



U.S. DEPARTMENT OF
ENERGY

Office of
Science

DOE/HEP Program and Budget Update

Astronomy & Astrophysics Advisory Committee (AAAC)

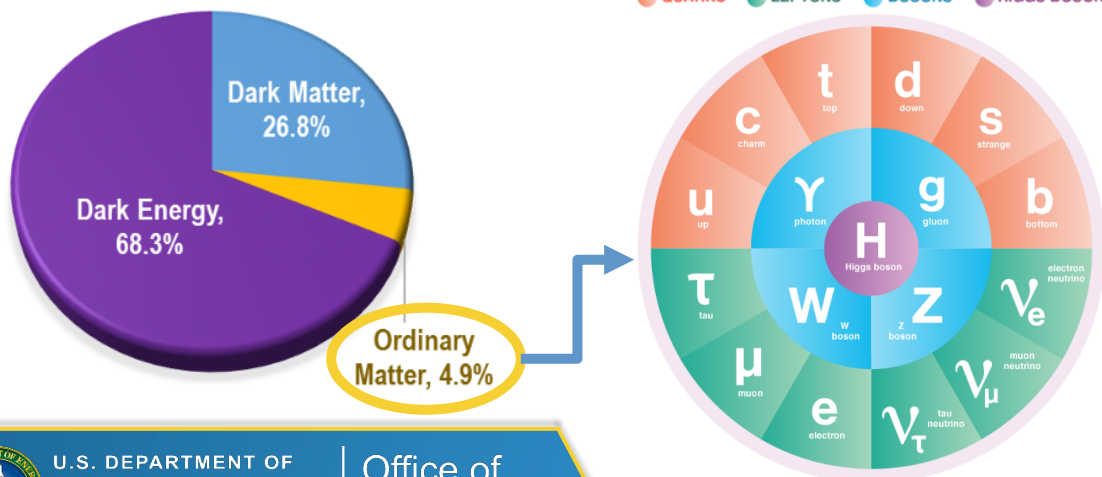
September 20, 2018

Eric Linder
Office of High Energy Physics

The High Energy Physics Program Mission

... is to understand how the universe works at its most fundamental level:

- ▶ Discover the elementary constituents of matter and energy
- ▶ Probe the interactions between them
- ▶ Explore the basic nature of space and time
- ▶ The DOE Office of High Energy Physics fulfills its mission by:
 - ▶ Building **projects** that enable discovery science
 - ▶ Operating **facilities** that provide the capability for discoveries
 - ▶ Supporting a **research** program that produces discovery science




Cosmic Frontier Experimental Research Program

→ Through ground-based telescopes & arrays, space missions, and deep underground detectors, research at the Cosmic Frontier aims to explore dark energy and dark matter, which together comprise approximately 95% of the universe.

Program Areas:

- Study the nature of Dark Energy
- Direct Detection searches for Dark Matter particles
- CMB – Inflationary Epoch, Dark Energy, Neutrino Properties
- Cosmic-ray & Gamma-ray studies – indirect searches for dark matter particles

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

→ Strong interaction with Theory, Detector R&D, Computational HEP

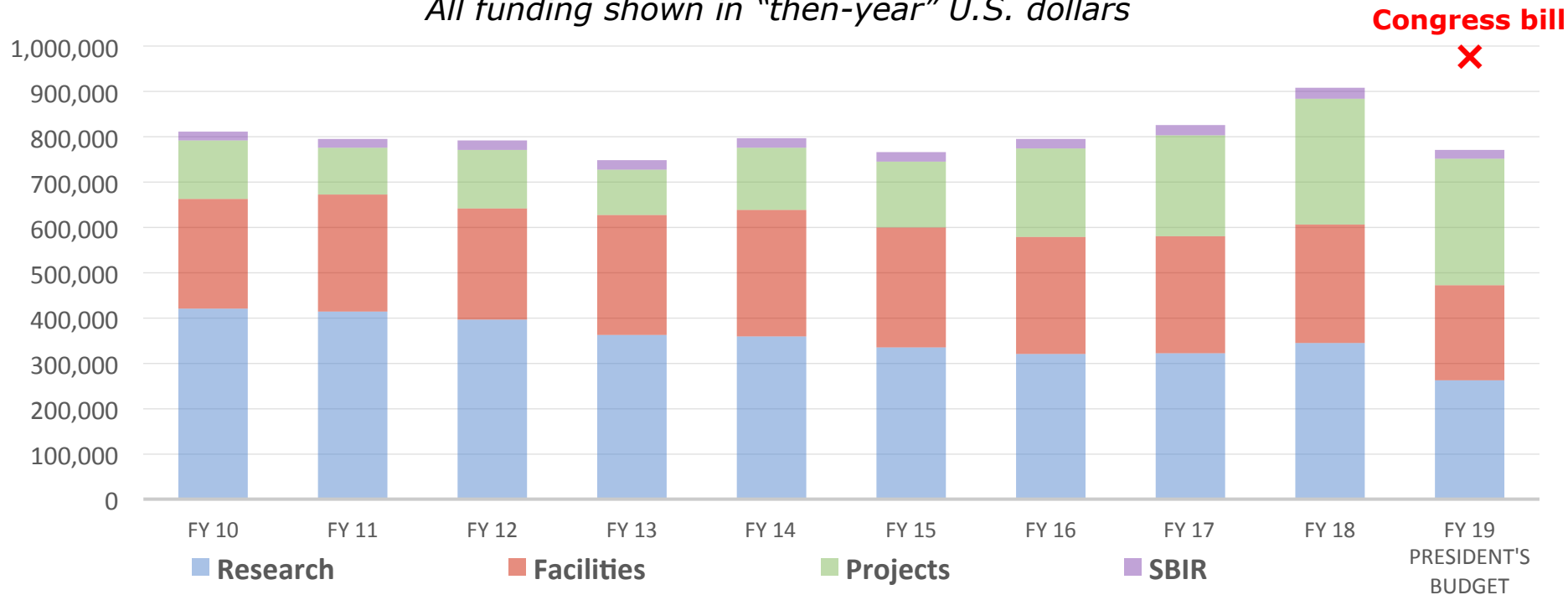


Overall HEP Budget Trend

- ▶ P5 strategy continues to define investments in future of the field
- ▶ FY 2019 Congressional bill increases project funding above Request
 - ▶ Profiles for high-priority projects recommended by P5 continue to ramp up
 - ▶ **Research funding could face pressure even if overall HEP budget rises**

HEP BUDGET ALLOCATION BY FISCAL YEAR (\$ IN K)

All funding shown in "then-year" U.S. dollars



DOE Office of Science

FY18 Enacted was \$6.26B

“The conferees provide \$6,585,000,000 for the Office of Science.” – FY19

FY19 DOE Office of Science Appropriations (\$ millions)										
Funding Line	FY17 Enacted	FY18 Enacted	FY19 Request	Change 18-19	House	Change 18-19	Senate	Change 18-19	Final*	Change 18-19
Office of Science	5,391	6,260	5,391	-14%	6,600	5%	6,650	6%	6,585	5%
Advanced Scientific Computing Research	647	810	899	11%	915	13%	980	21%	936	15%
Basic Energy Sciences	1,872	2,090	1,850	-11%	2,129	2%	2,193	5%	2,166	4%
Biological & Environmental Research	612	673	500	-26%	673	0%	715	6%	705	5%
Fusion Energy Sciences	380	532	340	-36%	590	11%	425	-20%	564	6%
High Energy Physics	825	908	770	-15%	1,005	11%	1,010	11%	980	8%
Nuclear Physics	622	684	600	-12%	690	1%	710	4%	690	1%

aip.org/fyi



Office of High Energy Physics

High Energy Physics.—Within available funds, the agreement provides \$15,000,000 for PIP-II; \$6,250,000 for ongoing efforts for commissioning and initial operation of the camera for the Large Synoptic Survey Telescope Camera; \$10,000,000 to continue the upgrade of FACET II; \$105,000,000 for the HL-LHC Upgrade Projects; and \$22,450,000 to complete the dark energy and dark matter experiments, of which \$5,450,000 is for DESI and \$14,450,000 is for LUX ZEPLIN.

- ✓ **All Cosmic Frontier projects are fully supported.**
- ✓ **FY19 completes the funding for construction of LSST, DESI, LZ, SuperCDMS-SNOlab.**
- ✓ **Commissioning and Operations Funding is ramping up.**

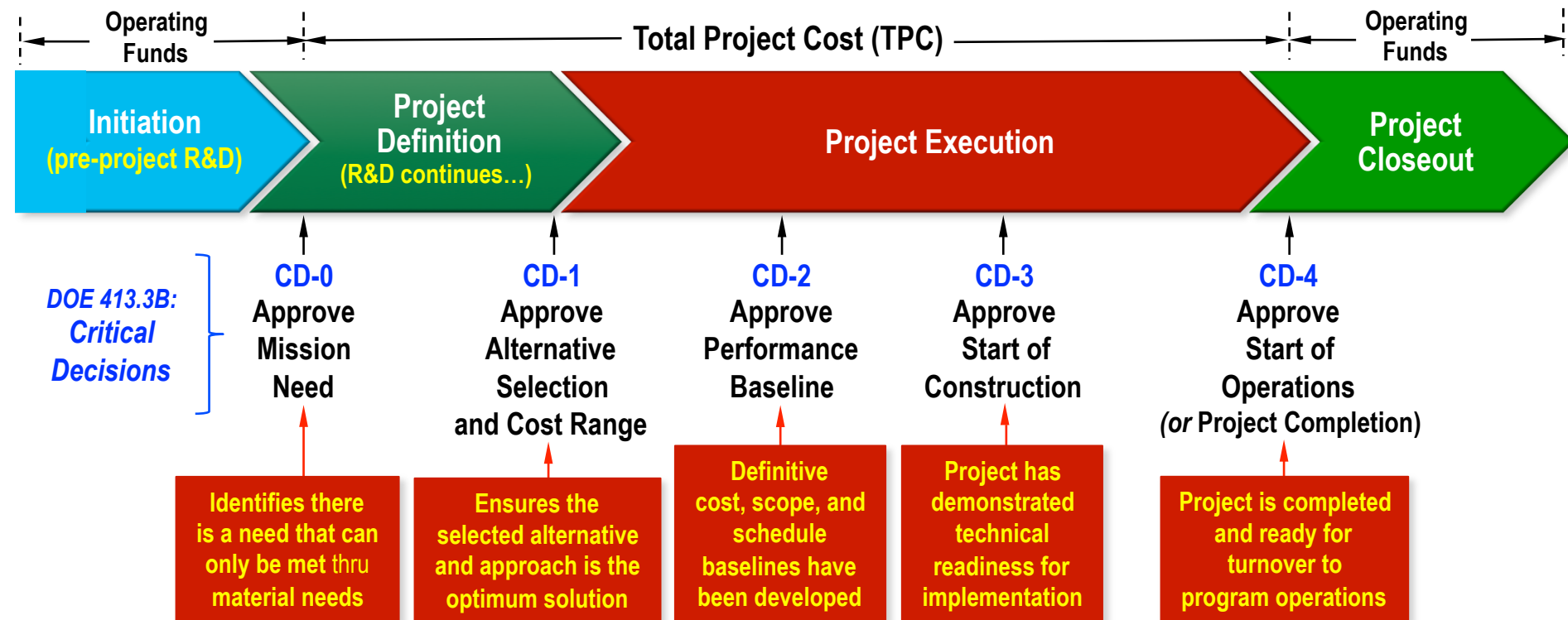


HEP MIE Project Status

Subprogram	TPC (\$M)	CD Status	CD Date
INTENSITY FRONTIER			
Long Baseline Neutrino Facility / Deep Underground Neutrino Experiment (LBNF/DUNE)	1,300 – 1,900	CD-3A	September 1, 2016
Proton Improvement Project (PIP-II)	653 - 928	CD-1	July 23, 2018
Muon g-2	46.4	CD-4	January 16, 2018
Muon-to-Electron Conversion Experiment (Mu2e)	273.677	CD-3	July 14, 2016
ENERGY FRONTIER			
LHC ATLAS Detector Upgrade	33	CD-3	November 12, 2014
LHC CMS Detector Upgrade	33	CD-4A	September 19, 2017
High-Luminosity LHC (HL-LHC) Accelerator Upgrade	208 - 252	CD-1/3A	October 13, 2017
High-Luminosity LHC (HL-LHC) ATLAS Detector Upgrade	125-155	CD-0	April 13, 2016
High-Luminosity LHC (HL-LHC) CMS Detector Upgrade	125-155	CD-0	April 13, 2016
COSMIC FRONTIER			
LUX-ZEPLIN (LZ)	55.5	CD-3	February 9, 2017
Super Cryogenic Dark Matter Search - SNOLAB (SuperCDMS-SNOLAB)	18.6	CD-2/3	May 2, 2018
Dark Energy Spectroscopic Instrument (DESI)	56.328	CD-3	June 22, 2016
Large Synoptic Survey Telescope Camera (LSSTcam)	168	CD-3	August 27, 2015
ADVANCED TECHNOLOGY R&D			
Facility for Advanced Accelerator Experimental Tests II (FACET-II)	25.6	CD-2/3	June 8, 2018

DOE Project Management Process

- ▶ Construction projects and fabrication of large pieces of experimental equipment costing over \$10M are managed through a series of “Critical Decision (CD)” milestones
 - ▶ The CD process ensures successful project execution and scientific return on agency investments
 - ▶ **Successful delivery of construction projects+facilities is a central part of the DOE science mission**
 - **In particular, Office of Science practice (CD process & independent, external reviews) is considered gold-standard with an excellent record in DOE → “Failure is not an option”**
- DOE is committed to the successful execution of projects that have reached CD-2 (establish performance baseline of technical scope, cost & schedule) and to provide the funding profile needed to carry it out.



HEP Program Guidance

FACA panels & subpanels provide official advice:

- ▶ High Energy Physics Advisory Panel (HEPAP)
 - ▶ Jointly chartered by DOE and NSF to advise both agencies
 - ▶ **Provides the primary advice for the HEP program**
- ▶ Subpanels for detailed studies (e.g. Particle Physics Project Prioritization Panel ("P5") in 2008, 2014)
- ▶ **Astronomy and Astrophysics Advisory Committee (AAAC)**
 - ▶ Advises DOE, NASA, and NSF on selected issues in astronomy & astrophysics of overlap, mutual interest and concern

Formal Advice Also Provided by:

- ▶ National Academy of Sciences (NAS)
 - ▶ Decadal Surveys in Astronomy & Astrophysics, Elementary Particle Physics
 - ▶ Board on Physics & Astronomy (BPA), Committee on Astronomy & Astrophysics (CAA)

Other:

- ▶ Community science studies and input (e.g. Snowmass, Dark Energy Task Force, DPF input).
- ▶ CMB-S4 Concept Design Team (CDT), Gemini-Blanco-SOAR Telescopes roles subpanels of AAAC
- ▶ Astro-Particle International Forum (APIF) – Agency-level international group
- ▶ Tri-Agency Group (TAG) – DOE, NASA, NSF-AST meetings on LSST, WFIRST, Euclid coordination



ASTRO 2020 Decadal Survey

DOE, NASA, NSF worked together to deliver a statement of task to the National Academy of Sciences for an Astronomy & Astrophysics Decadal Survey (Astro 2020).

Funding proposal for the study is in peer review.

Once NAS starts the study, they are in charge.

In accordance with its Congressional Charter and the requirements of Section 15 of the Federal Advisory Committee Act, 5 U.S.C., the National Academies must provide independent, unbiased advice without actual or perceived interference or management of the outcome (findings and recommendations).



Cosmic Frontier Program

Drew Baden (IPA)
Karen Byrum (Detailee)
Eric Linder (IPA)
Kathy Turner



P5 Report – Cosmic Frontier

► Dark Energy

- Complete LSST as planned
- Build DESI as a major step forward in dark energy science

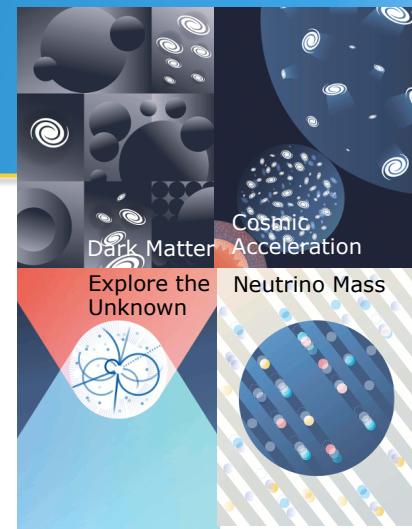
► Dark Matter

- Proceed immediately with a broad second-generation (G2) dark matter direct detection program with capabilities described in the text
 - Invest in this program at a level significantly above that called for in the 2012 joint agency announcement of opportunity
- Support one or more third-generation (G3) direct detection experiments
 - Guide G3 by the results of the preceding (G1, G2) searches
 - Seek a globally complementary program and increased international partnership in G3 experiments **(DM-G3 is in the P5 plan in later part of their 10 year plan.)**

► Cosmic Microwave Background (CMB)

- Support CMB experiments as part of the core particle physics program
- The multidisciplinary nature of the science warrants continued multi-agency support **(CMB-S4 Project is in P5 plan, starting ~midway through their 10 year plan.)**

► Explore the Unknown, including through cosmic rays and gamma rays



Cosmic Frontier Program

Study dark energy through staged program of complementary surveys (in partnership with NSF-AST)

- ▶ **Imaging surveys map cosmic structure over vast volumes of space:** *Dark Energy Survey (DES)* operating, *Large Synoptic Survey Telescope (LSST)* camera in fabrication
- ▶ **Spectroscopic surveys build deep, 3D maps of cosmic structure and growth:** *eBOSS* operating, *Dark Energy Spectroscopic Instrument (DESI)* in fab

Search for dark matter through direct detection experiments over a wide mass range (in partnership with NSF-PHY)

- ▶ **High- and low-mass WIMP sensitivity:** *LZ* and *SuperCDMS-SNOLAB*, in fab
- ▶ **Axion (ultralow mass) experiment:** *ADMX-G2* in operation

Study cosmic acceleration (inflation) at energies near the Planck scale and neutrino properties through the cosmic microwave background (CMB) (in partnership with NSF)

- ▶ **New generation South Pole experiment:** *SPT-3G* in operation
- ▶ **Next generation array 10x more sensitive:** *CMB-S4* in planning

Explore the unknown, e.g. through high energy particles from dark matter annihilations in cores of galaxies (in partnership with NSF, NASA)

- ▶ **Cosmic- and gamma-ray detectors on Earth and in space:** *HAWC*, *Fermi/GLAST*, *AMS* in operation



Cosmic Frontier Experiments

Activity	Location	Science	Current Status	# Collaborators	# Institutions	# Countries
Extended Baryon Oscillation Spectroscopic Survey (BOSS)	APO in New Mexico	dark energy stage III (spectroscopic)	operations started 2015	100 (60 US, 40 HEP)	34 (22 US, 10 HEP)	10
Dark Energy Survey (DES)	CTIO in Chile	dark energy stage III (imaging)	operations started Sep 2013	500	25 (13 US, 9 HEP)	7
Large Synoptic Survey Telescope (LSST) - Dark Energy Science Collaboration (DESC)	Cerro Pachon in Chile	dark energy stage IV (imaging)	science studies, planning	269 (195 US, 47 HEP)	63 (43 US, 22 HEP)	15
Large Synoptic Survey Telescope (LSST) - LSSTcam Project	Cerro Pachon in Chile	dark energy stage IV (imaging)	FY14 fab start; CD3 Aug 2015	142 (111 US, 111 HEP)	17 (11 US, 11 HEP)	2
Dark Energy Spectroscopic Instrument (DESI)	KPNO in AZ	dark energy stage IV (spectroscopic)	FY15 fab start; CD3 June 2016	200 (93 US, 74 HEP)	55 (21 US, 19 HEP)	9
DM-G1: Large Underground Xenon (LUX)	SURF in South Dakota	dark matter - WIMP search	Operations ended in 2016	102 (86 US, 64 HEP)	18 (15 US, 13 HEP)	3
DM-G1: Super Cryogenic Dark Matter Search (SuperCDMS-Soudan)	Soudan in Minnesota	dark matter - WIMP search	Operations ended in 2016	83 (72 US, 44 HEP)	20 (17 US, 7 HEP)	3
DM-G2: ADMX-G2	Univ Washington	dark matter - axion search	Operations started Jan. 2017	23 (21 US, 18HEP)	8 (7 US, 4 HEP)	2
DM-G2: SuperCDMS-SNOLAB	SNOLab in Canada	dark matter - WIMP search	FY15 fab start; CD3 May 2018	109 (86 US, 57 HEP)	22 (16 US, 7 HEP)	5
DM-G2: LZ	SURF in South Dakota	dark matter - WIMP search	FY15 fab start; CD3 Feb. 2017	252 (174 US, 161 HEP)	38 (26 US, 23 HEP)	5
SPT-3G	South Pole	CMB stage 3	Operations started Feb. 2017	59	9 (7 US, 5 HEP)	3
Very Energetic Radiation Imaging Telescope Array System (VERITAS)	FLWO in AZ	gamma-ray survey	HEP ops completed 2016	109 (76 US, 28 HEP)	20 (16 US, 5 HEP)	4
Pierre Auger Observatory	Argentina	cosmic-ray	HEP ops completed 2016	436 (61 US, 18 HEP)	90 (17 US, 6 HEP)	17
Fermi Gamma-ray Space Telescope (FGST) Large Area Telescope (LAT)	space-based	gamma-ray survey	June 2008 launch; operating	252 (104 US, 18 HEP)	109 (37 US, 3 HEP)	22
Alpha Magnetic Spectrometer (AMS-02)	space-based (on ISS)	cosmic-ray	May 2011 launch; operating	250	46 (6 US, 2 HEP)	16
High Altitude Water Cherenkov (HAWC)	Mexico	gamma-ray survey	Operations started Jan. 2015	120 (60 US, 7 HEP)	30 (13 US, 3 HEP)	4

Dark Energy

Precision measurements to differentiate between: cosmological constant and/or new fields; or modification to General Relativity

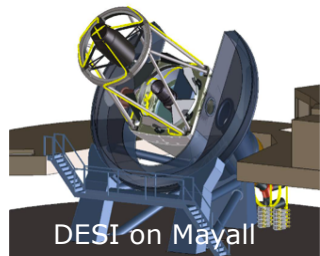
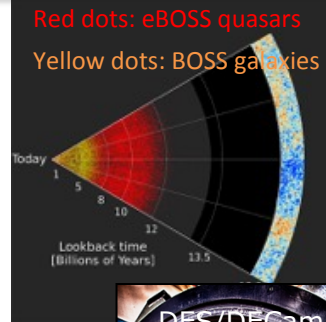
Staged, complementary suite of imaging and spectroscopic surveys to determine its nature (in partnership with NSF-AST)

Operating:

- *eBOSS* (spectroscopic) started in 2015, ends Feb 2019, funding extended
- *DES* (imaging) started 5-year survey in late FY13, ends Jan 2019, funding extended

In Fabrication phase:

- *Large Synoptic Survey Telescope* (LSST, Stage IV imaging)
 - HEP and NSF-AST (lead agency) partnership; HEP responsible for LSST camera (SLAC)
 - LSST is under construction; commissioning ops started FY18; science ops start FY23
 - Planning started for LSST Facility Operations phase and Dark Energy Science Collaboration (DESC) Operations
- *Dark Energy Spectroscopic Instrument* (DESI, Stage IV spectroscopic)
 - DESI is an "HEP experiment" in the fabrication phase; commissioning Spring 2019
 - Fabricate DESI instrumentation & data management system
 - HEP coordinating w/NSF-AST to "lease" the Mayall telescope; full support for dark energy operations starting FY19



Direct Detection of Dark Matter

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

- ▶ High- and low-mass WIMP sensitivity; Axion (meV mass) search

Operating/Completed:

Completed DOE funding for Operations of several current DM-Generation 1 (DM-G1) experiments in FY16/17

In Design, Fabrication:

DM-G2's selected by HEP & NSF-PHY in July 2014 following P5 report:

ADMX-G2 axion search at UWash (HEP); science ops started Jan 2017

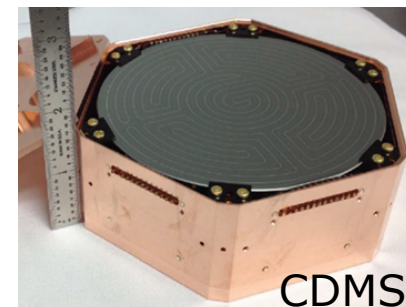
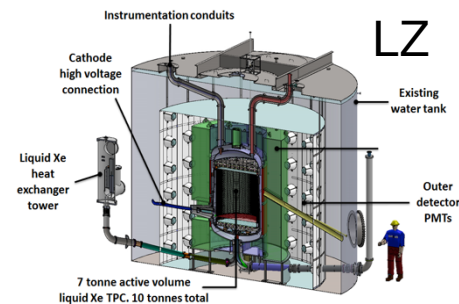
- Uses a strong magnetic field to resonantly convert dark-matter halo axions into detectable photons; currently searching in range 0.1 to 2 GHz
- Currently data-taking at design sensitivity

LZ at Homestake Mine in South Dakota (HEP)

- WIMP search through dual phase liquid Xe – ~10-1000 GeV mass range
- In fabrication; planning for operations phase started

SuperCDMS-SNOLab in Canada (HEP+NSF-PHY partnership)

- WIMP search using cryogenic solid-state crystals – ~1-10 GeV mass range
- In fabrication; planning for operations phase started



Cosmic Microwave Background

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

Current Experiments:

- **SPT-3G** – HEP provided support for major upgrade of the camera to greatly increase sensitivity; operations started Feb 2017 (NSF-led)

In Atacama: Polarbear/
Simons Array



➔ **CMB-S4 Community-based Collaboration** brought together ground based community to plan future

- Notional array of several telescopes in Chile & South Pole with on the order of 0.5 M detectors
- Needs scale-up of detector fabrication, testing, and readout

CMB-S4 Collaboration Science, Technology Books:

<https://arxiv.org/abs/1610.02743> ; <https://arxiv.org/abs/1706.02464>

Future Planning:

As recommended by P5, HEP is planning to participate in CMB Stage 4

- HEP labs already heavily involved in R&D to align with P5
- **Working with NSF to coordinate planning and a path forward**
- **CMB-S4 Concept Definition Taskforce report approved by AAAC** in Oct 2017, lays out straw concept, science goals, small and large telescopes in Chile and South Pole
- Not yet in CD process



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Exploring the Unknown

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

Many significant inter-agency & international partnerships

Operations continuing:

Fermi/GLAST (w/NASA)

- ▶ HEP is supporting the Instrument Science Ops Center at SLAC;
- ▶ In coordination with NASA, HEP is planning to continue support of critical efforts at SLAC if operations > 10 years

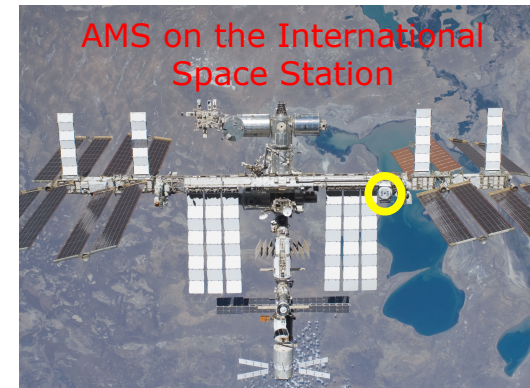
AMS (w/NASA)

- ▶ Operations continuing on ISS

HAWC (w/NSF)

- ▶ 5 year operations started early 2015

Lower program priority for new experiments



Science Highlight: SPT-3G

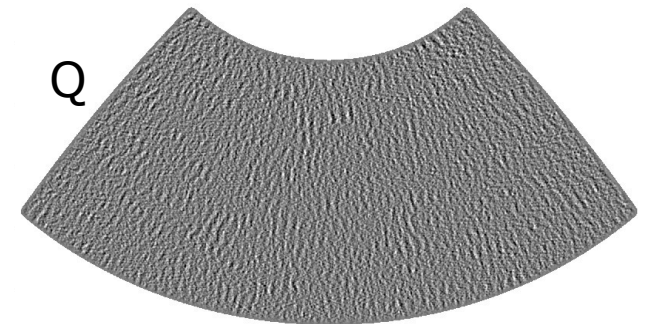
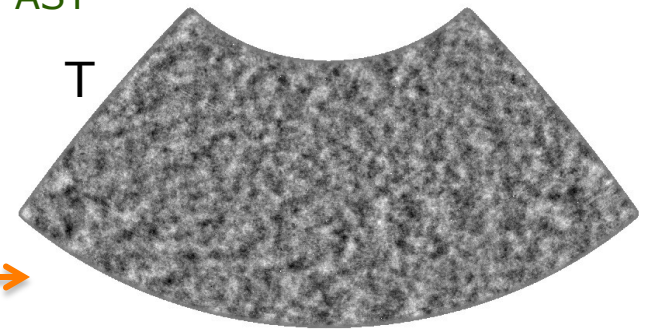
South Pole Telescope Generation 3

DOE-HEP partnership with NSF-OPP lead and NSF-PHY, NSF-AST

- HEP provided support for fabrication of SPT-3G detectors at ANL and partial support of operations

SPT-3G CMB temperature and polarization maps and power spectra from the 1500-square-degree survey.

- ▶ **In only ~1 week**, the sensitivity of SPT-3G CMB temperature and polarization anisotropy measurements exceed that obtained by Planck.
- ▶ Cross-hatching pattern in Q and U maps (horizontal-vertical in Q, diagonal in U) indicates high S/N per mode detection of CMB E-mode polarization.
- ▶ Initial, early-survey publication a few months after end of 2018 Austral winter season will present best constraint on TE/EE power spectra in multipole ranges $1500 < l < 2500$, $1100 < l < 1700$, respectively. Smaller area deep SPTpol data will still have best constraints on higher multipoles.

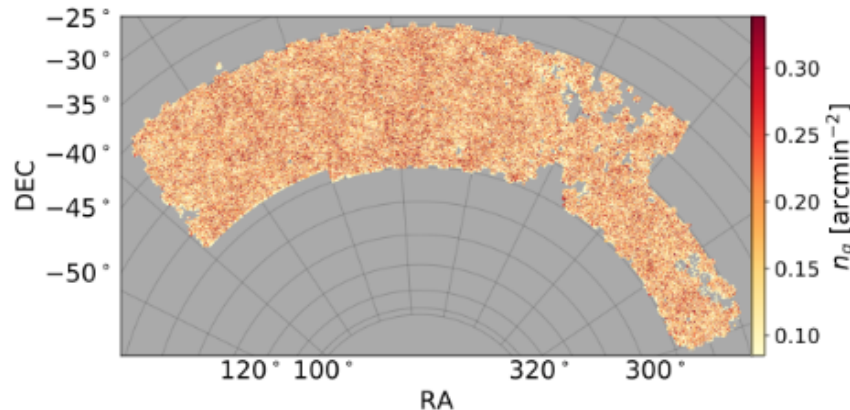


Science Highlight: Dark Energy Survey

Dark Energy Survey (DES)

DOE-HEP partnership with NSF-AST

- DOE provided DECam and partial support of operations
- Funded extension to Season 6, survey ends Jan 2019
- Released science papers using weak lensing, galaxy clustering, crosscorrelation (3x2pt)
- Papers using supernovae, CMB crosscorrelation (5x2pt), clusters forthcoming



Release of Y1 Key project data products – Oct 1 <https://des.ncsa.illinois.edu/releases/y1a1>

- ▶ Value added products, including photo-z catalog and Y1 Key project data vectors
- ▶ Release timed to final journal acceptance of Y1 Key project cosmology papers



Large Synoptic Survey Telescope (LSST) - Status

DOE-HEP & NSF-AST partnership:

- NSF & DOE Project Status review August 2018
- DOE is responsible for providing the LSSTcam

HEP MIE project funding completed in FY18;
Integration & Commissioning being funded on Operations budget (see FY19 Appropriations).

- Seven test rafts were installed successfully starting I&T efforts
- 14 science rafts have been assembled, tested and accepted (2Gpix)
- Only 10 sensors remain to be delivered

Dark Energy Science Collaboration (DESC):

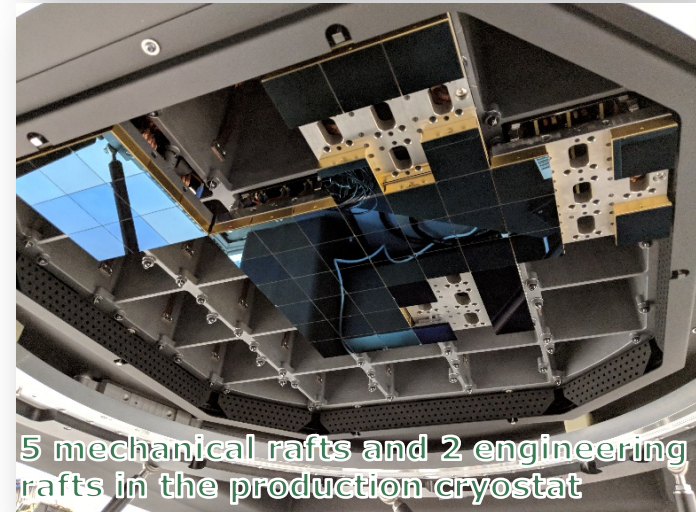
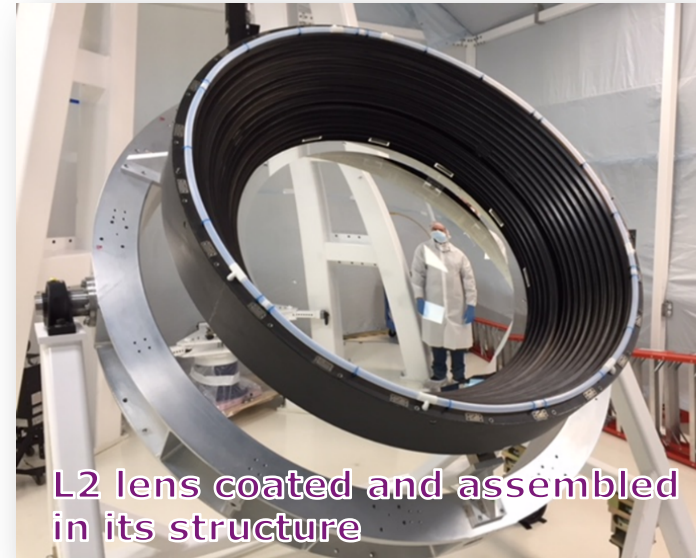
- Operations Plan review May 2018
- Data Challenge 2 Run 2.0 underway on Theta at ANL
- CosmoDC2 input catalog available for catalog studies

LSST DESC Science Requirement Document (SRD)

<https://arxiv.org/abs/1809.01669>

Some associated code and data products on public site

<https://zenodo.org/record/1409816>



Dark Energy Spectroscopic Instrument (DESI) - Status

DOE-led experiment, mounted and operated on the NSF's Mayall telescope at Kitt Peak.

- ▶ HEP has MOU w/NSF-AST to "lease" the Mayall telescope
- ▶ HEP MIE project funding completes in FY19
- ▶ Full support for dark energy ops starting FY19

Status:

- Project status & Operations plan review, Fall 2018
- Full dark energy survey operations starting FY20

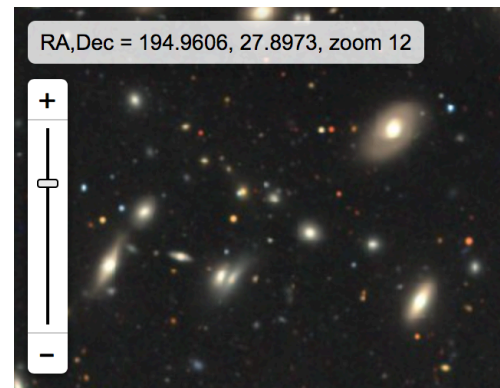
Targeting - Legacy Surveys

<http://legacysurvey.org/>

covering 14000 deg² in g,r,z + 4 IR bands

- ▶ Mayall z Band Legacy Survey (MzLS) – 100% complete
- ▶ Beijing-Arizona Sky Survey (BASS) on Bok – 95%
- ▶ DECam Legacy Survey (DECaLS) on Blanco – 90%

Data Release 7 in July 2018



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CMB-S4 – Status

► Collaboration

- ANL meeting March 2018, collaboration officially formed
 - Org chart, bylaws, organization, etc
 - Spokespeople: John Carlstrom (U Chicago), Julian Borrill (LBNL)

► Princeton Sep 2018

- Focused on R&D and science issues needed to get to CD1, wider astro community engagement
- Serious progress and coherence in collaboration in a short time

► pre-Project Design Group (pPDG) established following CDT report

- Will be POC on DOE R&D towards CMB-S4 CD-1
 - DOE provided \$1.5M FY18 R&D funding, went through pPDG to design/engineering (+LDRD+Research)
- DOE+NSF agree on Jim Yeck as pPDG lead (project manager experience from LHC, IceCube, LBNF, ESS)
- Collaboration and pPDG planning to a technically limited schedule, based on CDT study, preparing input to Astro 2020, and for DOE and NSF to plan support
- DOE is planning to work towards supporting pPDG and Collaboration's schedule

► DOE and NSF moving forward in sync:

- Collaboration to focus on a single design for both funding sources
- Enable DOE and NSF timescales to be in sync (DOE CD and NSF MREFC process)
- NSF/DOE Joint Coordination Group
 - Meet biweekly-monthly
 - Agencies, pPDG, spokespeople in close communication



HEP Science Portfolio Review (2018)

HEPAP was charged (Oct. 2017) to carry out a Portfolio Review

- ▶ Modeled on NSF Portfolio Review and NASA Senior Reviews
- ▶ Independent peer review of currently operating experiments supported by HEP

Draft report was presented and accepted at the May 2018 HEPAP meeting →

https://science.energy.gov/~media/hep/hepap/pdf/201804/Main_Panel_Report.pdf

https://science.energy.gov/~media/hep/hepap/pdf/201804/PGrannis_HEPAP_201805.pdf

We summarize the definitions of the groups and the subpanel's recommendations for the 13 experiments. The ordering within a group is alphabetical.

Group I (*Experiments that should be pursued with highest priority*):

- ▶ DES, eBOSS, NOvA, T2K

Group II (*Experiments with outstanding promise and relevance to the P5 Science Drivers, but whose funding could be reduced somewhat in the event of severe budget shortfalls*):

- ▶ HAWC, MINERvA, NA61/SHINE

Group III (*Experiments that address the P5 Drivers in important ways, but for which a reduction in funding would cause less harm to the DOE/HEP program than in the case of Groups I or II*):

- ▶ Daya Bay, Fermi/LAT, MicroBooNE, SuperK

Group IV (*Experiments that require further demonstration of likely success, or whose future program is less effective in advancing the P5 Science Drivers*):

- ▶ AMS, KOTO



2018 HEP University PI Meeting

HEP Principal Investigator (PI) Meeting

August 22-24, 2018 in Rockville, MD

<https://www.ornl.gov/heppi2018/>

Annual meetings – even years in DC area, odd years at APS/DPF meeting

- ▶ To brief and guide the HEP community on future FOAs and to provide a status and overview of the DOE-supported HEP program.
- ▶ The meeting includes:
 - ▶ General presentations during a plenary session covering the overall DOE-HEP program, budgetary issues, and different HEP FOAs at DOE to which PIs may apply
 - ▶ Parallel sessions led by individual DOE-HEP Program Managers (PMs) within the following subprograms: Energy, Intensity, and Cosmic Frontiers, Theoretical HEP, and Detector R&D, to provide detailed guidance on preparing comparative review applications for the merit review process, and the programmatic priorities and budgetary factors for the respective subprogram.
 - ▶ Opportunities for separate one-on-one sessions.
- **~150 participants**
- **Cosmic Frontier met with 25 PIs individually (plus many hallway conversations)**



Cosmic Frontier – Looking to the Future

HEP “Cosmic Visions (CV)” groups in dark matter and dark energy

- Allows interactions with small HEP community groups as 2-way line of communication for HEP-funded efforts and directions recommended by P5

CV-DM: Coordinate DM-G2 science optimization/develop DM new initiative for small projects

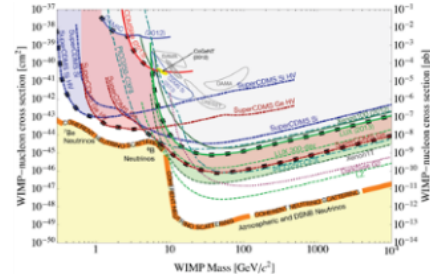
CV-DE: Investigate future HEP directions in the LSST & DESI era

Dark Matter Community workshop held March 2017 to

- Update identification of scientifically compelling areas to search; <https://arxiv.org/abs/1707.04591>

Basic Research Needs (BRN) process started mid 2018, report late 2018

- Chairs: Rocky Kolb (Chicago), Harry Weertz (ANL)
- Assess the science landscape for dark matter particle searches, AND
- Identify which high impact science areas would be suitable to be pursued with small projects in the HEP program (i.e. that need HEP infrastructure and capabilities)



Dark Energy future directions community workshops held – Investigate optimizing science in DESI/LSST era and/or follow-on projects

- Workshops held in 2016 at UChicago; in 2017 at LBNL
- White paper on small “enhance” efforts in Jan 2018 [arXiv:1802.07216](https://arxiv.org/abs/1802.07216); presentation to HEPAP May 2018
- Any major dark energy experiment will go through Astro 2020



Other HEP Efforts related to Cosmic Frontier

Theory program

- Vibrant Theory Program supporting all areas including Cosmic Frontier; QIS actively growing area; Support for Theory centers and groups at several universities and labs.

Advanced Detector Development program

- ▶ Active R&D developing next generation detectors, including CCDs, TES superconducting bolometers, MKIDs, readout electronics, optics. Key elements for DES, LSST, CMB-S4. Important impact on X-ray detector, medical detectors.

Computational HEP program

- Coordinates DOE Supercomputer allocations via various ASCR and DOE Competitions
 - ▶ Cosmic Simulations, Emulators, Data Analysis
 - ▶ Computational HEP, SCIDAC – focused computational challenges
 - ▶ HEP Center for Computational Excellence
- High Performance Computing – Comp HEP & ASCR coordination & partnerships on some efforts, including Cosmic Simulation and Data analytics
- Manages allocations on NERSC facility for HEP Cosmic Frontier Simulations and Experiments

Data Management

- Each Project/Experiment has provided a Data Management Summary to HEP
- Used for referencing in research proposals (DMP required!); also to check against AAAC *Principles for Access in Astrophysics* and SC *Statement on Digital Data Management*



AAAC Report (March 2018) – DOE response

AAAC Recommendation	DOE Response	Notes
Surveys release data	✓	All DOE surveys do
Agencies coordinate data/products	✓	TriAgency Group in midst of 2 year funded study on enabling LSST/WFIRST/Euclid data interconnects
Agencies broaden LSST/Euclid science area coordination	~✓	DOE supports LSST for dark energy. Can include other areas in TAG when NASA/NSF ready
Balanced portfolio	✓	Absolutely. 2018 Portfolio Review, P5, Decadal Survey, community studies
Agencies intercommunicate portfolio reviews	✓	Regular communication with NASA, NSF, international partners
Agency multimessenger communication	✓	DOE enables broader goals with, e.g. DES, DESI, FGST, HAWC, LSST. Close communication, partnership
Long term Ops, Research plans for LSST	✓	Joint LSST Ops, DESC Ops support and reviews. DESC Research. AAAC subpanel Gemini-Blanco-SOAR w/ NSF
CMB-S4 Concept Definition Task Force	✓	Study and report very helpful in planning



Funding Opportunities

- ▶ Research Opportunities in High Energy Physics (“Comparative Review”)
 - ▶ **Main funding source for university grants**
 - ▶ Cosmic Frontier supports scientists with critical roles on HEP experiment
- ▶ Workforce Development (WDTS) programs: <https://science.energy.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
 - ▶ Now accepting applications for Spring 2018, due Oct 2
 - ▶ **Visiting Faculty Program**
 - ▶ Summer research support for faculty/students from historically underrepresented institutions
 - ▶ One call per year, usually in Oct. Applications due in Jan.
- ▶ Office of Science programs:
 - ▶ **Early Career Research:** <https://science.energy.gov/early-career/>
 - ▶ **SC “General”** [DE-FOA-0001820]
 - ▶ HEP uses this primarily for conferences and unforeseen circumstances (e.g. equipment failure)



Early Career Awards – Cosmic Frontier

FY18:



Alexie Leauthaud
Dark Energy



Hee-Jong Seo
Dark Energy



Aritoki Suzuki
CMB detectors



Daniel Bowring
Dark matter QIS



Benjamin Safdi
Dark matter theory

FY17:



Anja von der Linden
Dark Energy



Michael Schneider
Dark Energy



Zeeshan Ahmed
CMB detectors



Marilena LoVerde
Neutrino theory

DOE Cosmic Frontier Conclusion


- ▶ Cosmic Frontier has great science! It is an exciting time to be in it!

- ▶ 4 MIE coming to fruition

- ▶ Experiments at all stages of lifecycle:

Concept, design, construction, commissioning, data!

- ▶ Astro 2020 Decadal Survey about to start

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