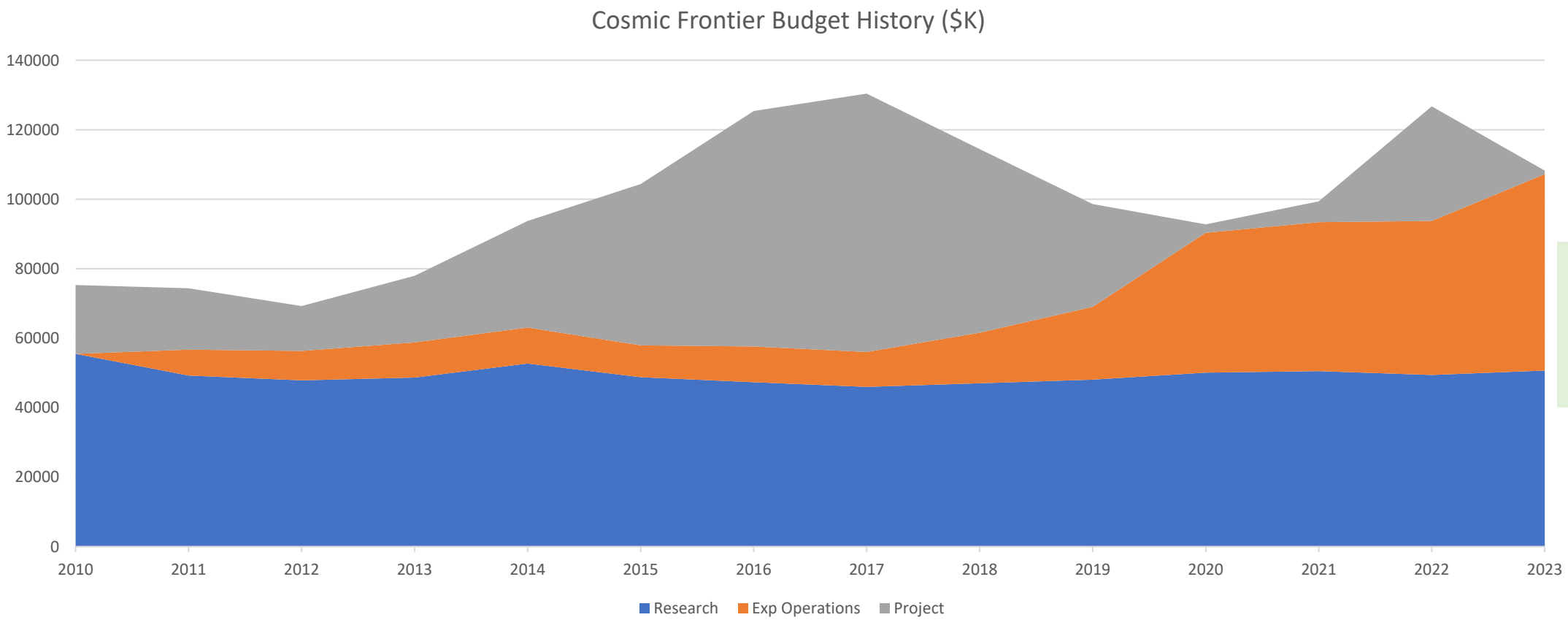
Cosmic Frontier Budget History

Cosmic Frontier ($K)	FY2021 Actual	FY2022 Actual	FY2022 Inflation Reduction Act	FY2023 as of March	FY2024 Request
Research	50,521	49,395		50,677	48048
Research (Univ+Lab)	*43,901*	*42,513*		*44,237*	
Future R&D	*1,700*	*1,475*		*1,800*	
AI/ML Research for CF	4,920	5,407		4,640	
Experimental Ops.	42,880	44,350		56,550	61,830
Projects: CMB-S4, LuSEE-Night (FY22)	6,000	23,000	10,000	1,000	9,000
Total	**99,401**	**116,745**	**10,000**	**108,227**	**120,342**

NOTES:

- The amounts shown in the table do not include workforce costs or SBIR/STTR funds.
- The CHIPS and Science Act 2022 (July) 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.
- FY 23 Request was $92.9M

Cosmic Frontier Budget History



FY22 includes $10M from the Inflation Reduction Act

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 completing in FY23

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

Astro2020: Other Recommendations & Current Status

Astro2020/AAAC – Recommendations (in addition to CMB-S4) →DOE, SC and HEP Efforts and Responses

There were a number of recommendations regarding →Diversity, Equity, Inclusion, Harassment, Discrimination, Demographics, Metrics

A significant number of efforts at high levels in the agencies have been going on in the last few years regarding all these issues, most in response to WH Executive Orders and OSTP memos. These will provide higher-level guidance and recommendations than those of specific agencies, scientific fields, etc.

- Based on these, the agencies have set up task forces and are working at a cross-agency level.

The Aug. 2022 CHIPS and Science Act includes a provision for OSTP to establish consistent guidelines across the Federal agencies for collecting data on applicants/awardees and to prevent harassment and discrimination.

- Agency working groups have been set up. These processes need to get carried out before we can give any details of final actions taken.

In the meantime, DOE has carried out some efforts aligned with these issues:

- SC is deeply committed to supporting Diverse, Equitable, Inclusive and Accessible work environments and funding
  - see SC Statement of Commitment: https://science.osti.gov/SW-DEI/SC- Statement-of-Commitment and The Roadmap to Equity and Justice at the Department of Energy | Department of Energy
- In April 2022, DOE issued the DOE Equity Action Plan aimed and strengthening barriers for investments at HBCU, including demographics and addressing climate issues, among other topics
- In Sept. 2022, DOE released our Diversity, Equity, Inclusion, and Accessibility (DEIA) Strategic Plan

Astro2020/AAAC – Recommendations (in addition to CMB-S4) ➔DOE, SC and HEP Efforts and Responses

Efforts Regarding ➔Diversity, Equity, Inclusion, Harassment, Discrimination, Demographics, Metrics

- Starting FY 2023, all SC FOAs require a Promoting Inclusive and Equitable Research (PIER) plan, with an associated merit review metric.
- New SC-hosted/funded conference requirements, including a code-of-conduct (with consequences if not followed) recruitment, and accessibility.
- DOE currently collects demographics as required/allowed by OMB; We are working to improve data collection and reporting capabilities.
- HEP specifically considers diversity on review panels for proposals and for projects, experimental operations and facilities.
  - *FY2022:* SC's *Reaching a New Energy Sciences Workforce (RENEW)* provides research opportunities to historically underrepresented groups in the physical and climate sciences through internships, training programs, and mentoring
  - FY2023: SC's *Funding for Accelerated and Inclusive Research (FAIR)* is aimed at undergraduate students.
- Other STEM opportunities
  - Programs for work at labs: 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 to work at DOE or a lab
  - DOE labs have specific workforce development & community programs aimed at a diversity of educational levels.
  - HEP traineeship FOA's in Instrumentation, Accelerator R&D, and Computing – address critical, targeted workforce development in focused areas. https://science.osti.gov/-/media/grants/pdf/foas/2021/SC_FOA_0002496.pdf

Astro2020/AAAC – Recommendations
➔DOE, SC and HEP Efforts and Responses

AI/ML

AI/ML techniques in high energy physics are vitally important for advancing the field. HEP funding has increased from $20M (FY20) to $38M (FY23). 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.

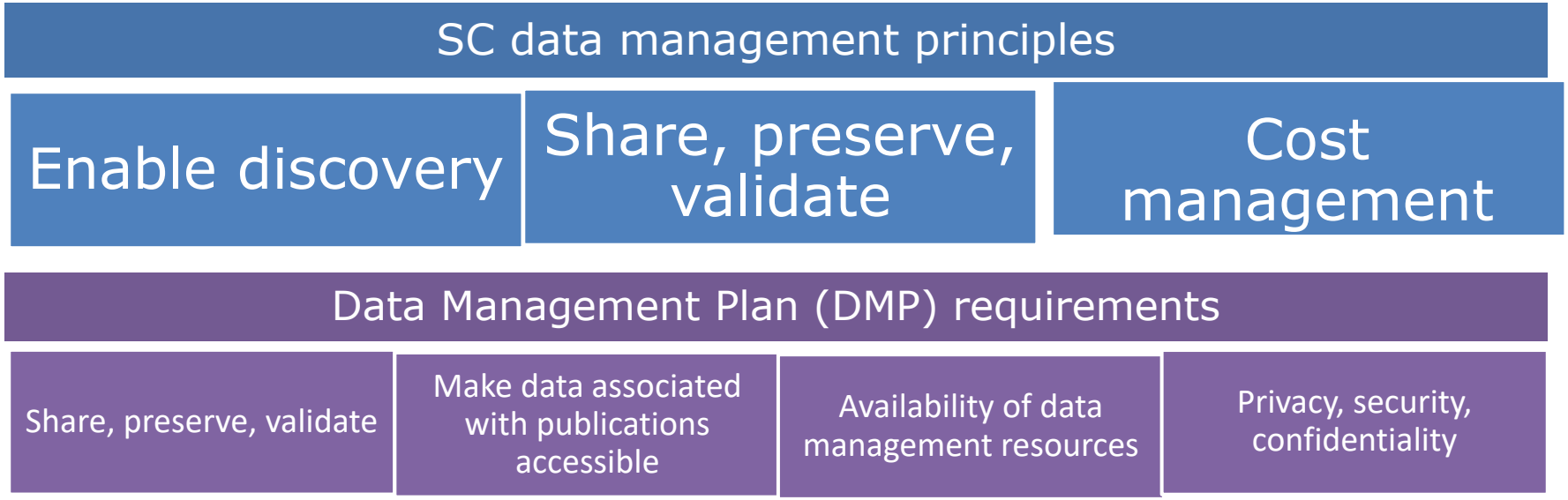
Data, Science

- SC has a data management policy (being updated)
- Data Management Plans are required and reviewed in all proposals.
- DOE is working to develop an implementation plan that meets the goals of the 2022 OSTP Public Access Memo and reflects the needs of the scientific communities the Office of Science supports.

- HEP is participating in the Future of Astrophysical Research Infrastructure workshop and related efforts.

- All survey projects (DES, eBOSS, DESI, Rubin Observatory, CMB-S4) are making data public after a proprietary period.
- DOE is participating with NSF and NASA on the Three Agency Group (TAG) and have met with 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.

DOE SC Data Management & Public Access



- **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 – Recommendations (in addition to CMB-S4)
➔DOE, SC and HEP Efforts and Responses – 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

Future Planning

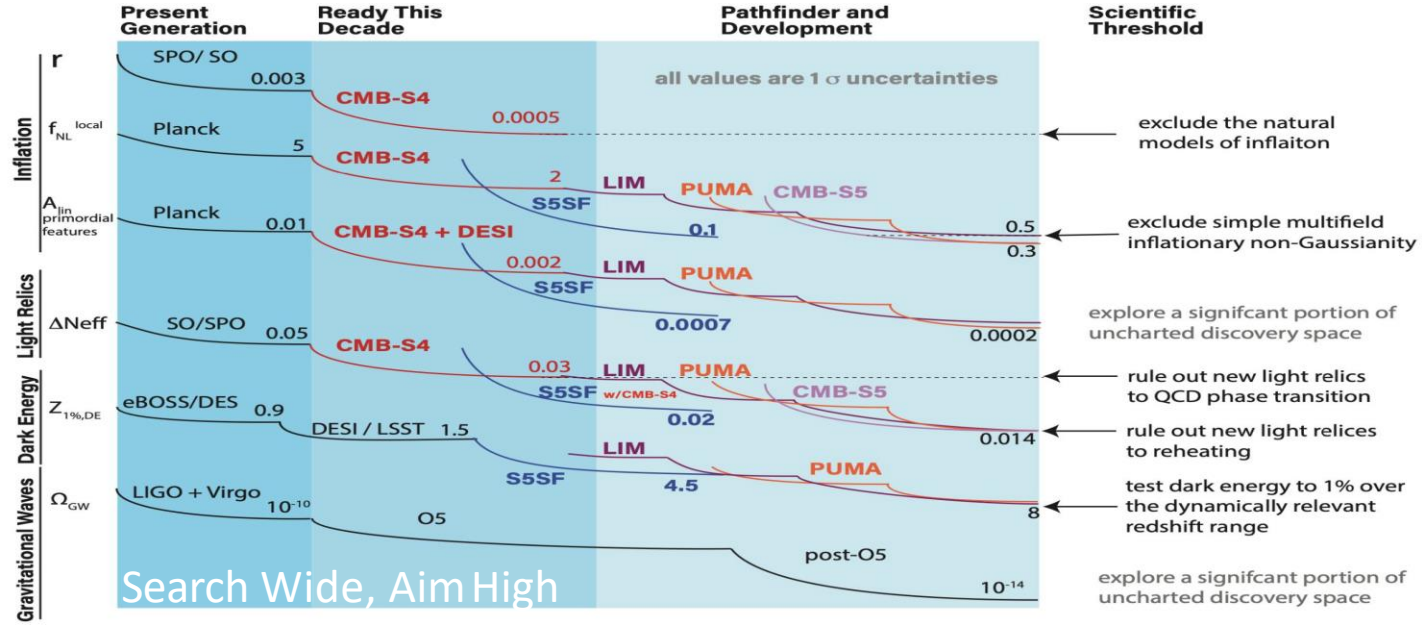
HEP - Strategic Planning Timeline ➔ SNOWMASS

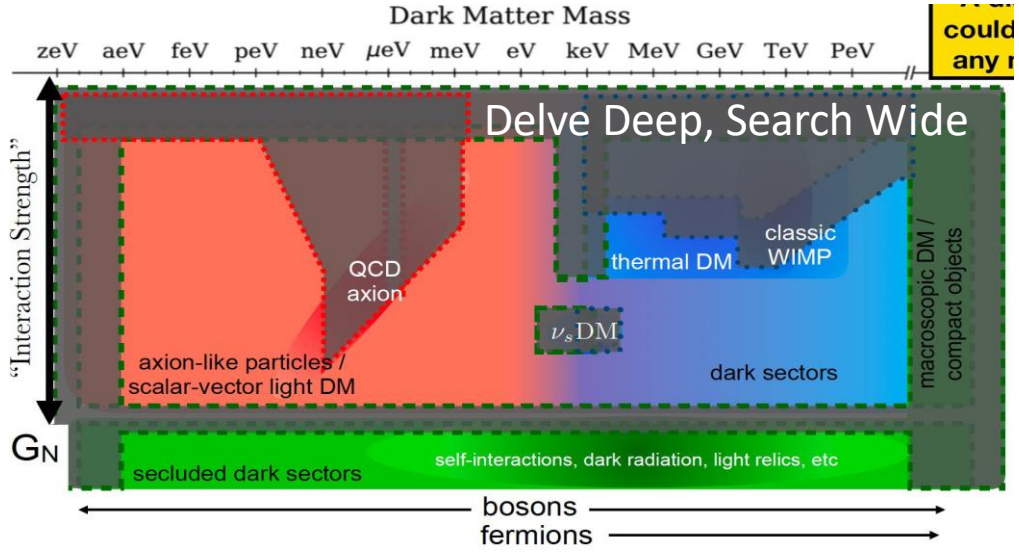
HEP community-wide "Snowmass" study process organized by the American Physical Society (APS) Division of Particles and Fields (DPF) & Division of Particles and Beams held July 2022. https://snowmass21.org/start

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

Snowmass:

- 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





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.

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

Town Hall's

- LBNL Feb. 22-23 – Cosmic Frontier
- FNAL/ANL Mar 21-24 -- Neutrino, Rare Processes and Precision Frontier, High-Energy Astrophysics
- BNL Apr. 12-12 -- Energy, Instrumentation, Computational Frontiers, Gravitational Wave
- SLAC May 3-5 -- Underground, Accelerator, Theory Frontiers, Community Engagement

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**

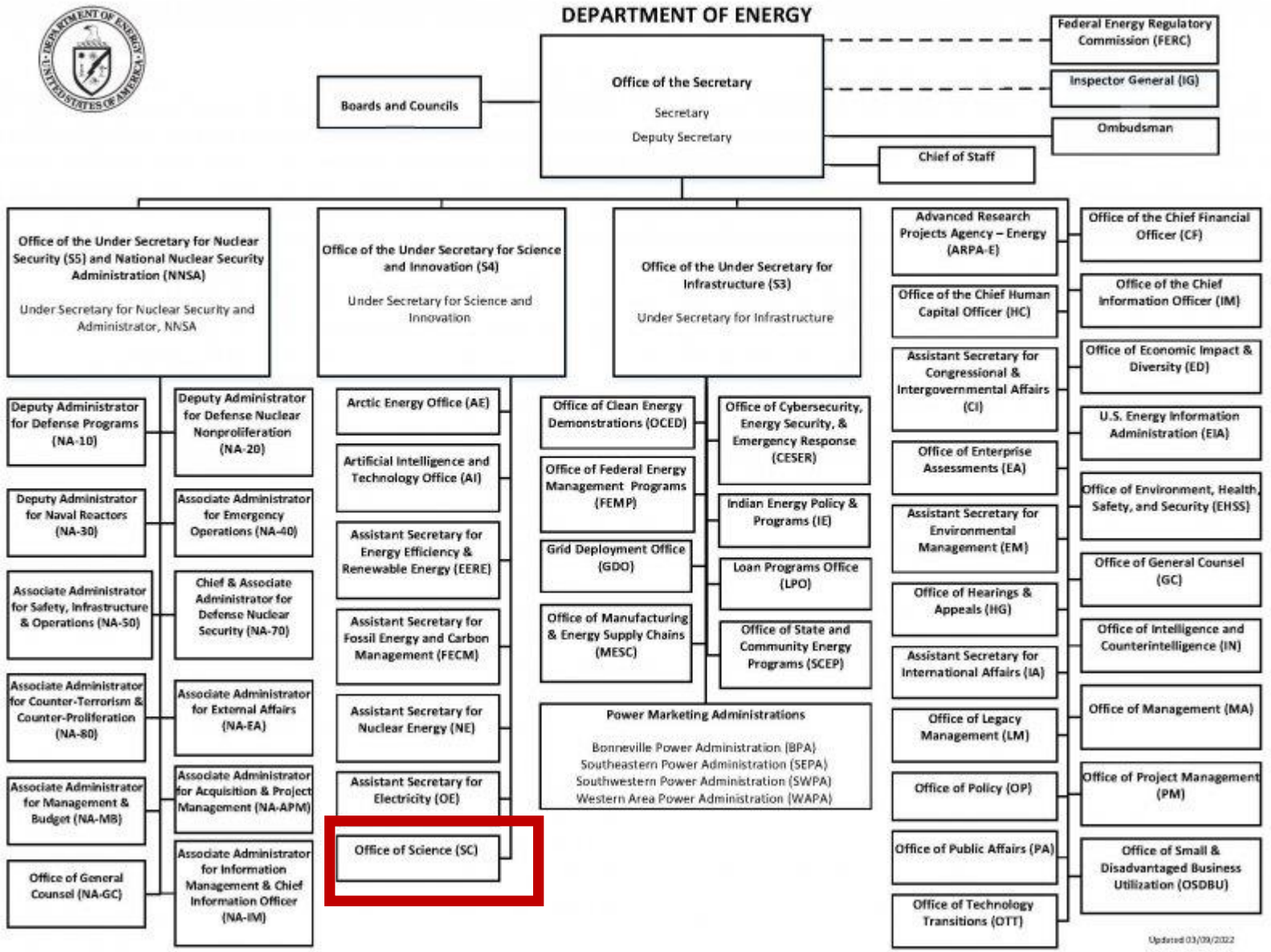
- Astro2020 + Snowmass workshop July 2022 + other plans → Input to next P5
  -- Lots of amazing new ideas and directions to consider!

The Future's Bright!

U.S. DEPARTMENT OF
ENERGY

Office of
Science

DOE Organization



PASAG (2009) Developed Prioritization Criteria for the Program →

The science addressed by the project is necessary

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

Particle physicist participation is necessary

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

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

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

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

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. 2020 → 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

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 – 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