



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Status of the DOE High Energy Physics Program

HEPAP Meeting, April 6, 2014

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DOE HEP PROGRAM STATUS

Enabling the Next Discovery

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



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



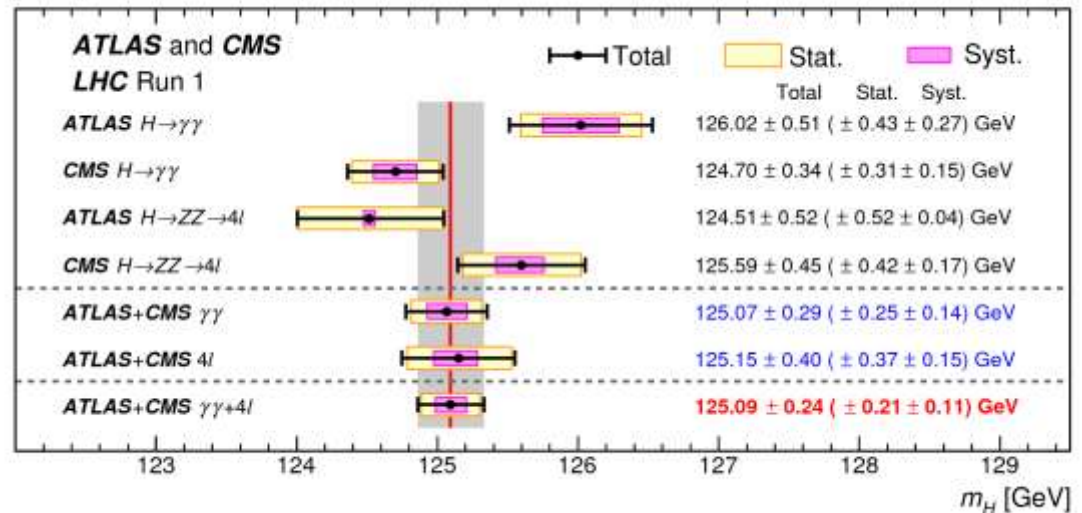
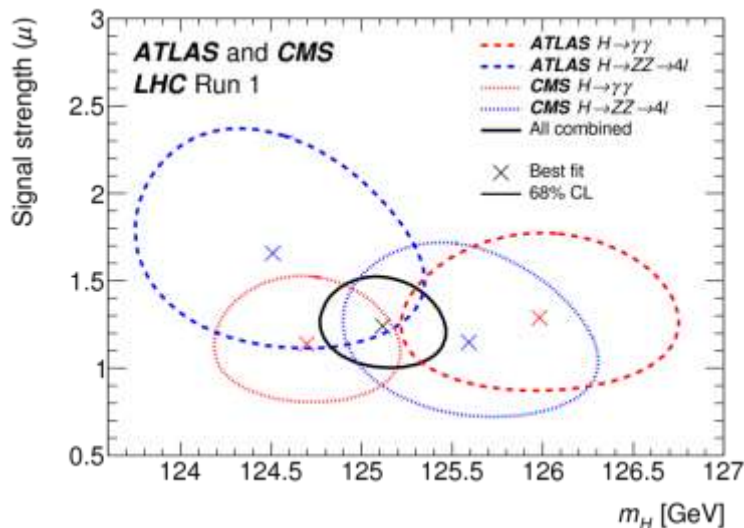
ENERGY FRONTIER

SL 153-12 E 2 WD

Energy Frontier Highlight:

Combined ATLAS and CMS Higgs Mass Measurement

- ATLAS and CMS recently released a combined measurement of the Higgs boson mass
 - 1st combination of the Higgs mass by the LHC experiments
 - Combines $H \rightarrow \gamma\gamma$ and $H \rightarrow ZZ \rightarrow 4\ell$ channels from both experiments
 - Measured masses from the individual channels and the two experiments are found to be consistent among themselves
 - $m_H = 125.09 \pm 0.21$ (stat.) ± 0.11 (syst.) GeV (0.19% precision!)



Energy Frontier Highlight:

LHC Prepares for Run 2

- **LHC restarted this past weekend, on April 5, 2015!**
 - Circulating beams achieved in opposite directions, passing through the detectors of all 4 LHC experiments
 - First collisions of Run II could begin as early as next month
- **Higher energy collisions at 13 TeV will increase the reach into search for new physics in high-impact topics:**
 - SUSY, dark matter, extra dimensions, ...
 - Run II aiming for an integrated luminosity $\sim 100 \text{ fb}^{-1}$
 - Higgs boson was first observed using $\sim 10.5 \text{ fb}^{-1}$



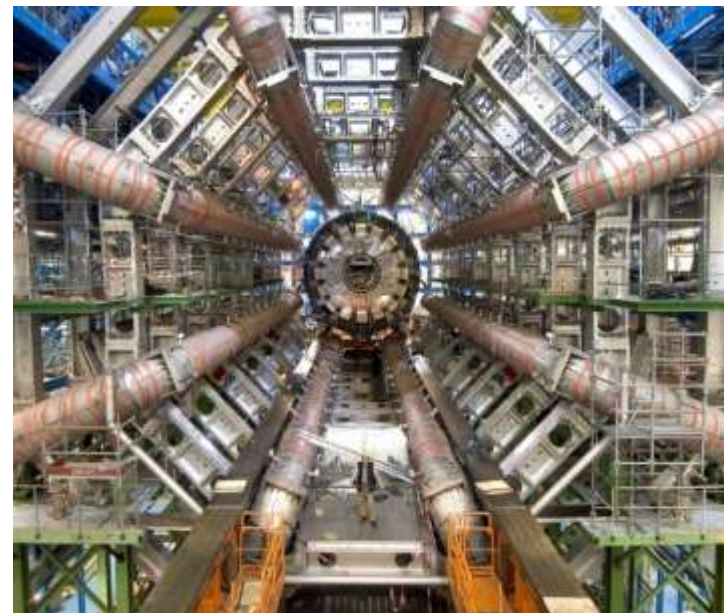
Energy Frontier Status Update

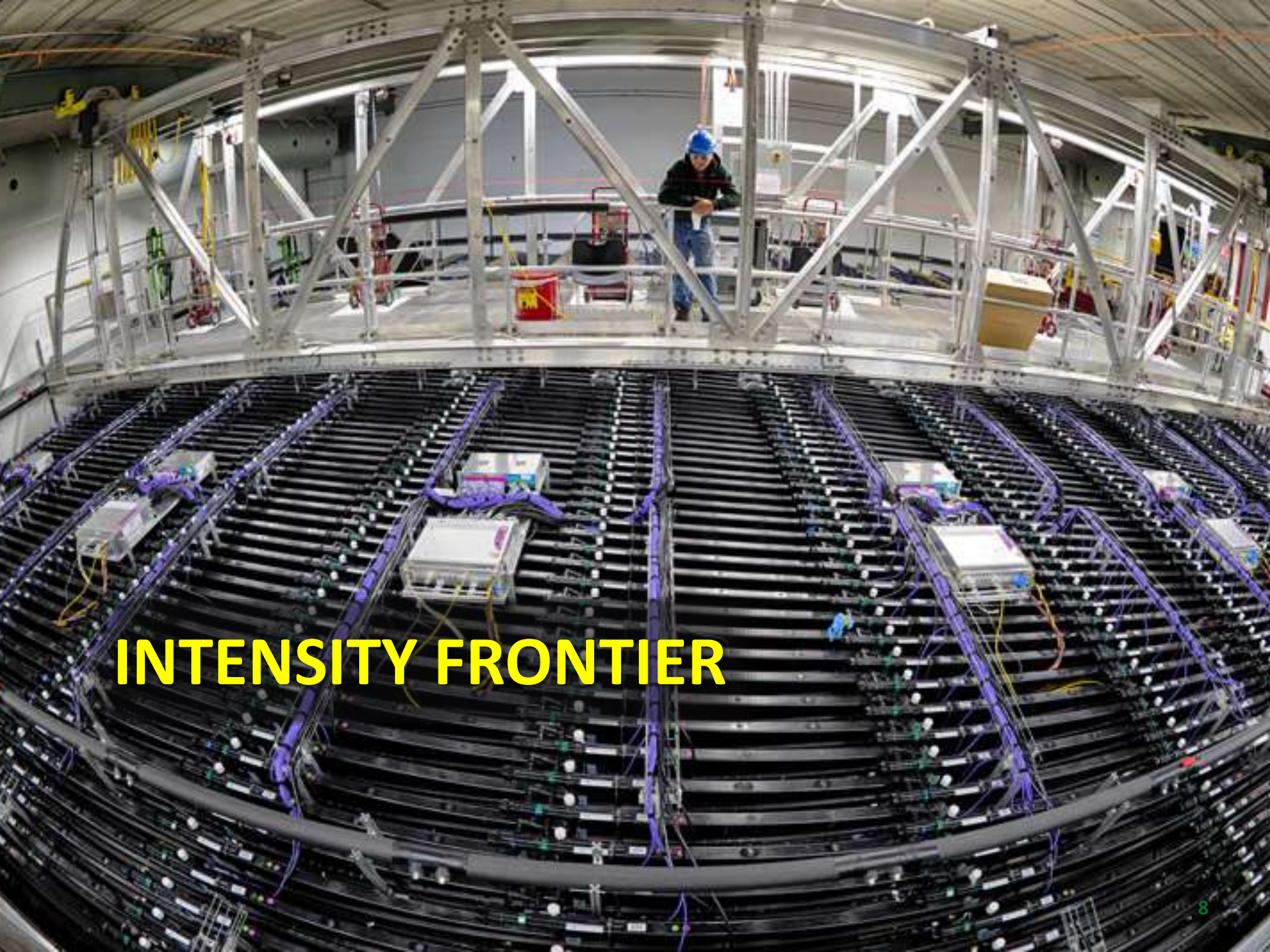
Current program

- 400+ LHC Run I papers submitted by *each* of the ATLAS and CMS Collaborations
- 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
 - Phase-1 U.S. CMS/ATLAS upgrades received CD-2/3 approval on November 12, 2014

Planned program

- Considering high-luminosity LHC upgrade around 2023 to extend discovery reach
 - Increase luminosity by 10 times LHC design value to explore new physics at TeV energies
 - DOE/HEP actively working with US-CMS/ATLAS to begin mounting HL-LHC Detector Upgrade Project
- The new bilateral CERN-DOE-NSF Cooperation Agreement is nearing signature
 - DOE has initiated drafting of the 3 Annexes (\equiv Protocols) to the umbrella agreement
- Modest investments in R&D for future options:
 - Lepton colliders
 - Very high energy hadron colliders





INTENSITY FRONTIER

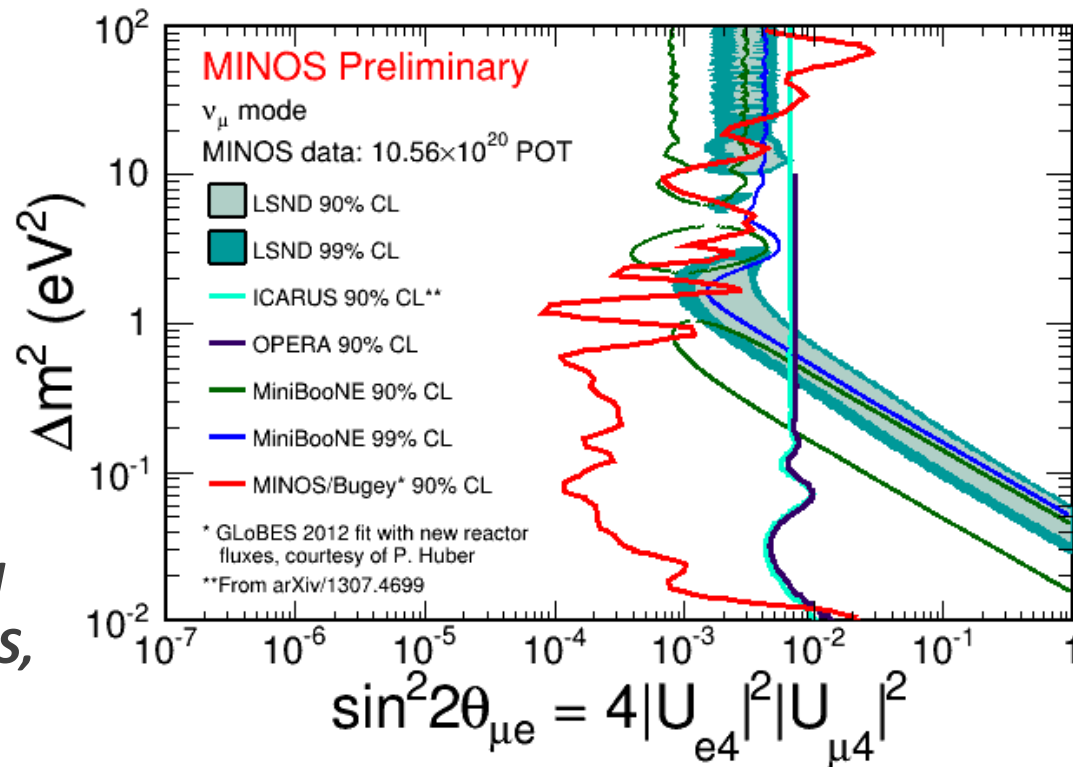
Intensity Frontier Highlight:

MINOS/MINOS+ Further Constrain Sterile Neutrinos

- MINOS/MINOS+ continues exploiting MINOS data and will be soon combining results with MINOS+
 - The MINOS/MINOS+ experiments are sensitive to several exotic oscillations channels, including sterile neutrinos

Combining MINOS NC and CC disappearance data with ν_e disappearance data from the Bugey Reactor gives combined limits comparable to MiniBooNE, LSND, ICARUS, and OPERA

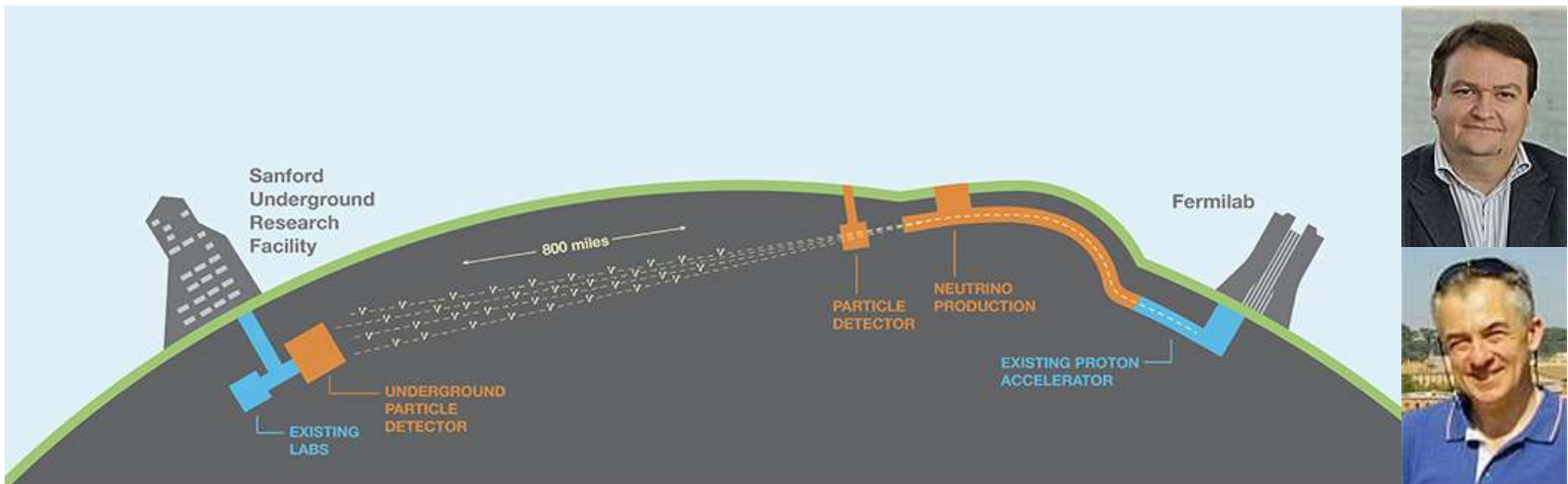
New results with 1st year's full dataset to be presented at APS, April 11th!



Intensity Frontier Highlight:

International Collaboration Established for DUNE

- The long-baseline neutrino experiment has transformed into the Deep Underground Neutrino Experiment (DUNE)
 - Major milestone in the implementation of the P5 report strategy
- Collaboration includes 700 scientists from 23 countries in Asia, Europe, and North and South America
 - André Rubbia (ETH Zurich) and Mark Thomson (University of Cambridge) have been elected spokespersons of the international collaboration
- First collaboration meeting April 16—18 at FNAL
 - DUNE seeks further international partners to participate in this world-class experiment!
- DOE is working with the International LBNF/DUNE programs to develop the organizational structure



Intensity Frontier Status Update

Exploring the unknown through precision measurements

- **Development of muon-beam based program at Fermilab continues:**
 - *Muon g-2*: Cryogenic test of the SC magnet system will be completed before baselining
 - *Mu2e*: Reached CD-2/3 on March 4, 2015
- **Collaborating with Japan on *K* meson, *c/b* quark, and τ lepton precision studies:**
 - *Belle II*: reached CD-3 in April 2014
 - *KOTO*

Identify the physics of dark matter

- ***APEX* and *Heavy Photon Search* performing particle beam based searches for DM**
 - *Heavy Photon Search (HPS)* expects first physics run this month!

Pursuing the physics associated with neutrino mass

- **Mass hierarchy & ν properties studied at Fermilab, Japan, China, and underground:**
 - *Daya Bay*, *MicroBooNE*, *MINERvA*, *MINOS+*, *NOvA*, *Super-K*, *T2K*
- **Sterile neutrino search and neutrino CP violation program continues to evolve:**
 - Fermilab short-baseline neutrino (SBN) program will complement *MicroBooNE* with *ICARUS* arrival in 2017, *LAr1-ND* installation in 2018
 - Workshop on Intermediate Neutrino Program (WINP) at BNL provided useful input for taking the next step in the non-FNAL neutrino program
 - *DUNE* established as international long-baseline neutrino experiment

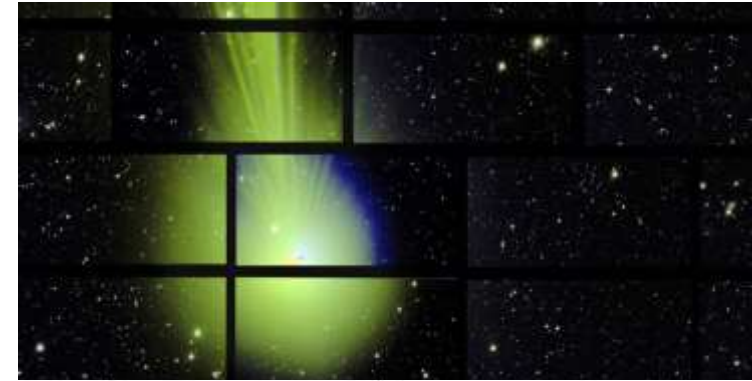
A large industrial facility, likely a particle accelerator or detector assembly hall. The central feature is a massive blue cylindrical structure, possibly a cryogenic storage vessel or a detector component. A complex white and black mechanical arm system, resembling a robotic manipulator or a transport system, is positioned around the structure. The arm has multiple joints and is supported by a network of white beams. The background shows a large, curved structure with a white circular opening. The floor is concrete, and there are yellow safety railings and various equipment scattered around. The lighting is bright, with several overhead lights illuminating the scene.

COSMIC FRONTIER

Cosmic Frontier Highlight:

DES Discovers Dwarf Galaxies, FGST Constrains Dark Matter

- Images from the Dark Energy Survey's 570-megapixel camera moves science forward as they continue to make headlines
 - Partnership with NSF; DECam mounted on the 4-meter Victor Blanco Telescope in the Chilean Andes
 - Captured a popular image of comet Lovejoy on December 27, 2014
- DES data has led to the discovery of 9 new dwarf satellite galaxies orbiting the Milky Way
 - Dwarf satellite galaxies are dominated by dark matter and present an excellent cosmic laboratory to search for signs of dark matter annihilation
 - Fermi Gamma-ray Space Telescope used the newly discovered dwarf galaxies to put a tight limit on dark matter annihilation cross-section
 - DES may find as many as 30 dwarf galaxies in the region of the sky it scans
 - 4 papers out in March 2015 using these data – from DES and FGST collaborations and independent work



Cosmic Frontier Status Update

Dark Energy

- *BOSS* and *DES* anticipate releasing new results soon!
- *Large Synoptic Survey Telescope (LSST)* received CD-3a in June 2014, CD-2 in Jan. 2015
 - CD-3 review scheduled for August
- *Dark Energy Spectroscopic Instrument (DESI)* received CD-1 in March 2015
 - CD-2 review scheduled for July; fabrication start approved in FY 2015
 - Finalizing MOA with NSF to transition Mayall telescope operations costs to DOE in FY2016 – FY2019

Dark Matter (direct detection)

- Progress continues on DM-G2 experiments: *ADMX-G2*, *LZ*, *SuperCDMS-SNOlab*
 - *LZ* & *SuperCDMS-SNOlab* MIE projects are approved for fabrication starts in FY 2015
 - *LZ* held CD-1 review in March 2015, *SuperCDMS-SNOlab* will have CD-1 review in summer 2015

Cosmic-ray, Gamma-ray

- *Fermi/GLAST*, *AMS*, and *HAWC* continue operations
 - *HAWC* gamma-ray observatory began taking data in late November 2014
- DOE operations efforts will complete in FY 2016 for *VERITAS* and *Auger*

Cosmic Microwave Background (CMB)

- *South Pole Telescope polarization (SPTpol)* continues operations
- *SPT-3G* had successful review of DOE roles/responsibilities in September 2014
 - Fabrication funding approved for FY 2015 – 16
- Community planning continues for a CMB Stage IV experiment

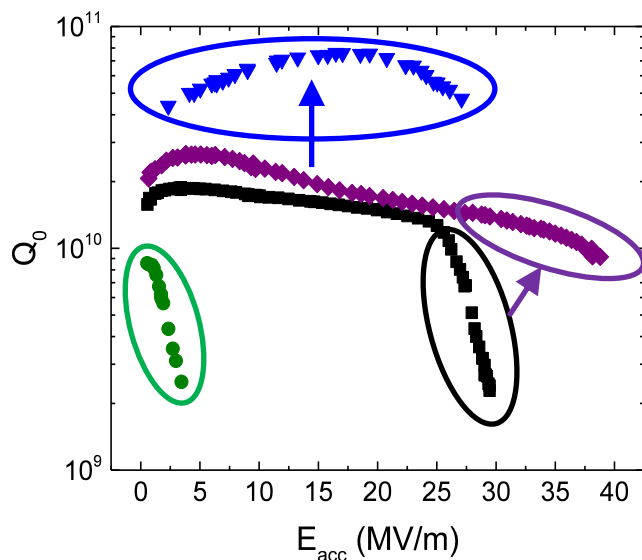
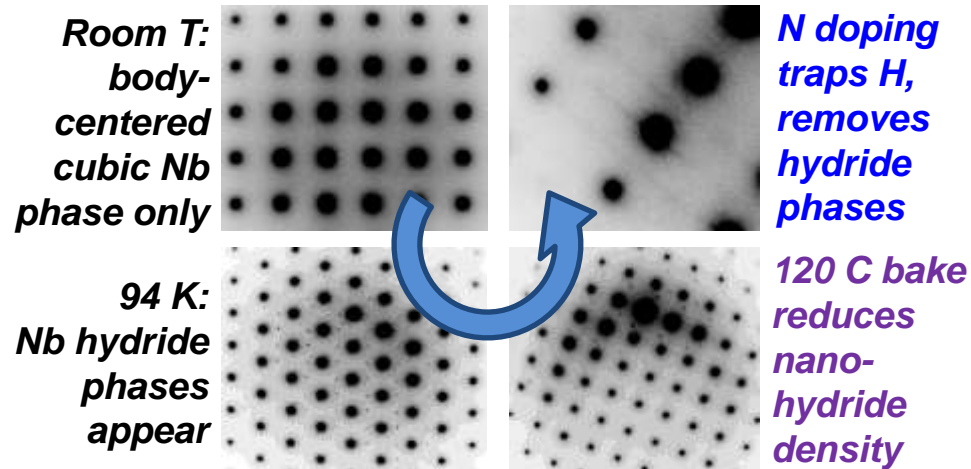


ADVANCED TECHNOLOGY R&D

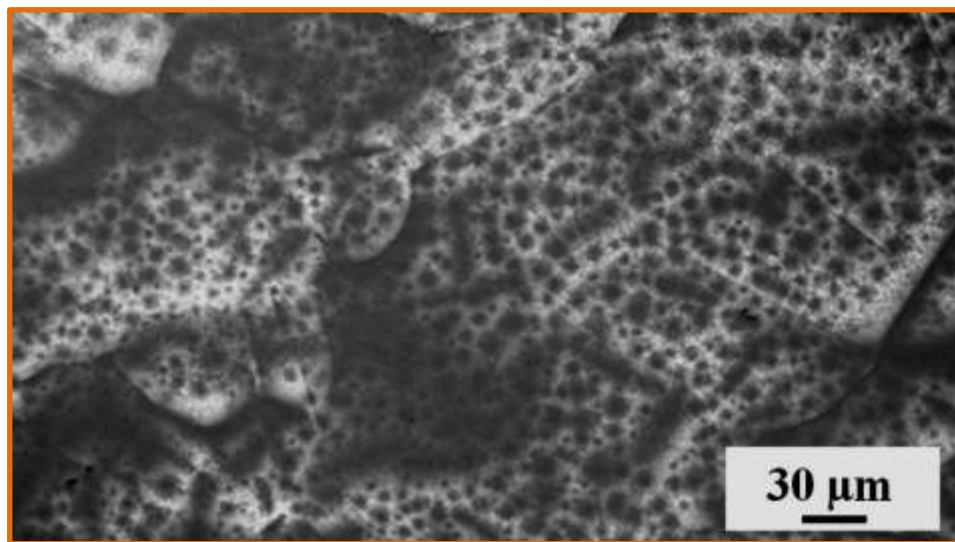
Advanced Technology R&D Highlight:

Advances in SRF Performance

- Recent SRF advancements have been driven by fundamental understanding of the underlying physics of the cavity surface
 - Microscopic mechanism of “Q-disease”
 - Origin of the “high field Q slope”
 - Mechanism of the “120 C baking”
 - Nitrogen doping to increase Q
 - Effect of cooling dynamics on Q



Trapped magnetic vortices imaged via Bitter Decoration

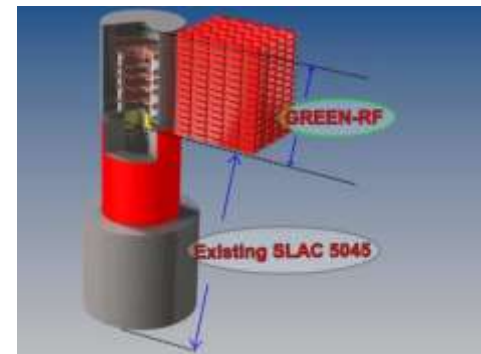
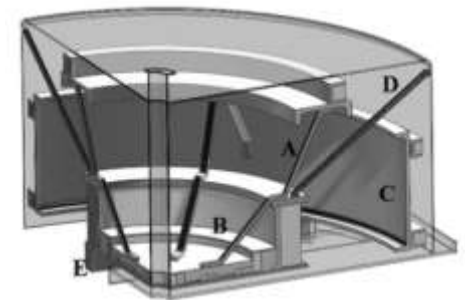
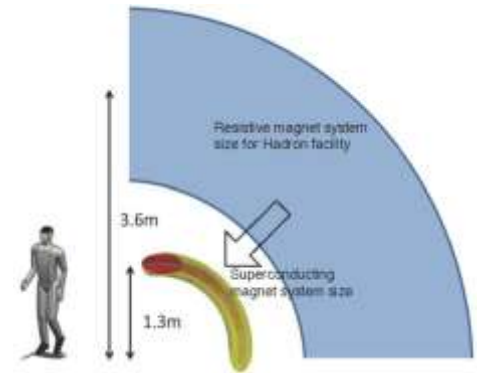


A large, complex, metallic structure, likely an accelerator component, illuminated by blue and yellow lights in a dark environment. The structure consists of several large, rounded, metallic sections connected in a line, with a smaller, cylindrical component on the left. The background is dark with some structural elements visible.

ACCELERATOR STEWARDSHIP

Accelerator R&D Stewardship Program Awards

- Two awards coordinated with the National Cancer Institute of the National Institutes of Health, targeting particle-beam-based cancer therapies:
 - LBNL, Paul Scherrer Institute, and Varian Particle Therapy, Inc.
 - Light-weight SC magnets to reduce the size and weight of particle beam delivery systems by nearly a factor of 10
 - MIT and ProNova Solutions, LLC
 - Innovative design for an ironless superconducting cyclotron capable of providing particle beams for cancer therapy
- Four grants coordinated with BES, NP, DOD and NSF focus on broad, promising new areas for improving general accelerator performance:
 - LBNL, LLNL and University of Michigan
 - Test technologies that promise to increase the speed of laser-based science by a factor of 1,000
 - SLAC and Communications & Power Industries, LLC
 - Energy recapture technology that could be applied to LCLS and other klystron-powered linacs
 - Cornell University
 - Advanced optimization techniques to automate the control of complex accelerators
 - Texas A&M
 - Beam dynamics in cyclotrons to increase beam power





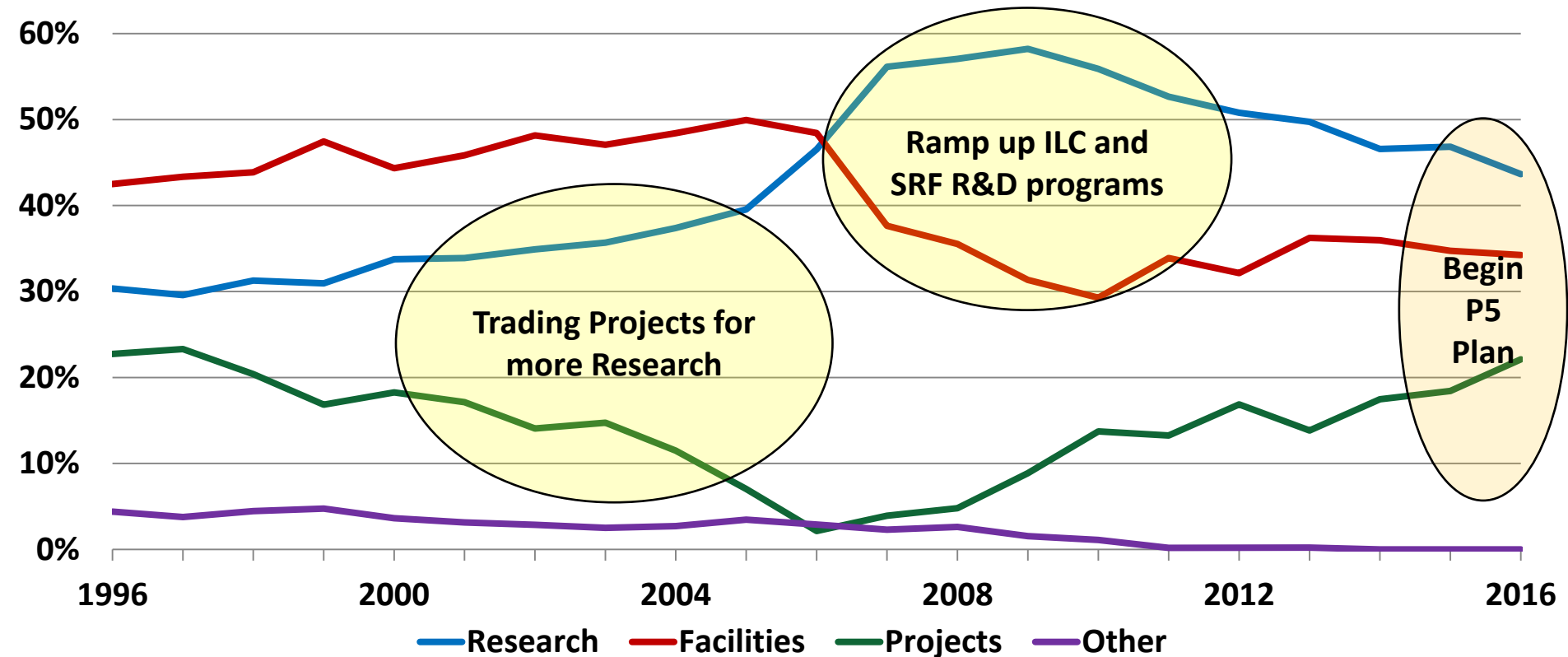
HEP BUDGET AND ISSUES

The FY 2016 HEP Budget Request

- **HEP is implementing the strategy detailed in the May 2014 report of the Particle Physics Project Prioritization Panel (P5), formulated in the context of a global vision for the field**
 - HEP Addresses the five compelling science drivers with research in three frontiers and related efforts in theory, computing and advanced technology R&D
 - Increasing emphasis on international partnerships (such as LHC) to achieve critical physics goals
- **Energy Frontier: Continue LHC program with higher collision energy (13+ TeV)**
 - The U.S. will continue to play a leadership role in LHC discoveries by remaining actively engaged in LHC data analysis and the initial upgrades to the ATLAS and CMS detectors
- **Intensity Frontier: Develop a world-class U.S.-hosted Long Baseline Neutrino Facility**
 - Continue the design process for an internationalized LBNF and development of a short baseline neutrino program that will support the science and R&D required to ensure LBNF success
 - Fermilab will continue to send world's highest intensity neutrino beam to NOvA, 500 miles away to Ash River, MN
- **Cosmic Frontier: Advance our understanding of dark matter and dark energy**
 - Immediate development of new capabilities continue in dark matter detection with baselining of 2nd-generation experiments; and in dark energy exploration with baselining of DESI and fabrication of LSST camera.

Funding Trends by Fiscal Year

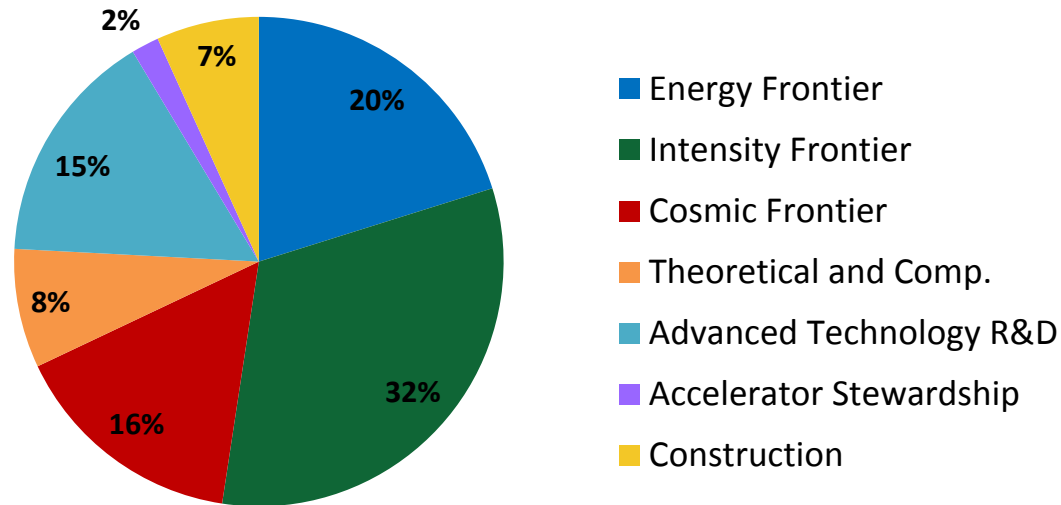
(FY 2016 shows President's Request)



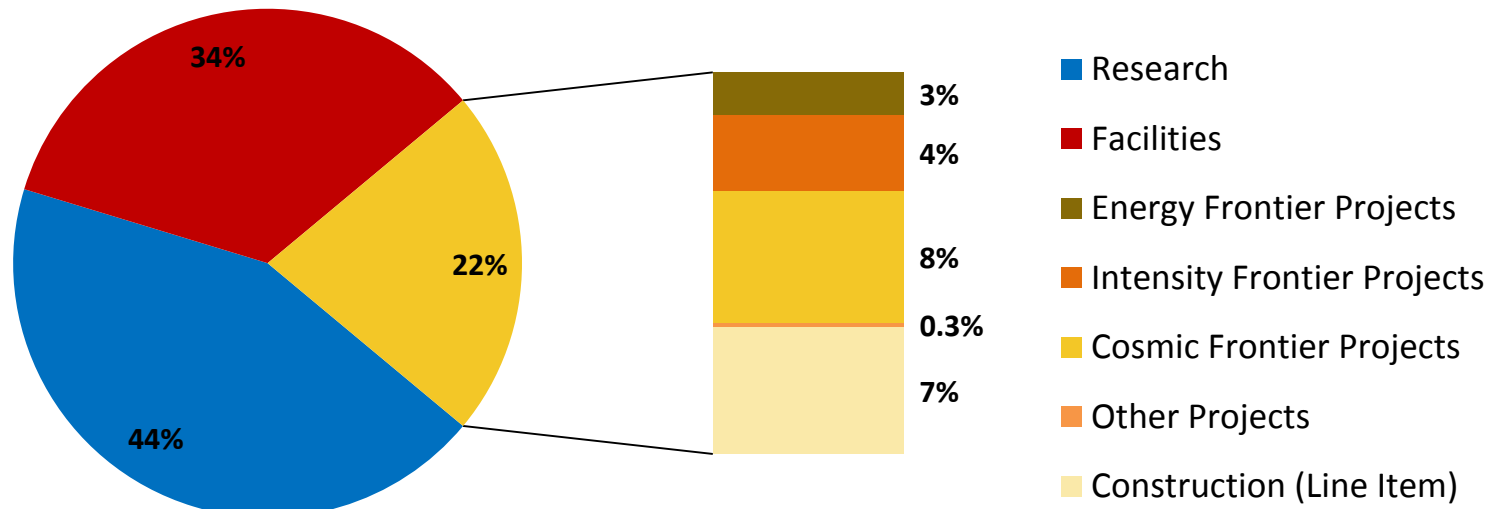
- P5 report recommendation suggests increasing the project budget fraction to 20%–25%
 - “Addressing the [science] Drivers in the coming and subsequent decades requires renewed investment in projects.”
- P5 report strategy has informed the HEP request in the FY 2016 DOE budget

FY 2016 HEP Budget Request Overview

HEP FY 2016 Request Funding by Subprogram

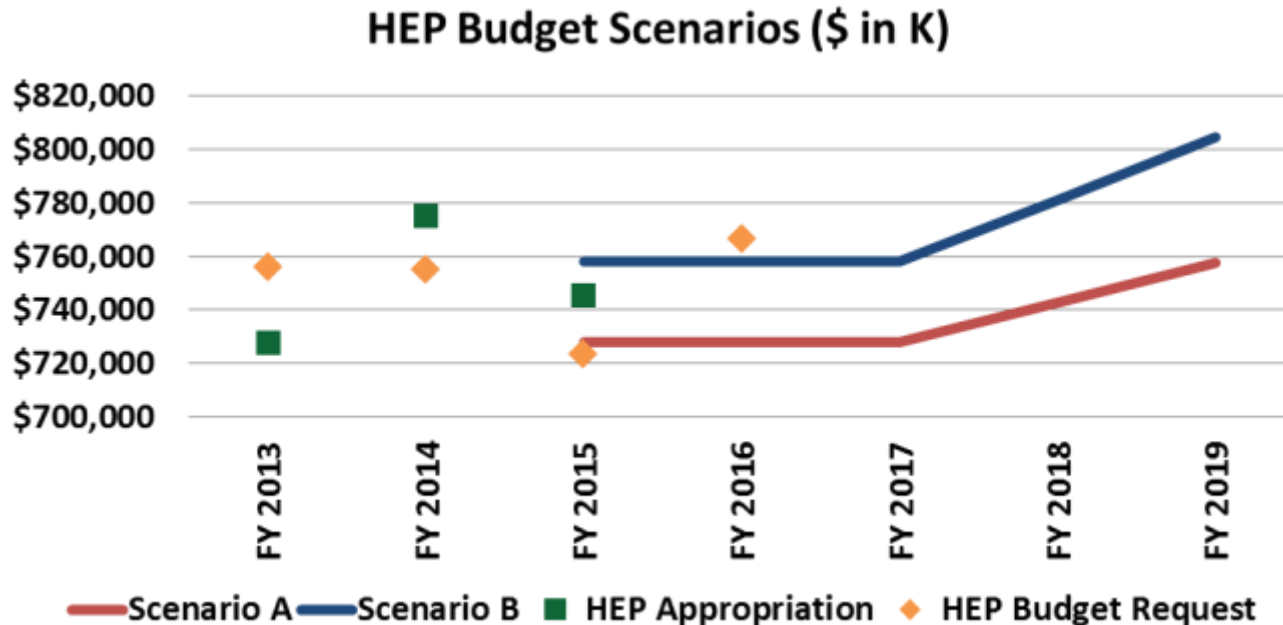


HEP FY 2016 Request Funding by Activity



Context: P5 HEP Budget Scenarios

- P5 was charged to consider three 10-year budget scenarios for HEP within the context of a 20-year vision for the global field
 - Scenario A was the lowest constrained budget scenario
 - Scenario B was a slightly higher constrained budget scenario
 - Scenario C was “unconstrained,” but not considered unlimited



**Budget Request and Appropriations do not include SBIR/STTR*

FY 2016 HEP Funding by Activity

HEP Funding Category (\$ in K)	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	Explanation of Changes (FY16 vs. FY15)
Research	373,932	337,383	334,703	<i>Research reductions support project investments</i>
Facilities	278,683	265,125	262,658	<i>Maintain efficient operations of facilities and ongoing experiments</i>
Projects	71,305	105,698	113,401	
<i>Energy Frontier Projects</i>	<i>0</i>	<i>15,000</i>	<i>19,000</i>	<i>Ramp up in LHC detector upgrades fabrication</i>
<i>Intensity Frontier Projects</i>	<i>37,400</i>	<i>43,970</i>	<i>33,700</i>	<i>Continue g-2 and FNAL acc. upgrade profiles; some LBNE efforts move to construction</i>
<i>Cosmic Frontier Projects</i>	<i>30,705</i>	<i>45,728</i>	<i>58,701</i>	<i>Increase supports LSSTcam, DESI and second generation dark matter experiments</i>
<i>Other Projects</i>	<i>3,200</i>	<i>1,000</i>	<i>2,000</i>	<i>Planned Lattice QCD hardware acquisition</i>
Construction (Line Item)	51,000	37,000	56,100	<i>Planned profile for Mu2e; engineering and design for LBNE</i>
SBIR/STTR	21,601*	20,794	21,138	
Total	796,521*	766,000	788,000	

FY 2016 High Energy Physics Budget

HEP Funding Category (\$ in K)	FY 2014 Current	FY 2015 Enacted	FY 2016 Request	Explanation of Changes (FY16 vs. FY15)
Energy Frontier	152,386	147,584	154,555	<i>LHC detector upgrade fabrication; R&D for high-luminosity LHC upgrades</i>
Intensity Frontier	250,987	264,224	247,196	<i>Operations and upgrade of NuMI for NOvA and MicroBooNE; R&D for LBNF and SBN</i>
Cosmic Frontier	96,927	106,870	119,325	<i>Planned ramp-up of LSSTcam; support of DESI and 2nd generation dark matter experiments</i>
Theoretical and Comp.	64,275	59,274	60,317	<i>Planned increase in Lattice QCD project; slight reduction in theory research efforts</i>
Advanced Technology R&D	150,270	120,254	115,369	<i>Reductions reflect shift to P5 priority areas; MAP reduction continues in response to P5</i>
Accelerator Stewardship	9,075	10,000	14,000	<i>Increase supports new research topic areas and expands open test facility efforts</i>
Construction (Line Item)	51,000	37,000	56,100	<i>Planned profile for Mu2e; engineering and design for LBNF</i>
SBIR/STTR	21,601*	20,794	21,138	
Total	796,521*	766,000	788,000	



IMPLEMENTING THE P5 STRATEGY

Implementing a World-Class Neutrino Program

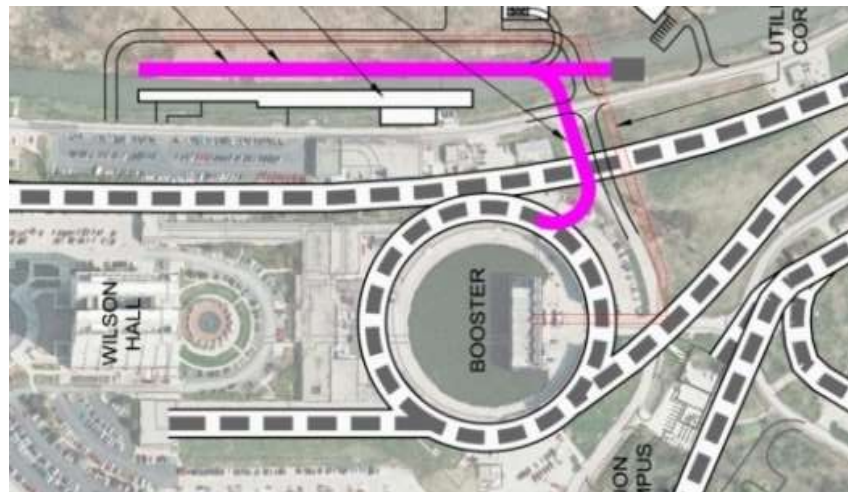
- **World-class short- and long-baseline neutrino program rapidly coming together, with strong support the international community**
 - Tomorrow's agenda includes highlights of the Workshop on the Intermediate Neutrino Program and discussion of the related Funding Opportunity Announcement
- **LBNF and DUNE are moving forward quickly and have presented plans that could present the opportunity to pursue scientific results from an underground detector in the early 2020s**
 - Next steps will include a “refresh” review of DUNE to assess the rapid progress that has been made in bringing together the international community
 - Outcome of this review and status of our international agreements with interested partners will inform any updates to the cost estimate and spending profile...

Accelerated Deployment of LBNF/DUNE

- **LBNF is prominent in being the first large infrastructure hosted by the U.S. for the international particle physics community**
 - This international effort is recognized as being important to the U.S. government
- **Accelerating the deployment of LBNF/DUNE would allow achieving science results early and enhance our ability to accommodate contributions from international partners**
 - Plans are being discussed that would accelerate the deployment of DUNE with of the first of four 10 kiloton underground detectors installed in the 2021 time frame
 - Realizing this schedule will be challenging!
- **We are investigating accelerating the LBNF/DUNE schedule in a way that aligns with the P5 vision to establish this international facility**

Proton Improvement Plan II (PIP-II)

- **P5 recommendation:**
 - “Upgrade the Fermilab proton accelerator complex to produce higher intensity beams. R&D for the Proton Improvement Plan II (PIP-II) should proceed immediately, followed by construction, to provide proton beams of >1 MW by the time of first operation of the new long-baseline neutrino facility.”
- PIP-II supports longer term physics research goals by providing increased beam power to LBNF while providing a platform for the future
- Infrastructure and workforce development due to LCLS-II work at Fermilab will be leveraged in support of PIP-II, further advancing SRF capabilities



SSR1



SSR2



LB650



HB650

P5 Guidance on Energy Frontier Machines

- P5 report identified LHC upgrades as the highest priority near-term large project and specifically recommends:
 - Complete “Phase-1” (2018) upgrades of ATLAS and CMS experiments
 - Continue collaborations for the accelerator upgrades for the High-Luminosity LHC and “Phase-2” upgrades of ATLAS and CMS (2023-25)
 - U.S. collaborates with CERN and global partners in superconducting magnet R&D, with particular emphasis on Nb₃Sn technology
- P5 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
- P5 recognized that a very high-energy proton-proton collider is the most powerful future tool for direct discovery of new particles and interactions under any scenario
 - Participate in global conceptual design studies and critical path R&D for future very high-energy proton-proton colliders
 - Continue to play a leadership role in superconducting magnet technology focused on the dual goals of increasing performance and decreasing costs
 - Eventual technical involvement in other R&D subjects will be informed by the HEPAP Accelerator R&D Subpanel Report

DOE Goals for Future Circular Collider Work

- **A critical first step is for active U.S. theorists to do their part to guide agreement in the U.S. (and global?) community on the energy and luminosity requirements of a very high energy proton-proton collider, while fleshing out physics goals and driving discussion in the U.S.**
 - The HEP community may want to establish a Snowmass-like process in this focused area to help engage the community in these studies
 - A limited, focused effort is required, since we must maintain balance with the current DOE program dedicated to implementing the exciting but challenging program that has been laid out for us by P5
- **DOE looks forward to receiving a white paper from the U.S. high-field magnet community for coordinated U.S. participation in an international R&D activity on SC magnets for a very high energy proton-proton collider**
 - Establishing a coordinated plan within the U.S. and with international partners is crucial for implementing a successful program
 - Builds on the successful collaboration on the LHC and HL-LHC magnets
 - Level of effort will be informed by the Accelerator R&D Subpanel Report

DOE Goals for ILC Work

- Japan has expressed interest in hosting the International Linear Collider (ILC) and is actively working through a decision making process
- As recommended in the P5 strategic plan, DOE plans to provide modest and appropriate support through the period of Japanese decision making
 - U.S. has played key roles in the design of the ILC accelerator, including leadership in the Global Design Effort
 - Continued intellectual contributions to the accelerator and detector design are still necessary to enable a site-specific bid proposal
 - P5 recommended ILC support at some level in all budget Scenarios through a decision point within the next 5 years
 - Report emphasized that support for these efforts would ensure a strong position for the U.S. within the ILC global project
- DOE is making an effort to maintain ILC accelerator activities in balance with other programmatic priorities

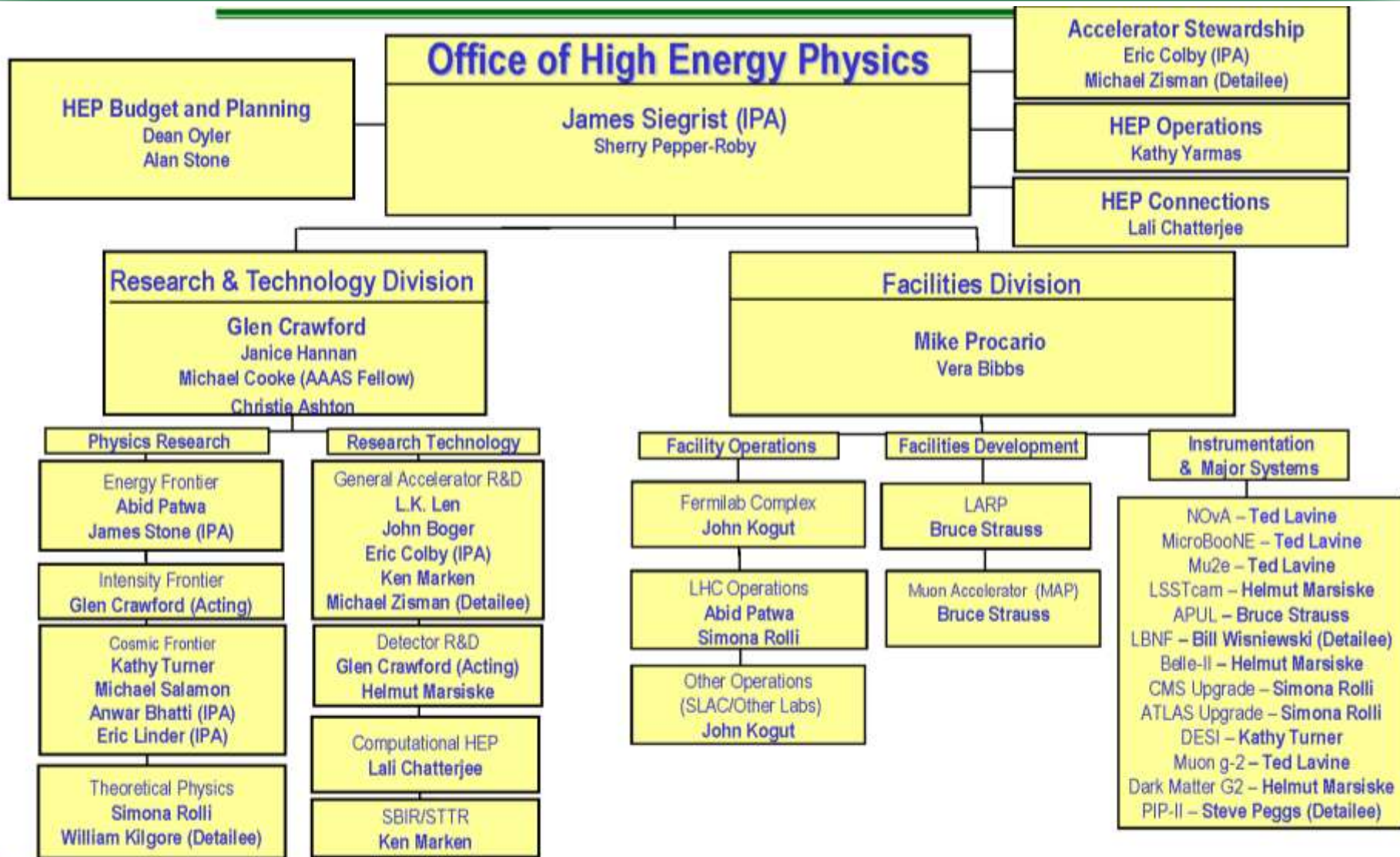


OFFICE NEWS AND MISCELLANY

HEP Program Status Updates

- **(Lots of) Comings and Goings**
 - Dave Boehnlein (Energy Frontier IPA, FNAL) departed Jan 2015
 - Keith Dienes (Theory IPA, Arizona/NSF) departed Jan 2015
 - Peter Kim (Detector R&D Detailee, SLAC) departed Feb 2015
 - Larry Price (Computing Detailee, ANL) departed Mar 2015
 - Tina Kaarsberg (Detailee, DOE EERE) arrived Nov 2014 → **SBIR, Stewardship, infrastructure**
 - Eric Linder (Cosmic IPA, LBNL) arrived Jan 2015 → **Operations, data management**
 - Steve Peggs (Detailee, BNL) arrived Mar 2015 → **PIP-II**
 - Bill Wisniewski (Detailee, SLAC) coming April 2015 → **LBNF**
 - **Intensity Frontier Detailee TBA coming June 2015**
- **New Assignments and Opportunities**
 - Helmut Marsiske now assisting with Detector R&D program
 - Michael Salamon ~full-time on International agreements
 - Abid Patwa managing LHC Ops and Phase II detector upgrades
 - Approval for **4 new Fed staff positions**
 - **Physicist (Program planning, strategic communications) closed**
 - Reviewing candidates now
 - **Science Advisor (Technology R&D) posting soon**
 - **Intensity Frontier and Detector R&D program managers next**
 - **Interested parties should contact HEP management**

HEP Organization Chart



Optimally Implementing the HEP Program

- DOE HEP has created internal working groups aimed at identifying ways to better move forward with the P5 vision
 - HEP Cross-cuts within the Office of Science
 - Leveraging connections between HEP and other program offices
 - HEP Office Operations
 - Optimizing internal operations to more efficiently implement our program
 - HEP Research Initiatives
 - Identifying opportunities for near-term high-priority directed investments (e.g. WINP-based FOA)
- Later talks will discuss other aspects of the DOE program:
 - Accelerator Stewardship
 - University Accelerator R&D
 - FY 2015 Annual University Comparative Review

Computing in HEP

- **HEP Computing and Data Challenges continue to grow for all Frontiers**
 - Data production exceeded 10 PB last year!
- **HEP Computational program is looking into addressing P5 Recommendation 29 on computing**
 - We need to draw in all available resources and expertise
- **Later talks will discuss ways to move computing efforts forward:**
 - Dr. Steve Binkley, Associate Director for Advanced Scientific Computing Research (ASCR), will discuss DOE facilities and the partnerships available for HEP to use
 - The HEP Forum for Computational Excellence (FCE) will discuss their plans to respond to P5 Recommendation 29

HEP Science & Technology Connections Updates

- **Joint HEP-ASCR Study Group**

- “Grand Challenges at the Intersections of QIS (Quantum Information Science), Particle Physics, and Computing” was held on December 11, 2014

- Report presents a set of Grand Challenge questions along with potential paths forward for advancement of associated technology and fundamental science insight

- <http://science.energy.gov/hep/news-and-resources/reports/>

- Will be discussed in talks by J. Preskill and S. Binkley

- **HEP-BES Round Table**

- “Common Problems in Condensed Matter Physics and Particle Physics” was held February 2, 2015

- Report in progress

- Also see “Materials-by-design & implications for HEP” by Mike Norman (Argonne) at the December 2014 HEPAP Meeting



Take-Away Messages

- **These are exciting times!**
 - LHC turning back on at 13 TeV
 - NOvA, T2K taking data and running well
 - New results on dark matter
 - New Intensity Frontier experiments (Belle II, dark photon searches, precision muon experiments) are “just around the corner”
- **P5 Report has legs**
 - We continue to hear support for the focused, realistic P5 plan and “particle physics is global” message
 - Strong interest in establishing a major *international* science facility hosted in the U.S.
 - U.S.-CERN agreements on LHC and neutrino programs are making good progress
 - LBNF/DUNE moving forward faster than expected
 - We are trying to capitalize on this momentum
- **FY 2016 HEP budget is moving in the right direction**
 - There are still difficulties in some areas and overall the budget climate is uncertain
 - Continued strong support and consistent messaging from the community will be needed to sustain progress



BACKUP

High Energy Physics Highlights:

Recent Major Prizes and Awards in HEP

- **Saul Perlmutter (UC Berkeley/LBNL), along with other members of the Supernova Cosmology Project he leads, shared the 2015 Breakthrough Prize in Fundamental Physics**
 - For the most unexpected discovery that the expansion of the universe is accelerating, rather than slowing as had been long assumed.
- **Stanley G. Wojcicki (Stanford University) received the 2015 W.K.H. Panofsky Prize in Experimental Particle Physics**
 - For his leadership and innovative contributions to experiments probing the flavor structure of quarks and leptons, in particular for his seminal role in the success of the MINOS neutrino oscillation experiment.
- **Hasan Padamsee (Fermilab) received the 2015 APS Robert R. Wilson Prize for Achievement in the Physics of Particle Accelerators**
 - For his leadership and pioneering world-renowned research in superconducting radiofrequency physics, materials science, and technology, which contributed to remarkable advances in the capability of particle accelerators.
- **Chandrashekar Joshi (UCLA) is recognized with two achievements:**
 - 2014 Inductee of National Academy of Engineering for contributions to the development of laser and beam-driven plasma accelerators.
 - 2014 Distinguished Engineering Educator Award by the Engineers' Council
- **Justin Schwartz (NC State) received the 2014 IEEE Award for Continuing and Significant Contributions to the Field of Applied Superconductivity**



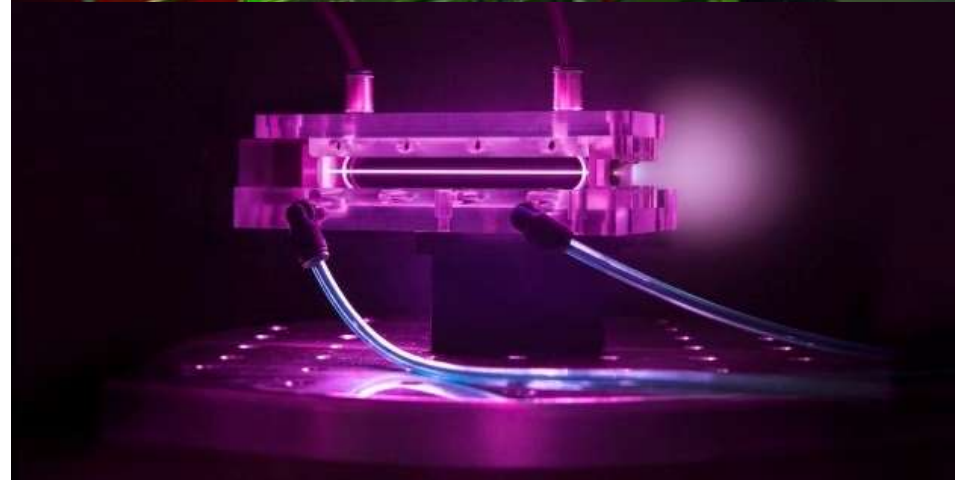
Progress on Internationalization of Long-baseline Program

- **Significant progress has been made on internationalization of LBNE:**
 - International Meeting for Large Neutrino Infrastructures, Paris, June 22-23, 2014
 - FNAL Interagency Meeting on a Global Neutrino Program, July 14, 2014
 - World Neutrino Summit at Fermilab, July 21–22, 2014
 - Interim International Executive Board (iIEB) Board Meeting at Fermilab, September 23-24, 2014
 - iIEB SURF site visit, October 8-9
 - Fermilab has developed a first draft of a governance document
 - Open community meetings for potential PIs held at CERN and Fermilab on December 5 and 12, respectively
 - International governance white paper drafted in December
 - Letter of Intent delivered to Fermilab PAC on December 21
- **First meeting of the Experiment at the Long Baseline Neutrino Facility (ELBNF) collaboration took place January 22-23, 2015**
 - 145 institutions from 23 countries

High Energy Physics Highlights:

BELLA Sets Record in Laser-driven Plasma Wakefield Acceleration

- Research in plasma wakefield acceleration aims to create compact and cost-effective acceleration technology for future particle accelerators
- The Berkeley Lab Laser Accelerator (BELLA) set a new world record for laser-driven plasma wakefield acceleration:
 - BELLA accelerated electrons to 4.25 GeV using a 9 cm plasma channel created by a 390 terawatt laser pulse
 - Today's technology would require a 200 meter long accelerator to achieve the same energy



HEP Facilities and Operations

FY 2016 Request: \$262,658,000

- The **Large Hadron Collider (LHC)** at CERN will resume operations in Spring 2015 at collision energies nearly double that used for the Nobel prize winning discovery of the Higgs boson
- The **NOvA** experiment is taking data using the world's most powerful neutrino beam sent along the world's longest baseline, 500 miles from Fermilab to Ash River, MN
- **MicroBooNE** begins taking data in early 2015 as the first stage of Fermilab's short-baseline neutrino program that will address key scientific questions while developing the technology for a world-class long-baseline experiment
- The **Dark Energy Survey (DES)** continues surveying the sky using its 570-Megapixel camera to uncover the nature of dark energy by measuring the 14-billion-year history of cosmic expansion
- The **LUX** dark matter experiment, located a mile under the Black Hills of South Dakota, is taking data through 2016 in order to significantly improve the world's most sensitive search it produced in 2013



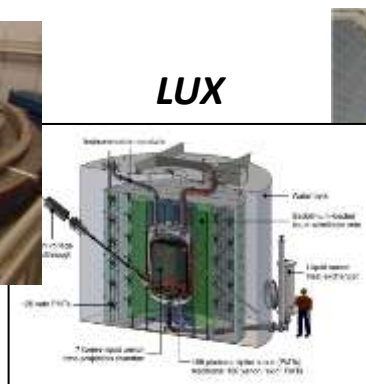
HEP Projects

FY 2016 Request: Projects \$113,401,000; Construction \$56,100,000

- The community-endorsed P5 strategy recommends a prioritized and time-ordered list of experiments to address the most pressing scientific questions
 - Investments will produce a continuous flow of major scientific results throughout a twenty-year timeframe
- Major projects, in time order, include: *(funding reflects FY16 request)*
 - Completion of the **Muon g-2** (\$10.2M) and **Muon to Electron Conversion (Mu2e)** (\$40.1M) experiments at Fermilab
 - Immediate investments in **second-generation dark matter** experiments (\$11M)
 - Fabrication of the **Dark Energy Spectroscopic Instrument (DESI)** (\$5.3M) and the **LSST Camera** (\$40.8M)
 - High-luminosity upgrades to the **Large Hadron Collider (LHC)** (\$19M)
 - A U.S.-hosted **Long Baseline Neutrino Facility (LBNF)** (\$20M) that receives the world's highest intensity neutrino beam from an improved accelerator complex at Fermilab



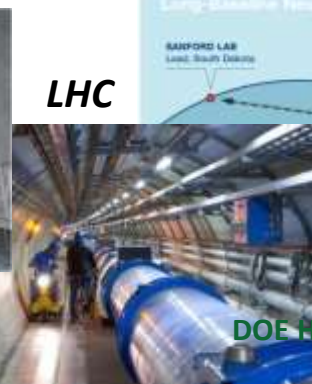
Muon g-2



LUX



DESI



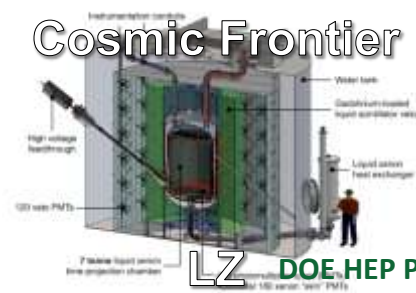
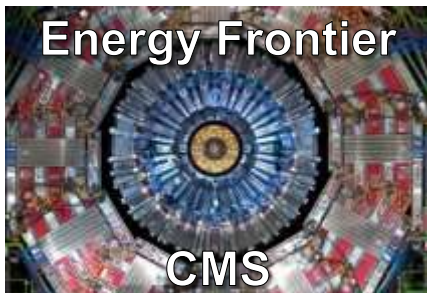
LHC



LBNF

HEP Program: FY 2016 Priorities

- **HEP is implementing the strategy detailed in the May 2014 report of the Particle Physics Project Prioritization Panel (P5), formulated in the context of a global vision for the field**
 - HEP Addresses the five compelling science drivers with research in three frontiers and related efforts in theory, computing and advanced technology R&D
 - Increasing emphasis on international partnerships (such as LHC) to achieve critical physics goals
- **Energy Frontier: Continue LHC program with higher collision energy (13+ TeV)**
 - The U.S. will continue to play a leadership role in LHC discoveries by remaining actively engaged in LHC data analysis and the initial upgrades to the ATLAS and CMS detectors
- **Intensity Frontier: Develop a world-class U.S.-hosted Long Baseline Neutrino Facility**
 - Continue the design process for an internationalized LBNF and development of a short baseline neutrino program that will support the science and R&D required to ensure LBNF success
 - Fermilab will continue to send world's highest intensity neutrino beam to NOvA, 500 miles away
- **Cosmic Frontier: Advance our understanding of dark matter and dark energy**
 - Immediate development of new capabilities continue in dark matter detection with baselining of 2nd-generation experiments; and in dark energy exploration with baselining of DESI and fabrication of LSST camera.



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

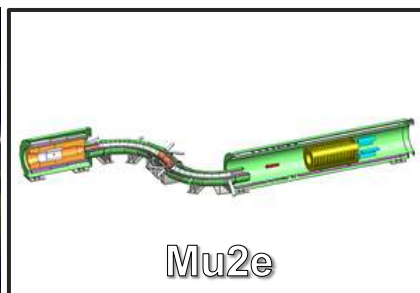
HEP Program: FY 2016 Priorities

- **Accelerator Stewardship**

- This subprogram focuses on the broader applications of accelerator technologies, including major thrusts in technology to enable ion-beam cancer therapy and R&D for high-power ultrafast lasers
- The FY 2016 funding request provides support for a new research thrust in energy and environmental applications of accelerators and expands the open test facilities effort
- The main facility supporting this subprogram, the Brookhaven Accelerator Test Facility (ATF), will undergo relocation and expansion in FY 2016 to accommodate more users

- **Construction/Major Items of Equipment (MIEs) support reflects P5 priorities:**

- The Long Baseline Neutrino Facility (LBNF) continues its design phase as the project baseline cost and technical scope are revised while incorporating international in-kind contributions
- The LHC ATLAS and CMS Detector Upgrade projects continue fabrication
- Muon g-2 continues accelerator modifications and fabrication of the beamline and detectors
- LSSTcam fabrication support increases according to planned profile
- Dark Energy Spectroscopic Instrument (DESI) will be baselined in 2016
- Fabrication proceeds on the dark matter experiment MIEs: SuperCDMS-SNOlab and LZ
- Construction continues for the Muon to Electron Conversion Experiment (Mu2e)



U.S. Investments Towards an ILC: LCLS-II

- Expertise from HEP is being used to fabricate the advanced SRF cavities needed for constructing the Linear Coherent Light Source II, a Basic Energy Science facility being built at SLAC
 - Joint project including FNAL, ANL, JLAB, and LBNL
 - Fermilab will advance SRF capabilities and infrastructure through LCLS-II responsibilities, including:
 - Low-loss cavity development (may lead to cost reductions)
 - Design, fabrication and testing of 17 cryomodules of varying frequencies
 - Design and fabrication of cryogenic distribution system
 - Assistance with linac accelerator physics and LLRF control

