High Energy Physics (HEP) Program Status Report to the NAS Committee on Astronomy & Astrophysics (CAA) Meeting

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OUTLINE

HEP PROGRAM – MODEL, GUIDANCE, STRATEGIC PLANNING

HEP PROGRAM BUDGETS

HEP PROGRAM STATUS

COSMIC FRONTIER PROGRAM STATUS

HEP PROGRAM – MODEL, GUIDANCE, STRATEGIC PLANNING

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

- **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

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 (θ_{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 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 reality of a challenging funding landscape, where choices have to be made and resources stewarded carefully, and confronts those 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

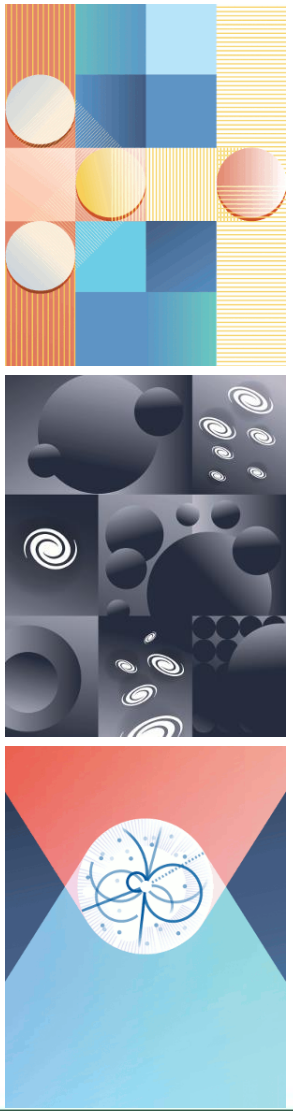
P5 Science Drivers of Particle Physics

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.



DOE/HEP Response to P5 Report

- **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 →

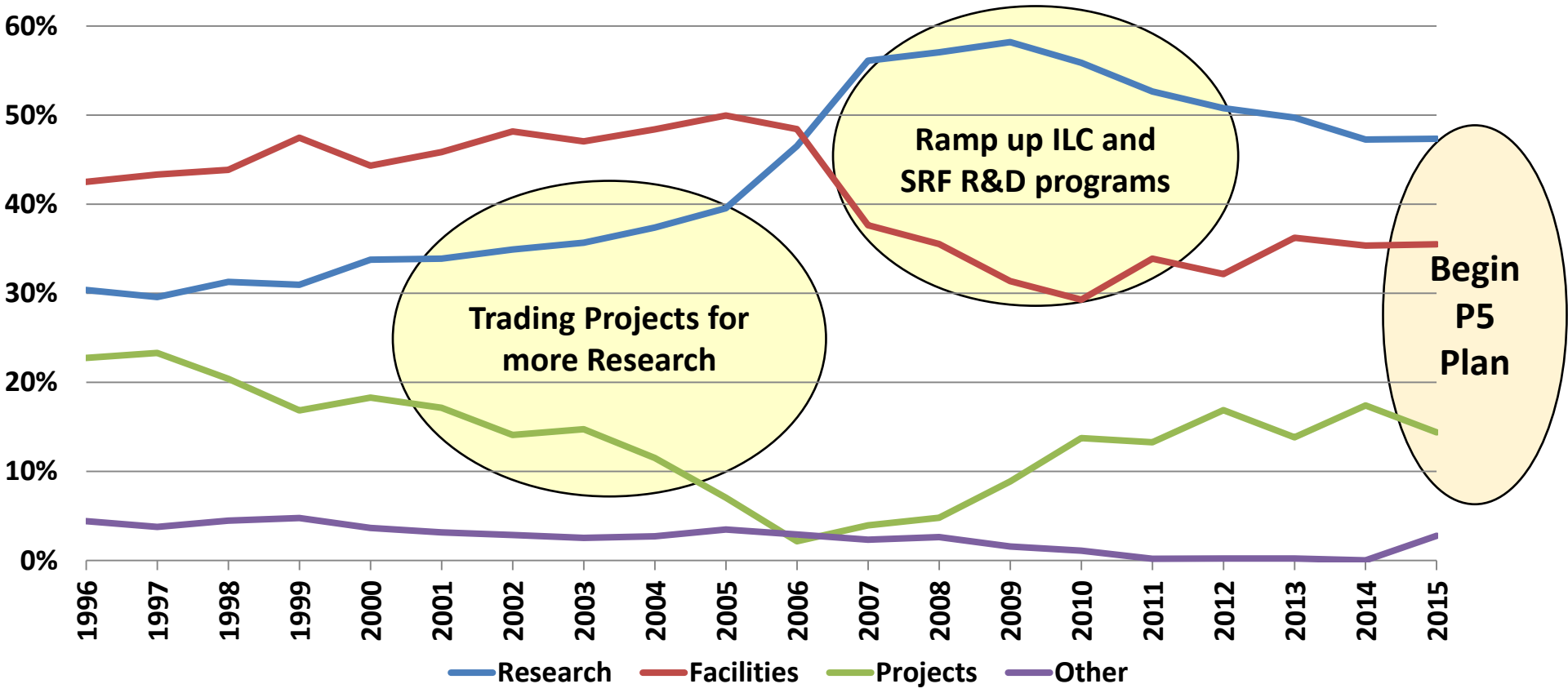
• **Program optimization criteria**
– **Science**: based on the Drivers, assess where we want to go and how to get there, with a portfolio of the most promising approaches.
– **International context**: pursue the most important opportunities wherever they are, and host world-leading facilities that attract 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 *(in $K)*	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
Cosmic Frontier	**80,063**	**96,927**	**101,245**	**Ramp-up of LSSTcam**
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	
Total*	**727,523**	**774,920**	**744,000**	

***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 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 (through 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


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, K0TO

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 → 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

- **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

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 further develop/optimize program following the P5 report**

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
Grants	*12,233*	*13,157*	
National Laboratories	*36,419*	*39,555*	
Facility Operations and Experimental Support	10,111	10,357	7,238
Projects	19,159	30,705	41,000
MIE	*9,500*	*22,900*	*41,000*
HAWC - FY13 completed	*1,500*	*…*	*…*
*Large Synoptic Survey Telescope Camera (LSSTcam) – **FY14 start***	*8,000*	*22,000*	*35,000*
Second Generation Dark Matter (DM-G2)	*…*	*900*	*6,000*
Future Project R&D	*9,659*	*7,760*	*…*
TOTAL	**77,951**	**93,729**	**93,673**
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.

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 planning a review of Cosmic Frontier operating experiments later in 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

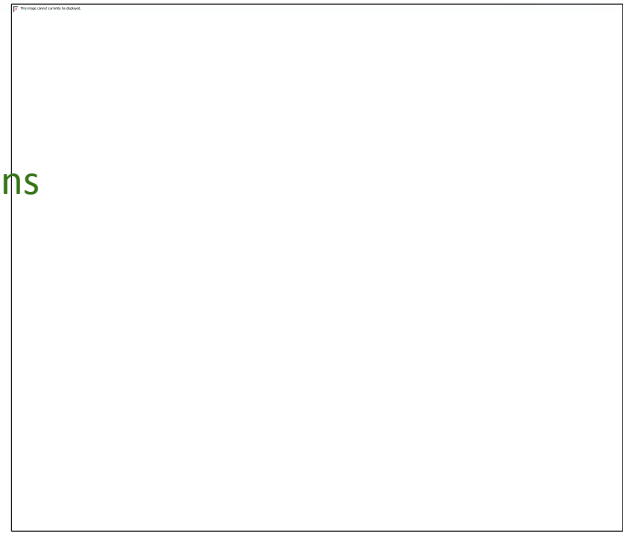
HEP Response:

- 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 2nd year of operations
  - DOE/NSF partnership; DOE responsible for camera
- **Supernova surveys continue operations**



LSST

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

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
- CD-2 "baseline" review in November 2014 (starts tomorrow!)

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-III" 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
  - CD-1 review held Sept. 9-11, 2014; R&D in FY2015; MIE 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:

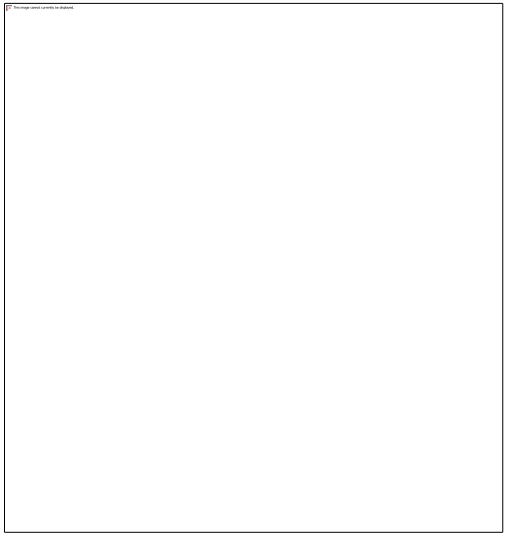
- The P5 recommendation will be used to highlight the importance of the DESI and argue for the additional funds needed to implement it as a high priority.
- (The FY15 President's Request does not include fabrication funding or a request to approve the start of fabrication)
- A successful Independent 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)

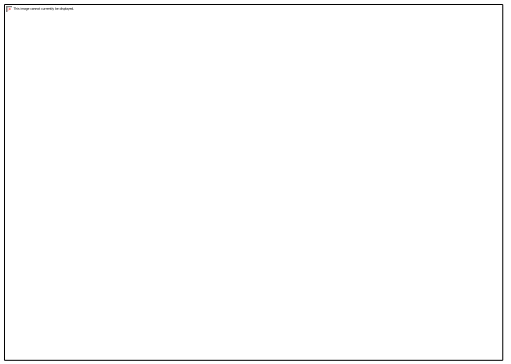
- **Weakly Interacting Massive Particle (WIMP) searches**
  - **SuperCDMS-Soudan** (cryogenic germanium)
  - **LUX** (liquid xenon) - **Top story of the year in *Nature Magazine* "2013 in Review"**
  - **DarkSide-50** (liquid argon)
  - **COUPP-60** (bubble chamber fluids)
- **Search for Axions (convert 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**
    - ADMX-G2 (small project) starts fabrication in FY2015
    - LZ, SuperCDMS-SNOLAB (MIE projects) planning for fabrication start in FY2016
    - LZ CD-1 review being planned for January 2015.



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.
- 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
  - **ADMX-Gen2** to search for axions
  - Coordinated efforts in **R&D** to test and develop a broad range of technologies for future experiments

Dark Matter Direct Detection Program – Status & Strategy

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.

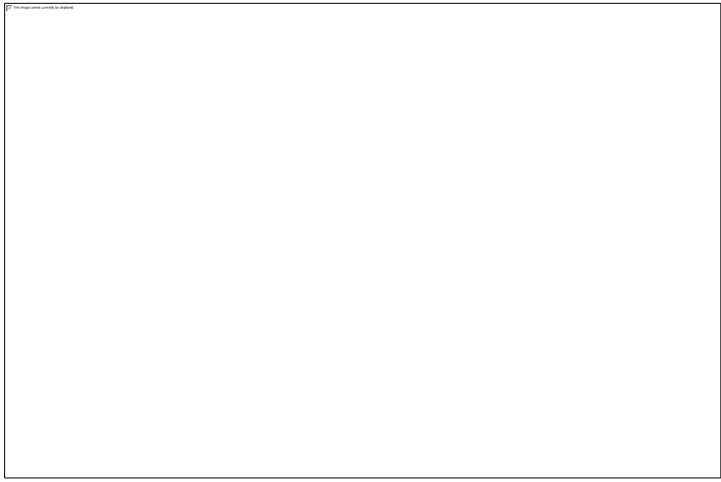
Cosmic Microwave Background (CMB) – Status & Strategy

→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
  - 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

Fabrication

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

Future Planning

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

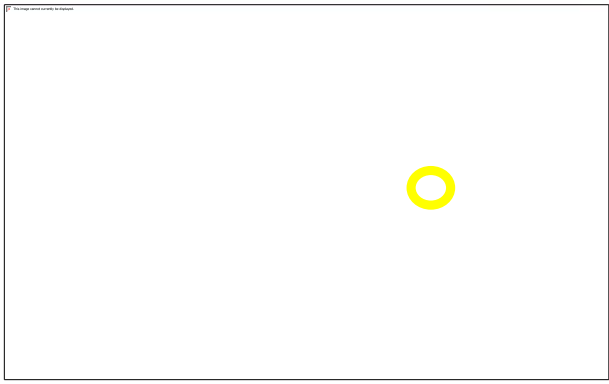
P5 #18: Support CMB experiments as part of the core particle physics program. The multidisciplinary nature of the science warrants continued multi-agency support.

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 later 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



AMS on the International Space Station

Operating

- **Alpha Magnetic Spectrometer (AMS);** launched 2011
  - Cosmic ray observatory on the International Space Station (ISS)
    - 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

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:

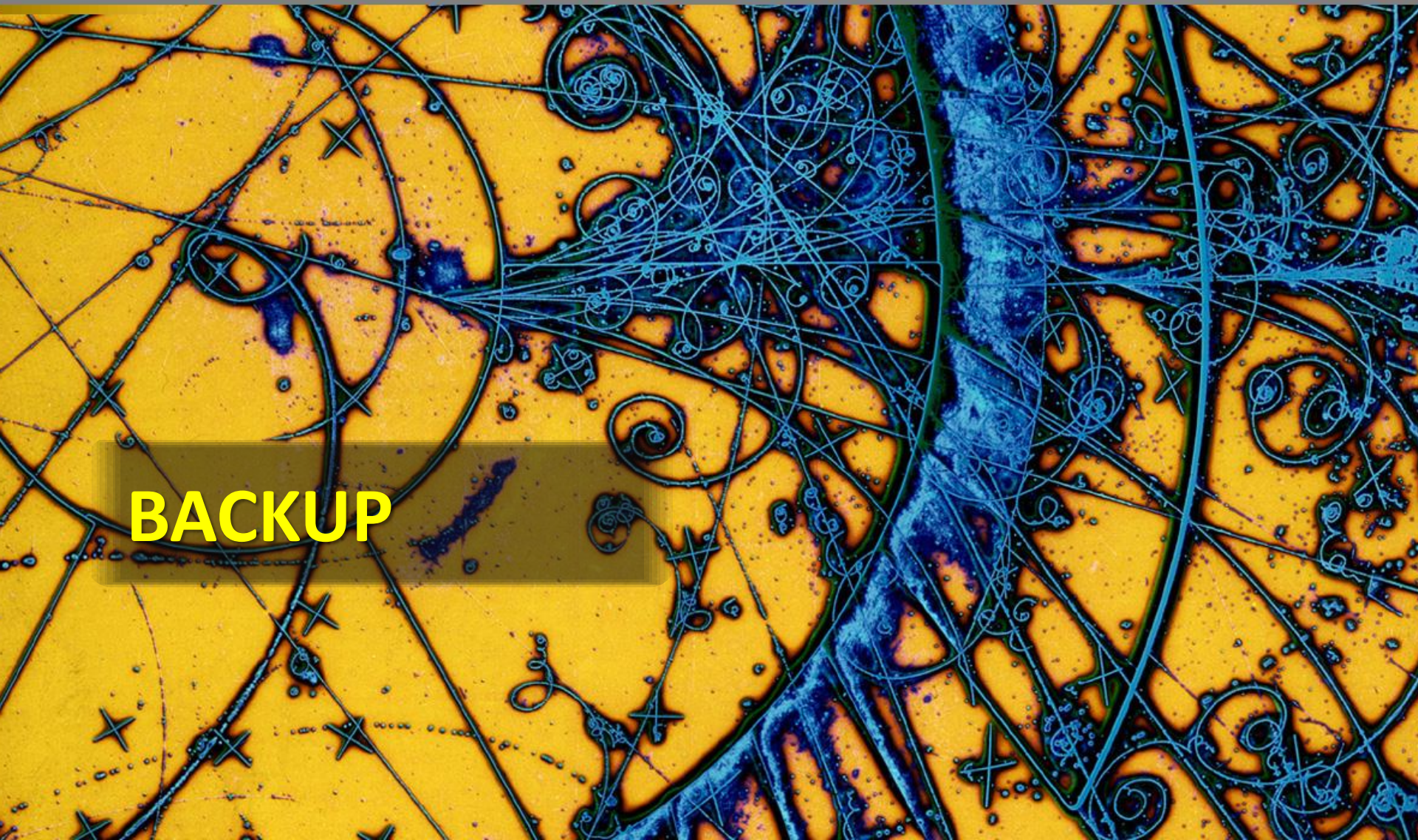
➔HEP isn't continuing support of research or R&D efforts on CTA.

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.

SUMMARY

- **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.


BACKUP

FY 2015 HEP Funding by Activity

HEP Funding Category *($ in K)*	FY 2013 Actual	FY 2014 Actual	FY 2015 Request	Explanation of Changes (FY15 vs. FY14)
Research	364,766	373,932*	352,227	Research reductions support project investments
Facilities	265,123	278,683	264,208	Small decrease in Cosmic Frontier operations as some experiments ramp down
Projects	85,853	71,305	81,970*	
Energy Frontier Projects	*0*	*0*	*15,000*	*LHC detector upgrade Major Item of Equipment (MIE) projects*
Intensity Frontier Projects	*63,494*	*37,400*	*24,970*	*Belle-II ramp down, FNAL acc. upgrade R&D reduction*
Cosmic Frontier Projects	*19,159*	*30,705*	*41,000*	*LSSTcam fabrication support and R&D related project costs*
Other Projects	*3,200*	*3,200*	*1,000*	*Lattice QCD hardware project completion*
Construction (Line Item)	11,781	51,000	25,000	Mu2e on profile; LBNE reduced in FY15 request (request made during P5 report development)
SBIR/STTR	0	0	20,595	
Total	**727,523**	**774,920**	**744,000**	

*** FY 2014 Research supported R&D for projects seeking starts in FY 2015**

Table of FY15 Request vs. Senate & House

Funding in $K	FY 2014 Actual	FY 2015 Request	FY 2015 House Mark	FY 2015 Senate Mark
Energy Frontier	152,386	153,639	157,888	156,069
Intensity Frontier	250,987	251,245	266,691	244,939
Cosmic Frontier	96,927	101,245	103,056	106,641
Theoretical and Computational	64,275	58,850	60,670	60,416
Advanced Technology R&D	150,270	114,242	125,605	119,638
Accelerator Stewardship	9,075	***19,184***	***3,000***	***19,184***
Construction	51,000	25,000	37,000	47,000
SBIR/STTR	0	20,595	21,090	20,595
Total	**774,920**	**744,000**	**775,000**	**774,482**

- **House and Senate marks very similar in total, above President's Request**
  - House language includes MIEs for ATLAS/CMS Phase I upgrades and DM-G2
- **Accelerator Stewardship very different between House and Senate marks**

Science Drivers and Research Frontiers

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

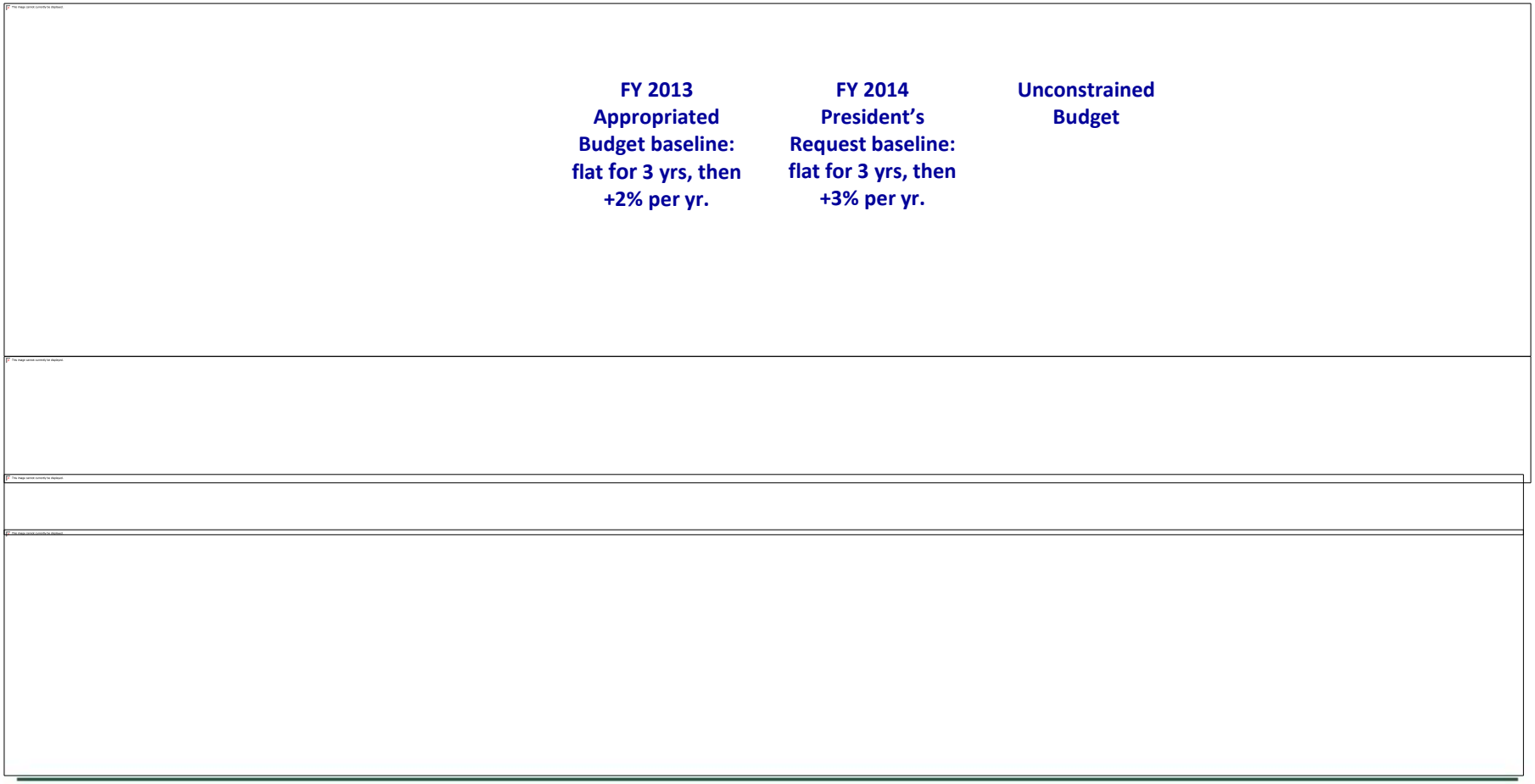
HEP Cosmic Frontier Program Experiments – current, planning

October 2014

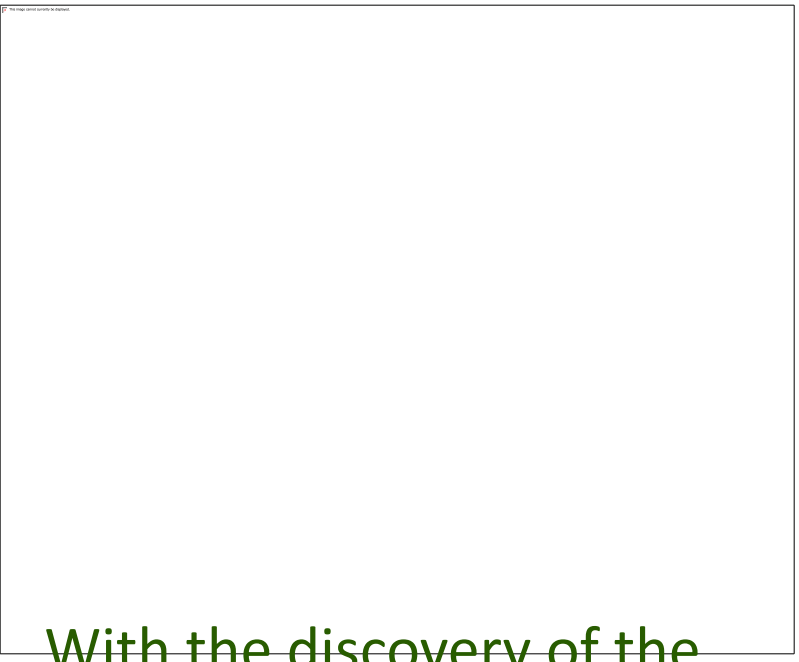
Experiment	Location	Description	Current Status	# Collaborators (# US, HEP)	# Institutions (# US, HEP)	# Countries
Baryon Oscillation Spectrosopic Survey (BOSS)	APO in New Mexico	dark energy stage III (spectroscopic)	operations ended in FY14	230 (150 US, 40 HEP)	(22 US, 8 HEP)	7
Dark Energy Survey (DES)	CTIO in Chile	dark energy stage III (imaging)	operations started Sept. 2013	300	25 (13 US, 9 HEP)	6
Large Synoptic Survey Telescope (LSST) - Dark Energy Science Collaboration (DESC)	Cerro Pachon in Chile	dark energy stage IV (imaging)	science studies, planning	232 (200 US, 134 HEP)	53 (41 US, 16 HEP)	3
Large Synoptic Survey Telescope (LSST) - LSSTcam Project	Cerro Pachon in Chile	dark energy stage IV (imaging)	CD3a approved; FY14 Fabrication start; CD2 review Nov. 2014	142 (111 US, 111 HEP)	17 (11 US, 11 HEP)	2
Dark Energy Spectroscopic Instrument (DESI)	KPNO in AZ (plan)	dark energy stage IV (spectroscopic)	CD0 approved Sept 2012; CD1 review Sept 2014	180 (95 US, 72 HEP)	42 (23 US, 18 HEP)	13
DM-G1: Axion Dark Matter eXperiment (ADMX-IIa)	Univ Washington	dark matter - axion search	operating	24 (20 US, 17 HEP)	7 (6 US, 3 HEP)	2
DM-G1: Chicagoland Observatory for Underground Particle Physics (COUPP-60); now PICO	SNOLab in Canada	dark matter - WIMP search	operating	60 (26 US, 8 HEP)	14 (6 US, 1 HEP)	5
DM-G1: DarkSide-50	LNGS in Italy	dark matter - WIMP search	operating	122 (66 US, 12 HEP)	26 (12 US, 3 HEP)	7
Large Underground Xenon (LUX)	SURF in South Dakota	dark matter - WIMP search	operating	102 (86 US, 64 HEP)	18 (15 US, 13 HEP)	3
Super Cryogenic Dark Matter Search (SuperCDMS-Soudan)	Soudan in Minnesota	dark matter - WIMP search	operating	83 (72 US, 44 HEP)	20 (17 US, 7 HEP)	3
DM-G2: ADMX-G2	Univ Washington	dark matter - axion search	Selected July 2014; Moving to fabrication phase in FY15	31 (29 US, 20 HEP)	8 (7 US, 4 HEP)	2
DM-G2: SuperCDMS-SNOLAB	SNOLab in Canada	dark matter - WIMP search	Selected July 2014; planning CD1 in FY15	94 (83 US, 54 HEP)	20 (17 US, 7 HEP)	4
DM-G2: LZ	SURF in South Dakota	dark matter - WIMP search	Selected July 2014; planning CD1 review in Jan. 2015	154 (118 US, 107 HEP)	28 (18 US, 17 HEP)	3
Very Energetic Radiation Imaging Telescope Array System (VERITAS)	FLWO in AZ	gamma-ray survey	operating	92 (74 US, 32 HEP)	20 (15 US, 5 HEP)	4
Pierre Auger Observatory	Argentina	cosmic-ray	operating	463 (51 US, 12 HEP)	100 (20 US, 5 HEP)	18
Fermi Gamma-ray Space Telescope (FGST) Large Area Telescope (LAT)	space-based	gamma-ray survey	June 2008 launch; operating	319 (157 US, 73 HEP)	49 (14 US, 3 HEP)	9
Alpha Magnetic Spectrometer (AMS-02)	space-based (on ISS)	cosmic-ray	May 2011 launch; operating	600	60 (6 US, 2 HEP)	16
High Altitude Water Cherenkov (HAWC)	Mexico	gamma-ray survey	Operations started in 2014	111 (54 US, 8 HEP)	31 (16 US, 2 HEP)	2

Projects Not Recommended by P5 Report

- **A number of projects were not recommended in any scenario**
  - Additional efforts beyond this list have been or will be curtailed (e.g. CTA)



The Standard Model & Known Unknowns



With the discovery of the Higgs, we have all the nominal pieces of the SM in place. But they don't all fit perfectly…

Known Beyond the Standard Model (BSM) physics:

- **Gravity at Microscopic Scales**
  - We have no theoretical model that works yet (but lots of ideas).
- **Earliest Moments of the Universe**
  - What caused the rapid early inflation of the universe? Is there a way to integrate inflation with the Standard Model?
- **Neutrino Masses**
  - Why are they so small? What is the mechanism that generates them?
- **Matter-Antimatter Asymmetry**
  - Matter exists and antimatter (almost) doesn't. We don't know why.
- **Dark Matter**
  - Clearly it exists. We have ruled out a lot of possible candidates but no clear evidence for what it is made of; the simplest explanations may be wrong.
- **Dark Energy**
  - Clearly it exists, but we don't know anything about it's nature.

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**

Accelerator Stewardship

- **Authorized for the first time in FY 2014 as a redirection of funds**
  - An initial Stewardship program was identified in discussions with Office of Science (SC) Basic Energy Sciences (BES) and Nuclear Physics (NP)
  - Program elements for FY 2015 awaiting appropriations
  - First Accelerator Stewardship call for proposals for FY 2015
    - Three applied R&D topic areas recommended by the Accelerator Task Force, and developed by subsequent workshops
      - Particle Beam Therapy Improvements
      - Ultrafast Laser R&D
      - Energy Efficiency Improvements for SC Accelerators
    - A basic R&D category for long-term generic accelerator R&D
    - Merit review process underway now
    - Awards subject to available funding
  - Accelerator Test Facility Pilot Program for FY 2015
    - Will gauge demand and nature of "outside" uses of SC accelerator R&D infrastructure
    - Defining agreement signed this summer. Will implement in FY 2015, subject to available funding

Advanced Technology R&D Strategy

- **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

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 planning a review of Cosmic Frontier operating experiments later in 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 (recommendation 4)

- 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 new project evaluation mechanism (e.g. the National Program Advisory Committee being considered by HEPAP) 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.

Cosmic Frontier – Dark Energy, CMB
(P5 Recommendations, OHEP Response)

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)

- 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.
- A successful Independent Project Review (IPR) will be used to show that DESI is ready to receive funding if it becomes available. The IPR is scheduled for Sept 9-11, 2014 to evaluate DESI's readiness for CD-1. (Fabrication funding is not in the FY15 Request)
- HEP will move forward in planning DESI in coordination with NSF, including upcoming discussions regarding the model for the DESI program.

P5 #17: Complete LSST as planned.

- 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.

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 will use this recommendation to open discussions with traditional CMB research support agencies (NSF, NASA) to come to agreement on any major DOE roles.
  - Going forward, these meetings would be followed by community planning meetings.
- A review of the proposed DOE responsibilities on the SPT-3G Project is being held Sept. 25-26

Cosmic Frontier – Dark Matter
(P5 Recommendations, OHEP Response)

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.

- 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.
- 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.
- 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.

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 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 planned that will be directed in part to potential G3 technologies.

Cosmic Frontier – Cherenkov Telescope Array (CTA)
(P5 Recommendations, OHEP Response)

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.

NSF-AST has said publicly that its budget is unable to accommodate this project as a strategic initiative; Only possibility is the competed mid-scale program.

➔**HEP doesn't plan to continue support of research or R&D efforts on CTA.**

- This could be re-considered if NSF moves forward on the project and requests a partnership with DOE, based on priorities, funding etc.

Cosmic Frontier – HEP Strategy in Response to P5

→P5 report recommendations addressed several thrust areas of the Cosmic Frontier:

Dark Energy

- Build DESI as a major step forward in dark energy science; first project to add to HEP program when above the lowest funding scenario
- Complete LSST as planned

Dark Matter

- Proceed immediately with a broad second-generation (DM-G2) dark matter direct detection program
  - 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 (DM-G3) direct detection experiments
  - Guide DM-G3 by the results of the preceding (DM-G1, -G2) searches
  - Seek a globally complementary program and increased international partnership in DM-G3 experiments

Cosmic Microwave Background (CMB)

- Support CMB experiments as part of the core particle physics program
  - The multidisciplinary nature of the science warrants continued multiagency support

Gamma-ray Astrophysics

- Invest in CTA (Cherenkov Telescope Array) as part of the small projects portfolio if the critical NSF Astronomy funding can be obtained.

→HEP Path Forward:

- The Cosmic Frontier has high priority projects ready to start fabrication in FY16 (DESI and DM-G2). The LSST-camera project started fabrication in FY14.
- Planning for CMB program starting
- Not moving forward on CTA efforts
- To review the status of the operating experiments and ensure alignment with the P5 vision, HEP is planning a review of Cosmic Frontier operating experiments in December 2014 (last review was 2012).

Cosmic Frontier – Dark Energy, CMB
(P5 Recommendations, OHEP Response)

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)

- 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.
- A successful Independent Project Review (IPR) will be used to show that DESI is ready to receive funding if it becomes available. The IPR is scheduled for Sept 9-11, 2014 to evaluate DESI's readiness for CD-1. (Fabrication funding is not in the FY15 Request)
- HEP will move forward in planning DESI in coordination with NSF, including upcoming discussions regarding the model for the DESI program.

P5 #17: Complete LSST as planned.

- 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.

Cosmic Frontier – Dark Matter
(P5 Recommendations, OHEP Response)

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- 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 planned that will be directed in part to potential G3 technologies.

U.S. Portfolio of G2 Dark Matter Experiments

- **The U.S. portfolio of selected G2 dark matter investments will include the following:**
  - **LUX-Zeplin (LZ)** and **SuperCDMS–SNOLAB** for their collective sensitivity to both low and high-mass WIMPS
  - **ADMX-Gen2** to search for axions
  - Coordinated efforts in **R&D** to test and develop a broad range of technologies for future experiments

- **Schedule:**
  - Must get Congressional approval for start of the G2 projects. Until then, can engage in R&D activities only.
  - Cannot start new projects during a Continuing Resolution. However, House and Senate marks call for G2 project starts in FY15. Failure to get a project start in FY15 may end up causing a major delay in executing this program.
  - Originally planned with completion of fabrication in FY16, the schedule has now been extended to FY18

P5 Recommendations relating to DM R&D

- **"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."**
  - In response, we plan to support a healthy R&D effort as an important part of the DDDM program, assuming adequate Congressional levels of support
  - Many of the G2 review panel members emphasized the importance of continuing R&D on LAr DDDM technology and on bubble chamber techniques for potential use in future G3 experiments

Cosmic Frontier – Cherenkov Telescope Array (CTA)
(P5 Recommendations, OHEP Response)

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

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

Solicitations for Funding Support

- **Research Opportunities in HEP ("Comparative Review")**
  - Annual solicitation that is the funding vehicle for HEP research support
  - FY15 FOA to by released in a number of weeks.
- **Office of Science Early Career Awards**
  - Annual competition for young investigators
    - Within 10 years of Ph.D., 3 tries
    - $150k/$500k per year for 5 years (university/lab)
- **Office of Science Continuing Solicitation**
  - No deadline; renews every FY
  - Project R&D, small experiments (fab, operations), conferences, even research (lowest priority).
- **Ad hoc, topical solicitations (e.g., Second Generation DM)**
- **Research Opportunities in Accelerator Stewardship**
- **[Small Business Innovation Research]**
- **[Science Discovery through Advanced Computing (SciDAC)]**

Cosmic Frontier: Comparative Grant Review Statistics

Statistics on Received & Funded proposals:

	FY12			FY13			FY14		
	Amount	# proposals	# PI's	Amount	# proposals	# PI's	Amount	# proposals	# PI's
Request	$3.3M	11	21	$7.7M	28	53	$7.5M	29	40
Funded	$1.6M	5	12	$3.4M	20	28	$3.2M	19	25
Success rate	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.

There is a lot of pressure on the Cosmic Frontier program with respect to the support requested vs. funded. This is good. Lots of good people are interested in the program. We hope the program will grow to sufficiently support the growing portfolio of projects, as people redirect their efforts and new people join.

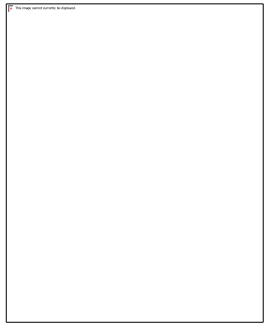
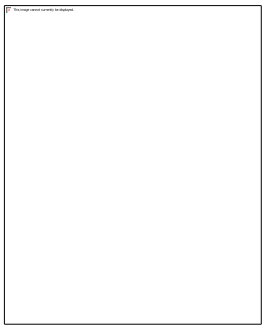
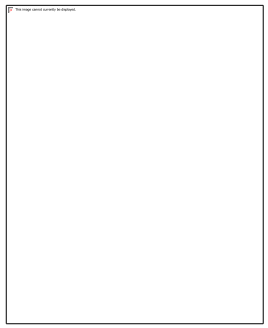
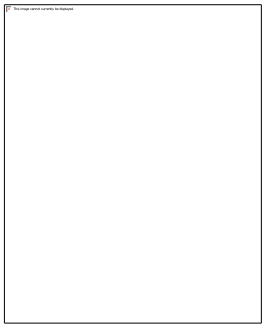
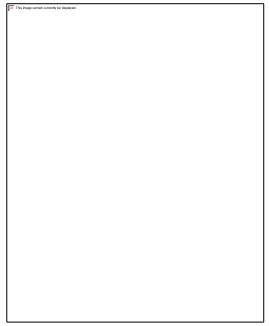
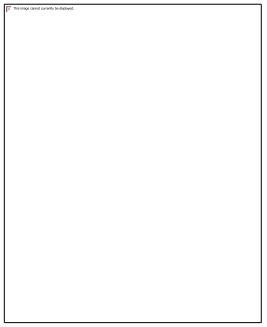
Cosmic Frontier – University Research Grant Funding by Thrust

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

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).

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

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)