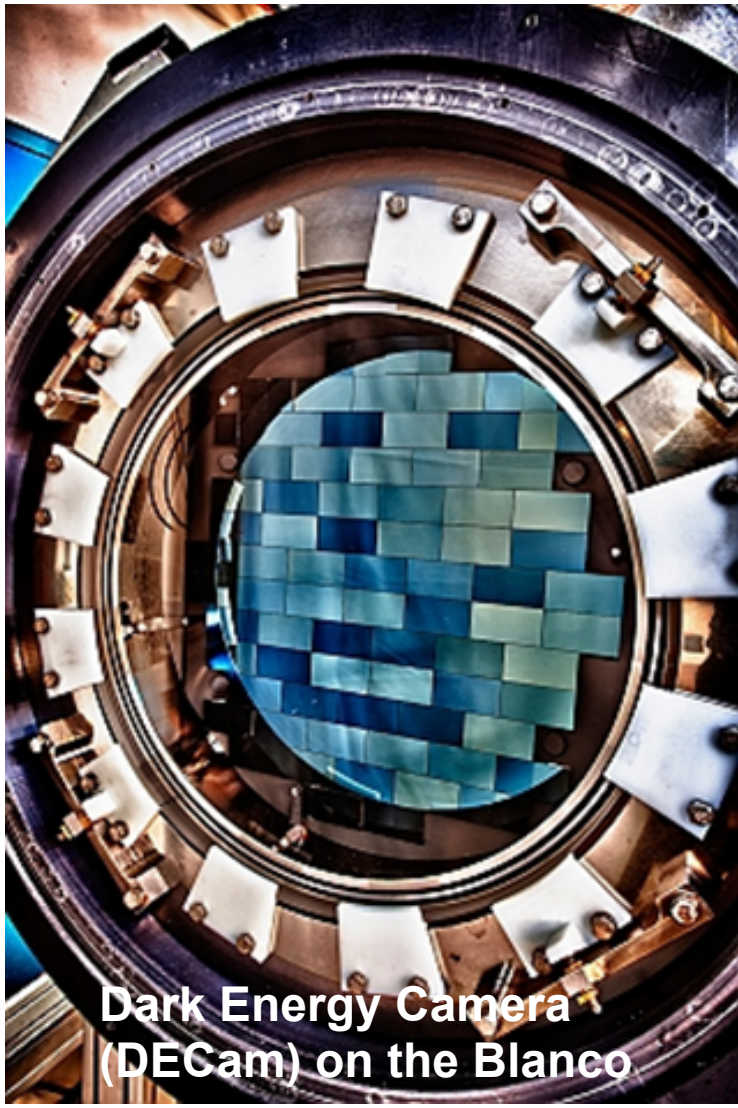
DOE High Energy Physics (HEP)

report to the

AAAC Panel



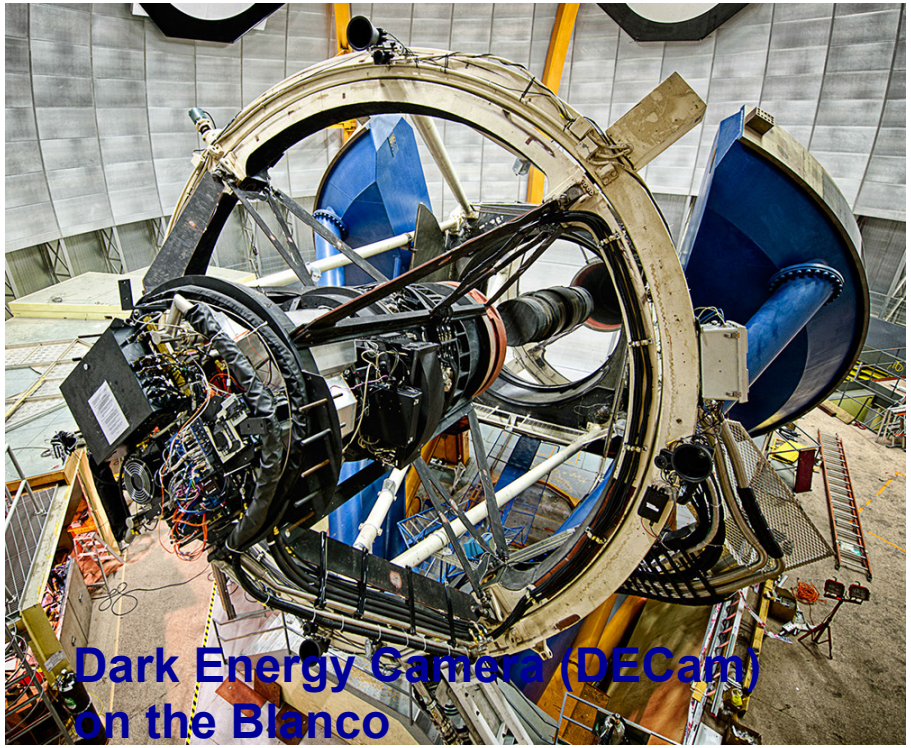
27 October 2016
Kathy Turner

HEP Cosmic Frontier Program Managers:
Anwar Bhatti (IPA), Eric Linder (IPA), Michael Salamon, Kathy Turner

Outline

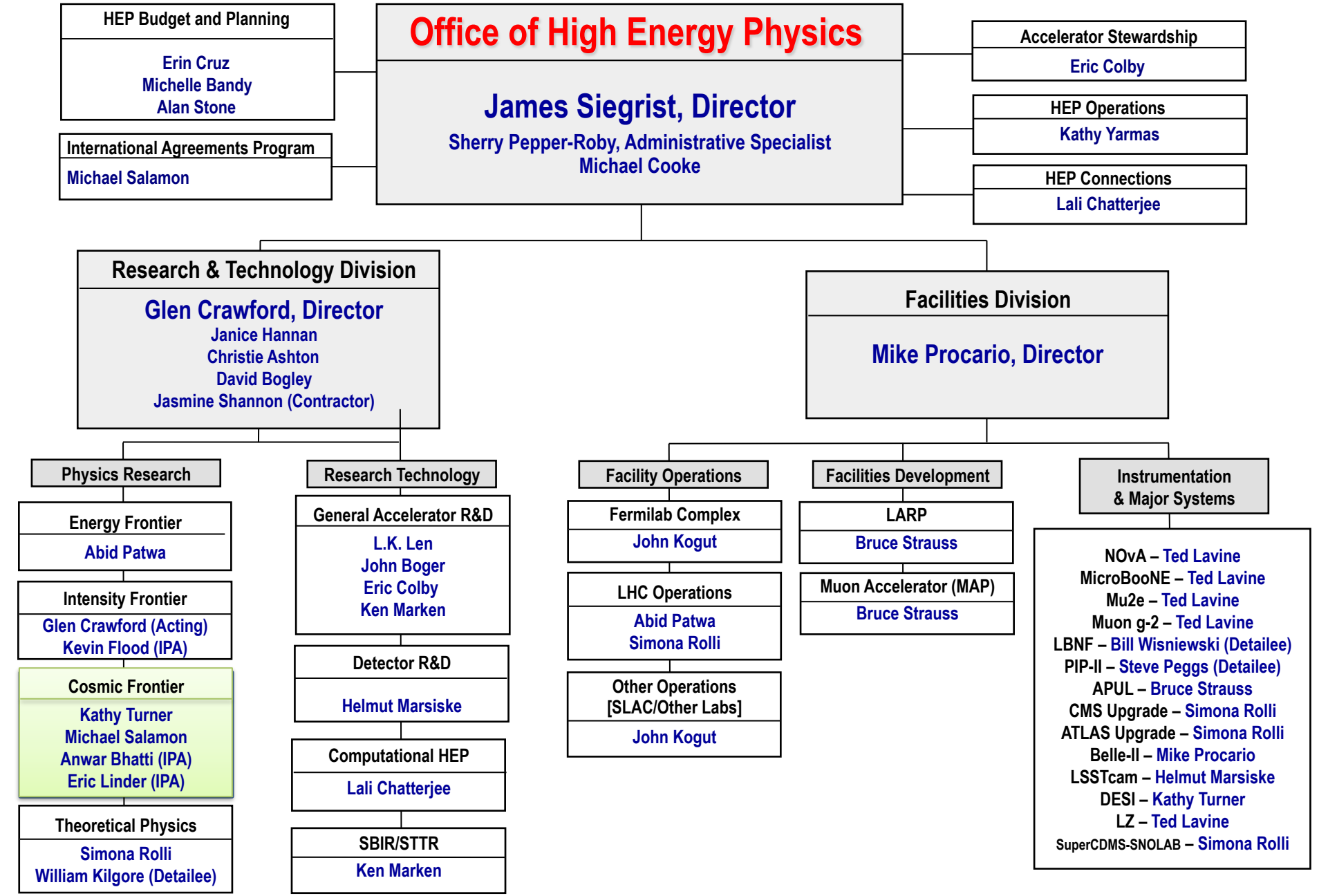
HEP

- Organization
- Mission
- Program Guidance & Planning
- Budgets
- Status


Dark Energy Camera (DECam) on the Blanco

COSMIC FRONTIER details

- Program, planning, status, budget
- Research funding, statistics, priorities



U.S. DEPARTMENT OF ENERGY | Office of Science

September 2016

The High Energy Physics Program Mission

Office of Science → part of a "Mission" Agency (HEP 1 of 6 Office)

- Provides science leadership & support to enable significant advances in specific areas
- Strategic planning process with community input to develop science drivers and a specific portfolio of facilities & experiments
- Laboratory System with comprehensive resources & infrastructure to carry out program.
- Interagency & International partnerships to optimize and maximize the science.

HEP Mission…is to understand how the universe works at its most fundamental level:

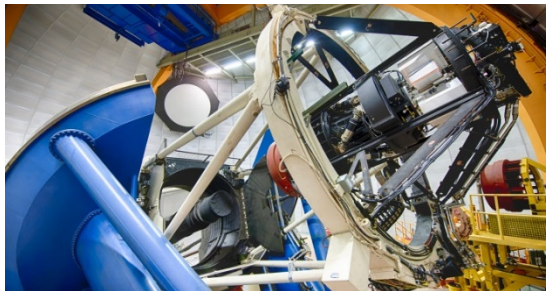
- Discover the elementary constituents of matter and energy
- Probe the interactions between them
- Explore the basic nature of space and time

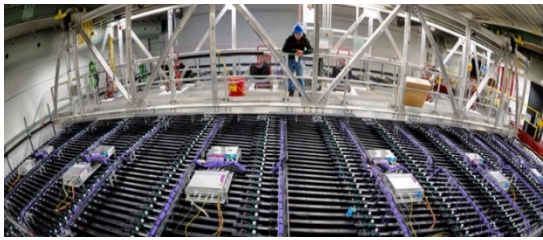
…and fulfills its mission by developing a program to carry out the strategic plan:

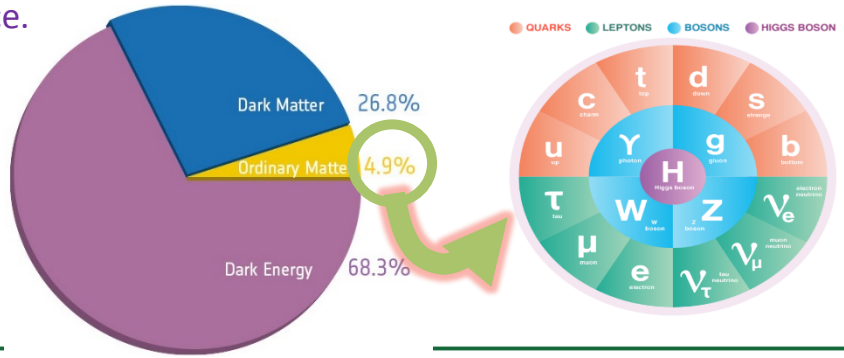
- Building projects that enable discovery science
- Operating facilities that provide the capability to perform discovery science
- Supporting a balanced research program that produces discovery science

Key Support Features:

- Support theoretical and experimental research in both particle physics & accelerator science and technology.
- Support scientific collaborations to participate in all phases of experiment in order to produce the best possible science results.
- Support the development of key technologies and trained manpower needed to work at the cutting edge of science.

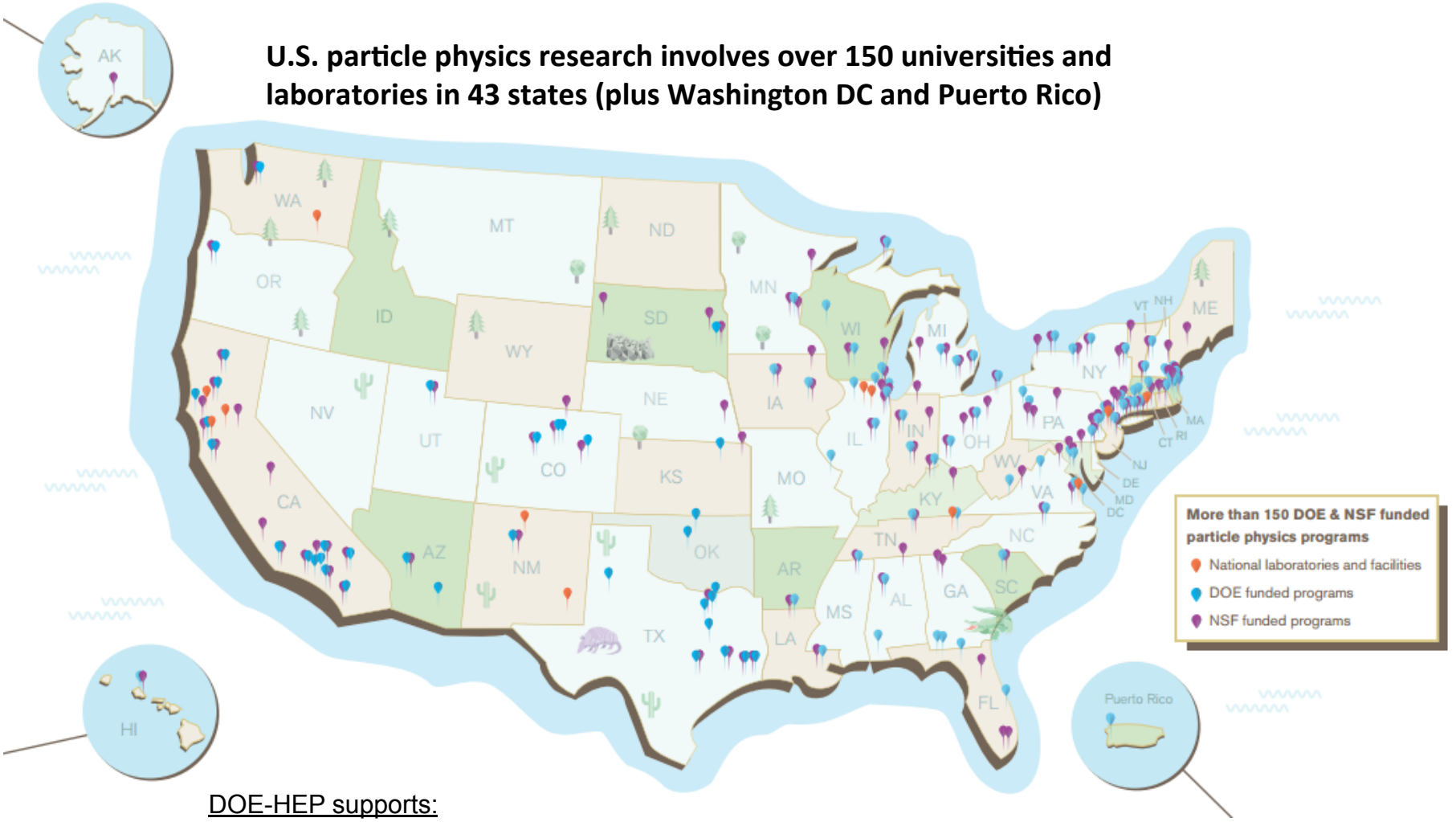






The U.S. High Energy & Particle Physics Program (DOE & NSF)

U.S. particle physics research involves over 150 universities and laboratories in 43 states (plus Washington DC and Puerto Rico)



DOE-HEP supports:

- Major programs at 5 SC national labs (+specialized effort at other SC and NNSA labs)
- ~ 4200 FTEs (including scientists, technical and computing specialists, administrative staff)
- University research program with ~250 active grants to >100 institutions, involving approximately 1,700 FTEs

PROGRAM GUIDANCE & PLANNING

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 program**
  - Subpanels for detailed studies (e.g. Particle Astrophysics Science Assessment Group "PASAG" in 2009, **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
  - Subpanels:
    - These were joint AAAC & HEPAP: TFCR (2006), DETF (2006), DMSAG (2007)
    - AAAC only: CMB-S4 CDT (being formed)

Formal Advice Also Provided by:

- **National Academy of Sciences (NAS)**
  - Reports: New Worlds New Horizons (2010) Decadal Review of Astronomy & Astrophysics, "Mid-decade review" (2016)
  - Ongoing: Board on Physics & Astronomy (BPA), Committee on Astronomy & Astrophysics (CAA)

Other:

- Community science studies and input (e.g. Snowmass)

Cosmic Frontier
Guidance from Astro2010 "New Worlds New Horizons" Report (August 2010)

Specific Recommendations to DOE :

A program fitted under the **DOE budget doubling scenario** means that roughly $40 million per year would be available by the end of the decade, after due allowance for an underground dark matter detection program as recommended by HEPAP-PASAG. This amount will be sufficient to allow participation in LSST, WFIRST, and ACTA as well as some of the smaller astrophysical initiatives recommended by HEPAP-PASAG under Scenario C. In addition, a $2 million per year Theory and Computation Networks program is recommended.

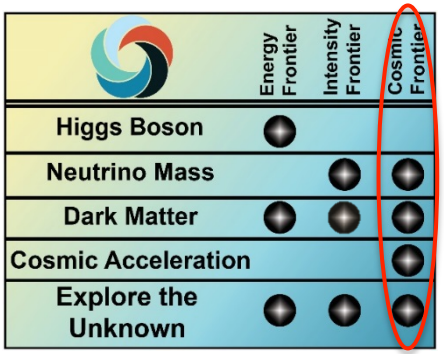
However, **if the budget is lower**, the HEPAP-PASAG recommended investment in dark matter detection will be reduced and the available funds will decrease to $15 million under Scenario A. DOE is a minor partner in the two largest projects that the survey committee has recommended—LSST and WFIRST—and it is likely that the phasing will involve choices by NSF and NASA, respectively. Other considerations being equal, the recommended priority order is to collaborate first on LSST because DOE will have a larger fractional participation in that project, and its technical contribution is thought to be relatively more critical. ACTA, Theory and Computation Networks, and the smaller initiatives have lower priority.

Summary: In lower scenarios, DOE should participate in LSST ahead of WFIRST since DOE is making a larger relative $ contribution and its technical role is thought to be relatively more critical. DOE may have opportunities to contribute to mid-scale ground-based projects with NSF (ground priority #2), and should contribute to ACTA with NSF and to the Theory & Computation Network (TCN). These smaller programs and ACTA have lower priority than LSST & WFIRST.

P5 "Strategic Plan for US Particle Physics in the Global Context" - Long Range plan approved May 2014

P5 study assessed and prioritized HEP projects over a 20-year timeframe within reasonable budget assumptions and positions the U.S. to a be a leader in some (but not all) areas of HEP.

- **P5 plan is a compelling, unified vision for HEP**
- **5 science drivers**
  - Use the Higgs boson as a new tool for discovery — 2013
  - Pursue the physics associated with neutrino mass — 2015
  - Identify the new physics of dark matter
  - Understand cosmic acceleration: dark energy and inflation — 2011
  - Explore the unknown: new particles, interactions, and physical principles



- **The global vision in P5 addresses the five Science Drivers with a balanced program that deeply intertwines U.S. efforts with international partners**
  - Large, medium, small projects; time phasing with continuous science output
  - Investments in the US and abroad
  - "The United States and major players in other regions can together address the full breadth of the field's most urgent scientific questions if each hosts a unique world-class facility at home and partners in high-priority facilities hosted elsewhere."

- **DOE execution of the P5 strategy requires navigating many factors, including:**
  - Balancing scope of HEP program: projects, operations, research
  - U.S. budget formulation and execution
  - Coordination among U.S. and international partners

P5 Report – Program & Project Criteria

HEP will use P5 criteria to develop the program and determine which projects, and at what level, to invest in.

• **Program optimization criteria**

– **Science**: based on the Drivers, assess where we want to go and how to get there, with a portfolio of the most promising approaches.

– **International context**: pursue the most important opportunities wherever they are, and host world-leading facilities that attract the worldwide scientific community; duplication should only occur when significant value is added or when competition helps propel the field in important directions.

– **Sustained productivity**: maintain a stream of science results while investing in future capabilities, which implies a balance of project sizes; maintain and develop critical technical and scientific expertise and infrastructure to enable future discoveries.

• **Individual project criteria**

– **Science:** how the project addresses key questions in particle physics, the size and relevance of the discovery reach, how the experiment might change the direction of the field, and the value of null results.

– **Timing**: when the project is needed, and how it fits into the larger picture.

– **Uniqueness**: what the experiment adds that is unique and/or definitive, and where it might lead. Consider the alternatives.

– **Cost vs. value**: the scope should be well defined and match the physics case. For multidisciplinary/agency projects, distribution of support should match the distribution of science.

– **History and dependencies**: previous prioritization, existing commitments, and the impacts of changes in direction.

– **Feasibility**: consider the main technical, cost, and schedule risks of the proposed project.

– **Roles**: U.S. particle physics leadership

Advancing the P5 Vision

P5 Recommendations:
Highest priority major projects are Large Hadron Collider (LHC) detector (ATLAS, CMS) upgrades in the near-term and Long Baseline Neutrino Facility (LBNF; aka LBNE) in the midterm.

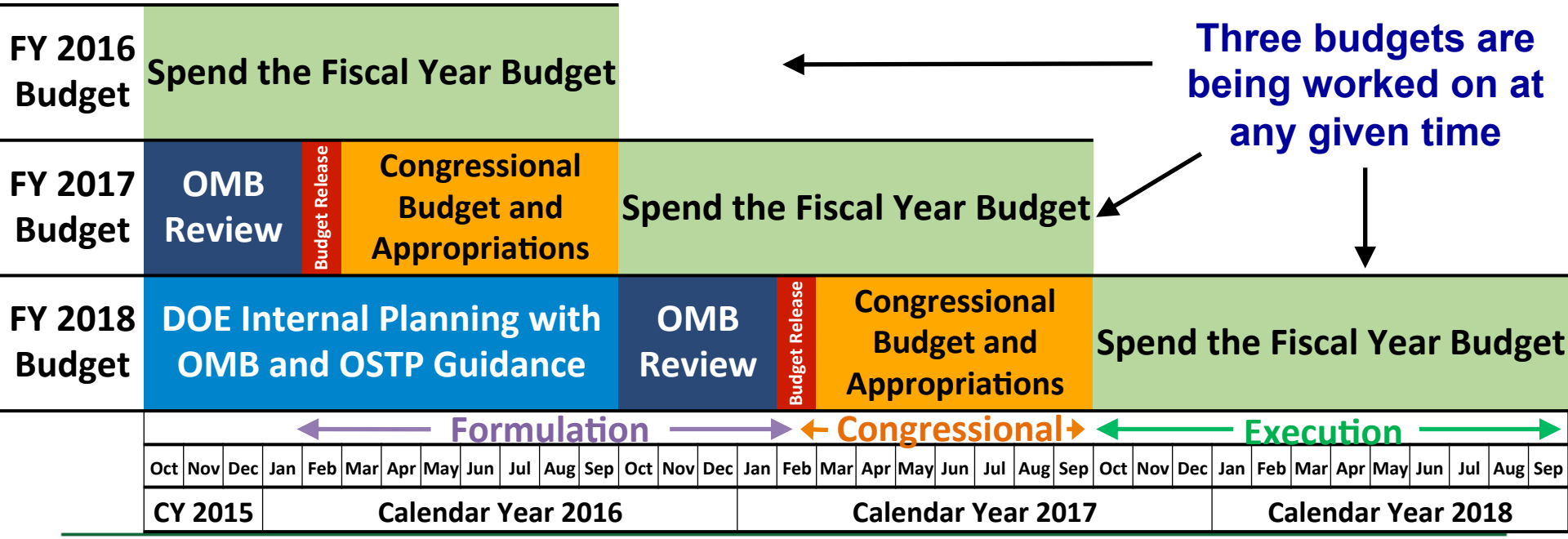
- **Energy Frontier: Continue LHC program with higher collision energy (13+ TeV)**
- **Intensity Frontier: Develop a world-class U.S.-hosted Long Baseline Neutrino Facility (LBNf)**
  LBNF will be the first truly large-scale international [ground-based] experiment hosted by the US
- **Accelerator Stewardship: broader applications of accelerator technologies**
- **Cosmic Frontier: Advance our understanding of dark matter and dark energy**
  - Highest priorities are continuing studies & development of new capabilities in direct dark matter detection & dark energy exploration
  - **Near term Cosmic Frontier projects are ready to go; studying the nature of dark energy & direct detection searches for dark matter particles**
  - Lay the ground work for future projects → including in CMB

HEP is implementing the global vision for particle physics set forth by P5,which continues to receive strong support from the Administration & Congress
- Have developed & aligned the HEP program along P5 recommendations; started near term projects and planning to support P5 recommendations later in the decade.
- Full implementation takes time & must strive to maintain balance – work with partners and stakeholders: DOE management, HEP community, DOE Laboratories, Congress, OMB, other US and international Agencies, and within the fiscal environment

BUDGETS

The U.S. Federal Budget Cycle

- **Formulation:** Executive branch prepares the President's Budget Request as per Office of Management and Budget (OMB) guidance
- **Congressional:** Congress considers the President's Budget proposals, passes a budget resolution, and enacts the regular appropriations acts and other laws that control spending and receipts. **Note: If budget isn't passed by the FY start, need a Continuing Resolution (CR) to avoid a Government shutdown; funding planned at previous FY level.**
- **Execution:** OMB apportions funds to Executive Branch agencies, which obligate and disperse funding to carry out their programs, projects, and activities

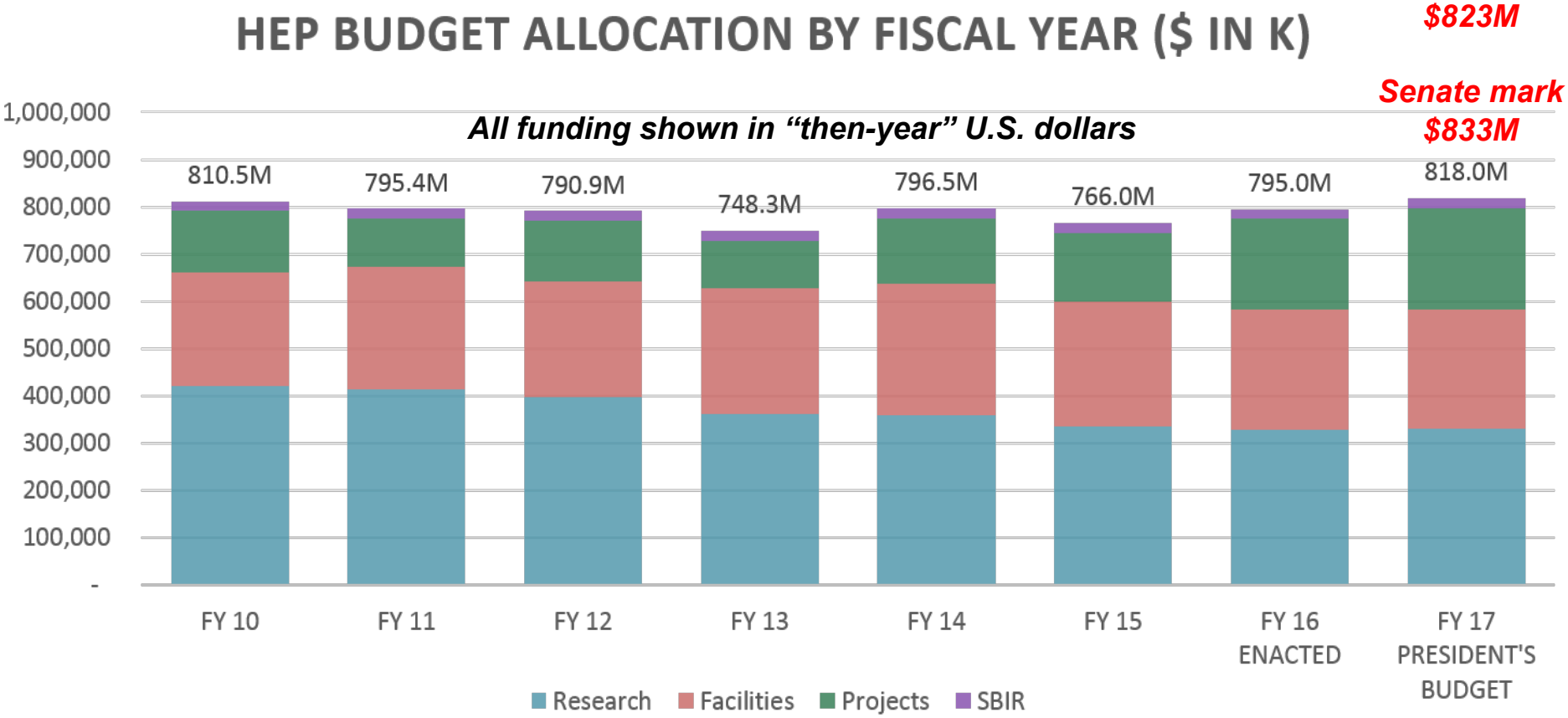


Overall HEP Budget Trend

- Significant dip in FY13 from Congressional sequestration
- FY15 request developed prior to P5 report release
- The enacted FY16 HEP Budget of $795M was above the Request & squarely in P5 Scenario B.

House mark $823M

Senate mark $833M



→HEP must coordinate Projects, Facilities/Operations, and Research efforts to succeed in its mission
In recent years have traded Research for Project investments; Research expected to be ~flat in FY17.

FY 2017 HEP Budget Strategy

The FY17 President's Request for HEP ($818M) aims to continue the successful P5 implementation

The FY17 HEP budget request reflects the way that implementing the P5 strategy has evolved as the U.S. and international community has adopted and responded to it

- LHC (including upgrades) remains the highest-priority large project in the near-term
- LBNF/DUNE, the highest-priority large project in its time frame, has been reconfigured and is gaining international support much more rapidly than anticipated in the P5 strategy
- U.S. Administration and Congress strongly support establishing LBNF/DUNE as the first U.S.-hosted international science facility

This presents opportunity to advance the P5 strategy on shorter time scale through additional funding: "Scenario B+"

- HL-LHC accelerator and detector upgrades per CERN schedule
- Support all other projects in P5's Scenario B
- Maintain balance between Research, Operations, and Projects
- Additional funding *beyond* the above priorities would support accelerating the implementation of LBNF/DUNE

FY17 priorities include:

- Start the HL-LHC accelerator and detector projects
- Solidify international partnerships to establish LBNF/DUNE
- Complete existing projects, including suite of dark matter and dark energy experiments
- Maintain balance between research, facility operations, and projects

Cosmic Frontier Priorities: to advance leadership efforts in the dark matter, dark energy programs

- Fabrication ramp-up supports key P5 recommended projects: LSSTcam, DESI, SuperCDMS-SNOLab, LZ
- ADMX-G2 & SPT-3G are starting operating phase.
- Planning efforts for the future: CMB-S4, small R&D efforts on DM-G3

FY 2014-2017 HEP Program - Budget Status

HEP Budget History ($K)	FY14 PRB	FY14 Actual	FY15 PRB	FY15 Enacted	FY16 PRB	FY16 Enacted	FY17 PRB
Energy Frontier	154,687	152,386	153,639	147,584	154,555	150,723	150,998
Intensity Frontier	271,043	250,987	251,245	264,224	247,196	243,121	234,144
Cosmic Frontier	**99,080**	**96,927**	**101,245**	**106,870**	**119,325**	**130,582**	**130,069**
Theory & Comp. Physics	62,870	64,275	58,850	59,274	60,317	59,083	59,656
Advanced Tech R&D	122,453	150,270	114,242	120,254	115,369	115,494	118,285
Accelerator Stewardship	9,931	9,075	19,184	10,000	14,000	9,000	13,744
SBIR/STTR	21,457	0	20,595	20,794	21,138	20,897	22,580
HEP Subtotal	741,521	723,920	719,000	729,000	731,900	728,900	729,476
Construction, Line Item	35,000	51,000	25,000	37,000	56,100	66,100	88,521
HEP TOTAL	**776,521**	**774,920**	**744,000**	**766,000**	**788,000**	**795,000**	**817,997**
Office of Science TOTAL	5,152,752	5,066,372	5,111,155	5,067,738	5,339,794	5,350,200	5,672,069

*FY14 SBIR/STTR was ~ $21M, so FY2014 actual was ~ $796M.
PRB = President's Request Budget

FY16: The enacted budget was above the Request and squarely in P5's Scenario B.
FY17: We are currently in a CR

…Planning is difficult… We typically have plans for a full-year CR, the PRB and then the enacted budget.

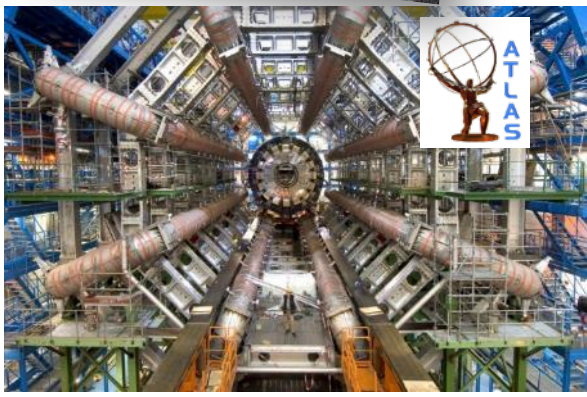
HEP PROGRAM STATUS

Energy Frontier Status

P5 recognized that a compelling and comprehensive LHC program is a core part of U.S. particle physics, and DOE intends to support key leadership roles in all areas of the ATLAS and CMS experiments

– U.S. participation is enabled by leveraging U.S. expertise in accelerator science & technology to exploit future opportunities

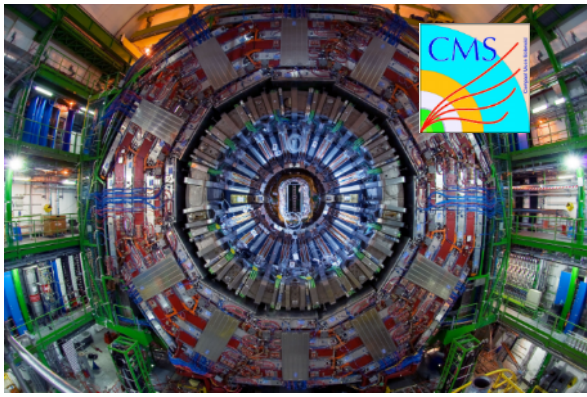
The lion's share of DOE HEP investment remains the LHC program and will be for many more years – partnership is strong!



Fabrication Projects

Phase-1 upgrades to the LHC detectors

– CMS/ATLAS upgrades received CD-2/3 approval in Nov. 2014 & are on track for completion in 2019.



Planned Program

High-luminosity LHC upgrades in 2024-2026 will extend the discovery reach -- will Increase luminosity by 10 times LHC design value to explore new physics at TeV energies

– DOE/HEP is supporting the development of a suite of in-kind contributions that utilize the expertise of the U.S. accelerator community including the national laboratories (quadrupole magnets, crab cavities and electron-lens)

– DOE/HEP actively working with US-CMS and US-ATLAS to establish the detector upgrade projects

- **Mission-Need (CD-0) in 2016; CD-1 planned in late 2017**

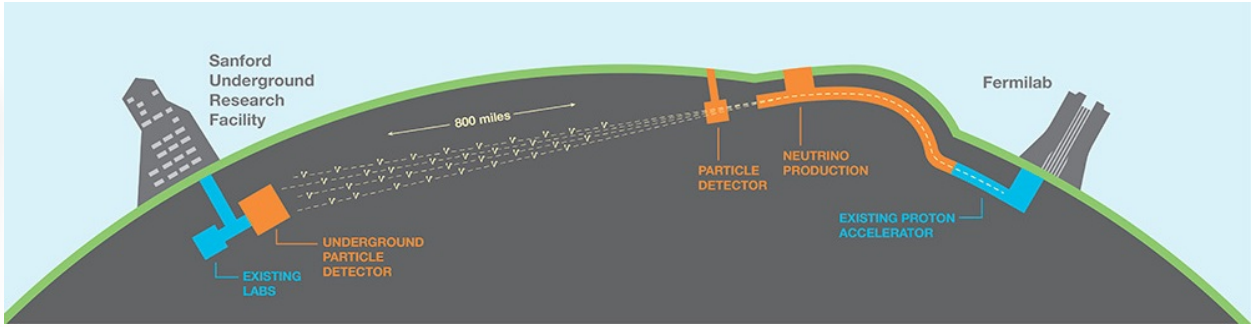
Intensity Frontier Status

Intensity Frontier experiments address the P5 Science Drivers through intense beams and sensitive detectors

- **Exploring the unknown through precision measurements:** Muon g-2, Mu2e, Belle II, K0TO
- **Identify the new physics of dark matter:** APEX and Heavy Photon Search
- **Pursuing the physics associated with neutrino mass:** NOvA, Daya Bay, MINERvA, Super-K, T2K ongoing; ramping up Fermilab Short-Baseline Neutrino Program (MicroBooNE, SBND, ICARUS)

P5 recommended Long Baseline Neutrino Facility (LBNF) as the centerpiece of a U.S.-hosted world-leading neutrino program, recognizing it as the highest-priority large project in its timeframe

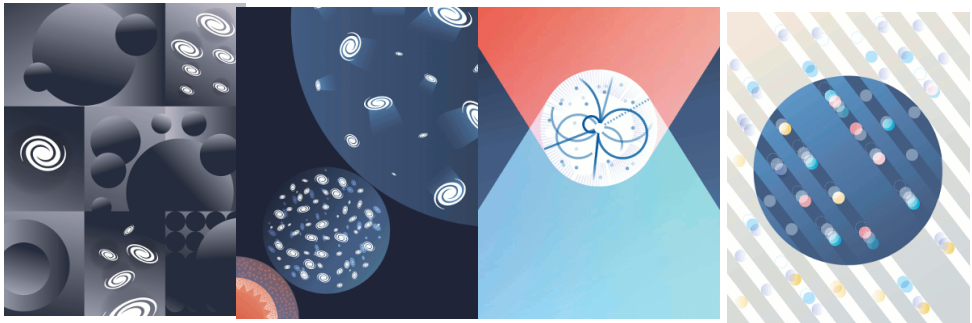
- **Given the compelling discovery potential, Fermilab is working closely with CERN and other global partners to establish a truly international "mega-science" facility with first physics in the mid-2020s**
- **LBNF will produce the world's most intense neutrino beam and send it 800 miles through the earth**
- **The Deep Underground Neutrino Experiment (DUNE) will be a large (40 kiloton) liquid argon neutrino detector located nearly 1 mile underground at the Sanford Underground Research Facility**
- **LBNF/DUNE project received CD-3A (early far-site construction) approval in September 2016**
  - FY17 investments in site preparation and cavern excavation aim to solidify international partnerships



Now…COSMIC FRONTIER Details

COSMIC FRONTIER:
PROGRAM, PLANNING, STATUS, BUDGET

Cosmic Frontier Program



Dark Matter | Cosmic Acceleration | Explore the Unknown | Neutrino Mass

Cosmic Frontier: Through ground-based telescopes, 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 era, Neutrino properties
- **Cosmic-ray & Gamma-ray studi**es – particle properties, high energy acceleration mechanisms, indirect searches for dark matter particles
- **Other**: computational cosmology

+ related Theory, Detector development, computational, etc.

May 2014 P5 Strategic Plan Recommendations - 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 **(DM-G2)** 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 Project 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 the P5 plan, starting about mid-way through their 10 year plan)
- Cosmic Rays and Gamma Rays
  - Invest in CTA only if the critical NSF Astronomy funding can be obtained
    - CTA has a broad science reach that transcends fields, with the dark matter detection capabilities of direct importance to particle physics; Using P5 Criteria, a de-scoped US component should be shared by NSF-AST, NSF-PHY and DOE.

Cosmic Frontier – Program Planning, P5 Implementation

P5 → science & project priorities in Dark Energy, Dark Matter (direct detection), CMB

- **Work proactively with our labs & community to carry out the program**

Develop Program following the P5 Plan & considering P5 Criteria:

- Science goals and how it will address DOE-HEP goals
- Make unique, significant, coherent contributions to facilities/experiments selected for the program at a level commensurate with expected science return on HEP physics goals
    - Roles & responsibilities in line with our contributions/expertise
    - **What does HEP community bring to the table?**

      Need to bring unique, visible, leadership contributions, especially if it's an area usually supported by another agency. Typically this is expertise in developing & delivering state-of-the art instrumentation, lab infrastructure & project management, "big data" computing facilities and expertise, and having a cohesive science collaboration to carry out all phases of the project/experiment and deliver precision results.
- For facilities with broader science program (e.g. astronomy facilities) than the interests of the HEP program, make project contributions at appropriate level & support research efforts for our science interests
- Balance & Stages: Staged implementation, results; varying project size; complementary and varying methods/technologies; balance between science areas and speculative/guaranteed results

Cosmic Frontier – Program Planning, P5 Implementation

Partners:

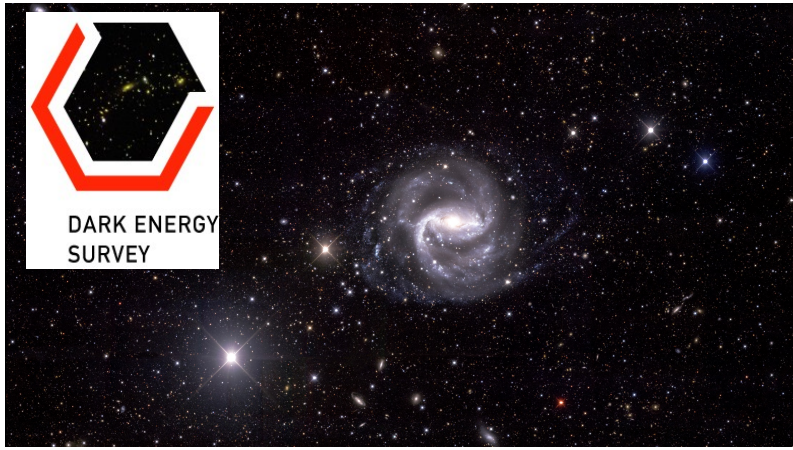
Form partnerships or use other agency's facilities when needed → We have significant planning & coordination with multiple offices in other agencies: NSF-PHY, NSF-AST, NSF-PLR, NASA

Plan Funding:

- Long-term support for our responsibilities in designing, building and operating projects
- **Support for HEP-style science collaboration in all stages, including coordinated data analysis to get the best possible science results**

Move Forward to Execute P5 Plan

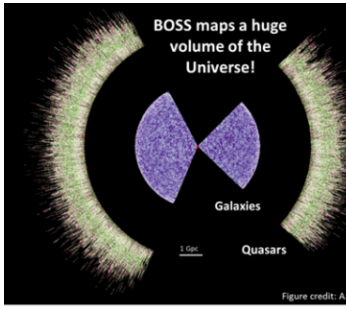
- Plan successful completion of current operating experiments
- Move forward on planning & fabrication for near-term projects recommended by P5
- Support for future projects later in P5 plan (e.g. CMB-S4, DM-G3) is extremely limited
  - **Discussions with other agencies and community to determine possible future paths**
- Ensure **the** science team is in place to adequately carry out the experiments **&** projects



Cosmic Frontier – Dark Energy

Precision measurements to differentiate between Cosmological Constant and new fields or modification to General Relativity

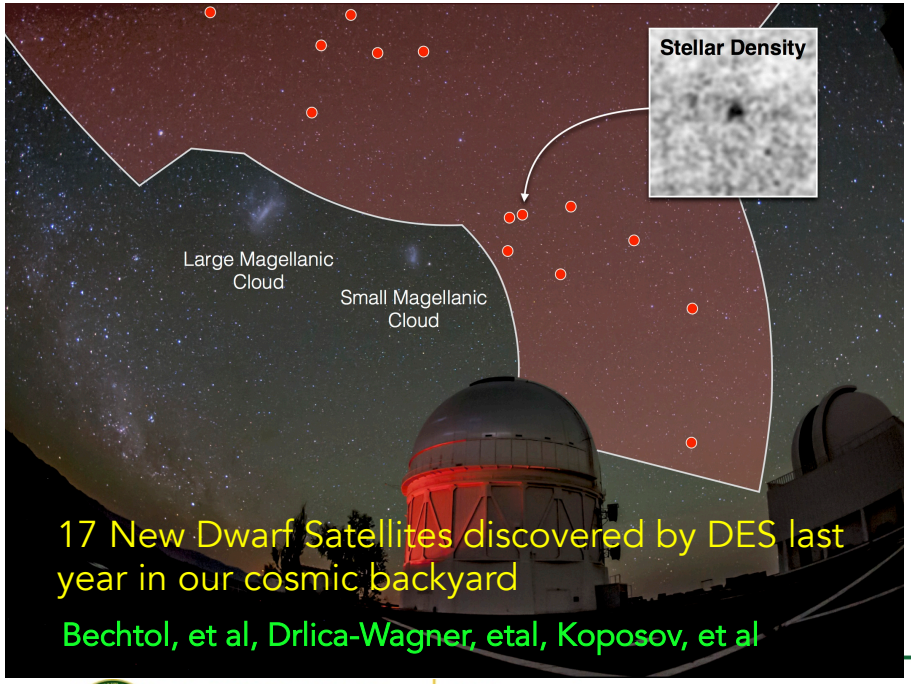
- staged, complementary suite of imaging, spectroscopy & supernova surveys

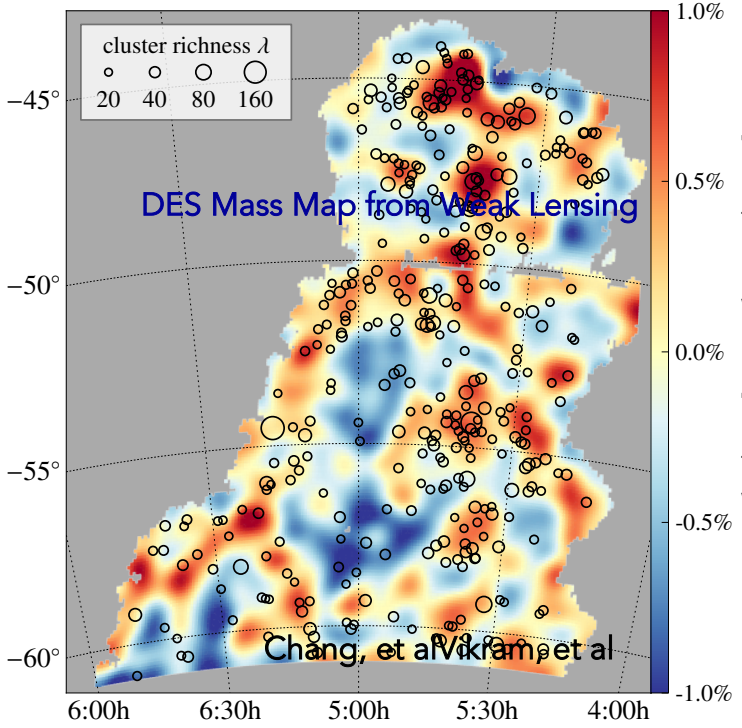


Operating/Completed:

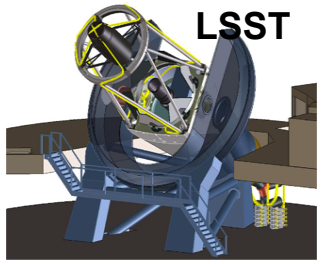
– ***BOSS* (spectroscopic)** final results; **eBOSS (spectroscopic)** started in 2015

– ***DES* (imaging)** started 5-year survey in late FY13; HEP built the camera which operates on the Blanco telescope; partner w/NSF-AST



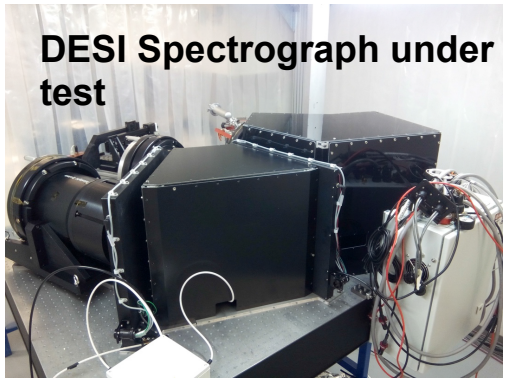


Cosmic Frontier – Dark Energy Projects



Large Synoptic Survey Telescope **(LSST, Stage IV imaging)**

- HEP and NSF-AST (lead agency) partnership; HEP responsible for the LSST camera (SLAC)
- LSSTcam CD-3 (full fabrication approved) Aug. 2015
- LSST Project Status review Aug 2016; Commissioning phase review Jan. 2017
- LSST Facility Operations phase planning started
- LSST Dark Energy Science Collaboration (DESC) Ops review ~ March 2017



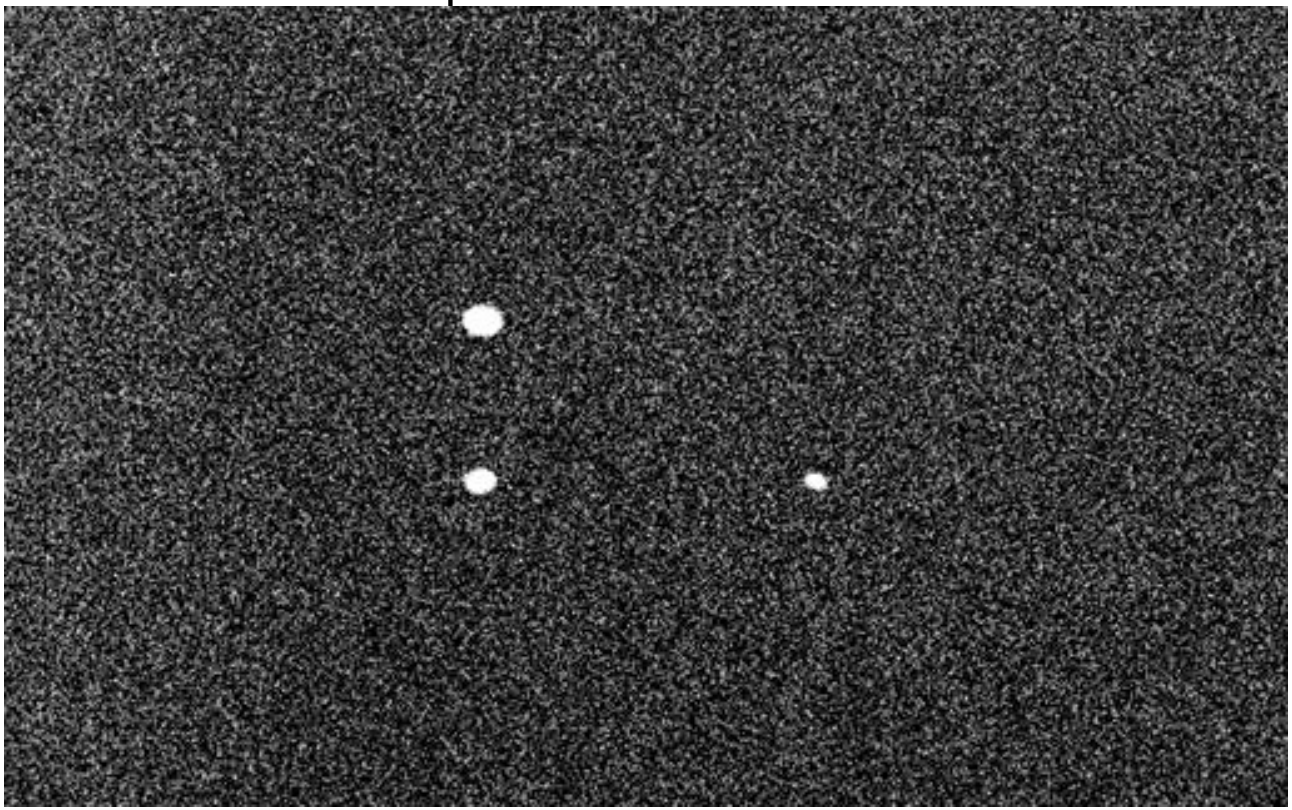
Dark Energy Spectroscopic Instrument **(DESI, Stage IV spectroscopic)**

- "HEP experiment" with LBNL managing; CD-3 (full fabrication approved) June 2016
  - build DESI instrumentation & data management system for use on Mayall telescope
- HEP coordinating with NSF-AST to use ("lease") the Mayall telescope;
  - HEP partial support in FY16-18; full support for dark energy operations starting in FY19
- DESI Operations phase planning started; Project and Operations plan reviews in summer 2017

ProtoDESI a Success !!

Completed, all goals accomplished!

- Held lessons-learned workshop



Fiber Photometry Camera Image showing light from target stars emerging from three fibers while guiding the telescope using the DESI GFA

Cosmic Frontier:
Direct Detection Dark Matter (DDDM)

→Learn the identity and nature of Dark Matter with staged program of experiments with multiple technologies & methods

Operating:
Completing Operations on current DM-Generation 1 (DM-G1) experiments in FY16/17: **ADMX-II, LUX, CDMS-Soudan, DarkSide-50, COUPP/PICO, DAMIC**

Design, Fabrication:
Progress continues on DM-G2's selected by HEP & NSF-PHY in July 2014

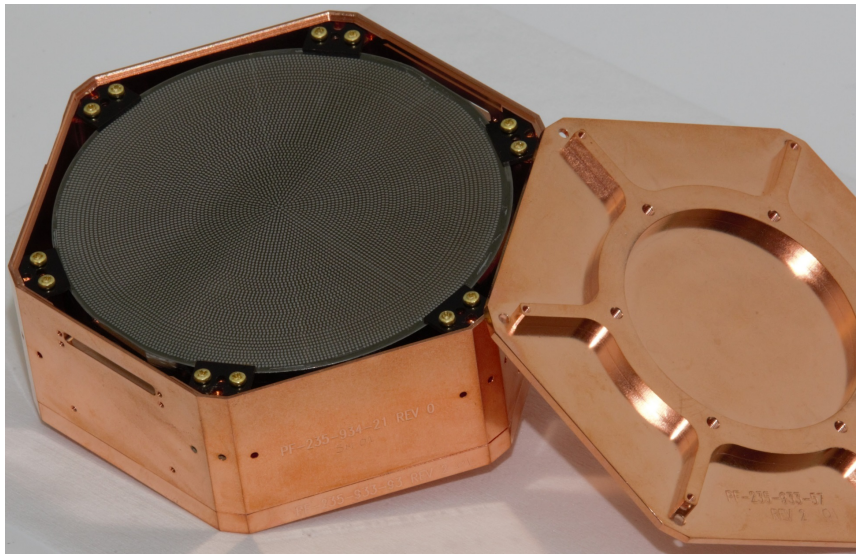
- **ADMX-G2** axion search at U.Wash. (HEP)
  - operations starting; status review Sept. 2016

- **LZ** at Homestake Mine in South Dakota (HEP, LBNL project office)
  - WIMP dark matter search through dual phase liquid Xe – higher mass range
  - Fabrication start (CD-1/3a) in FY15; CD-2/3a approval Aug. 2016

- **SuperCDMS-SNOLab** at Sudbury Neutrino Observatory in Canada
  - WIMP search using cryogenic solid-state crystals – lower mass range
  - HEP+NSF-PHY partnership, SLAC Project Office
    - CD-1 approval in Dec. 2015; Status review held July 2016

Cosmic Frontier:
Direct Detection Dark Matter (DDDM)

LZ: Large-scale prototype testing using liquid Xenon is underway at SLAC



SuperCDMS SNOLAB: first 100mm HV prototype detector

Flange sections for the LZ cryostat manufactured from ultra-low radioactivity Titanium

Cosmic Frontier: CMB

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


In Atacama: CLASS, ACT, PolarBear/Simons

Current Experiments:

- ***SPT-3G*** **– HEP provided support towards major upgrade of the camera to greatly increase sensitivity; Operations starting early 2017 (NSF-led)**


South Pole Telescope (SPT) and BICEP/Keck 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 Book:**
https://arxiv.org/abs/1610.02743


Eric Linder – looking for CMB a the Atacama

Future Planning:

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

- **HEP labs already heavily involved in R&D to align with P5**
- **HEP will coordinate efforts & roles within HEP program**

- **Working with NSF to coordinate planning and a path forward**
- **Charging AAAC to hold a CMB-S4 Concept Definition Taskforce** (see separate agenda item)**.**

Cosmic Frontier – Cosmic-ray, Gamma-ray

Use ground-based arrays, space telescopes, and an experiment on the International Space Station to perform indirect searches for dark matter, fundamental physics

→ **Significant inter-agency & international partnerships**

HEP Operations Roles Completing in FY16:

VERITAS *(w/NSF)*

– HEP operations support completed; finalizing HEP-supported analysis

Auger *(w/NSF-PHY)*

– HEP participation in operations & research ramping down in FY16; no participation planned on upgrade

Operations continuing:

Fermi/GLAST *(w/NASA)*

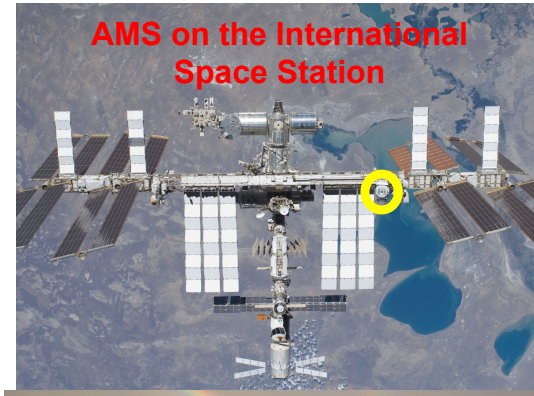
– HEP is supporting the Large Area Telescope Instrument Science Ops Center at SLAC; In coordination with NASA, HEP is planning to continue support of critical efforts at SLAC if operations go past 10 years

AMS *(w/NASA)*

– operations continuing

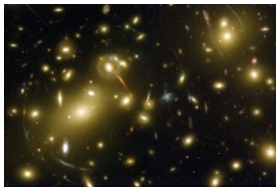
HAWC *(w/NSF)*

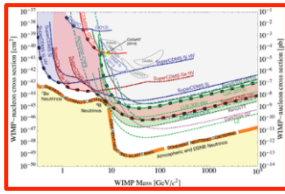
– 5 year HEP-supported operations started early 2015



Cosmic Visions (CV) Groups – looking towards the future

Following P5, HEP Labs & Community are redirecting programs to align with P5 priorities, including planning for the future.





HEP has started "Cosmic Visions (CV)" groups in several areas

- Allows interactions with small HEP community groups (~ monthly) as a 2-way line of communication for HEP-funded efforts.

NOTE: Of course, any HEP-funded R&D/technology plans need to be in the context of the larger non-HEP and global community

CV-CMB

Coordinate HEP technology R&D and other efforts for future CMB-S4 planning

CV-DE

Investigate future HEP directions following the end of construction of DESI and LSST; to complement, build on or extend these experiments in investigating the physics of dark energy.

CV-DM (Dark Matter Direct Detection)

Coordinate and investigate HEP technology R&D to optimize science from DM-G2 experiments and for future DM-G3 planning; Investigate other dark matter search avenues.

Cosmic Frontier Budget History – details

	FY14 Actual	FY15 PRB	FY15 Actual	FY16 PRB	FY16 Actual	FY17 PRB
Research	**52,712**	**45,435**	**48,779**	**50,079**	**47,326**	**46,991**
Grants	*13,157*	*11,422*	*11,773*	*12,565*	*12,705*	*11,607*
Labs	*39,555*	*34,013*	*37,006*	*37,514*	*34,621*	*35,384*
Exp Operations	**10,357**	**7,238**	**9,185**	**7,120**	**10,274**	**8,925**
Projects	**30,660**	**41,000**	**46,403**	**58,701**	**67,780**	**70,200**
Major Projects (MIE)	**22,900**	**41,000**	**44,178**	**57,100**	**64,600**	**69,500**
LSSTcamera	*22,000*	*35,000*	*35,000*	*40,800*	*40,800*	*45,000*
DM-G2	*900*	*6,000*		*11,000*		
LZ			*3,050*		*10,500*	*10,500*
SuperCDMS-SNOLAB			*2,250*		*3,000*	*4,000*
DESI			*3,878*	*5,300*	*10,300*	*10,000*
Small Project			***1,025***	***1,601***	***2,035***	***0***
All				*1,601*		*0*
ADMX-G2			*925*		*935*	
SPT-3G			*100*		*1,100*	
Future R&D	***7,760***	***0***	***1,200***	***0***	***1,145***	***700***
All						*700*
DESI (BigBOSS)	*1,100*					
Dark Matter	*5,260*		*200*		*1,145*	
SPT-3G	*1,400*		*1,000*			
TOTAL	**93,729**	**93,673**	**104,367**	**115,900**	**125,380**	**126,116**

Cosmic Frontier
Interagency & International Considerations & Activities

Interagency projects: can provide necessary or added resources provide opportunities to increase science.

- Depending on science, project, contribution, agency considerations it may make sense to partner, provide facilities, and/or coordinate efforts.
- While all government agencies follow the same rules, there are differences in the detailed agency and community practices which need to be taken into account to ensure data and science analysis return
  - Processes for planning/deciding on projects, managing/funding projects, funding research, etc
  - HEP emphasis on collaboration for coordinated science planning & analysis.

Interagency Coordination: NSF, NASA, DOE talk regularly about program planning, overlaps, issues

Agency Coordination & Oversight: Joint Oversight Groups (JOG) and Agency Coordination Groups (ACG)

- International Finance Board for FGST w/NASA-AST, Auger
- DES, LSST: JOG with NSF-AST
- HAWC, SuperCDMS, VERITAS: JOG with NSF-PHY (also CONACYT for HAWC, NSF-AST for VERITAS Project)
- SPT-3G: JOG with NSF-PHY, NSF-AST & NSF-PLR
- DESI: ACG with NSF-AST

Other Groups:

- **Tri-Agency Group (TAG)** – DOE, NASA, NSF-AST meetings with LSST, WFIRST, Euclid US-leads to discuss commonalities, coordination, optimization of data, simulations, software
- **Astro-Particle International Forum (APIF)** – was led by Global Science Forum; KIPAC/SLAC taking over as host in 2017+

→DOE making country-level agreements to allow international science partnerships to move forward.

Other HEP Efforts Related to Cosmic Frontier

Theory program

- Vibrant Theory Program supporting all areas including Cosmic Frontier; 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 Forum 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

  NERSC used for analysis of many CMB experiments: in 2014 ~10 experiments with ~100 users, with ~10M CPU-hours
  HEP has an MOU with NASA for Planck analysis at NERSC – in 2014, 100M CPU-hours.
  NERSC Allocations 2015:
  - Total HEP Target Plus OT: 340 M Hours (expected to triple by 2018); Cosmic Frontier related is ~ 40% of this.

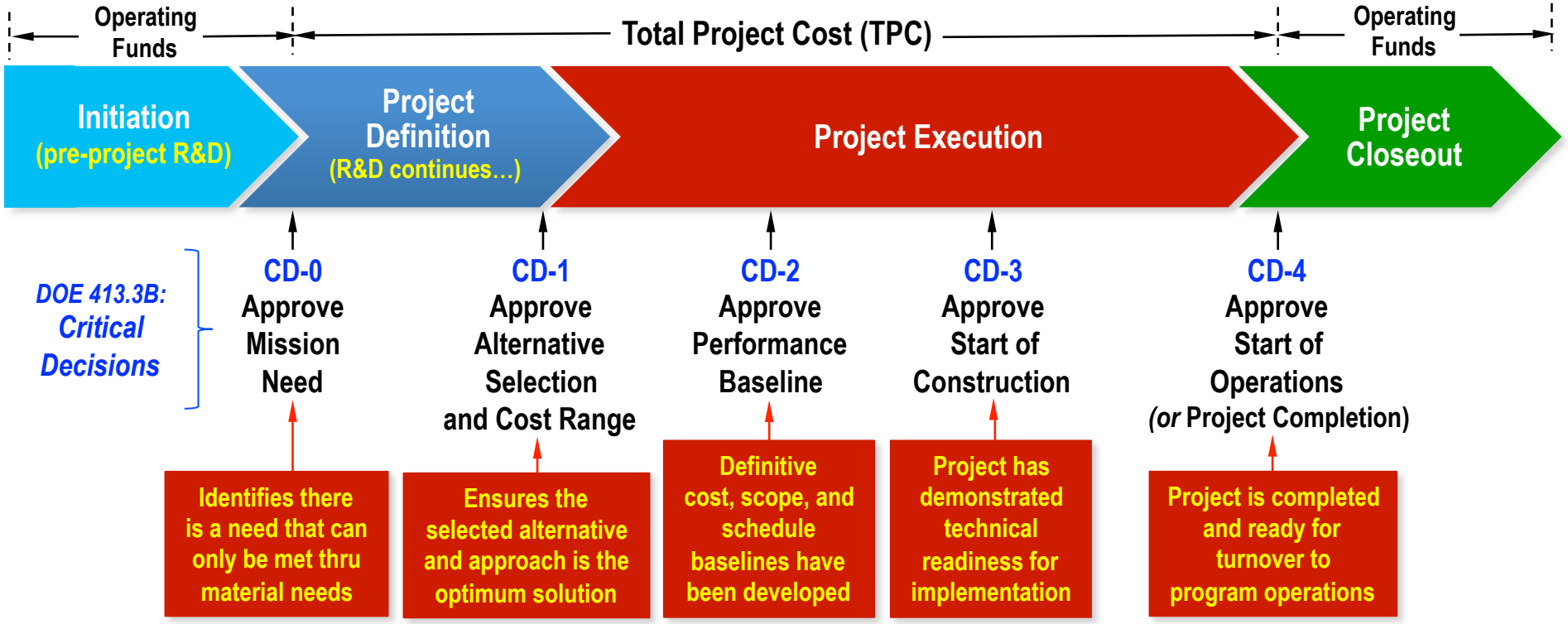
Data Management

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

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, but funding must still be appropriated (Linked to – *but independent of* – the budget process!)
- **Successful delivery of construction projects and 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) against which the project success or failure will be measured - and to provide the funding profile needed to carry it out.



COSMIC FRONTIER:
RESEARCH FUNDING, STATISTICS, PRIORITIES

Research Support – Priorities

Research budgets: Support scientists on all phases of an experiment

Priority – to support effort to plan and carry out priority science topics on our experiments, i.e. Need to make sure the science it was designed for is carried out!

- Support research efforts directly in line with program & project priorities, responsibilities & science goals
- Distribution of efforts across areas will necessarily change to support changing priorities
- Sufficiently support the Science Collaborations (HEP model) to carryout out experiment in all phases - project's design, fabrication and operations & to plan and carry out data analyses to deliver the best science

Priority Areas:

Dark Matter :
Complete G1 operations & analysis; **construct and plan G2 experiments**, modest future R&D

Dark Energy :
Complete BOSS analysis; DES operations & analysis; **construct and plan LSST and DESI**

CMB: Begin planning for CMB-S4

Cosmic/Gamma-ray: Efforts completing on gamma-ray experiments, Auger, Holometer

Not funded in our program: Support for gravity wave, planet searches, heavy ions, AMO, etc.

Research Support – Model, Review Processes

In practice, HEP traditionally supports teams/collaborations of scientists with the necessary expertise and responsibilities to take experiments through all phases, from R&D, Fabrication, Operations, & Data Analysis

Research model for funding is for scientists to be closely integrated on HEP experimental collaborations, and have key roles and responsibilities on projects/experiments and collaborations; Scientists at labs and universities tend to review best if they are working in this model.

Peer Reviews reflect HEP traditions & P5 Strategic Plan & Criteria. Considerations ➔

- Does the activity directly support & significantly advance our science/experiment and priorities?
- For experiments with broad science program, is the effort are needed to support OHEP science interests? - Need to ensure that we are concentrating on the most important efforts for HEP program (e.g. dark energy on multi-use facility).
- What are the priority efforts needed now for a particular experiment?
- Will the effort make significant/visible/leadership impact & contributions?
- What is the experience, responsibilities and commitment (% time) of the researcher? Will they have time to make significant contribution?
- Will they support the collaboration in carrying out the project/experiment?
- Will they work in the "HEP model" by making significant, continuous contributions to the experiment, in addition to their own data analysis?
- Need to ensure some room for development of ideas for new projects that are aligned with the science drivers.

University research is supported by a competitive, proposal-driven process

- Grants issued after peer review of proposals to Funding Opportunity Announcements (FOAs)
- Program alignment is built into proposal review process

Laboratory research is mission driven and funded through Field Work Proposals

– HEP holds comparative reviews of Lab research programs every ~ 3 years (Cosmic Frontier in July 2016)
– Program guidance and alignment is provided by HEP with input from the labs, advisory committees, reviews etc.

Schedule of DOE/HEP-based Funding Opportunity Announcement (FOA) Solicitations

Ongoing: "FY 2016 Continuation of Solicitation for the Office of Science Financial Assistance Program" **[DE-FOA-0001414]**

- **Also known as the "general *or* open annual DOE/SC solicitation"**
  - **SC-wide FOA that invites applications in support of work in any of six SC offices, incl. HEP research**
- **Published annually, typically at beginning of FY (October), remains open until successive issuance**

New: "FY 2017 Research Opportunities in High Energy Physics" **[DE-FOA-0001604]**

- **Issued for *new* or *renewing* grant applications, evaluated through comparative review (CR) process**
  - **Optional but encouraged Letter of Intent (LOI) was due August 23**
  - **Final applications were due September 20**

New: "Early Career Research Program" **[DE-FOA-0001625]**

- **SC-wide invitation for junior investigators (within 10-years post PhD) from labs or universities**
  - **Early career development of outstanding scientist's research programs in areas supported by DOE/SC**
  - **Required pre-application were due September 8, final applications due November 14**

Cosmic Frontier – Statistics on Comparative Review Research Grants (Universities)

			FY12	FY13	FY14	FY15	FY16
Cosmic $M request Y1			$3.3	$7.7	$7.5	$6.8	$7.8
Cosmic $M funded Y1			$1.6	$3.4	$4.4 w/FFF	$3.3 w/FFF	$4.3M w/FFF
Cosmic - proposal counts							
	proposals	received	11	33	29	27	43
	proposals	reviewed	10	28	28	27	36
	proposals	funded	6	18	19	14	21
	proposals	success rate	**60%**	**64%**	**68%**	**52%**	**58%**
Cosmic CR - PI counts							
	PI's	received	21	61	40	43	65
	PI's	reviewed	20	54	38	43	55
	PI's	funded	13	27	25	21	25
	PI's	success rate	**65%**	**50%**	**66%**	**48%**	**45%**

Funding:

- Typically the total of all requests is for ~ twice the funds we have available.
- We typically fund the grants at less than their request.
- FY16 Cosmic requests $26.5M(for full grant period) and $7.8M for Year1.
- Funds shown above are for the Year 1 of the grants approved this year. Funds for Years 2 and 3 of grants awarded in previous years are also provided out of the research budget.

Cosmic Frontier – Statistics on Early Career Awards (Open to Universities & Labs)

	FY10	FY11	FY12	FY13	FY14	FY15	FY16
# received - Univ	11	8	12	16	6	7	7
# received - Lab	10	4	7	9	7	5	6
# funded - Univ	**2**	**1**	**2**	**1**	**1**	**0**	**1**
# funded - Lab	**0**	**2**	**1**	**1**	**0**	**0**	**0**

We plan increased support for Early Careers in FY17 – now is the time to apply!

Awards (5-year):

FY10
Newman (Pitt)
Mahapatra (TAMU)

FY11
Chou (FNAL)
Slosar (BNL)
Hall (Maryland)

FY12
Mandelbaum (CMU)
Padmanabhan (Yale)
Carosi (LLNL)

FY13
Bolton (Utah)
Chang (ANL)

FY14
Dahl (Northwestern)

FY15: none

FY16
Rozo (Arizona)

Summary

An exciting time for the HEP Cosmic Frontier Program!
- 4 MIE Projects in Fabrication!

P5 developed compelling, realistic strategic plan with a community consensus vision
→HEP is moving forward with NSF to implement it.
-- Close coordination with the other agencies; significant partnerships.

The HEP FY2016 Budget & FY 2017 Budget Request continues the implementation of the P5 global vision for particle physics