



# DOE High Energy Physics (HEP)

report to the

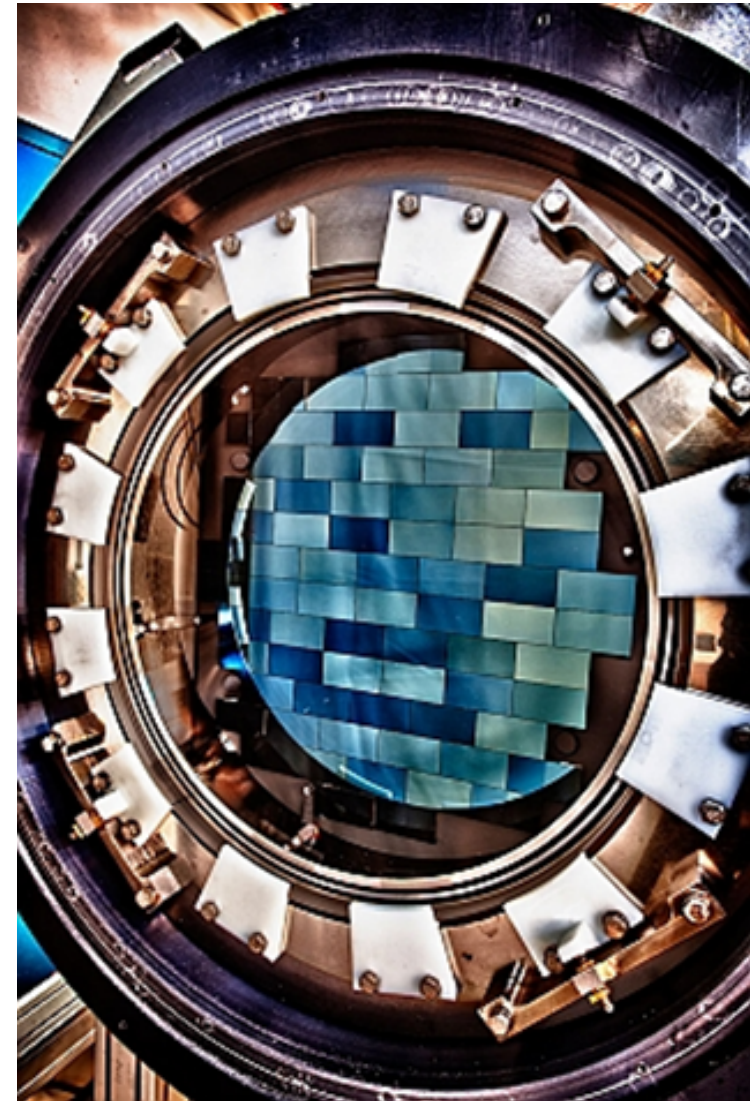
**AAAC Panel**

12 November 2015

Kathy Turner

HEP Cosmic Frontier Program Managers:

Anwar Bhatti (IPA), Eric Linder (IPA), Michael Salamon, Kathy Turner



# Outline

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## HEP

- Organization
- Model
- Program Planning
- Guidance
- Budgets
- Status

## COSMIC FRONTIER

- Budget
- Program Status
- Future planning



# HEP Mission & Program Planning

## Part of a Mission Agency

- Provides science leadership & support to enable significant advances in specific science areas
- Develops and supports a portfolio of selected facilities & experiments to obtain the science
- Laboratory System
  - Comprehensive resources to design, build, operate selected facilities, projects and instrumentation
  - Infrastructure, including computing facilities (NERSC, SCiDAC program etc)
- Interagency & International partnerships as needed to leverage additional science & expertise

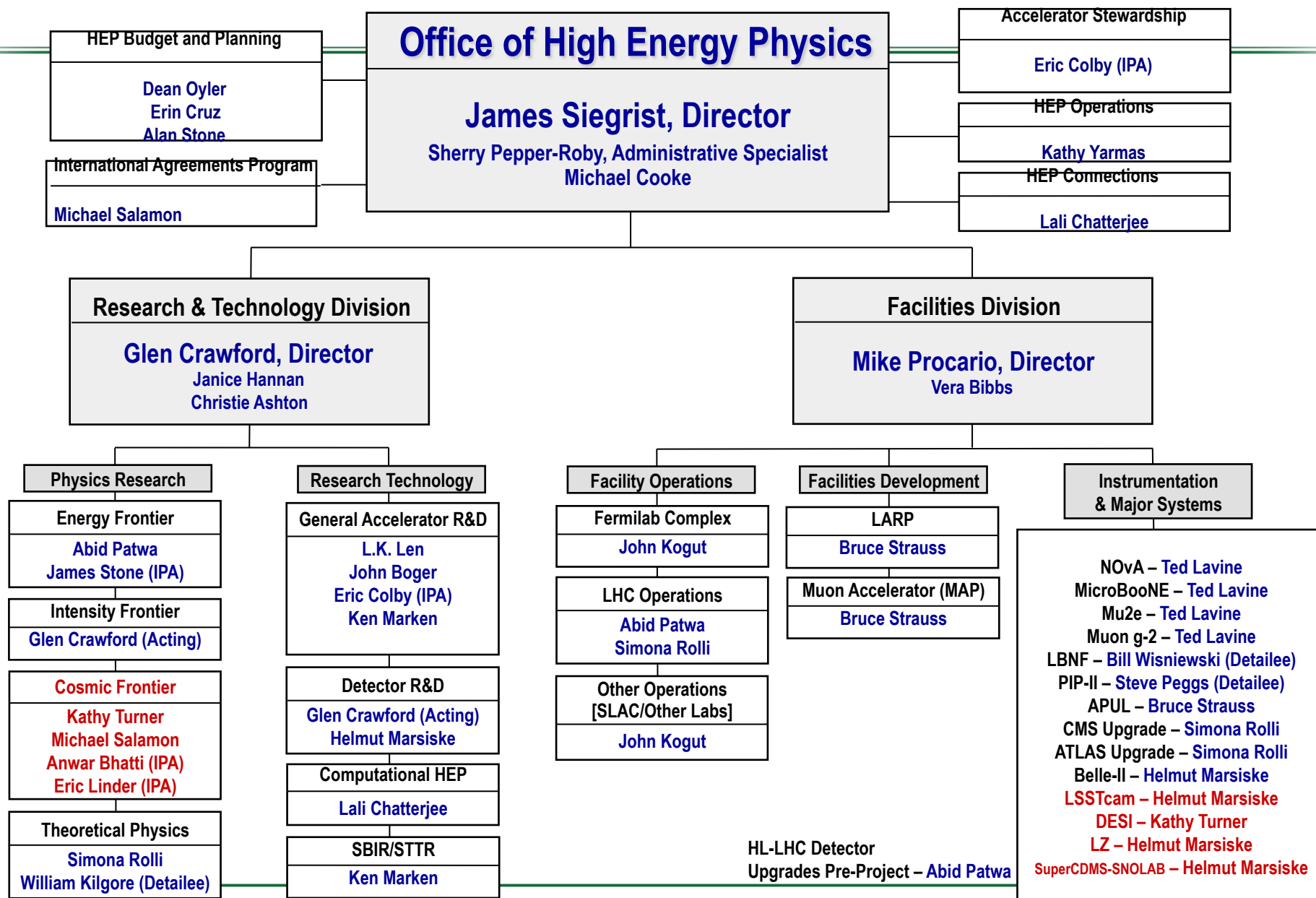
## Program Planning, Management & Execution

- Strategic planning process with community input to develop science drivers and a portfolio of facilities & experiments to obtain significant advances in these science areas.
- Program Offices follow the strategic plan to carry out a specific portfolio of selected facilities & experiments to obtain the science.



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







# The Office High Energy Physics (HEP) Program Mission

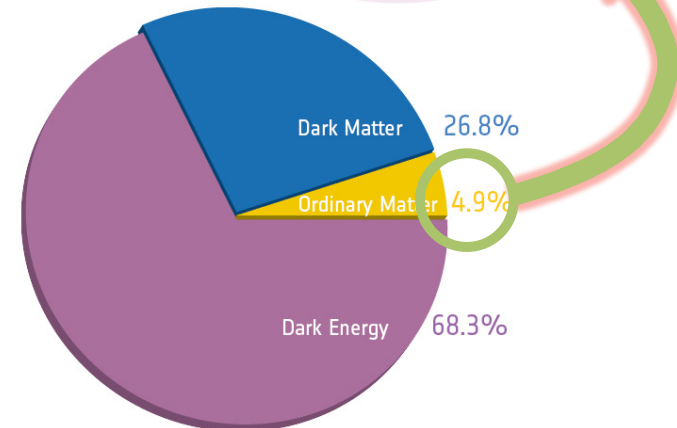
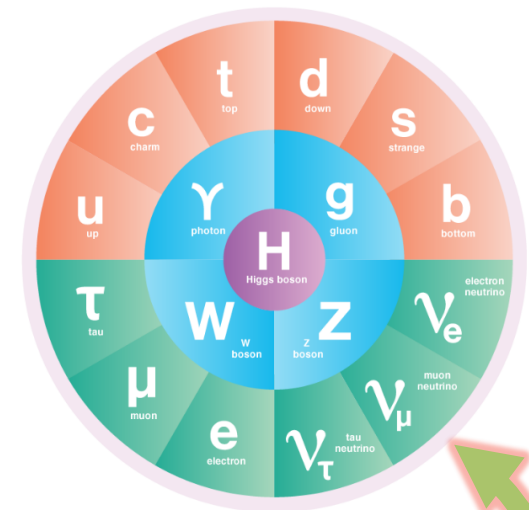
...is to understand how the universe works at its most fundamental level:

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

➔ HEP fulfills its mission by:

- 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

● QUARKS ● LEPTONS ● BOSONS ● HIGGS BOSON



# HEP Program Model

➔ The Mission Emphasis translates in to how the HEP Program is managed:

- **Planning Program**

- Strategic planning process with community input to develop a strategic plan for science drivers and portfolio of facilities and experiments to obtain significant advances in these science areas.

- **Implementation**

- HEP uses the strategic plan to develop and support a specific portfolio of selected facilities & experiments to obtain the science.
- Plan stages of experiments for ever-increasing precision
- Complementary approaches using different technologies & methods
- Long-term support for our responsibilities in designing, building and operating projects
- Collaboration/Teamwork: Support scientific teams with expertise in required areas to participate in all phases of a project/experiment, in order to produce the best possible science results



# HEP Program Guidance

## FACA panels & subpanels provide official advice:

### → High Energy Physics Advisory Panel (HEPAP)

- Reports to DOE and NSF
- Provides the primary advice for the program
  - Subpanels for detailed studies, e.g.
    - Particle Astrophysics Science Assessment Group “PASAG”, DEFT, TFCR, DMSAG
    - **Particle Physics Project Prioritization Panel (“P5”) – Strategic Planning Process**

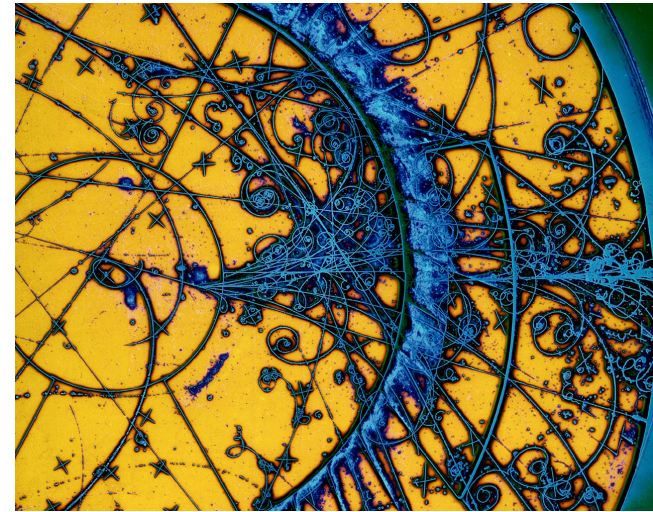
### → Astronomy and Astrophysics Advisory Committee (AAAC)

- Reports to NASA, NSF and DOE on areas of overlap

## National Academy of Sciences

- Reports: New Worlds New Horizons (2010), “Mid-decade review” in astronomy/astrophysics
- Ongoing: Board on Physics & Astronomy (BPA), Committee on Astronomy & Astrophysics (CAA)

Other: community science studies, reviews, DPF input, etc.



# 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” (2014)

Community Science Opportunities described in **2013 Snowmass report** - provided input to P5

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

- **P5 plan is a compelling, unified vision for HEP (approved May 2014 by HEPAP) – 5 science drivers**
  - Use the Higgs boson as a new tool for discovery
  - **Pursue the physics associated with neutrino mass**
  - Identify the new physics of dark matter
  - Understand cosmic acceleration: dark energy and inflation
  - Explore the unknown: new particles, interactions, and physical principles
- **A balanced approach is critical**
  - The report recognizes the challenging funding landscape, where choices have to be made & resources stewarded carefully, and confronts these challenges head on.
  - An important reason the P5 plan has widespread HEP community support is its balanced approach: Time-phased, projects of different scales, science goals, on- and off-shore, short-term and longer-term



**HEPAP unanimously approved a new long term strategic plan from the “P5” subpanel in May 2014**






# Enabling the Next Discovery – 2014 P5 Strategic Plan

**Science drivers** identify the scientific motivation while the **Research Frontiers** provide a useful categorization of experimental techniques



	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●

# HEP Program following May 2014 P5 Report

## Priorities going forward



HEP is following the P5 strategic plan in developing and executing the program:

- developing & aligning the HEP program along P5 recommendations
  - **Continue or start development of recommended near-term projects**
  - **Planning activities to support P5 recommendations later in the decade.**
- strive to maintain the recommended balance; currently moving forward in target areas
- Full implementation takes time – work with partners and stakeholders: DOE management, HEP community, DOE Laboratories, Congress, OMB, other US and international Agencies, and within the fiscal environment

### 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 mid-term; Near term Cosmic Frontier projects are ready to go

- **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 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



# 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.

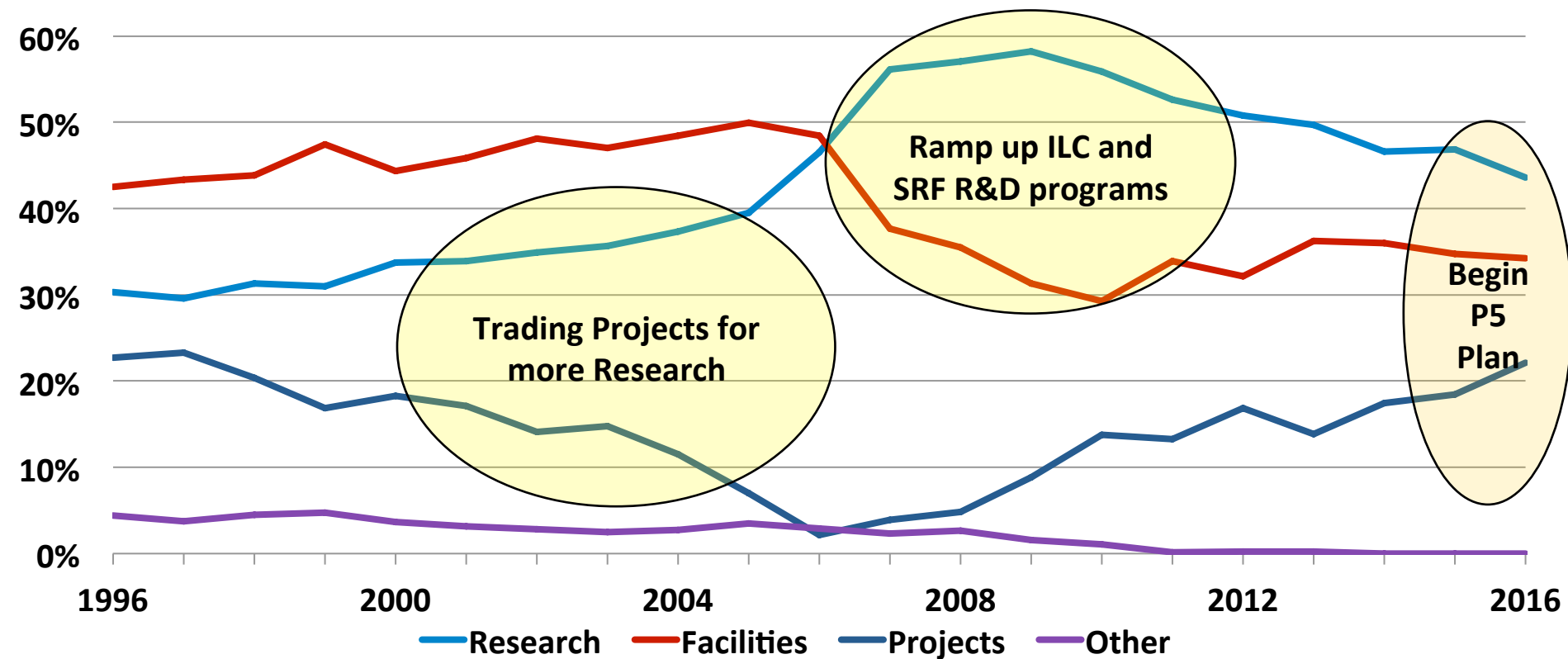
- Individual project criteria

- **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



# Funding Trends by Fiscal Year

(FY 2016 shows President's Request)



- P5 report recommendation suggests increasing the project budget fraction to 20%–25%
  - “Addressing the [science] Drivers in the coming and subsequent decades requires renewed investment in projects.”
- P5 report strategy has informed the HEP request in the FY 2016 DOE budget



# FY 2014-2016 HEP Program - Budget Status

HEP Budget History (\$K)	FY 2014	FY 2014	FY 2015	FY 2015	FY 2016	FY 2016	FY 2016
	Request	Actual	Request	Enacted	Request	House Mark (~ 5/6/15)	Senate Mark (~ 5/27/15)
Energy Frontier	154,687	152,386	153,639	147,584	154,555		
Intensity Frontier	271,043	250,987	251,245	264,224	247,196		
<b>Cosmic Frontier</b>	<b>99,080</b>	<b>96,927</b>	<b>101,245</b>	<b>106,870</b>	<b>119,325</b>		
Theoretical and Computational	62,870	64,275	58,850	59,274	60,317		
Advanced Technology R&D	122,453	150,270	114,242	120,254	115,369		
Accelerator Stewardship	9,931	9,075	19,184	10,000	14,000		
Construction	35,000	51,000	25,000	37,000	56,100		
Total	755,064	774,920	723,405	745,206	766,862		
SBIR/STTR*	21,457	0	20,595	20,794	21,138		
<b>HEP Total</b>	<b>776,521</b>	<b>774,920</b>	<b>744,000</b>	<b>766,000</b>	<b>788,000</b>	<b>776,000</b>	<b>788,100</b>
Office of Science Total	5,152,700		5,111,155	5,067,738	5,339,800	5,100,000	5,143,900

\*FY14 SBIR/STTR was ~ \$21M, so FY2014 actual was ~ \$796M.





# HEP Energy Frontier - Status

## Current program

LHC Run II began on June 3, 2015 with collisions at 13 TeV! US continues to play a leadership role

- will increase the reach into search for new physics in high-impact topics:
  - SUSY, dark matter, extra dimensions, probe the nature of the Higgs, etc.

## Fabrication Projects

### Phase-1 upgrades to the LHC detectors

- Phase-1 U.S. CMS/ATLAS upgrades received CD-2/3 (baseline/construction start) approval on November 12, 2014

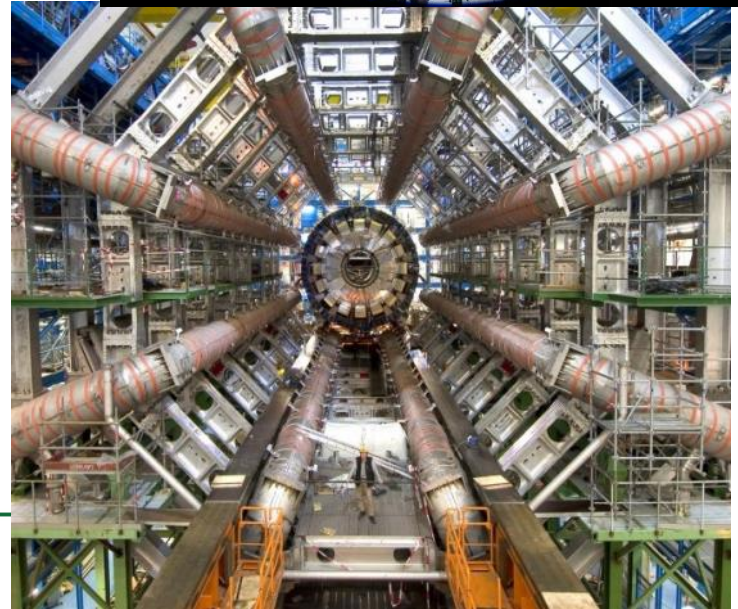
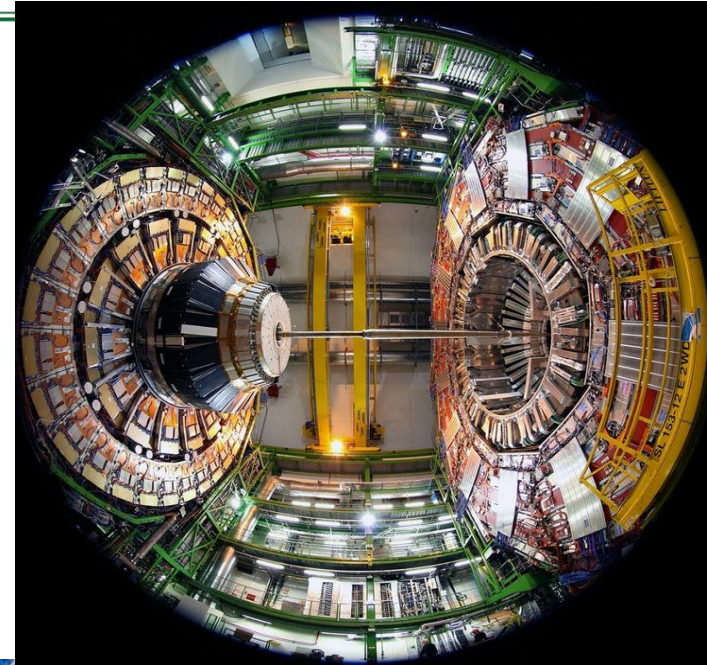
## Planned program

Considering high-luminosity LHC upgrade around 2023 to extend discovery reach

- Increase luminosity by 10 times LHC design value to explore new physics at TeV energies
- DOE/HEP actively working with US-CMS/ATLAS to begin mounting HL-LHC Detector Upgrade Project

**Modest investments in R&D for future options:**

- Lepton colliders
- Very high energy hadron colliders



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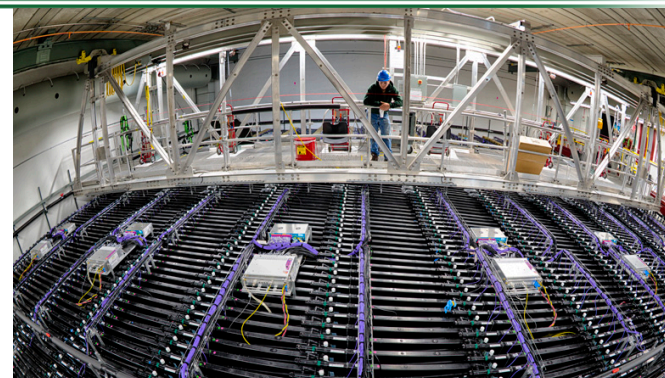
# Intensity Frontier Status

## Exploring the unknown through precision measurements – muon-beams,

- P5 recommended development of muon-beam based program at Fermilab:
  - **Muon g-2**: Successfully tested SC magnet and held CD-2 review in June 2015
  - **Mu2e**: Reached CD-2/3 on March 4, 2015
- Collaborating with Japan on *K* meson, *c/b* quark, and  $\tau$  lepton precision studies:
  - **Belle II**: reached CD-3 in April 2014
  - **KOTO** (J-PARC) physics data taking in Spring and Fall 2015

## Identify the physics of dark matter

- **APEX** and **Heavy Photon Search (HPS)** performing particle beam based searches for DM particles



## Pursuing the physics associated with neutrino mass

- Mass hierarchy &  $\nu$  properties studied at Fermilab, Japan, China, and underground:
  - **Daya Bay, MicroBooNE, MINERvA, MINOS+, NOvA, Super-K, T2K**
- Sterile neutrino search and neutrino CP violation program continues to evolve with P5 recommendations for short-baseline neutrino (SBN) and long baseline neutrino programs
  - A coordinated set of short-baseline neutrino experiments will address the observed anomalies in current neutrino experiments while advancing the R&D necessary for LBNF and DUNE
  - **DUNE** established as international experiment for the Long Baseline Neutrino Facility (LBNF)

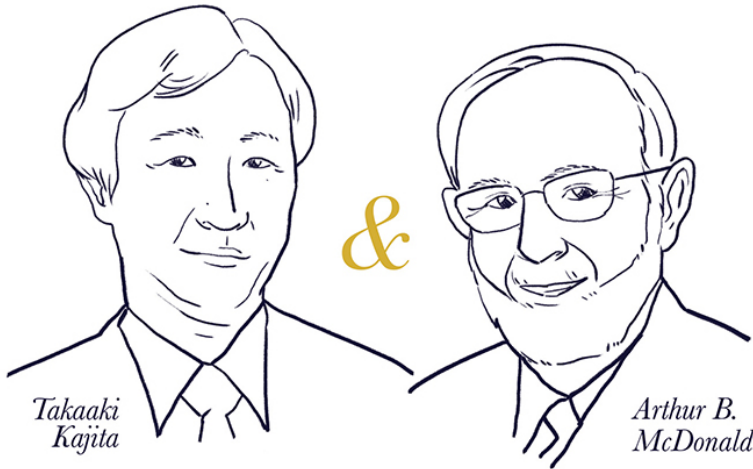
**LBNF/DUNE is a key element of the global vision presented in the P5 report, and a major domestic milestone as the first international science facility hosted in the U.S.**





# Banner Year For Neutrinos

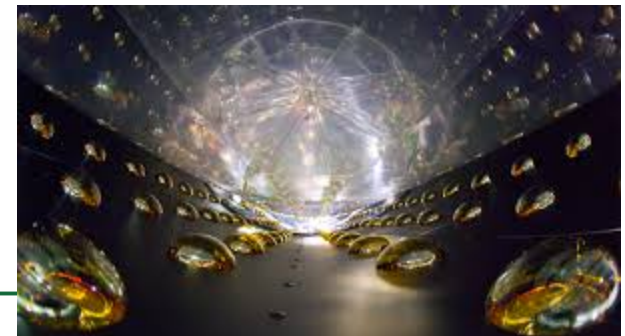
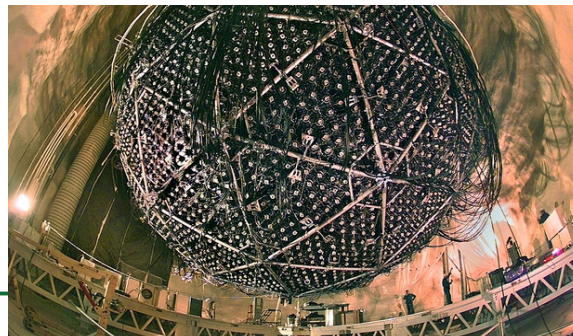
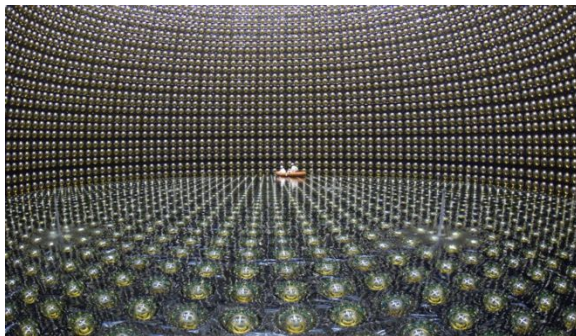
2015 NOBEL PRIZE  
*in Physics*



**NEUTRINO OSCILLATIONS**  
The discovery of these oscillations shows that neutrinos have mass.



The Breakthrough Prize will be split among 1,370 physicists. Seven leaders of five experiments (SuperK, SNO, Daya Bay, K2K and KamLAND) as well as all of the co-authors of the scientific papers reporting the experiments' groundbreaking results will become Breakthrough laureates. The five teams will share the prize money (\$600,000 to each), with two thirds of those purses going to the leaders and one third to the collaborators.



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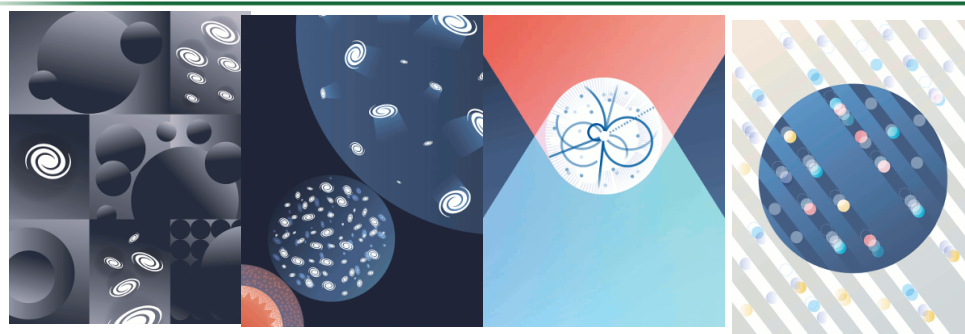
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## **COSMIC FRONTIER**

- **Guidance, Planning**
- **Program Status**
- **Future planning**
- **Budget**
- **Research support**



# 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 thrusts:

- Study the nature of **Dark Energy**
- Direct Detection searches for **Dark Matter** particles
- **Cosmic-ray & Gamma-ray studies** – particle properties, high energy acceleration mechanisms, indirect searches for dark matter particles
- **CMB** – current minor efforts planned to expand
- **Other:** computational cosmology; + related Theory, Detector development, computational, etc.

## Status


- **Continue development near term projects recommended by P5.**
- **Planning activities to support P5 recommendations later in the decade.**





# May 2014 P5 Report – Cosmic Frontier Recommendations

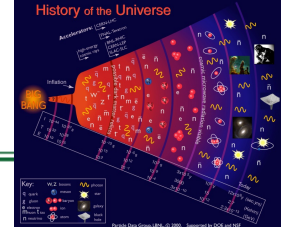
P5 strategic plan: 5 science drivers

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Higgs Boson	●		
Neutrino Mass		●	●
Dark Matter	●	●	●
Cosmic Acceleration			●
Explore the Unknown	●	●	●

## P5 report recommendations addressed to the Cosmic Frontier →

- **Dark Energy**
  - Build DESI as a major step forward in dark energy science
  - Complete LSST as planned
- **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 Project is in the P5 plan later in the decade.)**
- **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 later in the decade.)**
- **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 & Execution

## Build Program following the P5 Plan & P5 Criteria with

- Make significant, coherent contributions to facilities/experiments selected for the program at a level commensurate with expected science return on HEP physics goals
- Support an HEP-style science collaboration in all stages, including coordinated data analysis to get the best possible science results
- Form partnerships or use other agency's facilities when needed (e.g. telescopes)
- For facilities with broader science program (e.g. LSST) than the interests of the HEP program
  - project contributions at appropriate level & support research efforts for our science interests

## For projects being considered:

- Balance & Stages: Staged implementation, results; varying project size; varying methods/technologies; balance between science areas and speculative/guaranteed results
- 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.



# Cosmic Frontier

## Interagency & International considerations

**Interagency projects:** can provide necessary or additional resources leading to opportunities for increased science.

- Depending on science, project, contribution, agency considerations it may make sense to partner, provide facilities, and/or coordinate efforts.
  - Partnerships between agencies and other offices within agencies (co-fund/manage the construction/operations)
  - Use of other agency's facilities (e.g. install/operate instrument on a telescope)
- 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

### **Project Coordination & Oversight:**

Joint Oversight Group (JOG), Finance Board, or Interagency Coordination Group (ICG):

HEP & NSF/PHY: VERITAS, HAWC, Auger, SuperCDMS-SNOLab

HEP & NSF/AST: DES, LSST, DES

HEP & NSF/PHY, AST, OPR: SPT-3G

HEP & NASA-AST: FGST

### **International Efforts**

- DOE making country-level agreements to allow science partnerships to move forward.
- HEP participating on the Global Science Forum's Astro-particle Physics International Forum (APIF)



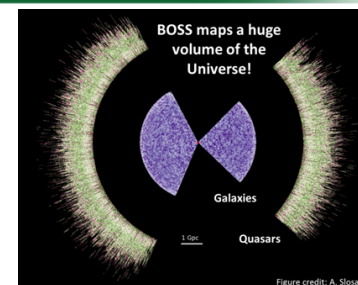
# Cosmic Frontier Status – Dark Energy

→ Staged program of complementary suite of imaging and spectroscopic surveys

**P5 recommendation:** DESI & LSST

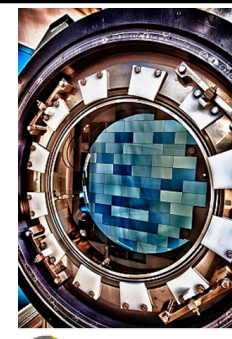
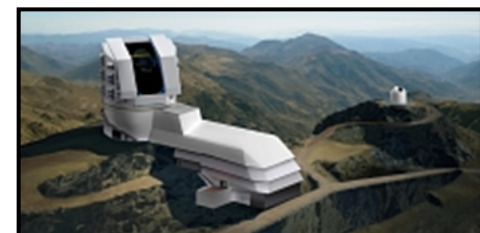
## Operating:

- **BOSS (spectroscopic) ended in FY14**; final data released & final results out soon
- **eBOSS started in 2015**
- **DES (imaging) started 5-year survey in late FY13**; partner with NSF-AST



## Design, Fabrication:

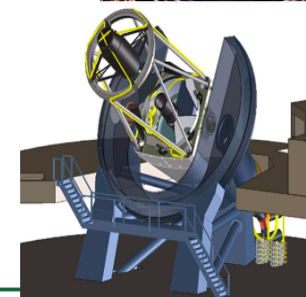
- **Large Synoptic Survey Telescope (LSST, Stage IV imaging)**
  - LSST camera project started fabrication in FY14; CD-3 in Aug. 2015
  - Partner with NSF-AST (lead agency)
  - LSST Operations phase planning started; proposal expected in 2016
- **Dark Energy Spectroscopic Instrument (DESI, Stage IV spectroscopic)**
  - Long-lead fabrication started in FY15; CD-2 (baseline) in Sept. 201
  - Coordination with NSF-AST; DOE/NSF MOU for “transition phase” and now working on MOU for operations phase.



**Research efforts:** In addition to operations, fabrication responsibilities for the above, there are research-only activities on **Euclid, WFIRST, & supernova surveys**

**Future planning:** Cosmic Visions Dark Energy (CV-DE) planning group started

- » HEP Community group to coordinate HEP community and HEP supported R&D efforts and planning for future data, experiments and projects



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# Direct Detection Dark Matter (DDDM)

→ Staged program of experiments with multiple technologies & methods

## Operating:

DM-Generation 1 (DM-G1): **ADMX-II, LUX, CDMS-Soudan, DarkSide-50, COUPP/PICO, DAMIC** – completing operations efforts by FY 2016

## Design, Fabrication – progress continues on DM-G2 experiments

Progress on DM-G2 experiments selected by HEP & NSF-PHY (July 2014):

- **ADMX-G2** is a small project (below MIE); started at the end of FY14 (HEP)
- **LZ** Fabrication start in FY15; CD-2/3b planned for late FY16 (HEP)
- **SuperCDMS-SNOlab** CD-1 review held Nov 2015 (HEP+NSF-PHY partnership)

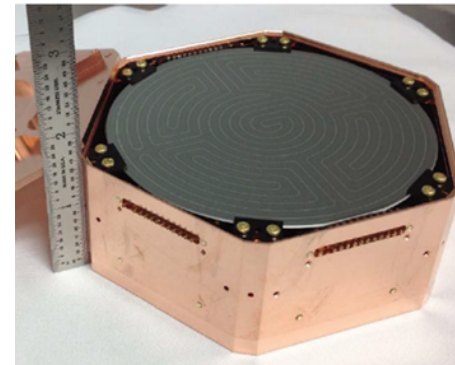
## HEP plans for future (P5)

- HEP concentrating on getting the DM-G2 experiment(s) successfully started
- Limited R&D support planned in FY17+ for
  - Near term consideration of off-project efforts to support the DM-G2's
  - Technology studies towards DM-G3

## Future planning:

### **Cosmic Visions Dark Matter (CV-DM) planning group being set up**

- » HEP Community group to coordinate HEP community and HEP supported R&D efforts – towards G2 and G3



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# Cosmic Frontier – CMB

→ HEP has been involved at a low level in CMB for decades, esp. in technology and computing. HEP considerations for ground-based CMB efforts going forward based on P5 recommendation:

- Bring expertise in large instrumentation, project management, large science collaborations, computing/data

## HEP – direct support

- supporting research-only activities on **BICEP**, **POLARBEAR**
- commitments for research & computing resources for **Planck**
- supporting research, operations & fabrication on SPT (w/NSF)
  - South Pole Telescope polarization (SPTpol)** w/NSF
    - HEP provided support for outer-ring detectors; now operations
  - SPT-3G** w/NSF
    - HEP is funding R&D and fabrication for camera upgrade (FY14-16)
- supporting small efforts on technology studies, planning for **CMB-S4**

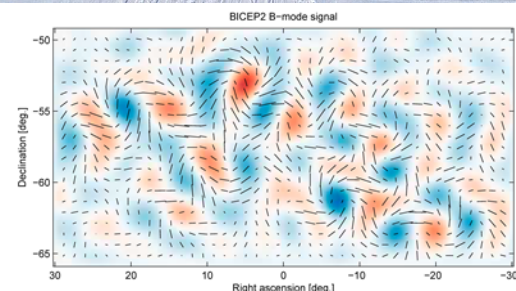
**DOE/SC** - NERSC computing for ground-based experiments and Planck

## Lab-Directed R&D (LDRD) support

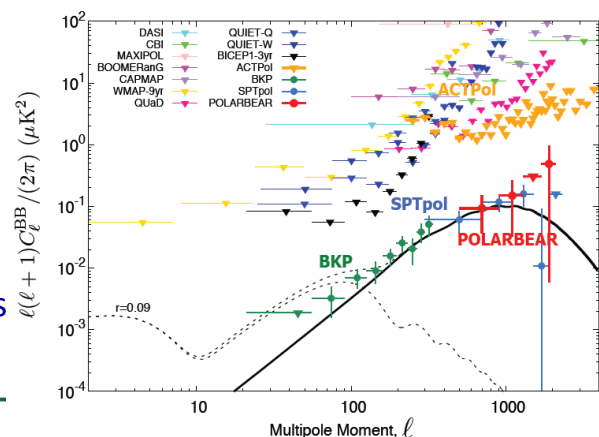
- LDRD efforts on project R&D, fabrication, technology efforts on experiments (BICEP, PolarBear, SPT, LiteBird, ACT + for future CMB-S4)

## Future planning: Cosmic Visions CMB (CV-CMB) planning group started

- » HEP Community group to coordinate HEP community and HEP supported efforts and planning for the future



Planck view of BICEP2 field



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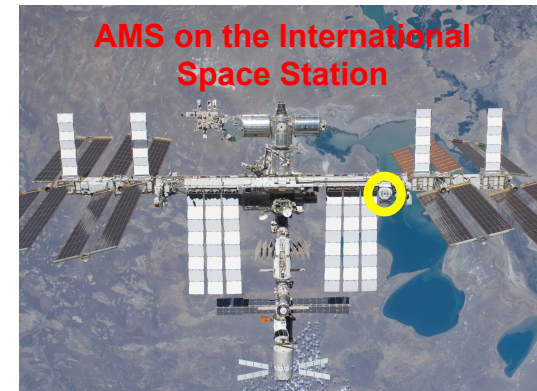
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# Cosmic Frontier – Cosmic-ray, Gamma-ray

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

## Operating/Analysis:

- **Fermi/GLAST** (w/NASA)
  - HEP participation planning in coordination with NASA; supporting the Large Area Telescope Instrument Science Ops Center at SLAC
- **VERITAS** (w/NSF)
  - HEP participation ramping down; Last year of operating funds provided in FY15 (budget period through April 2016); research efforts also winding down; their current funds will carry them until ~ FY17
- **Auger** (w/NSF-PHY)
  - HEP participation in operations & research ramping down in FY16; no participation planned on upgrade
- **AMS** (w/NASA)
  - operations continuing
- **HAWC** (w/NSF)
  - 5 year operations started early 2015



**VERITAS in Sonoran desert Arizona**



**HAWC full operating array**



## **P5 Recommendation - Cherenkov Telescope Array (CTA)**

- US Community is developing a plan to participate in a European-led next generation gamma ray observatory

HEP response to P5 recommendation, funding availability & programmatic priorities:

- → **HEP not continuing support of research, planning, R&D efforts on CTA.**



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# Related Efforts

## 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.

## Comp 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*



# Prizes, Awards

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## 2015

**Gruber Cosmology Prize – John Carlstrom**

**Cosmic Microwave Background; together with Jeremiah Ostriker and Lyman Page.**

**E.O. Lawrence Prize – David Schlegel; Galaxy redshift surveys, e.g. Baryon Oscillation Spectroscopic Survey.**

## 2014

**Breakthrough Prize in Fundamental Physics – Saul Perlmutter & Supernova Cosmology Project**

**Cosmic Acceleration; together with Adam Riess, Brian Schmidt.**

**Rossi Prize – Doug Finkbeiner, Tracy Slatyer, Meng Su ; Fermi bubbles**

## 2013

**Panofsky Prize – Blas Cabrera, Bernard Sadoulet; Direct detection dark matter techniques.**

**Gordon Bell Prize (supercomputing) finalists – Salman Habib, Katrin Heitmann, & team; Cosmological simulations.**

## 2012

**Panofsky Prize – William Atwood; Large Area Telescope, Fermi Gamma Ray Space Telescope.**

**Gordon Bell Prize (supercomputing) finalists – Salman Habib, Katrin Heitmann, & team; Cosmological simulations.**

## 2011

**Nobel Prize in Physics – Saul Perlmutter Cosmic Acceleration; together with Adam Riess, Brian Schmidt.**

**Rossi Prize – William Atwood, Peter Michelson & FGST/LAT Team; Large Area Telescope, Fermi Gamma Ray Space Telescope.**





# Science of the Year

## 2014

### Physics World – Top Ten

Mapping the cosmic web with the Lyman alpha forest.

### Scientific American – #4 Science Story of the Year

Cosmic Microwave Background B-mode polarization large angle measurements by BICEP.

### Nature Magazine – Top Stories

Cosmic Microwave Background B-mode polarization large angle measurements by BICEP.

### Discovery Magazine – #5 Science Story of the Year

Cosmic Microwave Background B-mode polarization large angle measurements by BICEP.

## 2013

### Physics World – Top Ten

South Pole Telescope detection of Cosmic Microwave Background B-mode polarization.

Planck satellite measurements of Cosmic Microwave Background anisotropies.

### Science News – #3 Story of the Year

Planck satellite measurements of Cosmic Microwave Background anisotropies.

### Science Magazine - Top 10 Science Breakthroughs of the Year

Origin of Cosmic Rays by Fermi Gamma Ray Space Telescope.

### Nature Magazine – Story of the Year

Direct detection dark matter limits by LUX.

## 2012

### Physics World – Top Ten

Kinematic Sunyaev-Zel'dovich effect detected.



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# Cosmic Visions – looking towards the future

→ Since the P5 report, HEP Labs are redirecting their programs to align with P5 priorities

- Aligning with projects: ADMX, LZ, SuperCDMS-SNOLAB, LSST, DESI, CMB current, CMB-future planning
- Strategic hires and increased efforts in dark matter, CMB & related Detector/technology R&D
- Considerable LDRD effort directed at CMB, dark energy, dark matter future technologies

HEP has started “Cosmic Visions” groups in several areas to have a line of communication with the HEP community members on HEP-funded activities

- Part of our program manager planning responsibilities → Follow on from Snowmass, P5 strategic plan.

“Cosmic Visions” CMB, Dark Energy, and Dark Matter groups have been (or being) set up

HEP interacts with these small community groups (~ monthly) as a 2-way line of communication

- to get info on HEP-community directions & planning and to provide feedback to the community

## CV groups:

Community groups that will collect, coordinate HEP community status and HEP funded efforts for R&D, planning, studies & options for future datasets, experiments, projects

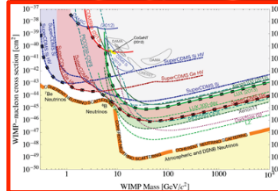
- Help coordinate and focus HEP community’s R&D efforts, planning, studies, options for the future.

## HEP:

Will use this to help guide/focus/coordinate/plan the HEP funds & efforts in developing/planning the science case, technologies, programmatic considerations etc. for the priority P5 science and technology directions

→ to optimally carry out near-term projects and to focus, inform and develop plans for future projects.

NOTE: Of course, any HEP-funded R&D/technology plans need to be in the context of the larger community (so as not to duplicate efforts or go off in directions that don’t make sense)



# Cosmic Frontier Budget History

	FY13	FY14	FY15	FY15	FY16
<u>Cosmic Frontier Budget History (\$K)</u>	<u>Actual</u>	<u>Actual</u>	<u>Request</u>	<u>Actual</u>	<u>Request</u>
<b>Research</b>	<b>48,652</b>	<b>52,712</b>	<b>45,435</b>	<b>48,779</b>	<b>50,079</b>
<b>Grants</b>		<b>13,157</b>	<b>11,422</b>	<b>11,773</b>	<b>12,565</b>
<b>National Laboratories</b>		<b>39,555</b>	<b>34,013</b>	<b>37,006</b>	<b>37,514</b>
<b>Facility Operations and Experimental Support</b>	<b>10,111</b>	<b>10,357</b>	<b>7,238</b>	<b>9,185</b>	<b>7,120</b>
<b>Projects</b>	<b>19,159</b>	<b>30,660</b>	<b>41,000</b>	<b>46,403</b>	<b>58,701</b>
<b>MIE</b>	<b>9,500</b>	<b>22,900</b>	<b>41,000</b>	<b>44,178</b>	<b>57,100</b>
<i>HAWC</i>	<i>1,500</i>				
<i>LSST camera</i>	<i>8,000</i>	<i>22,000</i>	<i>35,000</i>	<i>35,000</i>	<i>40,800</i>
<i>DM-G2</i>		<i>900</i>	<i>6,000</i>		<i>11,000</i>
<i>LZ</i>				<i>3,050</i>	
<i>SuperCDMS-SNOLAB</i>				<i>2,250</i>	
<i>DESI</i>				<i>3,878</i>	<i>5,300</i>
<b>Small Project Fabrication: SPT-3G, ADMX-G2</b>				<b>1,025</b>	<b>1,601</b>
<b>Future Project R&amp;D: SPT-3G, ADMX-G2, etc</b>	<b>9,359</b>	<b>7,760</b>		<b>1,200</b>	
<b>TOTAL – Cosmic Frontier</b>	<b>77,922</b>	<b>93,729</b>	<b>93,673</b>	<b>104,367</b>	<b>115,900</b>
<b>TOTAL – Cosmic Frontier w/other costs</b>		<b>96,927</b>	<b>101,245</b>	<b>106,507</b>	<b>119,325</b>
<b>TOTAL – HEP</b>		<b>774,920</b>	<b>744,000</b>	<b>766,000</b>	<b>788,000</b>

\*Totals are slightly less than shown in the HEP budget because there are extra funds in each HEP budget line for program reviews & direction, etc.



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DOE HEP Status at AAAC - 11/12/2015

31

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# RESEARCH support





# HEP Cosmic Frontier Program

## Research Funding – types, traditions

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### University research grants - competitive, proposal-driven process

- Program alignment is built into proposal review process
- We typically fund a faculty PI (or PI's) and their group (not individual research scientists, postdocs, etc.)

### Laboratory research efforts – lab field work proposals with comparative review of programs every 3 years (next Cosmic Frontier is July 2016)

- Program guidance and alignment is provided by HEP with input from the labs, advisory committees, reviews etc.

**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

- Science planning is expected throughout all phases to end up with coordinated data analysis by a collaboration (One precision result rather than 100 independent results)
- It is understood that people have different strengths and are involved in different aspects of project.
- Funding for theory/simulations/phenomenology/computational efforts in direct support of our experiments (otherwise should be proposed to the Theory program).

# HEP Cosmic Frontier Program

## Research Funding - priorities

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We are a science-mission-oriented agency. The projects are picked for the (P5) strategic plan that will provide significant leaps in science. Then we support the community to carry out these projects/experiments.

- Priority is to support experiments in our program, where we have responsibilities
- Distribution of efforts across science topics and projects will necessarily change to support changing priorities and status of the experiment

### Research Priorities for funding, aligned with P5

→ Keep efforts continuing at about current level for operating experiments; Ramp-down research for ones completing; Ramp-up for the projects in fabrication or planning phase, depending on needs

#### **Dark Matter :**

Complete G1 operations & analysis; construct and plan G2 experiments, modest R&D

#### **Dark Energy :**

DES operations & analysis; construct and plan operations for LSST and DESI

**CMB:** SPT-3G construction & operations; begin planning for CMB-S4

**Other:** Efforts completing on VERITAS, Auger, Holometer; efforts continuing at about constant level on AMS, HAWC, FGST



# HEP Cosmic Frontier Program Research Funding Model

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## Typical HEP researcher:

- Has an experimental program that may involve data taking & analysis on one experiment while planning or constructing the next experiment.
- Makes long term commitments to our experiment/project/science as a member of the collaboration.
- He/she has specific commitments (service work) & responsibilities for our projects/experiments that may include analyzing data with one experiment while constructing or planning the next one – in addition to the science analysis. These responsibilities may evolve over time as the experiment progresses through phases.
- Not funded for one particular study or effort here and there

## HEP community expects to support research efforts (and therefore should be part of the proposal):

- Roles/responsibilities & contributions on all phases of a project in addition to science data planning & analysis
- Participate on a coordinated collaboration to carry out all phases of a project and also to plan and carry out the data analysis. People have roles/responsibilities on the hardware/software/collaboration in addition to data analysis.

Note we do have umbrella grants but there are many cases of individual PI's in our program too; it's just that they work as part of a collaboration on a project/experiment.

# Cosmic Frontier – Research Funding Considerations

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## Peer reviews and program planning reflect these traditions – considerations :

- Is the activity in direct support of 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?
- What is the experience, responsibilities and commitment (% time) of the researcher? Will they have time to make significant contribution?
- Are people supporting the collaboration 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?
- Funding isn't optimized by funding small fractions of lots of different people that aren't making large or continuous contributions to the experiment.





# Cosmic Frontier

## Statistics on Comparative Review Research (University) Grants

				FY12	FY13	FY14	FY15
Cosmic CR – \$M request (Y1)				\$3.3	\$7.7	\$7.5	\$6.8
Cosmic CR – \$M funded (Y1)				\$1.6	\$3.4	\$4.4 w/FFF	\$3.3 w/FFF
Cosmic CR - proposal counts							
		#proposals	received	11	33	29	27
		#proposals	reviewed	10	28	28	27
		#proposals	funded	6	18	19	14
		<b>#proposals</b>	<b>success rate</b>	<b>60%</b>	<b>64%</b>	<b>68%</b>	<b>52%</b>
Cosmic CR - PI counts							
		#PI's	received	21	61	40	43
		#PI's	reviewed	20	54	38	43
		#PI's	funded	13	27	25	21
		<b>#PI's</b>	<b>success rate</b>	<b>65%</b>	<b>50%</b>	<b>66%</b>	<b>48%</b>

### 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.
- FY15 Cosmic requests \$21.9M (for full grant period) and \$6.8M 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 (Labs & Universities)

FY10 FY11 FY12 FY13 FY14 FY15

## 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



# FY15 Review Data — by Proposal

For the FY 2015 cycle, **153 proposals** requesting support totaling **\$221.88M** in one or more of the 6 HEP subprograms were received. Of these, 146 were reviewed.

	HEP Subprogram						HEP Total
	Energy	Intensity	Cosmic	Theory	Acc. R&D	Det. R&D	
Received	27	30	27	43	35	24	146
Declined w/o Review	2	0	0	0	2	3	7
Reviewed	25 (6)	30 (9)	27 (17)	43 (17)	33 (20)	21 (11)	139 (79)
Funded	19 (3)	19 (3)	14 (7)	27 (3)	7 (1)	9 (2)	63 (16)
Declined	6 (3)	11 (6)	13 (10)	16 (14)	24 (19)	12 (9)	72 (61)
“Success Rate” (%) (Previous/New)	76	63	52	63	21	43	45 (78/20)

## NOTES:

- Single proposals with multiple research thrusts are counted multiple times [1 /thrust]
- ( ) indicates # proposals from research PI/groups that did not receive DOE HEP funding in FY14.
- “Success Rate” is = # Funded/ # Reviewed.
- Most proposals are not fully funded at their “requested” level.
- About 43% of the proposals reviewed were from research groups that received HEP funding in FY14.
- FY15 overall success rate of reviewed proposals for previously (newly) funded groups was 78% (20%).
- Total grant awards funded in FY15 at \$32.95M [= 24.48M ‘renewal’ + 8.47M ‘new’ proposals]



# Summary

- An exciting time for HEP and the Cosmic Frontier!
- P5 developed compelling, realistic strategic plan with a consensus vision for US HEP  
→HEP is moving forward to implement it.
- Close coordination with the other agencies.

