



# High Energy Physics Program

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**Office of Science, U.S. Department of Energy**

# Outline

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- **Program Status Update**
- **Accelerator Stewardship**
- **HEP Budget and Issues**
- **Expectations**
- **Summary**



# Take-Away Messages

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- **Actively engaged with community in developing new strategic plan**
  - P5 will deliver their long term vision report in May
  - S. Ritz presented the context and groundwork yesterday
  - Will adapt to the new strategic plan as quickly as possible
- **Clear message from DOE management**
  - HEP needs to have a compelling and executable strategic plan, and the community needs to get behind it
- **Message in FY2014 Appropriation**
  - HEP has supporters in Congress
  - Projects delayed by extended Continuing Resolutions and sequester get moving
- **Message in FY2015 Budget Request**
  - Without a clear and endorsed plan we have a weak basis to argue for more funding in a constrained fiscal environment
  - Additional new projects struggling to get started
- **Message from HEP**

*“Bickering scientists get nothing” [Ritz]*



# HEP Budget Overview

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- **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 projects and Research
- **Impact of these actions:**
  - Workforce reductions at universities and labs
  - Several new efforts were delayed
    - FY15 request includes two MIEs for ATLAS and CMS detector upgrades, required to leverage discovery opportunities at the LHC
- **Key areas in FY2015 Request**
  - Maintaining forward progress on new projects while minimizing the impact of Research reductions to the extent possible
  - The FY 2015 budget request supports:
    - Full operation of existing HEP facilities and experiments
    - Planned construction funding profile for the Mu2e
    - MIEs for the ATLAS and CMS Detector Upgrades
    - Capital equipment funding for LSST, Muon g-2, and towards Belle II
    - Accelerator Stewardship funding for new research activities in high-impact areas



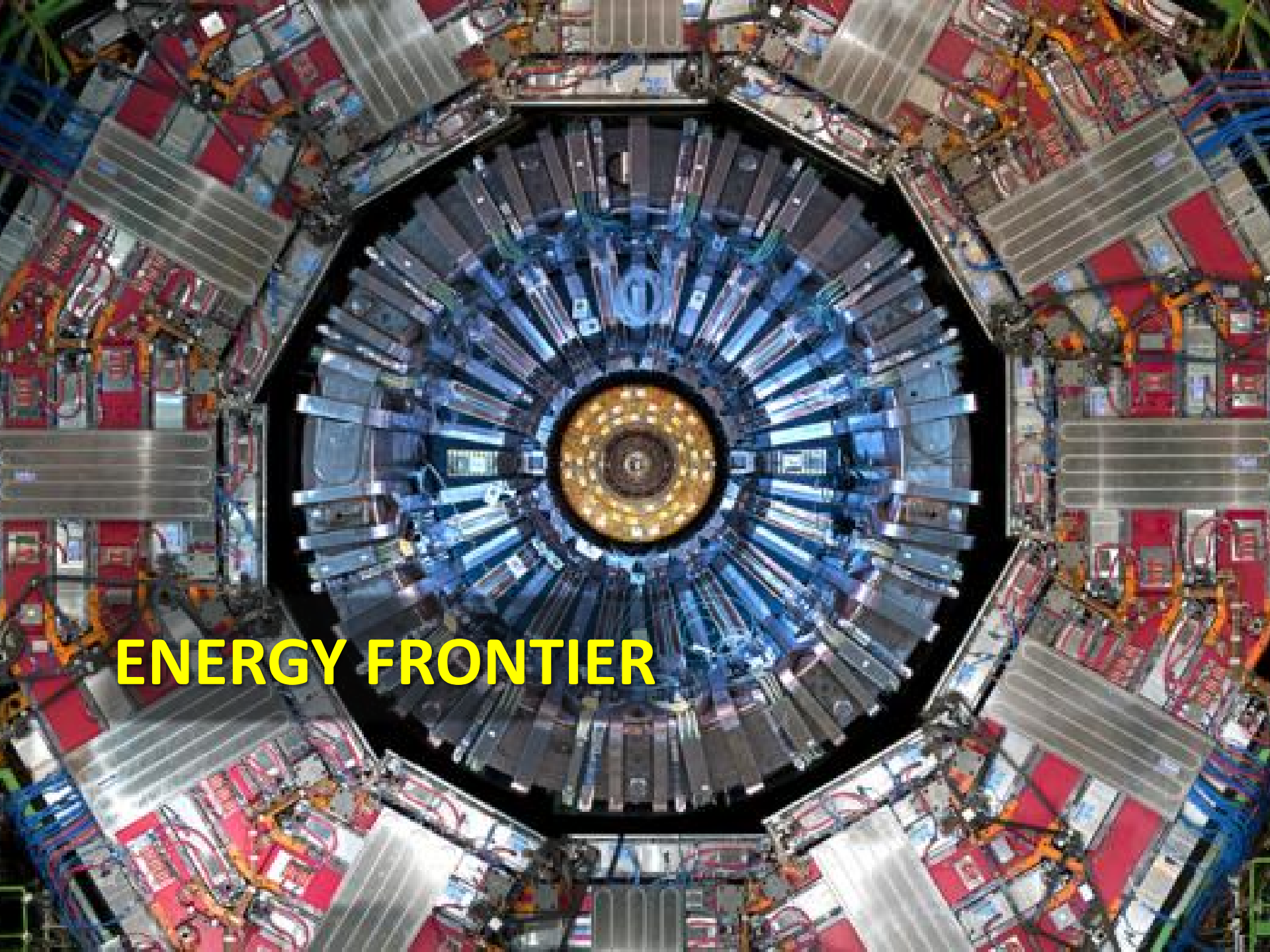
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# PROGRAM STATUS



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**ENERGY FRONTIER**

# Energy Frontier Physics Program

## Large Hadron Collider (LHC) at CERN

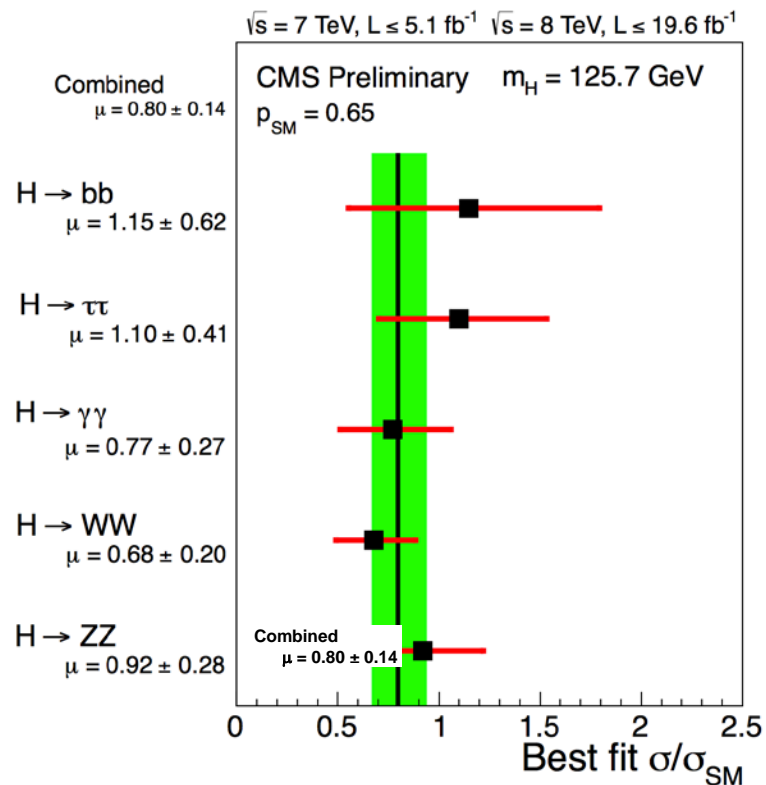
- Run I (proton) completed in Dec. 2012
- Working with experiments to execute plan for U.S. contributions to “Phase-I” [2018] upgrades
  - CD-0 approval: September 2012
  - CD-1 approval: October 17, 2013
    - CMS: \$29.2M – 35.9M
    - ATLAS: \$32.2M – 34.5M

## Fermilab Tevatron (DØ and CDF)

- Working with DØ and CDF collaborations on completion of legacy analyses as part of its ramp-down research program
  - Most efforts completed in FY13 and FY14
  - Final papers (e.g.,  $M_W^{Tevatron}$ ): FY15

## Current Program

- Analyze and publish results from LHC Run I
- 2013-2014 shutdown
  - Repair splices in LHC magnets
  - Detector maintenance and consolidation
  - Upgrades and repairs
- 2015: resume [Run 2] at 13~14 TeV: 100 fb<sup>-1</sup>
  - Continue precision Higgs measurements
  - Focus on new physics



CMS Higgs Boson Signal Strength  
[Lepton-Photon 2013]



# Future of the Energy Frontier

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- **Considering major update to LHC around 2020 to extend discovery potential**
  - High Luminosity LHC program (HL-LHC)
    - Increase LHC luminosity by a factor of 10 beyond its design value
- **US leadership in superconducting magnet technology generally and now Nb<sub>3</sub>Sn in particular is widely recognized and acknowledged**
- **U.S. LHC Accelerator Research Program (LARP) aims to leverage this expertise to serve needs of HEP community**
  - Consists of four US laboratories, BNL, FNAL, LBNL, and SLAC
  - Aims to realize the full capability of the LHC and maximize the discovery potential of U.S. investments in the LHC

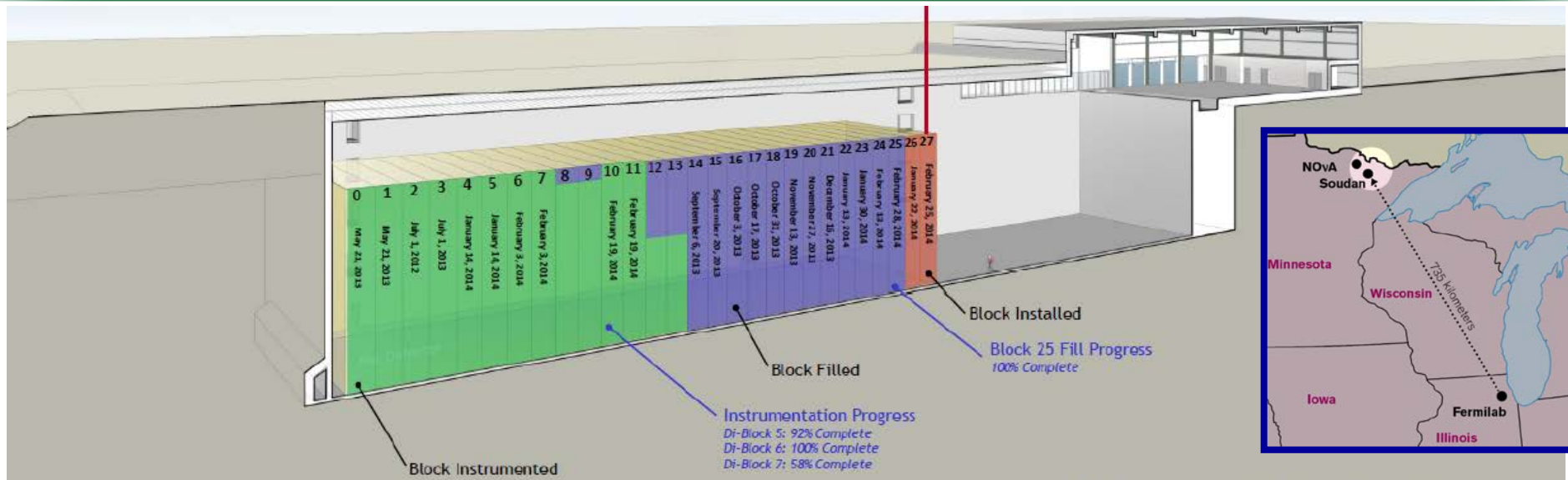




**INTENSITY FRONTIER**

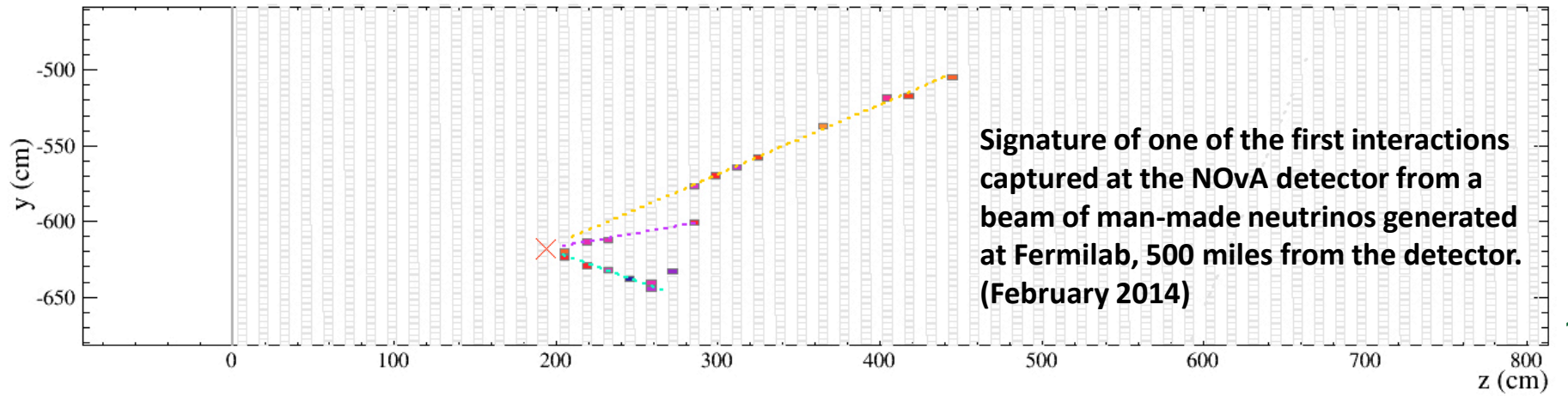


# NOvA Experiment Sees First Long-Distance Neutrino



**Total Project Cost: \$278M**  
**Last block set in place Feb. 25, 2014**  
**Project Completion: Nov 2014**

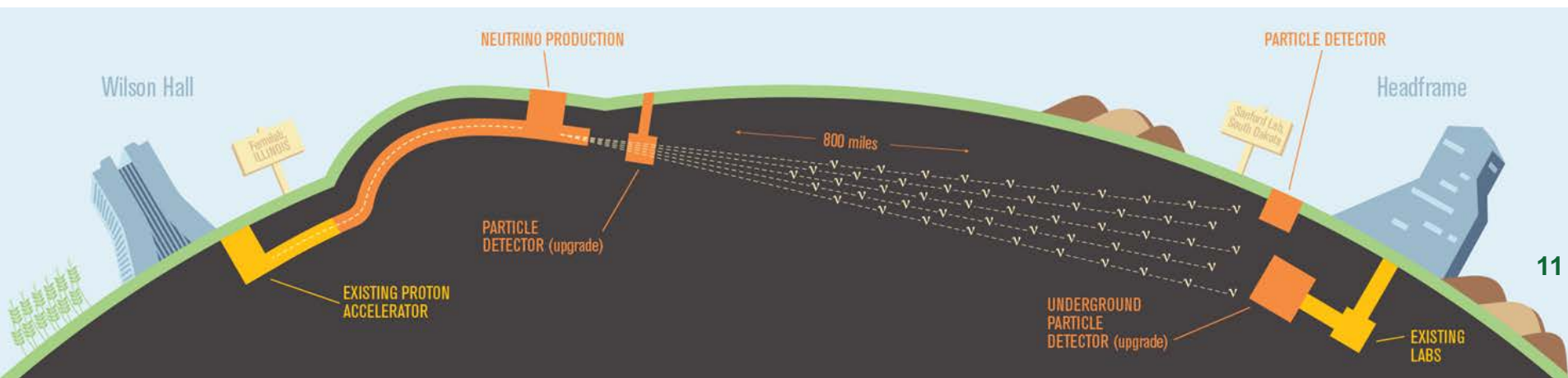
**14 kilotons = 28 NOvA Blocks**  
*28 blocks of PVC modules are assembled and installed in place*  
*26 blocks are filled with liquid scintillator*  
*13.00 blocks are outfitted with electronics*



**Signature of one of the first interactions captured at the NOvA detector from a beam of man-made neutrinos generated at Fermilab, 500 miles from the detector. (February 2014)**

# Long Baseline Neutrino Experiment

- **Reaction to the CD-1 approval from other countries was positive**
  - European Strategy Group recommended that CERN seek ways to partner with the U.S. on LBNE
    - Discussions are now ongoing. We need a new CERN-U.S. agreement that envisions CERN investment in the U.S. as well as U.S. investment at CERN.
  - U.S. and India will sign an agreement any day now to collaborate in several areas including LBNE
  - The European collaboration LBNO is discussing merging with LBNE
  - Brazilian, British, Italian, and Indian physicists have joined the LBNE collaboration. The collaboration has grown 30% with two-thirds of the growth from outside the U.S.
- **The U.S. particle physics community desires to locate LBNE underground to allow proton decay and neutrino astrophysics**
  - HEPAP through the SC Facilities prioritization panel found a underground detector more compelling
  - CERN and the Snowmass participants expressed similar views
  - **P5 will address this issue**







**COSMIC FRONTIER**



# Dark Energy Program

## Operating

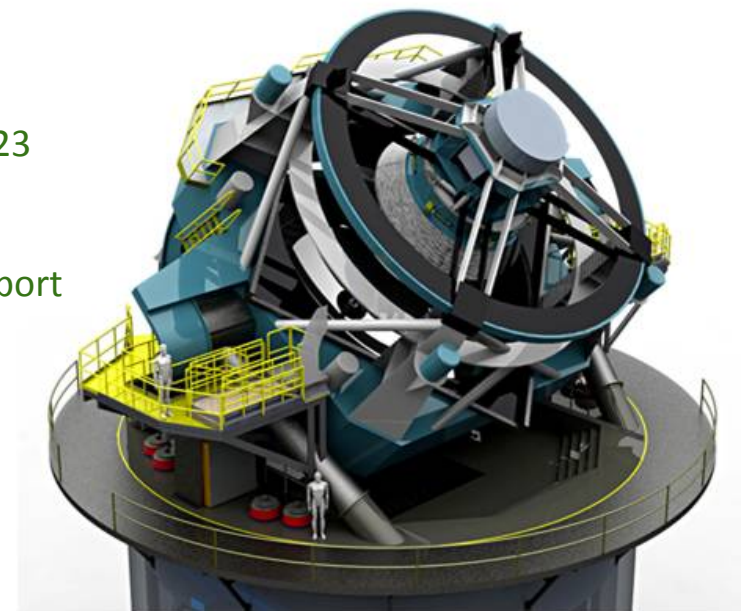
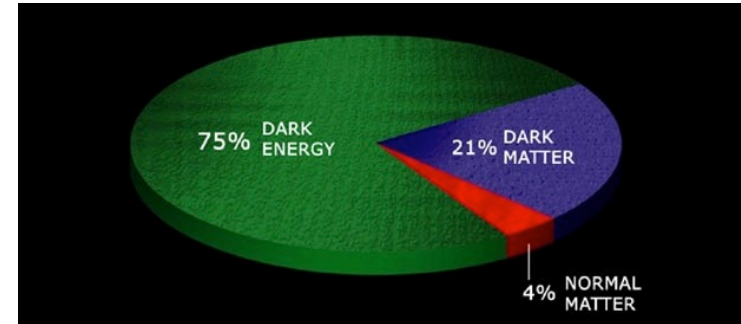
- **Baryon Oscillation Spectroscopic Survey (BOSS)**
  - Uses Baryon Acoustic Oscillation (BAO) method
  - 5 year ops completes in FY14
- **Dark Energy Survey (DES)**
  - 5 year ops started Sept 2013
  - DOE/NSF partnership; DOE responsible for camera
- **Supernova surveys continue operations**

## Fabrication

- **Large Synoptic Survey Telescope (LSST)**
  - Next generation imaging survey
  - Fabrication start approved in FY14, 10 year ops starts 2023
  - DOE & NSF partnership w/MOU
    - DOE responsible for the LSST-camera
  - Dark Energy Science Collaboration (DESC) formed to support science planning for precision dark energy results

## Future planning

- **Dark Energy Spectroscopic Instrument (DESI)**
  - Next gen. survey using BAO and Redshift Space Distortion (RSD) methods
  - Discussions with NSF for possible host telescopes
  - CD-1 review in summer 2014; R&D continuing in FY2015



LSST



# Dark Matter: Direct Detection Program Status

## Staged program

- Current experiments test multiple technologies to determine most powerful method for future generation

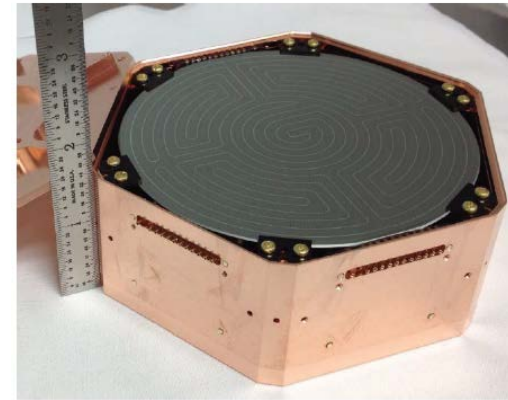
## Currently Operating: Generation 1 (DM-G1)

- 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 (interact with magnetic fields to make light)
  - ADMX-2a

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

- Select at least two DM-G2 experiments to move to fabrication phase:
  - Goal is to improve sensitivity by one or more orders of magnitude
  - CD-0 in Sept. 2012
  - Down select review in Dec. 2013
  - Plan to announce selection in 2014 after P5 report

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



CDMS



LUX

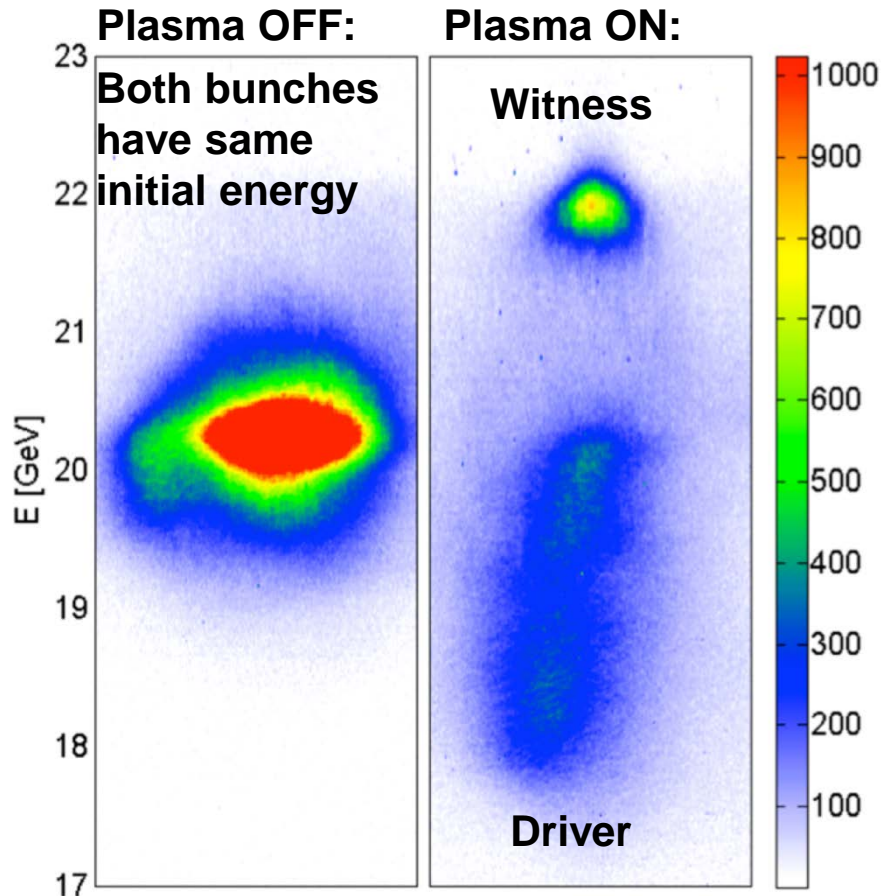






**ADVANCED TECHNOLOGY R&D**

# Recent Major Accomplishments: Technology R&D



FACET data from SLAC

## High quality $e^-$ beams in a 6 GeV/m acceleration field

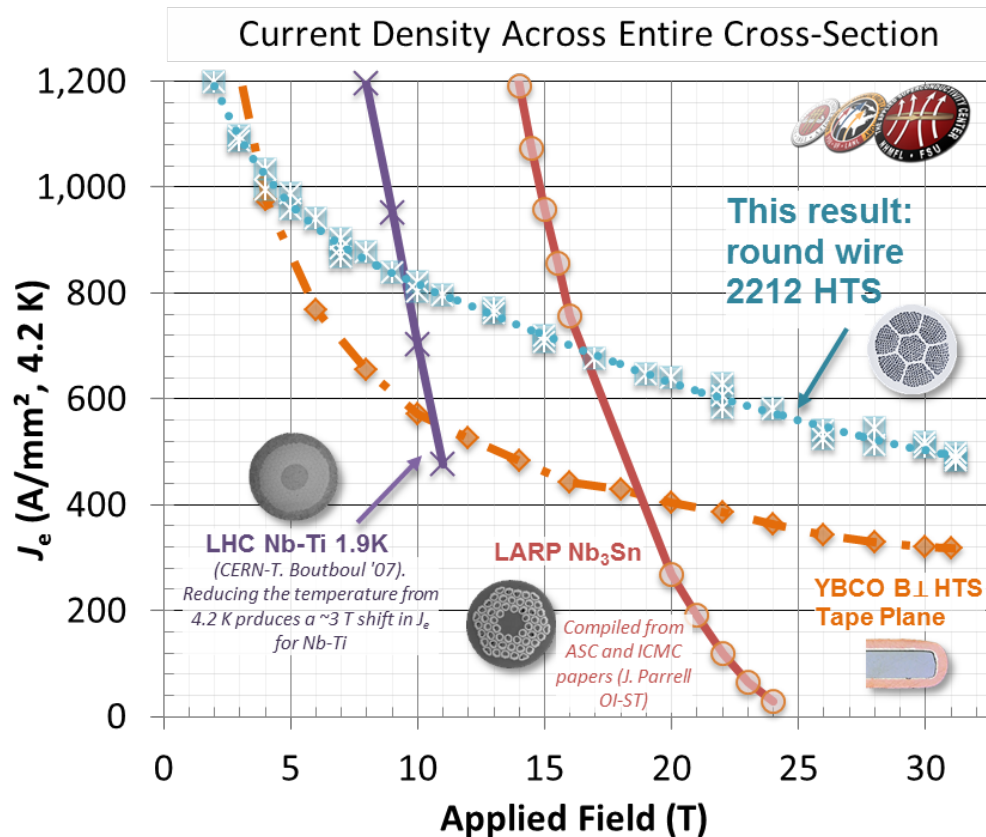
- New FACET facility demonstrates first acceleration of a witness bunch in beam driven plasma wakefield
- Accelerating Field 6 GeV/m, which is 300x that of the SLAC linac
- Important step towards meter scale high-energy plasma based accelerator

## Impact

**New technology with potential for far lower accelerator size and cost**



# Record Current in High Temperature Superconductor



**Achieved 500 A/mm<sup>2</sup> at 30T, 4.2K in Bi<sub>2</sub>Sr<sub>2</sub>CaCu<sub>2</sub>O**

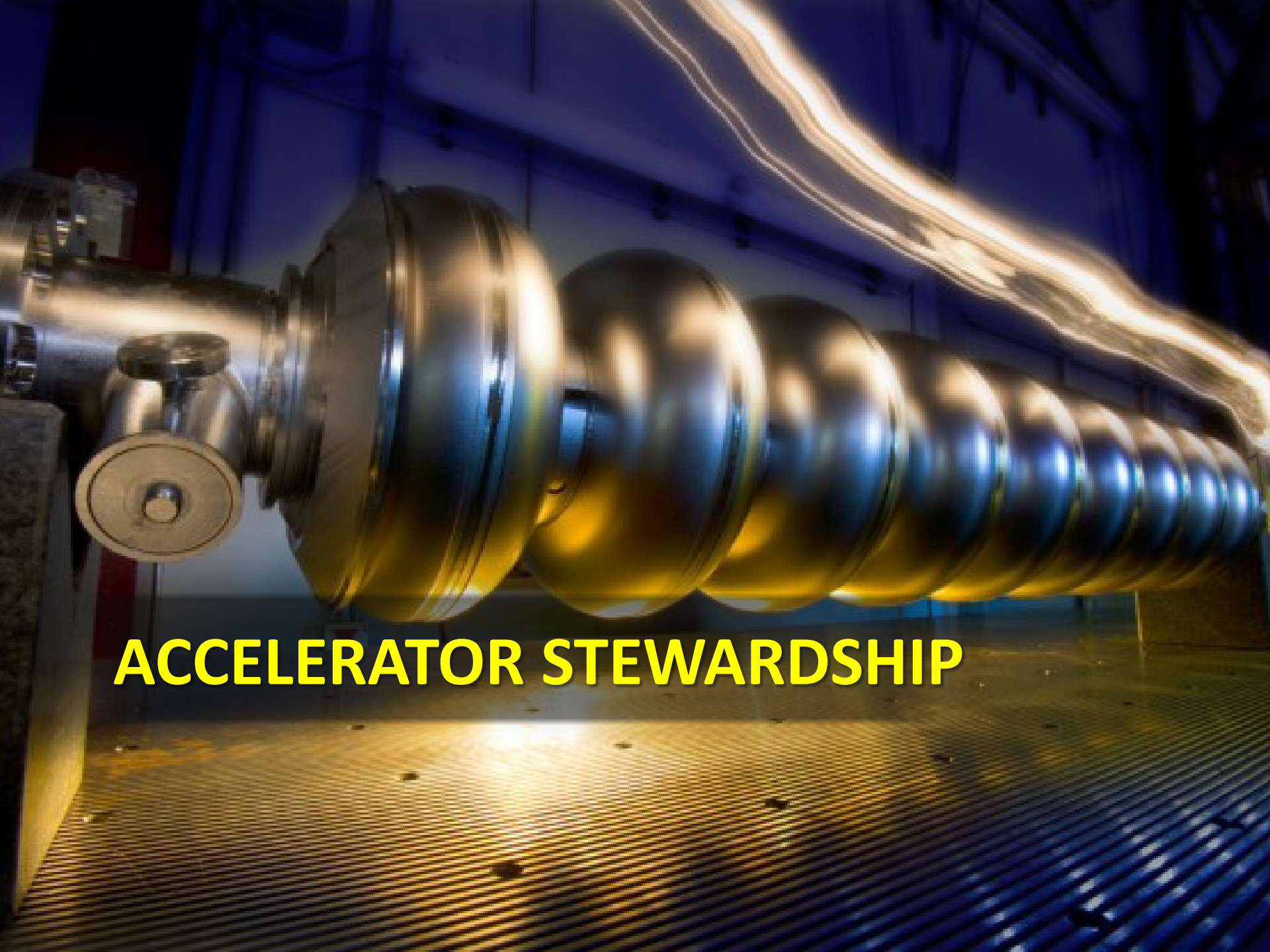
- Existing state-of-the-art conductors (Nb<sub>3</sub>Sn for LARP) sustain this performance only to 18 T
- LHC NbTi conductors sustain this performance only to 11 T
- This practical HTS magnet material is an isotropic round wire which can be cabled on existing machines
- Competing HTS materials are anisotropic tapes and not easily made into magnet cables

*Nature Materials* March 2014 DOI 10.1038/nmat3887

## Impact

This level of current density could technically enable magnetic field levels that double existing particle collision energies





**ACCELERATOR STEWARDSHIP**

# Formulating a National Accelerator Stewardship Program



Reports available at:

<http://science.energy.gov/~media/hep/pdf/accelerator-rd-stewardship>

## 2012 Holtkamp Accelerator Task Force

- Identified initial stewardship opportunities and potential impediments

## 2013 Ion Beam Therapy Workshop (with NIH)

- Identified the role of accelerator technology and facilities in further cancer therapy

## 2013 Laser Technology for Accelerators Workshop

- Identified high average power “ultrafast” lasers as key enabling technology for discovery and applied sciences

## 2014 Facilities Pilot Program Meeting

- Meeting of accelerator SC labs to discuss the potential user community needs and how to make the facilities more accessible

## 2013 RFI and 2014 Energy & Environment Workshop

- Will identify key accelerator R&D needed to advance energy and environmental applications of accelerators

# Accelerator R&D Stewardship Program Elements

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- **In its initial year, FY2014, Accelerator Stewardship begins with redirected funding:**
  - Approximately 2/3 of the funding is in existing activities that were identified as having broad impact beyond HEP
    - 8 University grants pursuing broadly applicable fundamental physics and technology R&D
    - Operations at Brookhaven-ATF, the Stewardship program's flagship facility
  - Approximately 1/3 of the funding applies to initiatives starting in FY2014:
    - ~½ will be used to prepare Brookhaven-ATF for increased utilization
    - ~½ will be used to open accelerator test facilities across the SC complex to “non-traditional” users (both OFAs and industry)
- **In FY2015 and beyond**
  - As the initial grants conclude, new grant applications will be sought (via FOA+PA) along the Stewardship thrusts: Laser Technology, Ion Beam Technology for Medicine, and Energy & Environment applications.

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# HEP BUDGET AND ISSUES



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# High Energy Physics Budget Highlights

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- **Research and Facilities Operations:**
  - **Energy Frontier:** LHC data taking resumes in 2015
    - The US will continue to play a leadership role in LHC discoveries and is actively engaged in the initial upgrades to the LHC detectors
  - **Intensity Frontier:** The Fermilab program continues its evolution as the leading accelerator facility on the intensity frontier
    - The newly completed NOvA detector begins taking physics data in FY2015.
    - Building several new experiments to access new phenomena that cannot be observed at the LHC, such as the Mu2e experiment, the muon g-2 experiment and the MiniBooNE experiment.
  - **Cosmic Frontier:** Advance our understanding of dark matter and dark energy
    - The recently-commissioned Dark Energy Survey continues its five-year mission, looking for the subtle effects of dark energy in shaping the evolution of universe
      - This search will be significantly extended in the future by the Large Synoptic Survey Telescope now under construction
    - The search for dark matter will enter new territory with R&D and design of selected next-generation dark matter detector technologies that can advance this field by an order of magnitude in sensitivity

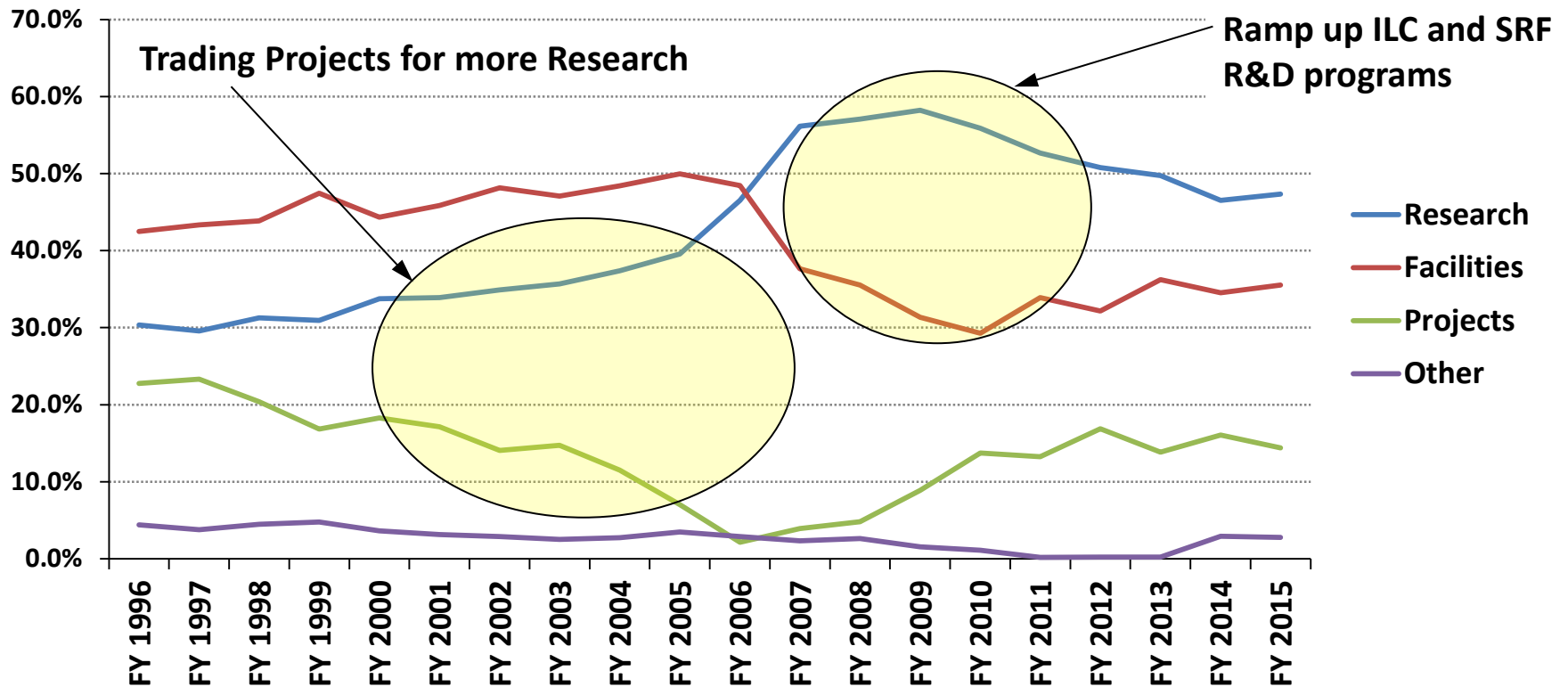
# High Energy Physics Budget Highlights

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- **Technology R&D :**
  - A new HEP subprogram that focuses on the broader applications of HEP-developed accelerator technologies known as “Accelerator Stewardship” was initiated in FY 2014 and is expected to begin new pilot programs and open new funding opportunities in 2015 to address high-impact R&D topics
- **Construction/Major Items of Equipment (MIEs):**
  - The Muon to Electron Conversion Experiment (Mu2e) will complete its design phase in FY 2015 and move into full construction
  - The Long Baseline Neutrino Experiment continues its design phase, which may include enhanced capabilities based on the level of partnership contributions. Potential LBNE collaborators in Europe, Asia, and South America have expressed interest
  - Funding is provided to initiate fabrication for new MIEs for the LHC detector upgrades and continue planned funding profiles of existing MIE projects. Total MIE funding increases to \$65M in FY2015 to support these new investments.



# Recent Funding Trends



- In the late 90's the fraction of the budget devoted to projects was about 20%
- Many projects started since 2006 are coming to completion
- We have not yet been successful at raising the project funding fraction beyond ~15%



# FY 2015 High Energy Physics Budget

(dollars in thousands)

Description	FY 2013 Actual	FY 2014 Enacted	FY2015 Request
Energy Frontier	149,446	154,687	153,639
Intensity Frontier	274,412	275,043	251,245
Cosmic Frontier	80,063	99,080	101,245
Theory and Computation	66,398	62,870	58,850
Advanced Technology R&D	142,291	122,291	114,242
Accelerator Stewardship	3,132	9,931	19,184
SBIR/STTR	0	21,619	20,595
Construction (Line Item)	11,781	51,000	25,000
<b>Total, High Energy Physics</b>	<b>727,523*</b>	<b>796,521</b>	<b>744,000</b>
<b>Office of Science</b>	<b>4,681,195</b>	<b>5,066,372</b>	<b>5,111,155</b>

**\*The FY 2013 Actual is reduced by \$20,791,000 for SBIR/STTR.**

# HEP Physics Funding by Activity

(dollars in thousands)

Funding (in \$K)	FY 2013 Actual	FY 2014 Enacted	FY 2015 Request
<b>Research</b>	<b>361,766</b>	<b>370,447</b>	<b>352,227</b>
<b>Facility Operations and Experimental Support</b>	<b>265,123</b>	<b>276,561</b>	<b>264,208</b>
<b>Projects</b>	<b>100,634</b>	<b>127,894</b>	<b>106,970</b>
<i>Energy Frontier</i>	3,000	12,000	15,000
<i>Intensity Frontier</i>	63,494	37,000	24,970
<i>Cosmic Frontier</i>	19,159	24,694	41,000
<i>Theory and Computation</i>	3,200	3,200	1,000
<i>Construction</i>	11,781	51,000	25,000
<b>SBIR/STTR</b>	<b>0</b>	<b>21,619</b>	<b>20,595</b>
<b>TOTAL HEP</b>	<b>727,523*</b>	<b>796,521</b>	<b>744,000</b>

\*The FY 2013 Actual is reduced by \$20,791,000 for SBIR/STTR.

# HEP Physics MIE Funding

Funding (in \$K)	FY 2013 Actual	FY 2014 Enacted	FY 2015 Request	Description
<i>Energy</i>	1,500	6,000*	7,500	LHC CMS Detector Upgrades
<i>Energy</i>	1,500	6,000*	7,500	LHC ATLAS Detector Upgrades
<i>Intensity</i>	19,480	0	0	NOvA ramp-down
<i>Intensity</i>	5,857	0	0	MicroBooNE
<i>Intensity</i>	5,000	8,000	970	Belle-II
<i>Intensity</i>	5,850	9,000	9,000	Muon g-2 Experiment
<i>Cosmic</i>	1,500	0	0	HAWC
<i>Cosmic</i>	8,000	22,000	35,000	Large Synoptic Survey Telescope (LSSTcam) Camera
<b>TOTAL MIE'S</b>	<b>48,687</b>	<b>51,000</b>	<b>59,970</b>	

\*OPC funding was supplied in FY2013 and FY2014. FY2015 is the first request for TEC funding



# MIE Issues

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- **Only able to implement two new MIE starts in FY15 request**
  - ATLAS and CMS Phase I Detector Upgrades
- **Other new MIE projects begun in prior years have are requesting fabrication funds required to maintain schedule**
  - Belle-II
  - Large Synoptic Survey Telescope
- **Long-term planning (P5) report will impact prioritization of future MIEs**
  - 2nd Generation Dark Matter detectors
  - Dark Energy Spectroscopic Instrument

# HEP Physics Construction Funding

Funding (in \$K)	FY 2013 Actual	FY 2014 Enacted	FY2015 Request
<b>Construction</b>	<b>28,388</b>	<b>61,000</b>	<b>35,000</b>
<b>Long Baseline Neutrino Experiment (TPC)</b>	<b>17,888</b>	<b>26,000</b>	<b>10,000</b>
<i>TEC</i>	3,781	16,000	0
<i>OPC</i>	14,107	10,000	10,000
<b>Muon to Electron Conversion Experiment (TPC)</b>	<b>10,500</b>	<b>35,000</b>	<b>25,000</b>
<i>TEC</i>	8,000	35,000	25,000
<i>OPC</i>	2,500	0	0

- Funding provided consistent with the planned profile for construction of the Muon to Electron Conversion (Mu2e) Experiment
- No construction funding provided for LBNE



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# EXPECTATIONS



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# HEP Performance Expectations for Particle Physicists

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- **DOE/HEP expects the community to fully support the result of the P5 and Snowmass deliberations**
  - The entire community has put an enormous amount of work and energy into this process
  - The Secretary has advised us (see Snowmass opening letter) to **'get a plan'** and **'stand behind our plan'**
  - DOE/NSF have fully supported the P5 process, and have not meddled with any aspect of it
- **The budget scenarios P5 had to deal with are extremely tight, so it is very likely your favorite project did not get the priority you hoped.**
  - DOE/HEP expects you will support the prioritization chosen by the committee in any case
  - We need to keep this in mind so that the field will be able to move ahead.
  - You must **suppress any feeling of entitlement** that the budget scenarios are too austere for a field as glorious as HEP.
- **The science priorities chosen by P5 might not match your personal preferences**
  - DOE/HEP expects you to respect the P5 science priorities and the P5 process
  - You need to keep this in mind so the field will be able to move ahead.
  - The global HEP program is at stake, not just your research or feelings.
  - Steve Ritz: **'Bickering scientists get nothing'**
- **NB.: Any argument along the lines that some project or research line in the P5 plan should be replaced with your favorite project instead will, if heard by the decision makers, result in a net loss of resources to the field.**



# Expectations on Issues Not Addressed by P5

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- P5 had a big enough job to do to come up with science and project prioritization, so they are not able to solve all the other ‘sociological’ issues facing our community
- Intense discussion in the community around the sociological issues can easily be mistaken by decision makers as disputes over the P5 plan, so please be careful to frame discussion points properly, *especially when discussing issues we face with others outside the field.*
  - Blogging, posting on public websites are a *de facto* public conversation
- The HEPAP chair intends to address some of these ‘sociological’ issues over the coming year with a subpanel and/or task forces.
- Your concerns in these areas should be communicated to NSF/EPP, DOE/HEP (grant monitors, program managers, AD), the HEPAP Chair, the FNAL Director, or the DPF chair line.
  - We will collect your ideas and try to fix issues over the coming year(s).



# Some Communication Do's and Don'ts

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- **Do:**

- Provide your unvarnished feedback on your opinions about the P5 report to NSF, DOE, Chair of HEPAP, Chair of P5, Director of FNAL, and/or DPF Chair line
  - We are constantly in contact and will be monitoring views of the community through all of these channels.
- Familiarize yourself with the P5 supplemental materials that will be provided and will be vetted by communications professionals for clarity and impact
- Take careful note (*listen!, don't lecture*) of how the folk you talk to react to the P5 story and pass those reactions back to NSF and DOE so we can adjust our messages about P5 to have maximum positive impact.
- Put yourself in the position of an outside observer of HEP, and ask yourself:
  - Do these strange people look like they know what they are doing?
  - Do they have their act together?
  - Do they have a clear and compelling message?

- **Don't:**

- Ever speak to someone outside our field and transmit a sense of our entitlement to support due to the glorious nature of Particle Physics research, past Nobel prizes, etc. This mistake can take many forms.
- Ever attack areas of our field in favor of your favored area since 'bickering scientist get nothing'
- Ever diminish other areas of science as somehow less important than HEP. Even if you actually think that.



# Take-Away Messages

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- **Actively engaged with community in developing new strategic plan**
  - P5 will deliver their long term vision report in May
  - S. Ritz presented the context and groundwork yesterday
  - Will adapt to the new strategic plan as quickly as possible
- **Clear message from DOE management**
  - HEP needs to have a compelling and executable strategic plan, and the community needs to get behind it
- **Message in FY2014 Appropriation**
  - HEP has supporters in Congress
  - Projects delayed by extended Continuing Resolutions and sequester get moving
- **Message in FY2015 Budget Request**
  - Without a clear and endorsed plan we have a weak basis to argue for more funding in a constrained fiscal environment
  - Additional new projects struggling to get started
- **Message from HEP**
  - *“Bickering scientists get nothing”* [Ritz]