



# **High Energy Physics (HEP) Program Status Report to the Astronomy & Astrophysics Advisory Committee (AAAC) Meeting**

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# OUTLINE

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**HEP PROGRAM – MODEL, GUIDANCE, STRATEGIC  
PLANNING**

**HEP PROGRAM BUDGETS**

**COSMIC FRONTIER PROGRAM STATUS**

**RESEARCH GRANTS RESULTS**



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# HEP PROGRAM – MODEL, GUIDANCE, STRATEGIC PLANNING



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# HEP Program Model

## The DOE Office of Science is a part of a mission agency

- Provide science leadership and support to enable significant advances in specific science areas
- Labs with a variety of resources needed to design, build, operate selected facilities & projects
- Lab infrastructure, including computing facilities (NERSC, SCiDAC program etc)
- Encourage scientific teams with expertise in required areas to participate in all phases in order to produce science results
- Partnerships as needed to leverage additional science and expertise

## The High Energy Physics – What makes us unique?

- **Long Term View:**
  - Develop and support a specific portfolio of selected facilities & experiments to obtain the science
  - Plan stages of experiments for ever-increasing precision
  - Long-term support for our responsibilities in designing, building and operating projects, as well as research support, for significant advances in science.
  - Support a science collaboration in all stages, leading to the best possible science results
- **Collaboration/Teamwork:**
  - People have long term commitments, responsibilities on the experiments, in addition to science research, to bring together all the tools needed to accomplish the science
- **Complementary Approaches**
  - e.g. searching for dark matter particle detection using accelerators, direct detection underground experiments and indirect searches from gamma-ray surveys



# HEP Program Guidance

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- **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”, Particle Physics Project Prioritization Panel (“P5”))
- **Astronomy and Astrophysics Advisory Committee (AAAC)**
  - Reports to NASA, NSF and DOE on areas of overlap
- **Other**
  - e.g. National Academies of Science studies, community science studies, reviews, etc.
- **Strategic Program Planning**
  - HEPAP unanimously approved a new long term strategic planning report from P5 in May 2014



# The Best of Times

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In recent years, we have new results that point the way forward:

- **Energy Frontier**
  - Discovery of the Higgs (and so far, nothing else) defines an extensive future work plan
- **Intensity Frontier**
  - Measurement of the “small” neutrino mixing angle ( $\theta_{13}$ ) enables qualitatively new investigations of fundamental questions with neutrinos
- **Cosmic Frontier**
  - Rapid advances in Dark Matter direct detection is starting to challenge models and perhaps upend the “standard” Dark Matter picture; precision Dark Energy studies; possible glimpses of inflation in the early universe
- **Technology R&D**
  - Recent progress in advanced accelerator concept R&D is spurring ideas for future accelerator test beds that can exploit these successes





# Strategic Planning – Goals & Process

Optimally exploring new physics possibilities on all frontiers requires strategic US participation as part of a coordinated global effort

- “Get a plan and stand behind it” –*E. Moniz, Secretary of Energy*

## Strategic Planning Goals & Process:

→ HEP needs a compelling & executable strategic plan, with community behind it

- APS-DPF led community planning process in 2013 (“Snowmass”)
- HEPAP P5 Subpanel in 2013/2014 (Steve Ritz, Chair) used Snowmass and other inputs to develop a strategic plan for the field
  - Plan to be executed over a ten year timescale in the context of a 20-year global vision for the field
  - P5 process was carried out in the context of realistic budget scenarios provided by the funding agencies in the charge

→ The P5 report “Strategic Plan for US Particle Physics in the Global Context” was delivered and approved by HEPAP in the May 22-23, 2014 meeting.





# P5 Science Drivers of Particle Physics



The U.S. long-term strategy report (P5) identified five intertwined science drivers, compelling lines of inquiry that show great promise for discovery:

- 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

The Science Drivers are studied using techniques in one or more of the HEP Program Experimental Research Frontiers: **Energy, Intensity, & Cosmic Frontiers**

→ Theory & Computation, Advanced Technology R&D, Accelerator R&D support the research areas.





# P5 Report Take-Away Messages

- **P5 plan is a compelling, unified vision for HEP**
  - Five intertwined science drivers define the big issues
  - Widespread community support not seen for 20+ years
- **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 enjoys such widespread HEP community support is that it takes a balanced approach to planning:
    - Time-phased, projects of different scales, balanced across Frontiers, on- and off-shore, short-term and longer-term science goals
- **HEP is global**
  - P5 strategic plan explicitly recognizes this fact, as does DOE implementation
  - **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.**
    - LBNF will be the first truly international experiment hosted by the US, with management modeled after the successful LHC scheme
  - **Near term Cosmic Frontier projects are ready to go**



# DOE/HEP Response to P5 Report

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- **We share the community's enthusiastic response to the P5 strategic plan**
  - HEP is developing & aligning the Program along P5 recommendations
  - Implementation strives to maintain the recommended balance
  - Currently, we are moving forward with implementation in targeted areas
  - But...given the current fiscal environment, full implementation of the plan will take some time, as we work with partners and stakeholders:
    - DOE management, HEP community, DOE Laboratories, Congress, OMB, other US and international Agencies, etc.



# P5 Criteria – Program & Project Criteria



## HEP will use P5's Criteria in developing our program →

- **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** [\(can also be applied to research efforts/proposals\)](#)

- **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





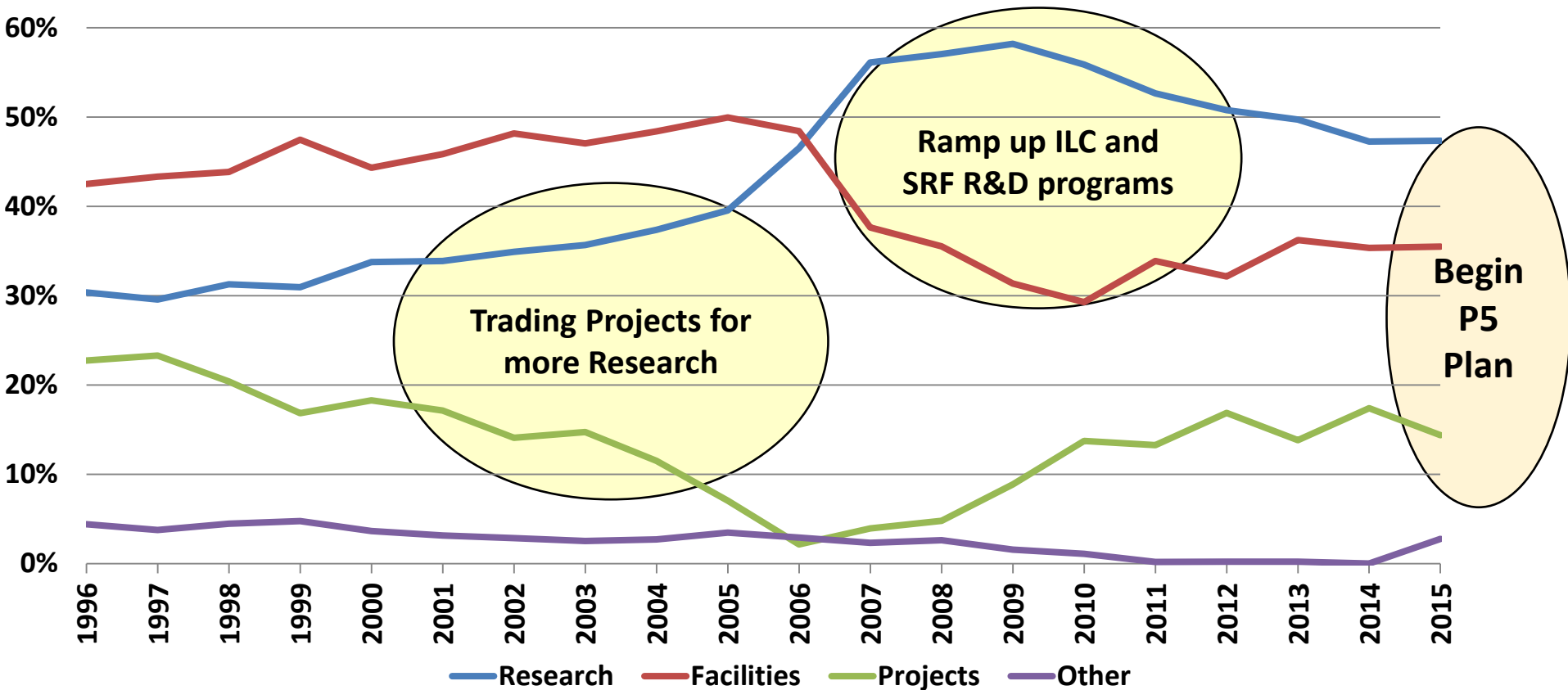


# HEP PROGRAM - BUDGET AND ISSUES



# Funding Trends by Fiscal Year

(FY2015 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 is guiding the FY 2015 budget; clear impacts should begin to become evident in FY 2016 President's Request budget



# FY2013 - FY2015 High Energy Physics Budget

HEP Funding Category ( <i>in \$K</i> )	FY 2013 Actual	FY 2014 Actual	FY 2015 Request	Explanation of Changes (FY15 vs. FY14)
Energy Frontier	149,446	152,386	153,639	Reduction for Tevatron completion offset by LHC upgrade activities
Intensity Frontier	274,412	250,987	251,245	Reductions for NOvA project completion, Belle-II offset by increase for beam line ops, effort at FNAL
<b>Cosmic Frontier</b>	<b>80,063</b>	<b>96,927</b>	<b>101,245</b>	<b>Ramp-up of LSSTcam</b>
Theory and Comp.	66,398	64,275	58,850	Reduced to offset investments in future facilities
Advanced Technology R&D	142,291	150,270	114,242	Reduced to offset project increase, shift towards directed R&D
Accelerator Stewardship	3,132	9,075	19,184	Support new R&D efforts, open accelerator test facilities to industry
Construction (Line Item)	11,781	51,000	25,000	Mu2e on profile; LBNE reduced in FY15 req. (req. made during P5 report development)
SBIR/STTR	0	0	20,595	
<b>Total*</b>	<b>727,523</b>	<b>774,920</b>	<b>744,000</b>	

\*The FY13/14 Actuals are reduced by \$20,791K/\$21,619K for SBIR/STTR, so ~ \$748.3M/\$796.5K should be used to compare to FY15.





# HEP Budget Notes – FY13, 14

## In the last few years --

- **Budget philosophy is to enable new world-leading HEP capabilities in the U.S. through investments on all three frontiers:** Accomplished through ramp-down of existing project operations and Research (~ -6%)
- **Impact of these actions:** Workforce reductions at universities and labs; Several new efforts were delayed
- **Program planning has been very difficult due to unstable budget environment.**

## FY 2013 Budget:

We were not able to start new Major Item of Equipment (MIE) projects: LSST-camera, Belle-II.

## FY 2014 Budget enacted:

- **MIE-fabrication start approved for LSST-camera, Belle-II, Muon g-2**
- Project Engineering & Design (PED) & Construction funds approved for Muon to Electron conversion (**Mu2e**) experiment
- Specific guidance in approved Budget for the additional \$21M provided over the Request:
  - Long Baseline Neutrino Experiment (LBNE) - \$26M in R&D, PED funds (\$16M over Request)
  - Homestake Mine Operations - \$15M provided (specific guidance was \$5M over Request)



# HEP Budget Notes – FY15

- The FY15 President's Request is below P5 funding Scenario A
- Based on the FY15 House and Senate markups of the appropriation bills, we anticipate that we will be able to implement Scenario B  
FY 2015 House & Senate bills: House \$775M, Senate \$774.5M
  - Gave specific amounts for each area (e.g. Cosmic Frontier)
  - Provided \$35M for LSST-camera and \$6M for DM-G2 projects (both as planned)
  - HEP should adjust Budget Request to align with P5 recommendations
  - HEP should develop a work plan to advance dark matter program, CMB Stage IV and DESI
- We are working to make adjustments to the HEP Program to align to P5 recommendations and argue for Scenario B funding.

Now in a Continuing Resolution (CR) through at least mid-Dec.);

→Have to plan to FY2015 Request (\$744M)

- Continue planned funding profiles of existing projects: **LSST-camera**, **muon g-2**, **Belle-II**, **Mu2e**
- Continue design studies for Long Baseline Neutrino Experiment/Facility, **R&D for DM-G2**, **DESI**
  - High-priority near-term efforts like second generation dark matter (DM-G2) experiments will get enough funding to keep the going through the CR and we will try to enhance their funding after an appropriation is passed
  - Decisions on how to fund longer term investments like Future Circular Collider studies or ILC R&D will be delayed until the budget situation is better known





The background is a medieval tapestry. It features a landscape with a sun with a human face on the right, a crescent moon at the top, and numerous stars. A large tree stands in the center. In the foreground, a figure in a yellow robe is reclining. The scene is framed by a dark, starry band that curves across the middle.

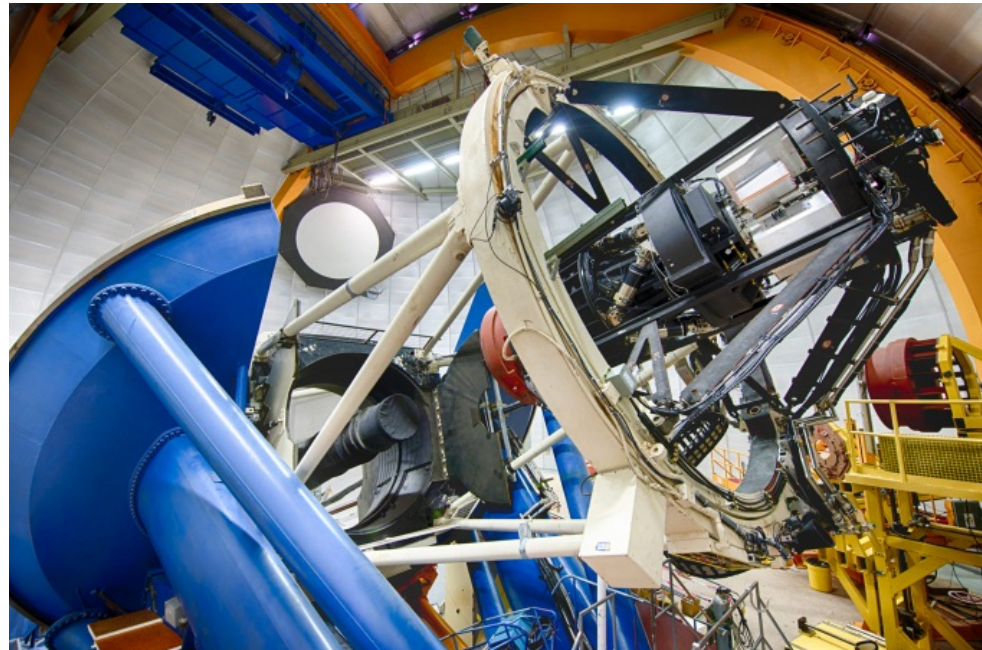
# HEP Program Status at the Cosmic Frontier



# Cosmic Frontier

## Program thrusts:

- Studies of the nature of **Dark Energy** using imaging and spectroscopic surveys
- Direct detection searches for **Dark Matter** particles
- Study of the high energy universe and indirect dark matter searches using **Cosmic-ray, Gamma-ray** experiments
- **CMB, Other** efforts, including small contributions to
  - **CMB** experiments to study the nature of inflation, neutrino properties, and dark energy;
  - computational cosmology efforts;
  - other experiments



## Future program:

- Consider other possibilities and develop & optimize program following the P5 report



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# Cosmic Frontier – Guidance & Considerations

## Build Program with:

- Staged implementation & results
- Mix of smaller, larger projects, using multiple methods and technologies as needed
- Balance between thrusts
- Balance of speculative efforts with ones that guarantee results

## Considerations

### PASAG → P5 Criteria:

- Science goals and how it will address DOE-HEP goals?
  - Experiments which are directly-aligned with goals
  - Experiments in which only part of the data is of interest to the HEP program
- What does HEP Community bring to the experiment? Visible, leadership contributions?

### Other considerations

- Are HEP project contributions in line with % of the project relevant to our science goals?
- Are roles and responsibilities on the project in line with our contributions?
- Partnerships - plusses and minuses
- Don't "mayonnaise" funds all over many small efforts.
- Domestic vs off-shore

→ The PASAG/P5 criteria and the above considerations can be applied to determining what projects we support and at what level as well as research funding priorities.





# FY2013 - FY2015 Budget: Cosmic Frontier

Cosmic Frontier (\$K)	FY 2013 Actual	FY 2014 Actual	FY 2015 Pres. Req.
Research	48,652	52,712	45,435
<i>Grants</i>	<i>12,233</i>	<i>13,157</i>	
<i>National Laboratories</i>	<i>36,419</i>	<i>39,555</i>	
Facility Operations and Experimental Support	10,111	10,357	7,238
Projects	19,159	30,705	41,000
<i>MIE</i>	<i>9,500</i>	<i>22,900</i>	<i>41,000</i>
<i>HAWC - FY13 completed</i>	<i>1,500</i>	<i>...</i>	<i>...</i>
<i>Large Synoptic Survey Telescope Camera (LSSTcam) – FY14 start</i>	<i>8,000</i>	<i>22,000</i>	<i>35,000</i>
<i>Second Generation Dark Matter (DM-G2)</i>	<i>...</i>	<i>900</i>	<i>6,000</i>
<i>Future Project R&amp;D</i>	<i>9,659</i>	<i>7,760</i>	<i>...</i>
<b>TOTAL</b>	<b>77,951</b>	<b>93,729</b>	<b>93,673</b>
Other Costs	2,112	3,198	7,572
Total – Cosmic	80,063	96,927	101,245





# Cosmic Frontier - P5 Recommendations



## Dark Energy

- P5 #16: Build DESI (Dark Energy Spectroscopic Instrument) as a major step forward in dark energy science, if funding permits; DESI should be the last project cut if budgets go from Scenario B to Scenario A (lowest)
- P5 #17: Complete LSST (Large Synoptic Survey Telescope) as planned.

## Cosmic Microwave Background (CMB)

- P5 #18: Support CMB experiments as part of the core particle physics program. The multidisciplinary nature of the science warrants continued multi-agency support.

## Dark Matter – Direct Detection

- P5 #19: 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.
- P5 #20: Support one or more third-generation (G3) direct detection experiments, guided by the results of the preceding searches. Seek a globally complementary program and increased international partnership in G3 experiments.

## Gamma-ray

- P5 #21: Invest in CTA as part of the small projects portfolio 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.

## Projects

- P5 #4: Maintain a program of projects at all scales



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# Cosmic Frontier P5 response – notes, plans, comments



## Projects:

The Cosmic Frontier has high priority projects ready to go in the near term (DESI and DM-G2) and HEP is working towards getting the additional funds (over the lowest funding scenario) to do DESI and an expanded dark matter program.

## Operating experiments:

To review the status of the operating experiments and ensure alignment with the P5 vision, we are holding a review of Cosmic Frontier operating experiments in December 2014 (last review was end of FY12).

## Priorities for funding:

- Following the P5 criteria, it will be a priority to support projects in which HEP has a major/visible role and in which there are significant leaps in capabilities and/or science.
- The priority for research funding will be to sufficiently support the science collaborations to carryout the project fabrication + operations and to deliver the science.
  - Ensure some room in the research program for development of ideas for new projects that are aligned with the science drivers.
- Research efforts on projects that are aligned with P5 science drivers, but which don't have HEP participation, will also be considered, taking into account the above and based on funding availability.

## P5 #4: Maintain a program of projects at all scales

### HEP Response:

- The suite of projects recommended by P5 fulfills this recommendation & HEP will work to bring these projects to successful completion.
- As these projects complete, HEP will use a project evaluation mechanism to select the next round of projects. We expect that the program will have a variety of project sizes as needed to address the science drivers.





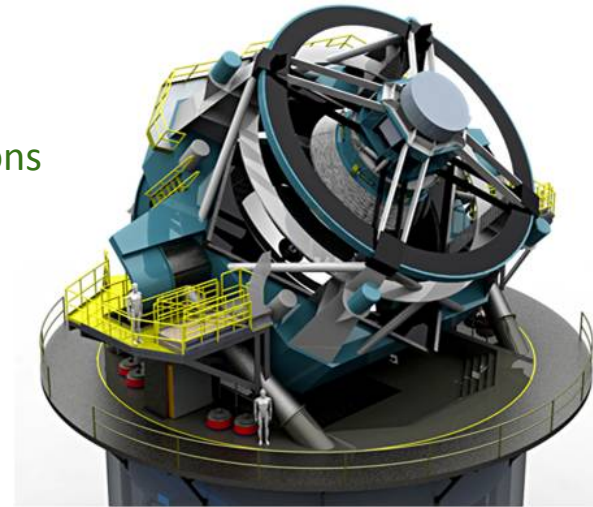
# Dark Energy – Status & Strategy

## Operating

- **Baryon Oscillation Spectroscopic Survey (BOSS)**
  - 5 year ops completed in FY14; data analysis continuing
  - “eBOSS” collaboration requesting support for continued operations
- **Dark Energy Survey (DES)**
  - 5 year ops started Sept 2013; now in 2<sup>nd</sup> year of operations
  - DOE/NSF partnership; DOE responsible for camera
- **Supernova surveys continue operations**

## Fabrication

- **Large Synoptic Survey Telescope (LSST)**
  - Next generation imaging survey; 10 year ops starts ~2023
  - DOE & NSF partnership w/MOU (July 2012)
    - DOE responsible for the 3 billion pixel LSST-camera, managed by SLAC
  - Dark Energy Science Collaboration (DESC) formed to support science planning for precision dark energy results



LSST

## P5 #17: Complete LSST as planned.

### HEP Response:

- Detailed plans by both DOE and NSF to carry out LSST exist. We will continue to execute the project according to the DOE-NSF agreement.
- Start of fabrication funding approved in FY14 & CD-3a fabrication start approved in June 2014
- Successful CD-2 “baseline” review held in early November 2014





# Dark Energy – Status & Strategy



## Future planning

- **Dark Energy Spectroscopic Instrument (DESI)**
  - Next generation “Stage-IV” survey using Baryon Acoustic Oscillation (BAO) and Redshift Space Distortion (RSD) methods; will complement LSST “Stage-IV” imaging survey
  - Continuing discussions and planning with NSF for hosting at Mayall Telescope
  - Plan is for DOE to provide the instrumentation and funding for operating the dark energy science operations
  - Successful CD-1 review held September, 2014; R&D in FY2015; Planning assuming an MIE fabrication start in FY2016

**P5 #16: Build DESI as a major step forward in dark energy science, if funding permits**  
**- DESI should be the last project cut if budgets move from Scenario B to Scenario A (lowest)**

## HEP Response:

- The P5 recommendation will be used to highlight the importance of the DESI and argue for the additional funds needed to implement it as a high priority.
- (The FY15 President’s Request does not include fabrication funding or a request to approve the start of fabrication)
- A successful Independent Project Review (IPR) is being used to show that DESI is ready to receive funding if it becomes available. The IPR was held Sept 9-11, 2014 to evaluate DESI’s readiness for CD-1. Plan to request approval for CD-1 by end of 2014.
- HEP is moving forward in planning DESI in coordination with NSF, including upcoming discussions regarding the model for the DESI program. → planning assuming an FY16 Fabrication start





# Dark Matter Direct Detection Program – Status & Strategy

→ Staged program: Current experiments test multiple technologies to determine most powerful method for future generation

## Currently Operating: Generation 1 (DM-G1)

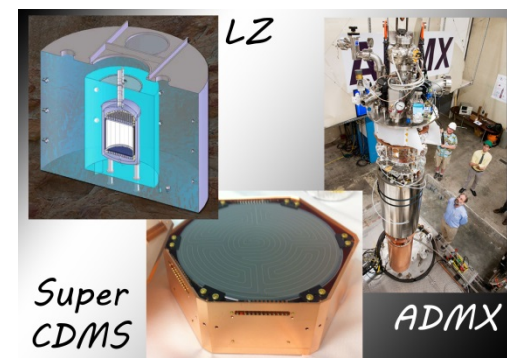
- Weakly Interacting Massive Particle (WIMP) searches
  - SuperCDMS-Soudan (cryogenic germanium)
  - LUX (liquid xenon) - **Top story of the year in *Nature Magazine* “2013 in Review”**
  - DarkSide-50 (liquid argon)
  - COUPP-60 (bubble chamber fluids)
- Search for Axions (convert to photons in intense magnetic field)
  - ADMX-2a



LUX

## Near Future: Generation 2 (DM-G2)

- DOE and NSF jointly selected a portfolio of DM-G2 experiments
  - Goal is to improve sensitivity by one or more orders of magnitude
  - In July 2014, DOE and NSF announced a jointly selected portfolio of DM-G2 projects: ADMX-G2, SuperCDMS-SNOLAB, and LZ



DM-G2 Portfolio

## Future Planning: Generation 3 (DM-G3)

- DM-G3 R&D and planning continues at a low level



# Dark Matter Direct Detection Program – Status & Strategy

**P5 #19:** 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.

## HEP Response:

- Coordinated HEP/NSF portfolio for the Direct Detection of Dark Matter (DDDM) will continue to be developed and implemented.
- The overall DDDM program will need to include DM-G2 project(s), operations of current experiments, background and material studies, and future R&D efforts.
  - Coordinated efforts in R&D to test and develop a broad range of technologies for future experiments
- Selection of DM-G2 concept(s) was announced in July 2014: ADMX-G2, LZ, SuperCDMS-SNOLab selected for DOE/NSF coordinated dark matter program to go forward to fabrication phase.
  - **LUX-Zeplin (LZ)** and **SuperCDMS–SNOLAB** for their collective sensitivity to both low and high-mass WIMPS
    - LZ, SuperCDMS-SNOLAB (MIE projects) planning for fabrication start in FY2016
    - LZ CD-1 review being planned for January 2015.
  - **ADMX-Gen2** to search for axions
    - ADMX-G2 (small project) starts fabrication in FY2015





# Dark Matter Direct Detection Program – Status & Strategy

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## HEP Response continued (to P5 #19)

- The P5 recommendation will be used to highlight the importance of an expanded DDDM program and argue for the additional funds needed to implement it as a high priority.
  - Original funding anticipated for DOE's G2 DDDM projects was ~\$29M (reference the DOE Funding Opportunity Announcement)
    - Following P5, we are planning a program with roughly a factor of two increase in G2 funding, with the period of construction stretched out to FY18
  - Cannot start new projects during a Continuing Resolution. However, House and Senate marks call for G2 project starts in FY15.

**P5 #20: Support one or more third-generation (G3) direct detection experiments, guided by the results of the preceding searches. Seek a globally complementary program and increased international partnership in G3 experiments.**

## HEP Response:

- HEP will concentrate on getting the DM-G2 experiment(s) successfully started. Actions for a specific DM-G3 program will take place later on.
- A robust Dark Matter R&D program is starting to be planned & will be directed in part to potential G3 technologies. This assumes adequate funding.



# Cosmic Microwave Background (CMB) – Status & Strategy

→ Gain insight into the evolution of the universe by understanding the oldest visible light

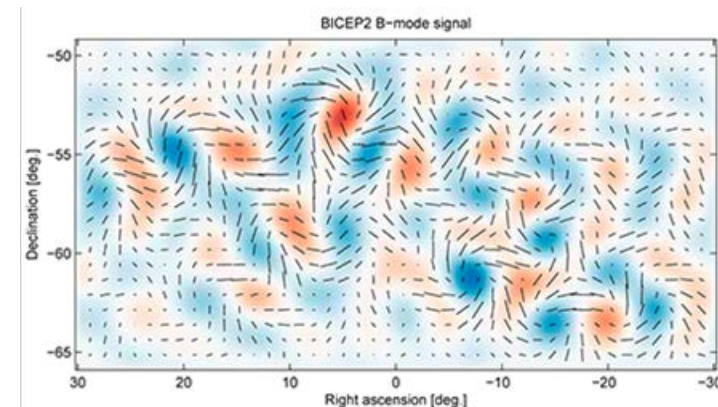
## Operating

- **South Pole Telescope polarization (SPTpol)**
  - HEP provided outer-ring detectors (managed by Argonne National Lab)
  - July 2013: first measurement of “B-mode” polarization in the CMB
    - *In **Physics World** “Top Ten Results of 2013”*
  - BICEP2 results in early 2014 hint at signature of inflation
    - Independent B-mode polarization analysis crucial!
- **Planck space mission**
  - HEP has MOU with NASA to provide supercomputing resources at NERSC

→ Current experiments are working to check/test BICEP2’s results



South Pole Telescope (SPT)



BICEP2 B-mode polarization  
March, 2014





# Cosmic Microwave Background (CMB) – Status & Strategy

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## Fabrication

- **SPT-3G**
  - HEP planning participation in major upgrade of the camera to greatly increase sensitivity
  - Successful project review of proposed DOE roles/responsibilities (managed by ANL) was held September 2014

## Future Planning

- **CMB Stage-IV (CMB-IV) experiment**
  - Community is developing science case & concept

**P5 #18: Support CMB experiments as part of the core particle physics program. The multidisciplinary nature of the science warrants continued multi-agency support.**

## HEP Response:

- HEP is using recommendation to open discussions with traditional CMB research support agencies (NSF, NASA) to come to agreement on any major DOE roles.
- Going forward, planning to hold community planning meetings.
- Design and concept studies will start when needed to support a project later in the P5 decade.





# High Energy Cosmic-ray, Gamma-ray Experiments – Status & Strategy

→ Explore mechanism for acceleration of space-time expansion and perform indirect searches for dark matter

## Operating

- **Alpha Magnetic Spectrometer (AMS);** launched 2011
  - Cosmic ray observatory on International Space Station
    - April 2013: High energy positrons consistent with either dark matter or pulsar origin
- **Pierre Auger Cosmic Ray Observatory**
  - High Energy Cosmic-ray observatory in Argentina; operating since 2007
- **Fermi Gamma-ray Space Telescope (FGST);** launched 2008
  - Gamma-ray observatory in space
    - Origin of Cosmic Rays result one of Science Magazine's 2013 "Top 10 Science Breakthroughs of the Year"
    - DOE funds operations of the Instrument Science Operations Center (ISOC) at SLAC
- **VERITAS**
  - Ground based gamma-ray array in Arizona; operating since 2007
    - Discovery of unexpected very high energy emission from the Crab Pulsar



AMS on the International Space Station





# High Energy Cosmic-ray, Gamma-ray Experiments – Status & Strategy

## Fabrication

- **HAWC**
  - Gamma ray array in Mexico
    - Partial operations now; full operations starting end FY2014
    - DOE deliverables completed September 2014



HAWC array (May 2014)

## Future Planning

- **Cherenkov Telescope Array (CTA)**
  - Community planning participation in a European-led next generation international gamma ray observatory

**P5 #21: Invest in CTA as part of the small projects portfolio if the critical NSF Astronomy funding can be obtained.** P5 comments:

- 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.

## HEP Response:

**➔HEP isn't continuing support of research or R&D efforts on CTA.**

Due to P5 program recommendations & priorities HEP is not continuing to fund research, R&D or planning efforts on CTA going forward. Currently ongoing efforts funded by HEP will be ramped down.



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# RESEARCH GRANTS RESULTS



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# FY14 Comparative Research Grants Review Data — by Proposal

	HEP Subprogram						HEP Total
	Energy	Intensity	Cosmic	Theory	Acc. R&D	Det. R&D	
Received	20	26	29	33	31	16	129
Declined Without Review	0	0	1	0	2	2	5
Reviewed	20 (7)	26 (11)	28 (14)	33 (17)	29 (20)	14 (4)	124 (71)
Funded	16 (4)	17 (3)	19 (5)	16 (1)	11 (4)	7 (0)	60 <sup>(a)</sup> (17)
Declined	4 (3)	9 (8)	9 (9)	17 (16)	18 (16)	7 (4)	62 (54)
“Success Rate” (%) (Previous/New)	80	65	68	48	38	50	48 (81/24)

## NOTES:

- Single proposals with multiple research thrusts are counted multiple times [1 /thrust]
- ( ) indicates number of proposals from research PI/groups that did not receive DOE HEP funding in FY13.
- “Success Rate” is = # Funded/ # Reviewed.
- Most proposals are not fully funded at the “requested” level.
- About 43% of the proposals reviewed were from research groups that received DOE HEP funding in FY13.
- Overall success rate of reviewed proposals for previously (newly) funded groups was 81% (24%).
- *For Ref:* FY13 Comp. Review proposal success rate was 62%; previously (newly) funded was 78% (34%).

<sup>(a)</sup> Total does not include 2 proposals currently ‘on-hold’ pending funding decisions from separate federal funding agency.





# Cosmic Frontier: Comparative Research Grant Review

## Statistics on Received & Funded proposals:

	FY12			FY13			FY14		
	Amount	# proposals	# PI's	Amount	# proposals	# PI's	Amount	# proposals	# PI's
<b>Request</b>	\$3.3M	11	21	\$7.7M	28	53	\$7.5M	29	40
<b>Funded</b>	\$1.6M	5	12	\$3.4M	20	28	\$3.2M	19	25
<b>Success rate</b>	48%	50%	60%	44%	71%	53%	43%	65%	63%

\* Note that \$4.4M was actually provided in FY14 when taking into account fully forward-funded grants.

### FY15:

- The # proposals, funding request and funding availability is similar to FY14.
- The review panel meeting takes place Nov. 19-21, 2014





# Cosmic Frontier – Research Grant Funding by Thrust Area

<b>Cosmic Frontier University Research Grants - all funding (\$K)</b>		<b>FY12</b>	<b>FY13</b>	<b>FY14</b>
		<b>actual</b>	<b>actual</b>	<b>current</b>
	Dark Energy	2856	3087	4451
	Dark Matter	3366	3599	4993
	Cosmic, Gamma-ray	5591	5542	3670
	CMB, Other	0	0	0
	<b>Total</b>	<b>11813</b>	<b>12228</b>	<b>13114</b>

Note: This includes all University Research funding for new/renewal comparative review grants, early careers, continuations and supplements. Support for lab research and projects (R&D, fabrication, operations is not shown).





# Cosmic Frontier – Early Career Review Statistics

## Statistics on Received & Funded proposals:

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

### Awards:

#### 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)





# HEP Early Career FY10-14 Demographics

Subprogram Awards	FY10 (L/U)	FY11 (L/U)	FY12 (L/U)	FY13 (L/U)	FY14 (L/U)	Total (L/U)
Energy	3 (1/2)	3 (1/2)	1 (0/1)	2 (0/2)	2 (1/1)	11 (3/8)
Intensity	2 (1/1)	1 (0/1)	3 (2/1)	1 (0/1*)	1 (1/0)	8 (4/4)
Cosmic	2 (0/2)	3 (2/1)	3 (1/2)	2 (1/1)	1 (0/1)	11 (5/6)
HEP Theory	6 (1/5)	4 (0/4*)	3 (0/3)	3 (1/2)	1 (0/1)	17 (2/15)
Accelerator	1 (1/0)	2 (2/0)	2 (1/1)	1 (0/1)	1 (1/0)	7 (5/2)
<b>HEP Awards</b>	<b>14 (4/10)</b>	<b>13 (5/8)</b>	<b>12 (4/8)</b>	<b>9 (2/7)</b>	<b>6 (3/3)</b>	<b>54 (18/36)</b>
<b>Proposals</b>	<b>154 (46/108)</b>	<b>128 (43/85)</b>	<b>89 (34/55)</b>	<b>78 (29/49)</b>	<b>75 (35/40)</b>	<b>524 (187/337)</b>

- Lab or University (L/U)
- Early Career Research Program has become even more competitive
  - Congress enacted legislation requiring Office of Science grants of less than \$1,000K to be fully funded in the year the award is issued.
  - This requires university Early Career grants awarded this year to be fully funded in the year awarded (starting in FY14)
  - Award rate across Office of Science is now ~5%.





# SUMMARY

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- **An exciting time for HEP and the field!**
  - **P5 developed compelling, realistic strategic plan with a consensus vision for US HEP**
- HEP will be moving forward to implement it.**



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# BACKUPS







# HEP PROGRAM STATUS



# Energy Frontier Status & Strategy



## **P5 report identified LHC upgrades as the highest priority near-term large project; recommended:**

- Complete “Phase-1” (2018) upgrades of ATLAS and CMS experiments
- Continue collaborations with the “Phase-2” (High-Luminosity LHC, 2023-25) upgrades of the accelerator and the ATLAS and CMS experiments

## **P5 report noted the strong scientific importance of the ILC global project:**

- Recommended modest and appropriate levels of ILC accelerator and detector design in areas where the U.S. can contribute critical expertise
- Report emphasized that support for these efforts would ensure a strong position for the U.S. within the ILC global project.

## **Current program**

- **LHC will resume operations in spring 2015 at collision energies of 13+ TeV**
  - Significant increase in energy from 7-8 TeV in Run I
- **The U.S. will continue to play a leadership role in LHC discoveries and is actively executing the initial upgrades (Phase-1) to the LHC detectors**
  - CD2/3 reviews for Phase-I U.S. CMS/ATLAS were held in August-September 2014

## **Planned program**

- **Considering high-luminosity update to LHC around 2023 to extend discovery potential**
  - Increase luminosity by a factor of 10 beyond LHC design value to explore new physics and new dynamics for W/Z, top, and Higgs at TeV energies
- **Very modest investments in R&D for future options:** Lepton colliders, Very high energy hadron colliders





# Intensity Frontier Status & Strategy



## **P5 recommended substantial investments in the U.S. neutrino program, including significant changes in direction**

- Reformulate the long-baseline neutrino program as an internationally designed, coordinated, and funded program with Fermilab as host
- Redirect specific activities and efforts at Fermilab to the Proton Improvement Plan II (PIP-II) program of updates to the accelerator complex, which will provide proton beams with power  $>1$  MW by the time of first operation of the new long-baseline neutrino facility
- Develop, with international partners, a **coherent short- and long-baseline neutrino program** hosted at Fermilab.

## **Current Operating or Approved Projects:**

### **Exploring the unknown through precision measurements**

- properties of charged leptons and search for extremely rare particle interactions: Muon  $g-2$ , Mu2e
- studies of K mesons, charm quarks and tau leptons to search for new states of matter: Belle-II, KOTO

### **Pursuing the physics associated with neutrino mass**

- Current program aims to determine neutrino mass hierarchy and measure neutrino properties: Daya Bay, MicroBooNE, MINERvA, MINOS+, NOvA, Super-K, T2K

### **Identify the physics of dark matter**

- Intense particle beam based searches for dark matter: APEX, Heavy Photon Search

## **Planned program**

### **Determine if there are sterile neutrinos & if they violate CP; In collaboration with International Partners**

- Making progress on internationalization of LBNE  $\rightarrow$  LBNF, with guidance from interim International Executive Board
- Encouraging community efforts to produce optimized short-baseline (SBN) proposal(s)



# The Accelerator R&D Stewardship Program

The mission of the HEP long-term accelerator R&D stewardship program is to support fundamental accelerator science and technology development of relevance to many fields and to disseminate accelerator knowledge and training to the broad community of accelerator users and providers.

- **Strategies:**
  - **Improve access to national laboratory accelerator facilities** and resources for industrial and for other U.S. government agency users and developers of accelerators and related technology
  - Work with accelerator user communities and industrial accelerator providers to **develop innovative solutions to critical problems**, to the mutual benefit of our customers and the DOE discovery science community
  - Serve as a catalyst to **broaden and strengthen the community of accelerator users and providers**
- **Engages the entire U.S. accelerator R&D ecosystem in a coordinated manner to solve high-impact challenges at a scale well beyond the reach of the SBIR program**

## Status

- **Authorized for the first time in FY 2014 as a redirection of funds**
- **Program elements for FY 2015 awaiting appropriations**
  - First Accelerator Stewardship call for proposals for FY 2015
  - Accelerator Test Facility Pilot Program for FY 2015





# Advanced Technology R&D Strategy

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- **P5 report recommended moving forward with a focused Advanced Technology R&D strategy:**
  - Play a leadership role in superconducting magnet technology focused on the dual goals of increasing performance and decreasing costs
  - Reassess the Muon Accelerator Program, in consultation with international partners
  - Pursue accelerator R&D with a focus on outcomes and capabilities that will dramatically improve cost effectiveness for mid-term and far-term accelerators
  - Focus resources toward directed instrumentation R&D in the near-term for high-priority projects
- **HEPAP has appointed a subpanel to evaluate the HEP accelerator R&D program and identify the most promising research areas to support the field**
  - Preliminary findings due in November 2014
  - Final report due in March 2015



# FY14 HEP Early Career Awards

- **Eric Dahl, *Northwestern University***
  - A Scintillating Xenon Bubble Chamber for Dark Matter Detection
- **Peter Graham, *Stanford University***
  - New Searches for Ultralight Particles
- **Anna Grassellino, *Fermilab***
  - Impurity Doping of Niobium for Ultra Efficient Superconducting RF Cavities
- **James Hirschauer, *Fermilab***
  - Search for new phenomena at the 13 TeV LHC: Fast start and strong finish
- **Stephanie Majewski, *University of Oregon***
  - Search for New Physics with Top Quarks and Upgrade to the ATLAS Liquid Argon Calorimeter
- **Xin Qian, *Brookhaven National Laboratory***
  - Detector Development towards Precision Measurements of Neutrino Mixing

