U.S. DEPARTMENT OF ENERGY | Office of Science

Status of the DOE High Energy Physics Program

HEPAP Meeting
December 1, 2016

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Office of Science, U.S. Department of Energy

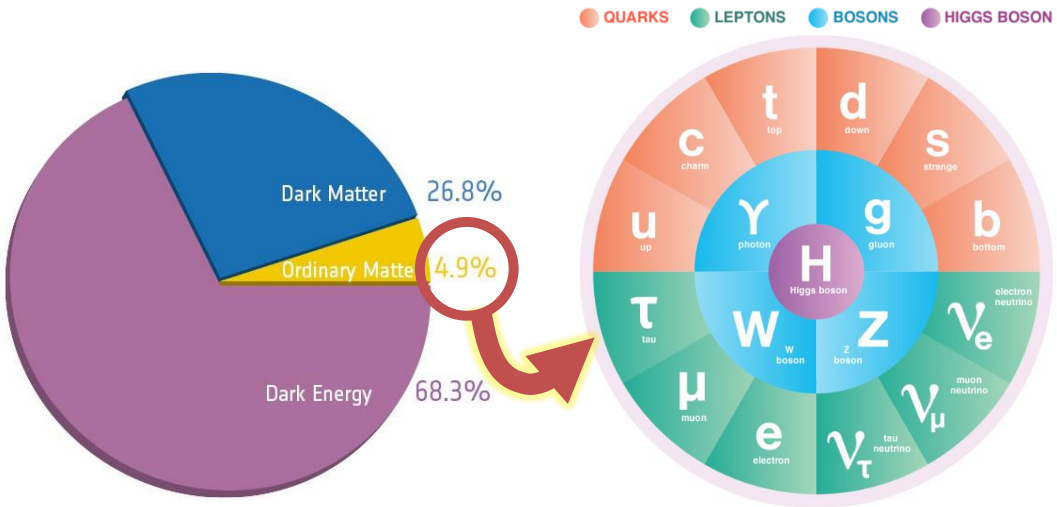
The High Energy Physics Program Mission

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

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

The Office of High Energy Physics fulfills its mission by:

- Building projects that enable discovery science
- Operating facilities that provide the capability to perform discovery science
- Supporting a research program that produces discovery science



Benefits and Broader Impacts of Particle Physics

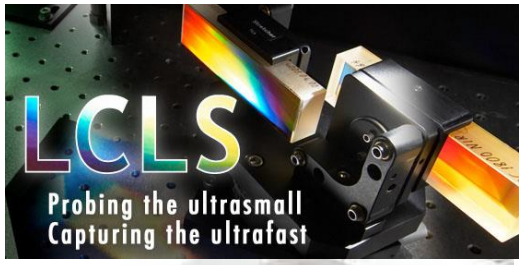
"Particle physics shares with other basic sciences the need to innovate, invent, and develop technologies to carry out its mission to explore the nature of matter, energy, space and time.

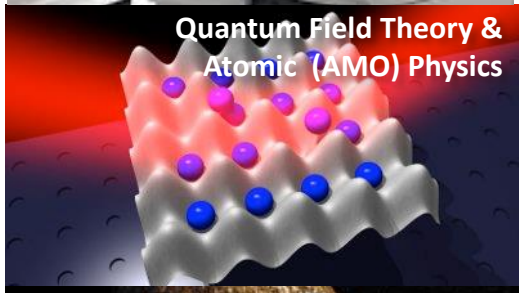
Advanced particle accelerators, cutting-edge particle detectors, and sophisticated computing techniques are the hallmarks of particle physics research.

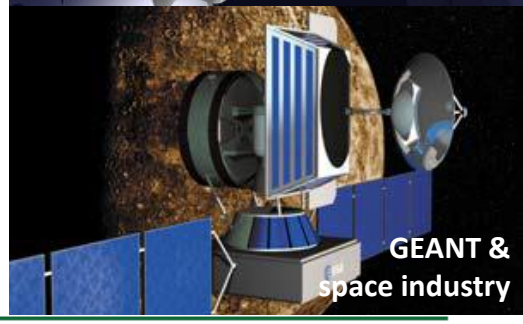
This dedicated research has benefited tremendously from progress in other areas of science to advance the current state of technology for particle physics.

In return, developments within the particle physics community have enabled basic scientific research and applications in numerous other areas.

This broad, connected scientific enterprise provides tremendous benefits to society as a whole."

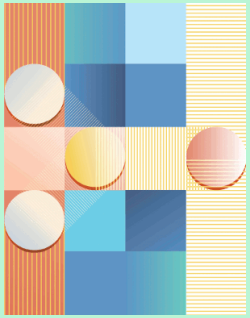




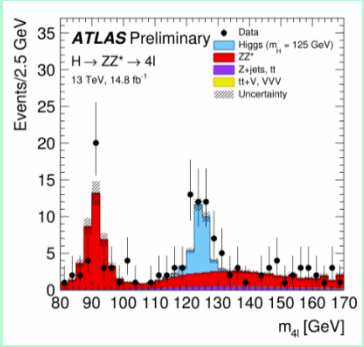


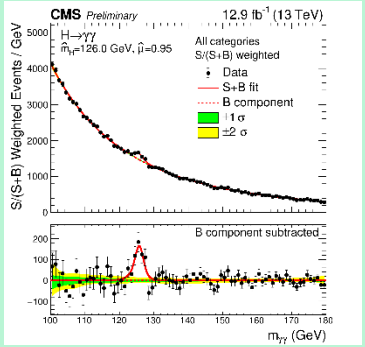
Addressing Compelling Questions in HEP:

Science Highlights from 2016

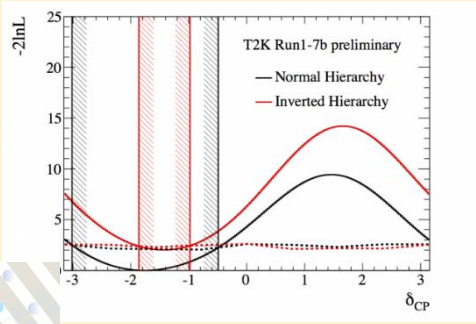


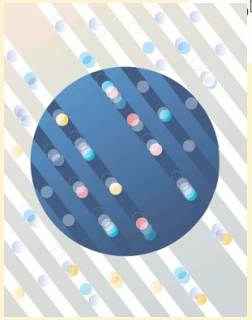
Higgs boson





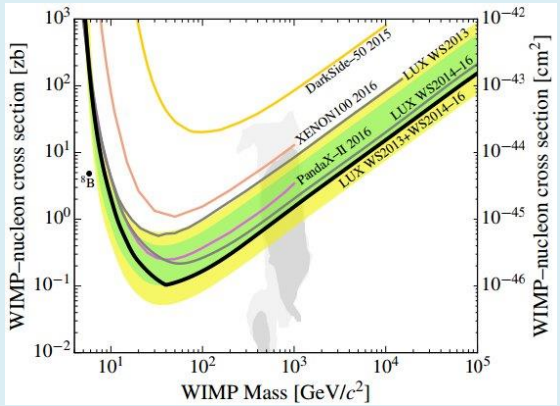
ATLAS and CMS examine Higgs boson production in 13 TeV center-of-mass energy collision events

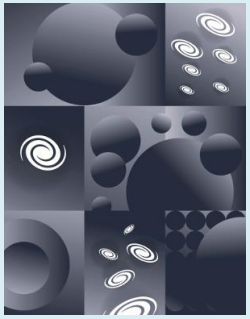




Neutrino Mass

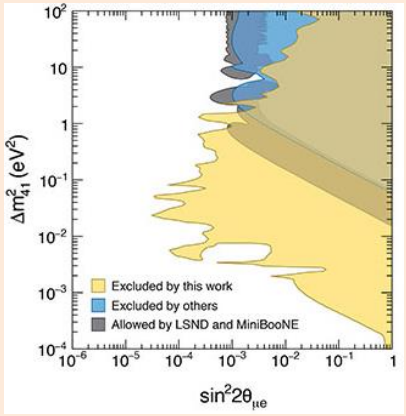
T2K data show preference for maximal mixing in θ_{23}, a value of δ_{CP} near the maximally violating value of -π/2, and the normal ordering of the neutrino mass hierarchy



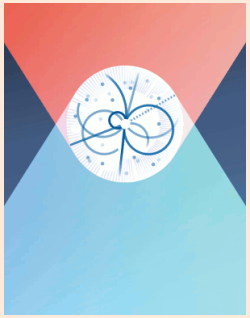


Dark matter

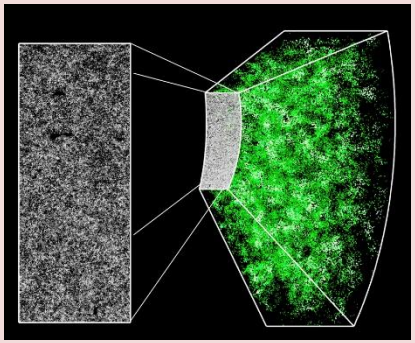
The final LUX run, of over 330 live days, led to a roughly four-fold improvement in sensitivity for high WIMP masses relative to previous results



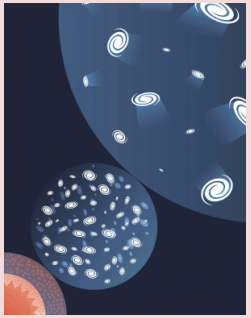
Combined analysis from MINOS and Daya Bay experiments constrain possible sterile neutrino properties



Explore the Unknown



Final BOSS data release, comprising 1.5 million galaxies and quasars, enabled measuring the expansion rate of Universe to 1% precision



Cosmic acceleration

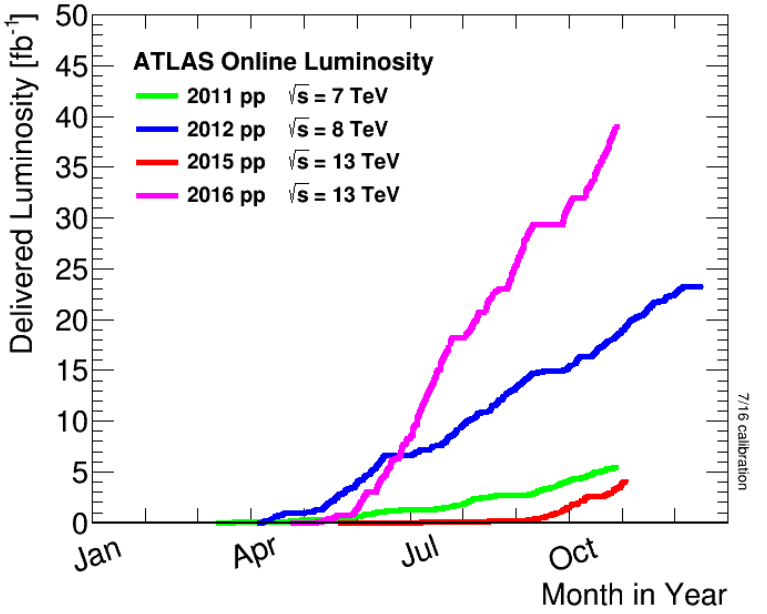
Energy Frontier Status

Compelling and comprehensive LHC program is core part of the P5 strategy

- DOE intends to support key leadership roles in all areas of ATLAS & CMS
- U.S. participation in LHC enabled by leveraging expertise in accelerator science & technology to exploit future opportunities

Current Program

- Over 590 LHC Run 1+2 papers submitted by *each* of the CMS and ATLAS Collaborations
- Excellent LHC performance in 2016 (Run 2)
  - Unprecedented peak inst. lumi. >40% beyond LHC design!
  - Data accumulation ~60% beyond 25 fb^{-1} goal for 2016!
    - Immediate challenges in computing support being coordinated with experiments via U.S. LHC Ops program
    - Plan to address at the DOE-NSF U.S. LHC Operations Program Review, end-January 2017



Near- and Longer-term Program

- Phase-1 U.S. ATLAS/CMS upgrades complete funding profile in FY 2017
  - Subsystem fabrication, installation and commissioning activities continue through Long-Shutdown 2 (2019)
- High-Luminosity LHC will extend discovery reach
  - Increased lumi. will explore new physics at TeV energies
  - DOE working with U.S.-ATLAS/CMS, NSF to mount projects
    - Mission-Need (CD-0) in 2016; CD-1 planned for 2017

International Linear Collider R&D

- Since P5 rollout, DOE discussing with the international community the framework of the ILC program based on P5 recommending the U.S. engage in modest and appropriate levels of ILC accelerator and detector design and consider higher levels of collaboration if ILC proceeds

- As part of its recommendations, MEXT ILC Advisory Panel in June 2015 noted:
  - "ILC project requires huge investments … that a single country cannot cover, thus it is indispensable to share the cost internationally."
  - "…through the end of 2017, it is necessary to closely monitor, analyze and examine the developments of LHC experiments."

- In FY16, formed DOE-MEXT Discussion Group to foster higher level cooperative efforts between the U.S. and the Government of Japan
  - Co-Chairs: Cherry Murray (SC Director, DOE), Hiroshi Ikukawa (Deputy Director-General, MEXT)
    - Group members include officials from DOE/SC/HEP and the MEXT Research Promotions Bureau
  - Face-to-face meetings in May and August 2016 focused on collaborative opportunities between U.S. and Japan for cost-reduction R&D towards ILC
    - Approach of cost-reduction R&D was endorsed by DOE SC management

- Near term, Japan has expressed interest with U.S. on collaborative ILC-related R&D
  - Enables maintaining appropriate level of U.S. engagement, should the ILC project move forward
  - Redirect current design R&D towards cost reduction efforts, emphasizing accelerator R&D (*e.g.*, SRF)
  - Other ILC-related accelerator and detector R&D will be considered under the new U.S.-Japan Science and Technology Cooperation Program in HEP Funding Opportunity Announcement (FOA)
    - *More detail on HEP FOAs be presented in Glen Crawford's HEPAP talk tomorrow*

Global Coordination of Other Future Energy Frontier Circular Colliders

- P5 reported that particle physics is a global field for discovery and why
  - "The United States and major players in other regions can together address the full breadth of the field's most urgent scientific questions if each hosts a world-class facility at home and partners in high-priority facilities hosted elsewhere."
    - "Hosting world-class facilities and joining partnerships in facilities hosted elsewhere are both essential components of a global vision."
- The global community is conducting design studies and technology R&D for future circular colliders
- Within fiscal constraints, current priority is investment through General Accelerator R&D portfolio in enabling technologies for future machines
  - For example, high-field magnet R&D on LTS and HTS technology
  - Labs and DOE need to coordinate level of U.S. activity relative to other HEP programmatic priorities
- Within the Energy Frontier portfolio, priority remains on support for LHC and HL-LHC

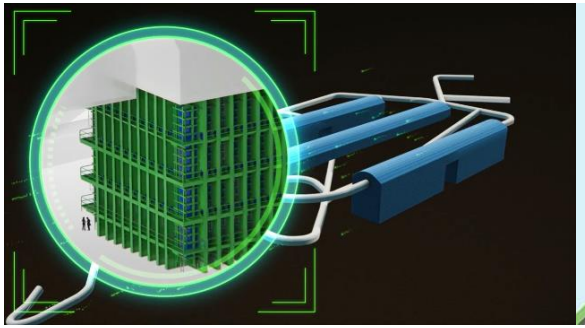
Intensity Frontier Status

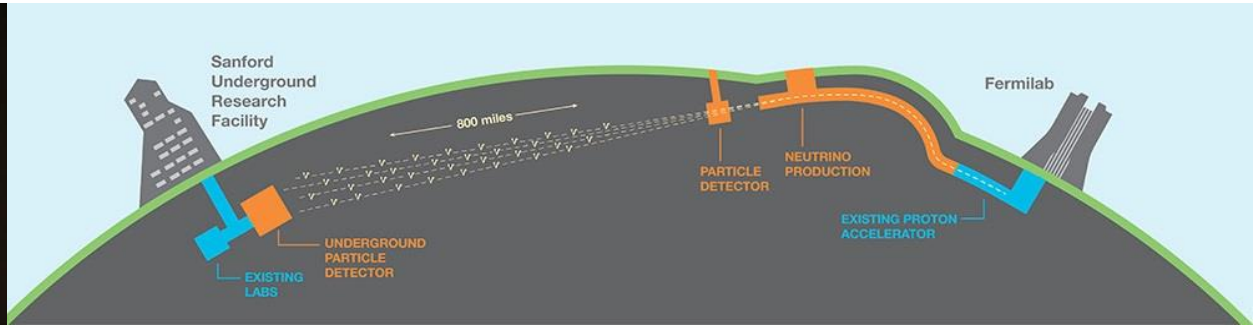
Intensity Frontier experiments address the P5 Science Drivers through intense beams and sensitive detectors

- **Exploring the unknown through precision measurements:** *Muon g-2, Mu2e, Belle II, K0TO*
- **Identify the new physics of dark matter:** *APEX* and *Heavy Photon Search*
- **Pursuing the physics associated with neutrino mass:** *NOvA, Daya Bay, MINERvA, Super-K, T2K* ongoing; ramping up Fermilab Short-Baseline Neutrino Program (*MicroBooNE, SBND, ICARUS*)

P5 recommended Long Baseline Neutrino Facility (LBNF) as the centerpiece of a U.S.-hosted world-leading neutrino program and the highest-priority large project in its timeframe

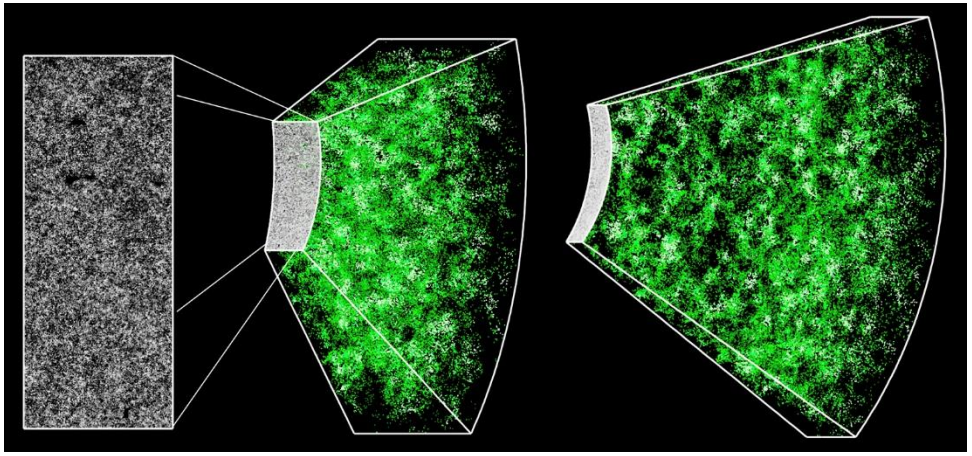
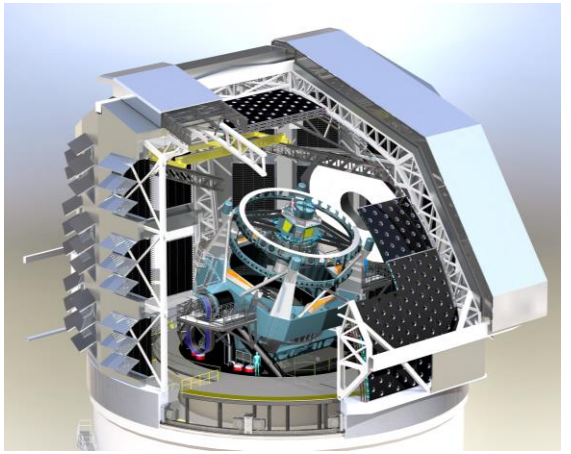
- **Given compelling discovery potential, Fermilab working closely with CERN and other global partners to establish an international "mega-science" facility with first physics in mid-2020s**
- **1.2 MW neutrino beam, 800 mile baseline to 40 kt LAr detector (DUNE) 4850' underground**
- **HEP strategy is to seek new additional funding for LBNF. Signs are promising.**
- **LBNF/DUNE project received CD-3A (early far-site construction) approval in September 2016**
  - **FY17 investments in site prep. and cavern excavation aim to solidify international partnerships**

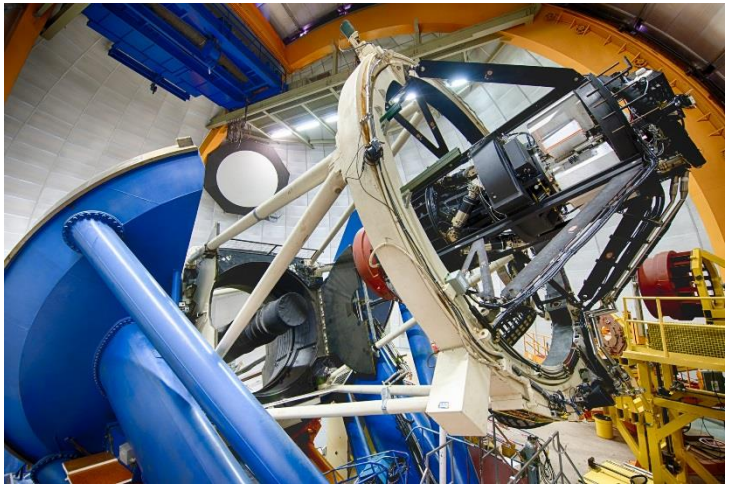
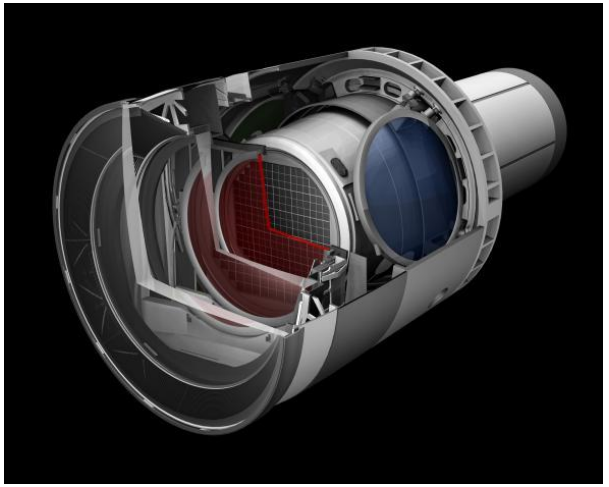




Cosmic Frontier Status

Detail on Cosmic Frontier activities will be presented in Kathy Turner's HEPAP talk tomorrow

HEP Computing

The P5 report and other particle physics community reports have recognized the critical importance of computing for the program

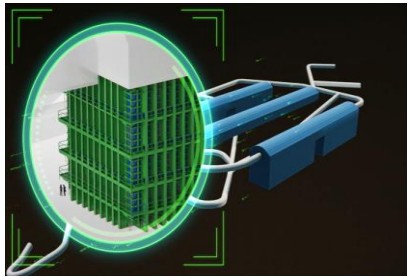
- **HEP Community needs to develop new cross-cutting computing models**
  - Work across experiments and laboratories to leverage external resources and create effective partnerships that prepare for the future while sustaining current priorities
- **White House National Strategic Computing Initiative (NSCI) has led to the DOE Advanced Scientific Computing Research (ASCR) Exascale Computing Projects work on hardware design**
  - HEP community has opportunity to work with ASCR to ensure new hardware is useful for future HEP needs
  - Optimized hardware then becomes widely available and lower cost to HEP
  - Timescale for this change well-matched to HEP needs (early 2020s)
- **New paradigms are emerging that may influence future directions in HEP computing:**
  - Deep Learning, Smart Networking, Neuromorphic and Quantum computing
- **Directed computing investments in partnership with ASCR, including through the HEP Center for Computational Excellence, are needed to meet future needs**
  - New HEP-ASCR Exascale Report: *http://hepcce.org/resources/reports/*

HEP BUDGET STATUS

HEP FY 2017 Budget Overview

Energy Frontier: Continue to support leadership roles in the highly successful LHC program

- Initial LHC detector upgrade project funding ends in FY 2017
- DOE Mission Need (CD-0) approved in April 2016 for the HL-LHC upgrades, P5's highest priority near-term project
  - R&D and developing TDRs for HL-LHC ATLAS and CMS now in-process
  - Scope, roles and responsibilities continue to be firmed up
- U.S. will continue to play a leadership role in LHC discoveries by remaining actively engaged in LHC data analysis



Intensity Frontier: Solidify international partnerships for U.S.-hosted LBNF/DUNE

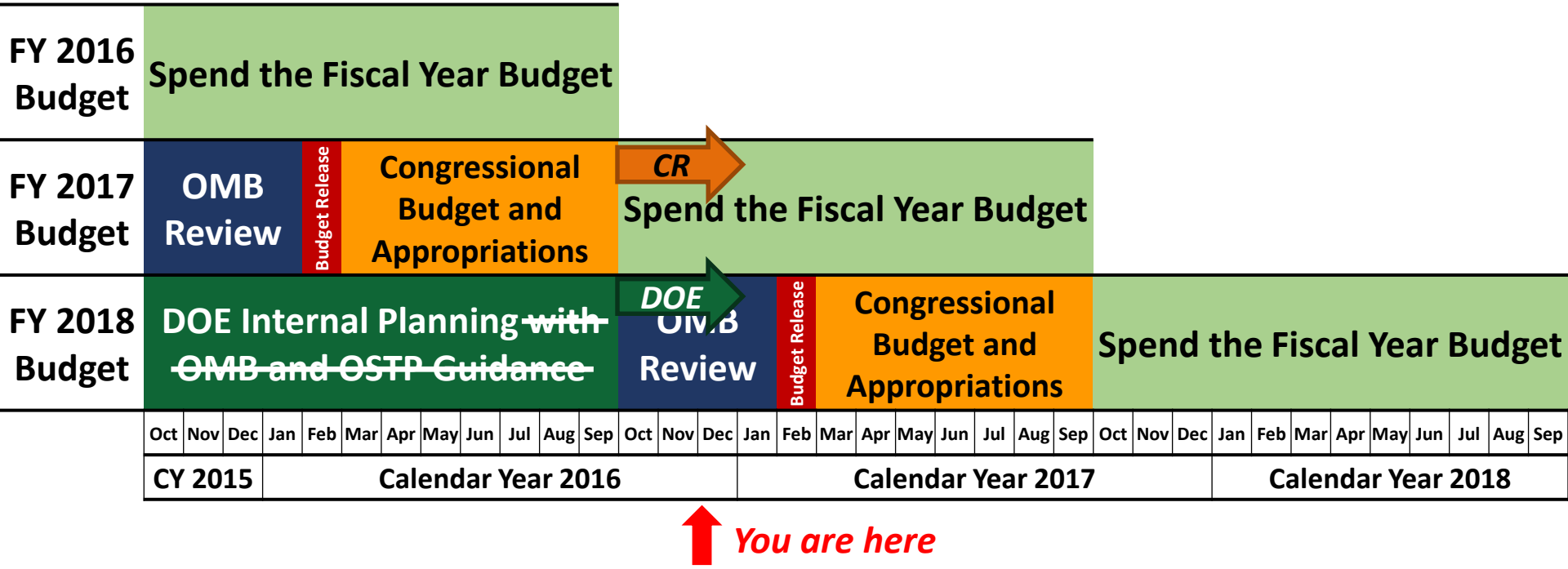
- Rapid progress on LBNF/DUNE has attracted attention from interested international partners and FY 2017 investments in site preparation and cavern excavation aim to solidify international partnerships
- Fermilab will continue improvements to accelerator complex while serving high-intensity neutrino beams to short-and long-baseline experiments, enabling full utilization of the FNAL facilities

Cosmic Frontier: Advance our understanding of dark matter and dark energy

- Fabrication funding ramp up in FY17 supports key P5 recommended Cosmic Frontier projects to study dark matter and dark energy
  - LSSTcam, DESI, SuperCDMS-SNOLab, LZ

The U.S. Federal Budget Cycle

- Typically, three budgets are being worked on at any given time
  - Executing current Fiscal Year (FY; October 1 – September 30)
  - White House Office of Management and Budget (OMB) review and Congressional Appropriation for coming FY
  - Agency internal planning for the second FY from now
- This year's cycle is not "typical"
  - Congress has not yet passed a budget for FY 2017 (*see next slide…*)
  - DOE planning for FY 2018 has proceeded so far without guidance from the White House



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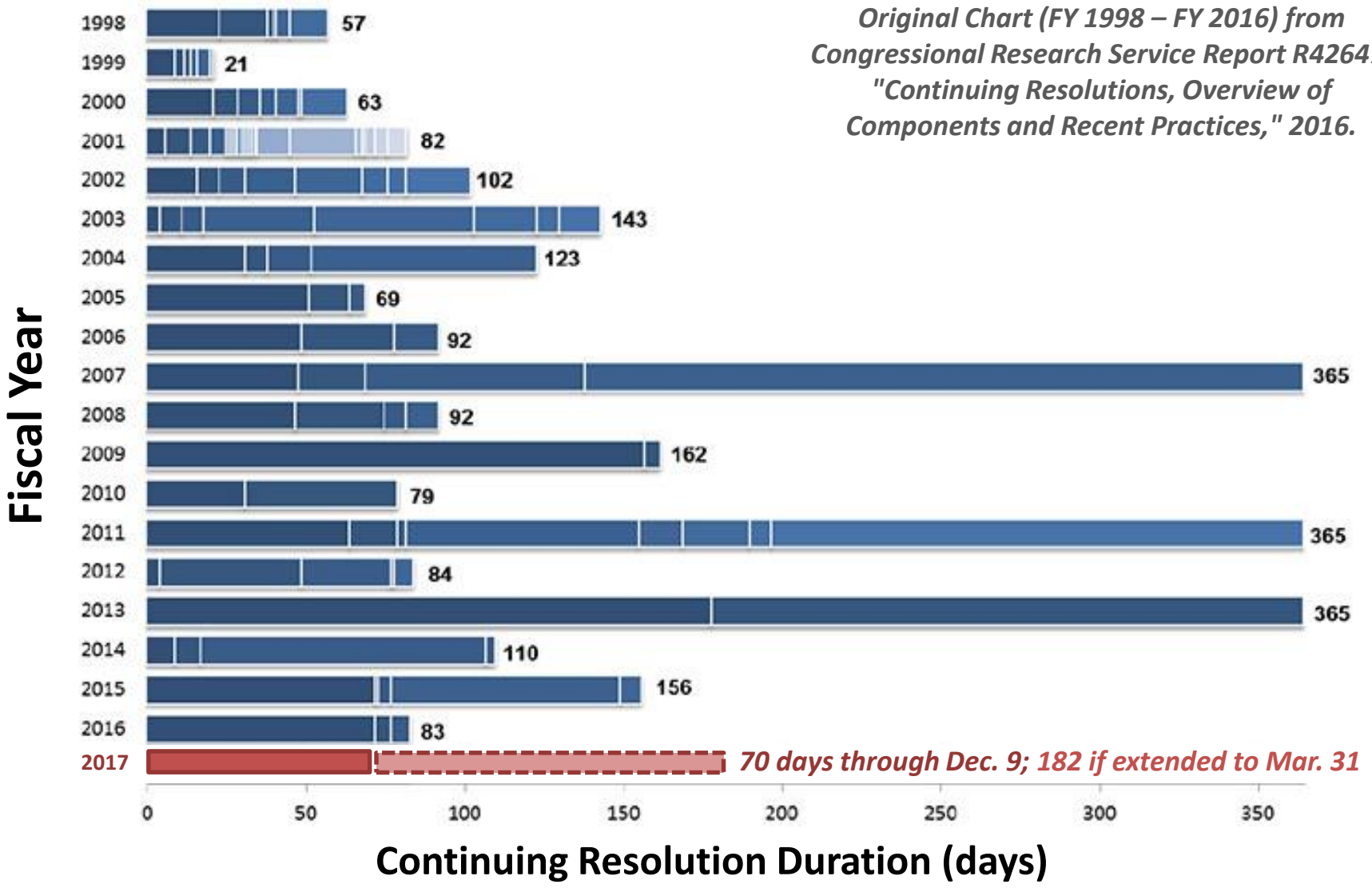
Breaking the Cycle: Continuing Resolution

- If the U.S. Congress and the President have not passed all appropriations bills by September 30, a Continuing Resolution (CR) may be passed to avoid a U.S. Government shutdown
  - Must pass some level of appropriations to have legal authority to spend money!
  - CRs typically extend level of funding from the previous year for a set amount of time
- A CR may impede the start of new projects
  - Projects with total cost >$10M must be line-items approved by Congress in an appropriations bill before its "new start," or its Total Estimated Cost (TEC) funding, can begin
  - It is possible, though not typical, for CRs to include "anomalies" that would allow new starts
- A CR may impact the ramp-up of new projects
  - DOE is committed to the successful execution of projects that have reached CD-2 and aims to provide the baseline funding profile
  - Projects that have not reached CD-2 are most likely to be impacted under a CR
- A CR may also impact future-year planning through such effects…

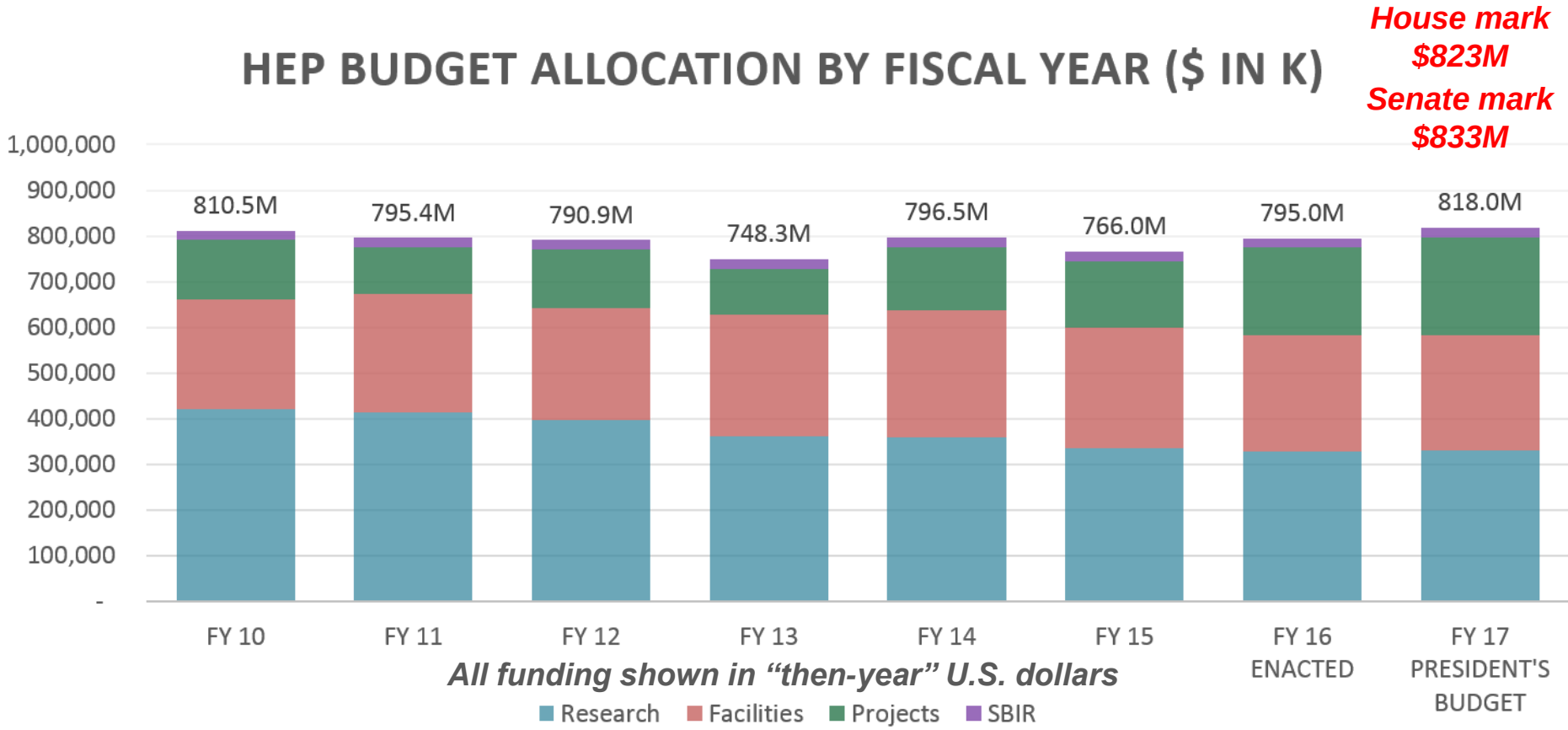
- Currently, an FY 2017 Continuing Resolution (CR) in effect through December 9, 2016
  - Funding through Dec. 9 equivalent to $791M level of funding, if extrapolated to full FY
  - Latest news suggests FY 2017 CR may be extended through March 31, 2017
- DOE has limited flexibility for adjustments under a CR, but will work closely with laboratory and project management to minimize any impacts
  - More about CR impact on FOAs will be presented in Glen Crawford's HEPAP talk tomorrow

Duration of CRs: FY 1998 – FY 2017



Original Chart (FY 1998 – FY 2016) from Congressional Research Service Report R42647, "Continuing Resolutions, Overview of Components and Recent Practices," 2016.

Overall HEP Budget Trend



- Significant dip in FY 2013 from Congressional sequestration
- FY 2015 request developed prior to P5 report release
- FY 2017 House/Senate markups increase project funding
- FY 2017 CR through Dec. 9, 2016, at $791M equivalent annual level of funding

OFFICE NEWS AND MISCELLANY

Schedule of DOE/HEP-based Solicitations

Ongoing: "FY 2017 Continuation of Solicitation for the Office of Science Financial Assistance Program" **[DE-FOA-0001664]**

- **Also known as the "general *or* open annual DOE/SC solicitation"**
  - **SC-wide FOA that invites applications in support of work in any of six SC offices, incl. HEP research**
- **Published annually, typically at beginning of FY (October), remains open until successive issuance**

New: "U.S.-Japan Science and Technology Cooperation Program in High Energy Physics"

- **Support U.S. investigators in bilateral cooperative research activities that involve substantial collaboration with Japanese investigators**
  - **Proposal due January 15, 2017, at 11 pm Eastern Time**

New: "Scientific Discovery through Advanced Computing: High Energy Physics" **[LAB 17-1697]**

- **HEP-ASCR Partnerships that enable and accelerate discovery via High Performance Computing**
  - **REQUIRED Letter of Intent due January 17, 2017, at 5 pm Eastern Time**
  - **Proposal due February 27, 2017, at 5 pm Eastern Time**

Upcoming: "Research Opportunities in Accelerator Stewardship"

- **Specifically for accelerator R&D which predominantly impacts non-HEP applications**
  - **REQUIRED Letter of Intent will result in encourage/discourage response**
  - **Eligibility will include academia, national labs, and industry**

More detail on HEP FOAs will be presented in Glen Crawford's HEPAP talk tomorrow

HEP Program Updates

HEP Personnel

- **Comings and Goings**
  - William Kilgore is now the Program Manager for Theoretical Physics
- **New Assignments and Opportunities**
  - Permanent position for Intensity Frontier PM (vice Petros) approved. *Hiring freeze?*
  - New IPA (Stewardship) starting this Winter
  - Interested in new IPA/Detailee for Energy Frontier starting 2017
  - *Interested parties should contact HEP management!*

HEP Advisory Panels

- **DOE HEP Committee of Visitors (COV) met September 27–29, 2016, to review the program years from FY 2013 through FY 2015**
  - COV Report will be discussed during this afternoon's HEPAP session

HEP Citation

- **Immediately after today's HEPAP session, we will recognize Professor Harvey Newman with a citation for his leadership roles in developing and implementing networking and computing models for the LHC**

P5 Vision Remains Clear

- **The P5 vision continues to drive the implementation of the HEP program**
  - **Support has been very strong within DOE, White House, and Congress since the report was issued in May 2014**
- **Transition will not erase the tremendous progress so far, but will mean introducing the P5 strategy to some new stakeholders**
  - **Steve Ritz will continue working with the community to update materials that maintain the visibility of the P5 report and discuss the status of P5 implementation**
  - **Current materials are available at: *http://www.usparticlephysics.org/***
- **P5's vision for the U.S. particle physics program requires all parts of our domestic and international program to succeed**
  - ✓ **DO:**
    - **Share your feedback about the P5 strategy implementation to the DOE**
    - **Understand the elements of the P5 strategy that are outside of your specific research efforts**
  - ✗ **DO NOT:**
    - **Attack areas of our field in favor of your preferred area**
    - **Misinterpret Administration and Congressional support of the P5 plan to be entitlements**

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