DOE High Energy Physics (HEP)

report to the

AAAC Panel

➔ Update to Oct. 2016 report

26 January 2017
Glen Crawford (Research & Technology Division Director)

HEP Cosmic Frontier Program Managers:
Anwar Bhatti (IPA), Eric Linder (IPA), Michael Salamon, Kathy Turner
• Significant dip in FY13 from Congressional sequestration
• FY15 request developed prior to P5 report release; FY16 Budget puts HEP squarely in P5 Scenario B.
• FY17 – is currently in a Continuing Resolution

HEP BUDGET ALLOCATION BY FISCAL YEAR ($ IN K)

All funding shown in “then-year” U.S. dollars

- HEP must coordinate Projects, Facilities/Operations, and Research efforts to succeed in its mission
In recent years have traded Research for Project investments
HEP: FY 2017 President’s Request ($818M) aims to continue the successful implementation of the P5 strategy
• Investing in portfolio of high-priority projects at small, medium, & large cost scales
• Request is carefully balanced between support for projects ($212M), facility operations ($252M), and scientific research ($354M) in order to produce scientific results while “building for discovery”

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

Priorities: Carry out P5 Plan
• Continue to advance leadership efforts in the dark matter, dark energy experiments & projects
• In last few years, moved from operating a broad, diverse suite of experiments to focusing the science & carrying out next generation (i.e. larger) experiments.
• We are working hard to understand the Operations and Research funding needs for these new projects and plan out-year budgets appropriately.
## Cosmic Frontier Budget History – details

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<tr>
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<th>FY15 Pres. Request</th>
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Staged program of complementary suite of imaging & spectroscopic surveys

*eBOSS & DES* continue operations; *BOSS* operations completed 2014, final results
- Review of DES’ science case for proposed 6th year of operations in Dec. 2016

**LSST - stage IV imaging**
- NSF-AST and HEP partnership
- LSSTcam MIE Project (HEP responsibility) received CD-3 in August 2015
- Operations planning activities ramping up: LSST commissioning phase (*Review Jan. 2016*) and facility operations phase (*proposal in summer 2017*)
- Science: Dark Energy Science Collaboration (DESC) – *Review of Operations plan April 2017*

**DESI – stage IV spectroscopic**
- HEP experiment, using NSF’s Mayall telescope facility (NSF’s NOAO is collaborator)
- DESI MIE Project received CD-3 in June 2016
- Project Status & Operations Planning reviews (in series) planned for summer 2017
- DESI science collaboration active

- HEP has research-only activities on *Euclid, WFIRST, & supernova surveys*
Staged program w/multiple technologies covering complementary phase space

Completed DOE operations support for current DM-G1 experiments in FY 2016.

HEP & NSF-PHY selected suite of 3 DM-G2 Projects (below) in July 2014
- Axion search; 2 WIMP searches over complementary mass range & technologies

ADMX-G2 (<MIE project) – axion search at U. Washington
  – Carry out series of experiments with dedicated upgrades for each frequency range
  – Status: Commissioning completing; Operations starting
  – FNAL is taking over Operations Management for Approved Range (0.5 to 2 GHz) operations

LZ (MIE Project) – Wimp search at Homestake Mine
  • CD-2/3B approval August 2016; CD-3 review for full fabrication start in Jan. 2017

SuperCDMS-SNOLab (MIE; partner w/NSF-PHY) – Wimp search
  • CD-1 approval December 2015; planning towards CD-2/3 in early FY18
  • Status mini-review Dec. 2016

Operations planning activities ramping up for all DM-G2’s
CMB

• SPT-3G (< MIE project) - partnership with NSF (PLR, AST, PHY)
  – HEP contributed to detector & now operations
  – Status: Commissioning completing and Operations starting

• HEP has research-only activities on a number of the current experiments

• CMB-S4 - Collaboration has developed a Science Book; significant Lab-led LDRD efforts

Cosmic-ray, Gamma-ray

• Operations continuing for Fermi/GLAST, AMS, and HAWC

• DOE operations funding completed in FY 2016 for VERITAS and Auger
Cosmic Frontier
Interagency & International Activities

**Interagency Coordination:** NSF, NASA, DOE interact regularly about planning, overlaps, issues

**Agency Joint Oversight Groups (JOG) & Agency Coordination Groups (ACG)**
- International Finance Board for FGST w/NASA-AST, Auger (HEP effort completed)
- DES, LSST: JOG with NSF-AST
- HAWC, SuperCDMS, VERITAS: JOG with NSF-PHY (also CONACYT for HAWC)
- SPT-3G: JOG with NSF-PHY, NSF-AST & NSF-PLR
- DESI: ACG with NSF-AST

**Tri-Agency Group (TAG)** – DOE, NASA, NSF-AST meetings with US-leadership on LSST, WFIRST, Euclid to discuss commonalities, coordination, optimization of data, simulations, software - starting investigation of what needs to be done now to allow Joint Data Processing & share simulations across projects.

**International:** Making country-level agreements for science partnerships; Agency Bi-lateral meetings

**Astro-Particle International Forum (APIF) – Agency-level group**
Global Science Forum hosted through 2016; KIPAC (SLAC/Stanford) has taken over as host with Roger Blandford as Chair.

**National Academies of Science Decadal Survey 2020** – Planning starting with Agencies & Community
Cosmic Frontier ➔ looking towards the future

**HEP “Cosmic Visions (CV)” groups in several areas**

- Allows interactions with small HEP community groups as 2-way line of communication for HEP-funded efforts and directions recommended by P5
  (NOTE: Of course, any HEP-funded R&D/technology plans need to be in the context of the larger non-HEP and global community)

**CV-CMB**

- Coordinate HEP technology R&D & planning efforts for future CMB-S4 (within purview of CMB-S4 CDT subpanel)

**CV-DE**

- Investigate future HEP directions following DESI & LSST project completion; optimizing science in DESI/LSST era and/or follow-on projects

**CV-DM**

- Coordinate and investigate HEP technology R&D to optimize science from DM-G2 experiments and for future DM-G3 planning
Following Snowmass & P5
- Community-based CMB-S4 collaboration developed a Science Book and a notional array
- HEP labs putting considerable LDRD into developing technology
- In the last year, HEP & NSF held discussions regarding possible avenues & processes for CMB-S4

Concept Definition Taskforce (CDT)
NSF and DOE presented plan in Oct. 2016 meeting to charge AAAC to carry out a CDT subpanel study.

- Charge letter (officially signed 11/21/16) by NSF-AST, -PHY,-PLR & DOE-HEP
- AAAC Chair Buell Jannuzi appointed Charles Lawrence (JPL) as CDT Chair; Members selected

See: https://www.nsf.gov/mps/ast/aaac/cmbs4cdt.jsp

- Phone meetings (~ biweekly) & “assignments” have started – First meeting 12/8/16
- F2F meetings #1 & 2 scheduled for end January, early March
**P5 Recommendations**

- Search for dark matter (DM) particles is a high science priority
- Maintain diversity of project scales (i.e. ensuring we also have small projects in program)

- It is important to cover all relevant phase space to the extent feasible.
- Majority of current efforts are aimed at WIMP/axion searches in Cosmic Frontier
- Accelerator-based experiments in Intensity Frontier are searching for dark sector particles
- LHC and other data searches for DM candidates (but aren’t dedicated dark matter search experiments).

There are also considerable theoretical studies of dark matter.

**Path Forward:** To respond to P5, HEP is interested in community input on the science case and experimental possibilities for small (whole project ~ $10 million or less) dark matter projects in unexplored parameter space (i.e. mass ranges or types of particles) not currently being (or on track to be) explored.

→ Can be non-accelerator or accelerator-based experiments!

The CV-DM group (group expanded to accelerator-based people) is spearheading a path to get this community input: Hold Community Workshop, followed by a White Paper by ~ June 2017

→ CV-DM Community Workshop being planned for March 23-25, 2017 at Univ of Maryland (www site public soon); see APS-DPF announcement on listserve on 1/11/17.

Based on results (and funding availability as always!), HEP could move forward with R&D to determine feasibility and process to select concepts to develop.
January 2017:  
Presidential Early Career Awards for Scientists and Engineers (PECASE) award to Eric Dahl (Northwestern & FNAL) for his work in dark matter detection  
See  

September 2016:  
Julian Borrill (LBNL/UCB) won the NASA Exceptional Public Achievement Medal for "conceiving and implementing the mission-critical high performance computing system for Planck data analysis".  
See  

January 2016:  
Roy Kerr, University of Canterbury, and Roger Blandford, Stanford University won the Crafoord Prize in Astronomy 2016 from the Swedish Royal Academy of Sciences “for fundamental work concerning rotating black holes and their astrophysical consequences”.  
http://www.crafoordprize.se/press/arkivpressreleases/thecrafoordprizesinmathematicsandastronomy2016.5.76308e0c152098549fa15a0.html
Summary

P5 developed compelling, realistic strategic plan with a community consensus vision

→ The HEP FY 2017 Budget Request continues the implementation of the P5 vision

• Close coordination with the other agencies; significant partnerships.

Cosmic Frontier Program – Exciting Time!

- 4 MIE Projects in Fabrication Phase
- 2 small Projects Fabrication → Finishing commissioning & starting Operations

• Research Support: Need to ensure Science work force to adequately carry out all phases of the Experiments (design, fabrication, operations, science analysis)

• Significant ramp-up in planning for Experiment Operations & Science

Future Planning:

o HEP Cosmic Visions Groups continuing
o Dark Matter – investigating small project for unexplored areas of phase space
o CMB - AAAC subpanel started to carry out a CMB-S4 Concept Definition Taskforce
o 2020 Decadal Survey planning started
BACKUPS
May 2014 P5 Strategic Plan
Recommendations - Cosmic Frontier

• Dark Energy
  – Complete LSST as planned
  – Build DESI as a major step forward in dark energy science

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

• Cosmic Microwave Background (CMB)
  – Support CMB experiments as part of the core particle physics program
  – The multidisciplinary nature of the science warrants continued multi-agency support
    (CMB-S4 Project is in the P5 plan, starting about mid-way through their 10 year plan)

• Cosmic Rays and Gamma Rays
  – Invest in CTA only if the critical NSF Astronomy funding can be obtained
    • CTA has a broad science reach that transcends fields, with the dark matter detection capabilities of direct importance to particle physics; Using P5 Criteria, a de-scoped US component should be shared by NSF-AST, NSF-PHY and DOE.
Cosmic Frontier – Program Planning, P5 Implementation

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

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

Develop Program following the P5 Plan & considering P5 Criteria:

• Science goals and how it will address DOE-HEP goals
• Make unique, significant, coherent contributions to facilities/experiments selected for the program at a level commensurate with expected science return on HEP physics goals
  o Roles & responsibilities in line with our contributions/expertise
  o What does HEP community bring to the table?
    Need to bring unique, visible, leadership contributions, especially if it’s an area usually supported by another agency. Typically this is expertise in developing & delivering state-of-the-art instrumentation, lab infrastructure & project management, “big data” computing facilities and expertise, and having a cohesive science collaboration to carry out all phases of the project/experiment and deliver precision results.
• For facilities with broader science program (e.g. astronomy facilities) than the interests of the HEP program, make project contributions at appropriate level & support research efforts for our science interests
• Balance & Stages: Staged implementation, results; varying project size; complementary and varying methods/technologies; balance between science areas and speculative/guaranteed results
FY 2014-2017 HEP Program - Budget Status

<table>
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<th>HEP Budget History ($K)</th>
<th>FY14 PRB</th>
<th>FY14 Actual</th>
<th>FY15 PRB</th>
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*FY14 SBIR/STTR was ~ $21M, so FY2014 actual was ~ $796M.
PRB = President’s Request Budget

**FY16**: The enacted budget was above the Request and squarely in P5’s Scenario B.
**FY17**: We are currently in a CR
→ Planning is difficult… We typically have plans for a full-year CR, the PRB and then the enacted budget

Research: Carefully planning to maximize science impacts; funding is flat in FY17 President’s Request
Cosmic Frontier: Through ground-based telescopes, space missions, and deep underground detectors, research at the cosmic frontier aims to explore dark energy and dark matter, which together comprise approximately 95% of the universe.

Program Areas
- Study the nature of Dark Energy
- Direct Detection searches for Dark Matter particles
  - CMB – Inflationary era, Neutrino properties
- Cosmic-ray & Gamma-ray & Other studies – particle properties, high energy acceleration mechanisms, indirect searches for dark matter particles, computational cosmology

Program Guidance
FACA panels provide official advice:
- HEPAP – Primary advice for the program
  - Subpanels: P5 2014 (previously P5 2008, PASAG 2009)
- AAAC (Astronomy and Astrophysics Advisory Committee) - Advises DOE, NASA, and NSF and Provides Annual Report to Congress et al.
  - Subpanels: CMB-S4 CDT starting; (previous w/HEPAP: TFCR 2006, DETF 2006, DMSAG 2007
- National Academy of Sciences (NAS)

Community science studies and input (e.g. Snowmass, Cosmic Visions groups)
We request that the AAAC establish a CMB-S4 CDT subcommittee to develop a concept for a CMB-S4 experiment.

Take as input the CMB-S4 Science Book & further information as appropriate, including global landscape of experiments on the ground, balloons, and space.

Specifically, the CDT is asked to deliver:

- The Science Requirements and their rationale
- Measurement and Technical Requirements derived from Science Requirements
- Project Strawman Concept
- Options and Alternatives (prioritized to the extent possible) for:
  - Concept design (e.g. sites, telescopes, detectors)
  - Concept staging and schedule
  - Collaboration and Data models and interfaces
- R&D development needed, with priorities, to demonstrate technical readiness
- Cost ranges for strawman concept, including explanations for how developed
The CDT should provide a report on the Science and Measurement Requirements to the AAAC by June 2017 and a final report to AAAC by October 2017 for consideration.

[The CDT’s] deliberations and recommendations will inform the agencies on a concept for the CMB-S4 and contribute to the agencies’ planning activities. The formation of the CDT does not imply any commitment by the agencies to specific funding or project status for CMB-S4.

Signed (completed 11/21/16)
Denise Caldwell, NSF-PHY
Eric Saltzman, NSF-PLR
James Siegrist, DOE-HEP
James Ulvestad, NSF-AST

Agency Points of Contact:
Richard Barvainis, NSF-AST
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