High Energy Physics Program Status

Jim Siegrist
Associate Director
Office of High Energy Physics
Office of Science, U.S. Department of Energy

Outline

- **Overview**
- **Program Status and Accomplishments**
- **HEP Budget and Issues**
- **HEP Funding Opportunities**
- **Office News**

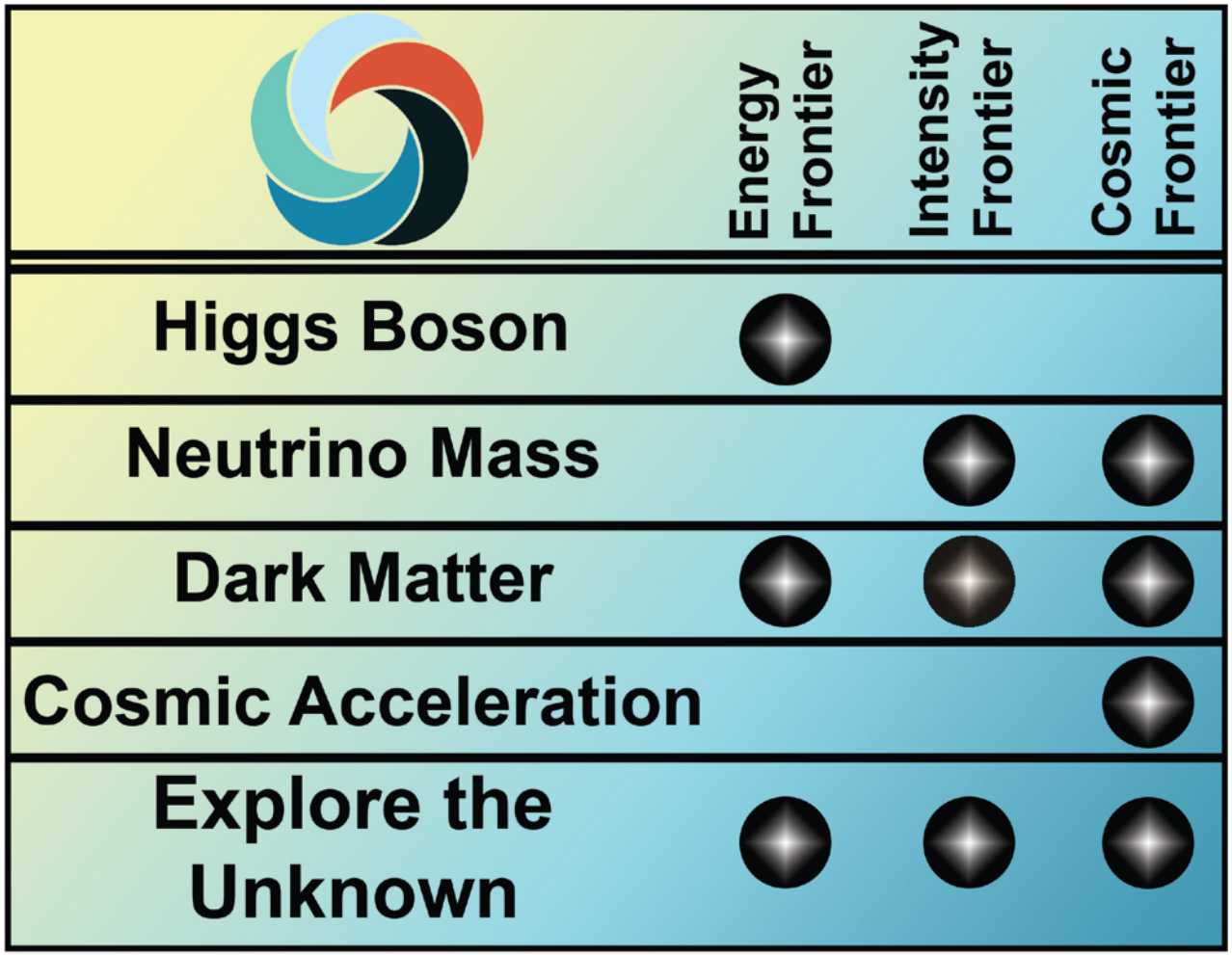
Take-Away Messages

- **P5 plan is a compelling, unified vision for HEP**
  - Five intertwined science drivers define the big issues
  - Widespread community support not seen for 20+ years
- **A balanced approach is critical**
  - Another important reason the P5 plan enjoys such widespread HEP community support is that it takes a balanced approach to planning:
    - Time-phased, projects of different scales, balanced across Frontiers, on- and off-shore
  - DOE implementation strives to maintain that balance
- **HEP is global**
  - P5 strategic plan explicitly recognizes this fact, as does DOE implementation
  - Highest priority major projects are LHC upgrades (near-term) and LBNF (mid-term).
    - LBNF will be the first truly international experiment hosted by the US, with management modeled after the successful LHC scheme
- **We share the community's enthusiastic response to the P5 strategic plan**
  - We are moving forward with implementation in targeted areas
  - But given the current fiscal environment, **full** implementation of the plan will take some time


HEP PROGRAM STATUS

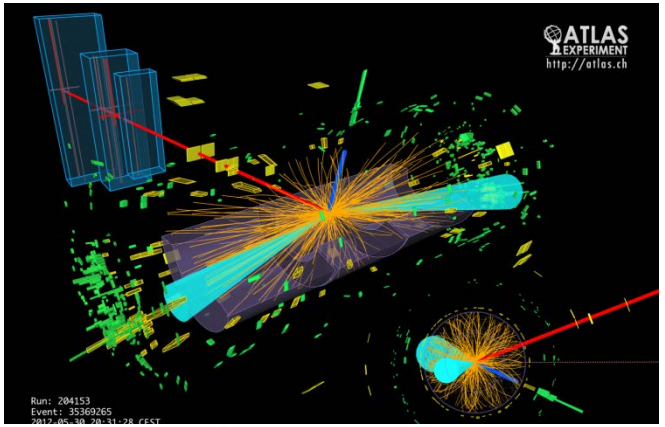
Science Drivers and Research Frontiers

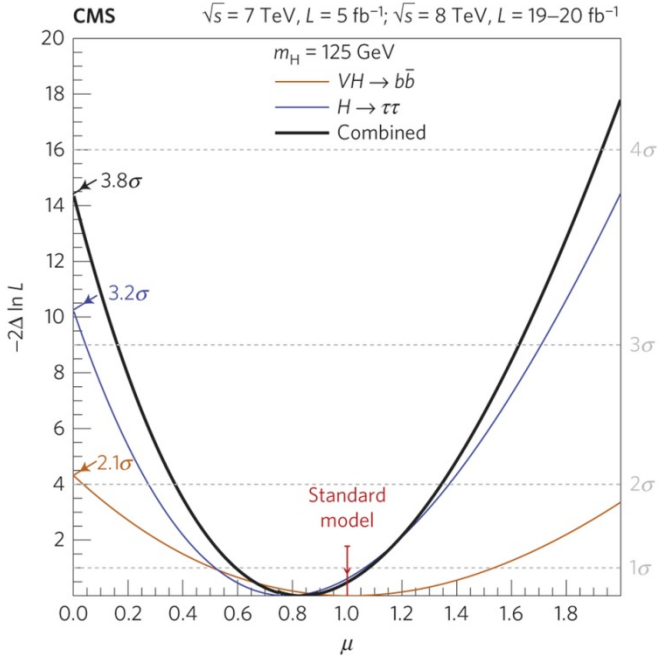
Science drivers identify the scientific motivation while the Research Frontiers provide a useful categorization of experimental techniques



Energy Frontier Highlight:
LHC Evidence for Leptonic Higgs Decays

- **Higgs boson has been observed decaying into bosons: *Z*, *W*, and photon**
  - Rates consistent with SM prediction
  - Higgs spin and parity properties also consistent with predictions
- **Decays to fermions (*b* quarks, tau leptons) important to observe in order to confirm Higgs decays as predicted by Standard Model**
  - Recent results from ATLAS and CMS show evidence for *b* and *τ* decays
    - CMS: 3.8σ for $b+\tau$ channels combined
    - ATLAS: 4.1σ for τ decays *(preliminary)*





Nature Physics 10, 557–560 (2014)

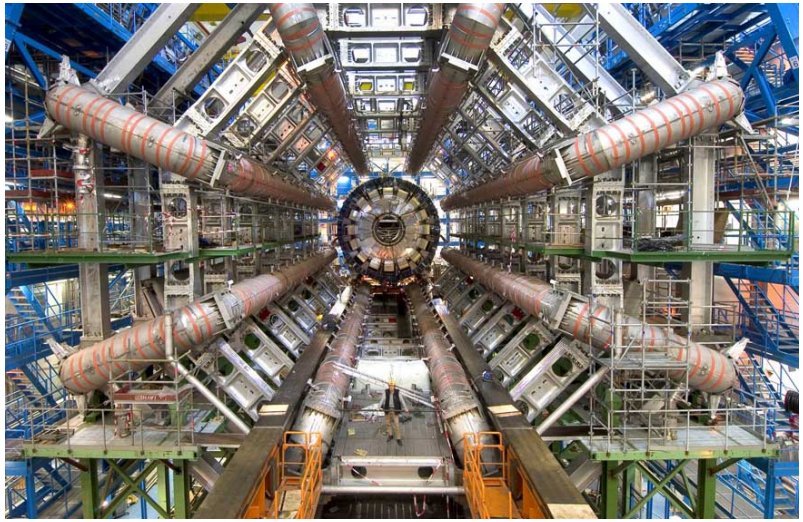
Energy Frontier Status

Current program

- **LHC will resume operations in spring 2015 at collision energies of 13+ TeV**
  - Significant increase in energy from 7-8 TeV in Run I
- **Higher energy will increase the reach of the LHC into the search for new physics in high-impact topics, including SUSY, search for dark matter, and extra dimensions**
- **The U.S. will continue to play a leadership role in LHC discoveries and is actively executing the initial upgrades (Phase-1) to the LHC detectors**
  - CD2/3 reviews for Phase-I U.S. CMS/ATLAS were held in August-September 2014

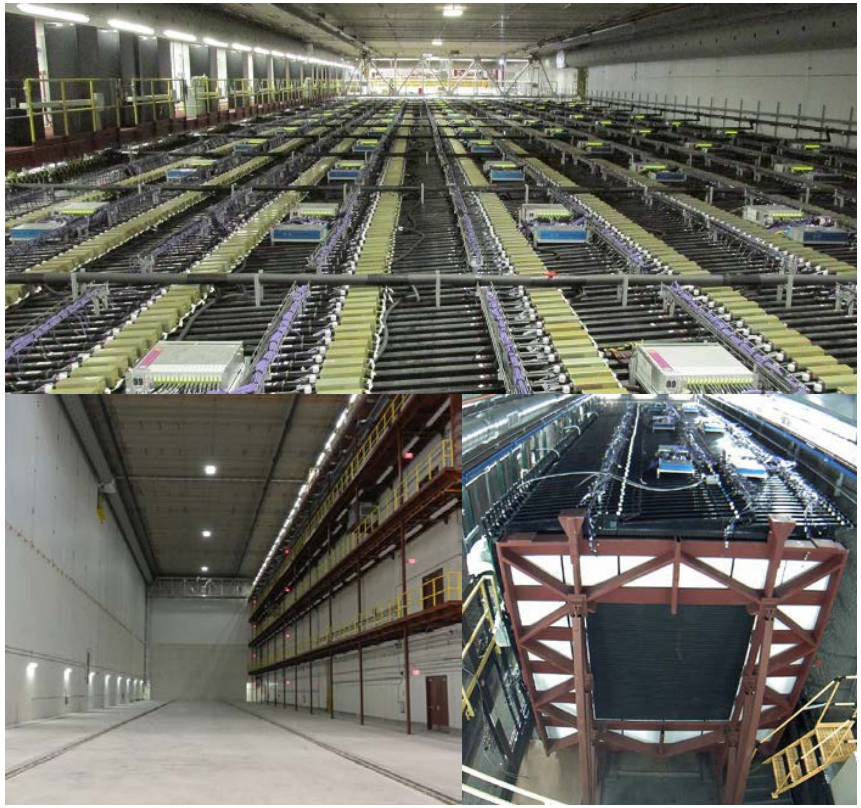
Planned program

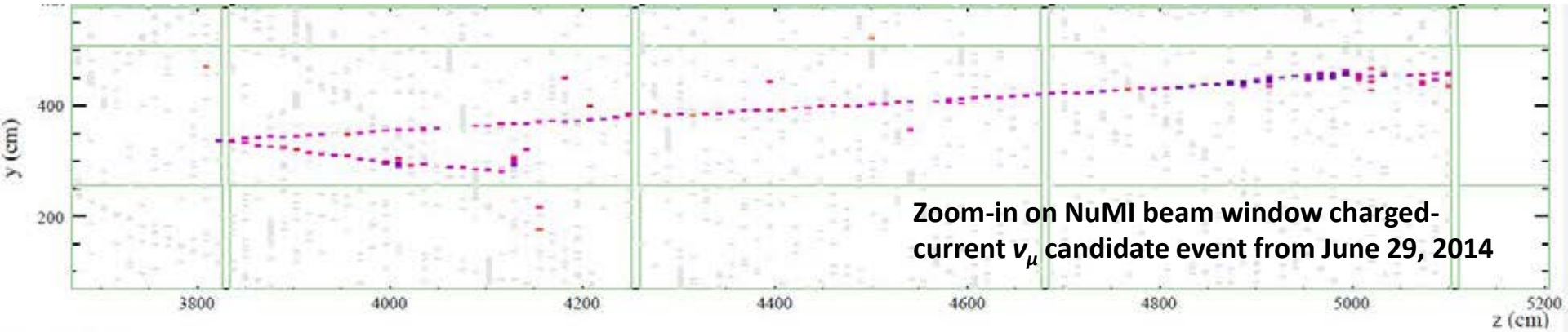
- **Considering high-luminosity update to LHC around 2023 to extend discovery potential**
  - Increase luminosity by a factor of 10 beyond LHC design value to explore new physics and new dynamics for W/Z, top, and Higgs at TeV energies
- **Energy Frontier Program Manager actively working with U.S. ATLAS/CMS to begin mounting HL-LHC Upgrade Project**
- **U.S. Department of State has given approval to begin negotiating with CERN on the U.S.-CERN LHC Agreement**
  - Bilateral agreement now under review by CERN
- ***Very* modest investments in R&D for future options:**
  - Lepton colliders
  - Very high energy hadron colliders



Intensity Frontier Highlight:
NOvA Experiment Project Completion

- **The neutrino beam and both detectors, near and far, are operating**
- **Project will finish on time and below budgeted TPC**
  - The NOvA MIE project is expected to return $2.4 million to the HEP Program
- **CD-4 approved September 24**





Zoom-in on NuMI beam window charged-current ν_μ candidate event from June 29, 2014

Intensity Frontier Status

Exploring the unknown through precision measurements

- **Exploit the quantum nature of particles to allow experiments to probe very high energies for new particles or forces beyond the Standard Model**
  - Precisely measure properties of charged leptons and search for extremely rare particle interactions
    - Program based on muon beams at Fermilab: **Muon g-2**, **Mu2e**
  - Precision studies of K mesons, charm quarks and tau leptons to search for new states of matter
    - Small program being carried out at foreign labs: **Belle-II**, **K0TO**

Pursuing the physics associated with neutrino mass

- **Neutrinos are the most abundant known particle in the universe, but also the least understood, and may be key to understanding matter-antimatter imbalance in universe**
  - Current program aims to determine neutrino mass hierarchy and measure neutrino properties
    - Experiments at Fermilab, China, Japan and underground: **Daya Bay**, **MicroBooNE**, **MINERvA**, **MINOS+**, **NOvA**, **Super-K**, **T2K**
  - Planned program seeks to determine if there are sterile neutrinos and if neutrinos violate CP
    - Neutrino program planning underway (see following slides for Long Baseline Neutrino efforts)
      - Encouraging community efforts to produce optimized short-baseline (SBN) proposal(s) in collaboration with international partners
      - Fermilab SBN Working Group established, Fermilab PAC will consider SBN proposal(s)
      - Workshop on other “neutrino small projects” in planning stages

Identify the physics of dark matter

- **Intense particle beam based searches for dark matter: APEX, Heavy Photon Search**

Progress on Internationalization of Long-baseline Program

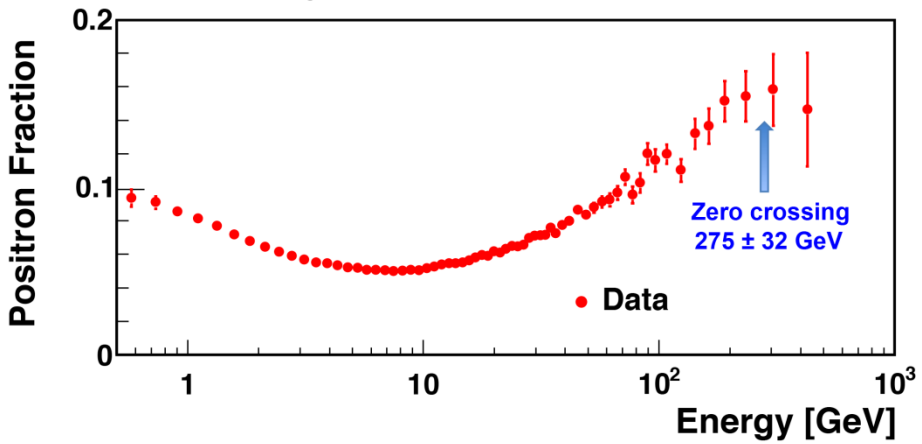
- **International Meeting for Large Neutrino Infrastructures, Paris, June 22-23, 2014**
  - Nations represented either by agencies or their laboratory leadership included Canada, CERN, China, France, India, Italy, Japan, U.K., and U.S.
  - At the conclusion of the meeting a communiqué was prepared by the agencies that summarized its assessment of the meeting, which included a call to the community:
    - "The agencies and laboratory directors invite the neutrino scientific community to develop urgently a coherent international program that exploits the … opportunities [presented at this meeting] . They will meet again in early 2015 in the U.S.A. to evaluate the progress made with respect to this goal."
- **FNAL Interagency Meeting on a Global Neutrino Program, July 14, 2014**
  - Potential schemes for FNAL-based project management structure and governance were discussed, initially adopting aspects of CERN organizational structure
    - Very positive responses and inputs
  - A Working Group will be established with agency appointees to develop project management and organization concepts

Progress on Internationalization of Long-baseline Program (continued)

- **World Neutrino Summit at Fermilab, July 21–22, 2014**
  - Invitation only workshop of the premier neutrino physicists from the U.S., Canada, Brazil, Japan, China, Italy, France, U.K., and Switzerland
  - Agreement to establish an interim international Executive Board (iiEB)
    - Board will arbitrate disagreements as well as be responsible to help form the collaboration and establish a collaboration governance
  - Agreement to establish 3 science working groups to discuss:
    - Physics (baseline, beam energy, and detector technology)
    - Facilities choices/issues
    - Systematics implications/necessary complementary program required
  - Agreement that the **primary** far detector technology be liquid argon (of some flavor)
    - Acknowledgement that benefits of a **second technology** should be studied
- **iiEB Board Meeting at Fermilab, September 23-24, 2014**
  - iiEB plans for underground liquid argon detector are consistent with Snowmass community consensus and the P5 report recommendations
  - SURF site visit planned for October 8-9 to help finalize facility decision

Cosmic Frontier Highlight:
AMS Updates Search for Dark Matter

- **New precision measurement by AMS of the positron fraction in primary cosmic rays**
  - Based on 10 million positron and electron events
  - Positron fraction ceases to increase at 275 ± 32 GeV
  - If excess positrons come from pulsars:
    - Fraction should slowly decrease beyond turning point
    - Dipole anisotropy should be observed
  - If excess positrons come from dark matter collisions
    - Fraction should decrease rapidly with energy due to the finite and specific mass of the dark matter particle
    - No dipole anisotropy will be observed



Cosmic Frontier Status

Dark Energy

- **Operating:** **BOSS** (spectroscopic) ends FY14, **DES** (imaging) started FY13, supernova surveys
- **Fabrication:** Large Synoptic Survey Telescope (**LSST**, Stage IV DE imaging) – NSF/DOE partnership w/MOU
  - LSST-camera CD-3a (Fabrication Start) approved June 2014
  - Dark Energy Science Collaboration formed to plan, deliver science
- **Planning:** Dark Energy Spectroscopic instrument (**DESI**) Stage IV spectroscopic survey to complement LSST
  - CD1 review Sept. 2014; Planning for fabrication start FY16

Dark Matter (direct detection) – *See additional talks on Tuesday*

- **Operating:** 1st generation (DM-G1) experiments - **ADMX**, **LUX**, **CDMS-Soudan**, **DarkSide**, **COUPP**
- **Planning:** DOE and NSF announced in July 2014 selection of DM-G2 experiments to move forward to fabrication phase: **ADMX-G2**, **LZ**, **SuperCDMS-SNOLab**
  - LZ & SuperCDMS-SNOLab MIE projects are planning for a fabrication start in FY16

Cosmic-ray, Gamma-ray

- **Operating:** **Fermi/GLAST**, **VERITAS**, **Auger**, **AMS**
  - DOE operations efforts completed by FY16 for VERITAS and Auger
- **Fabrication:** **HAWC** gamma-ray observatory starts full science operations in late 2014
  - **DOE is not moving forward with participation in the Cherenkov Telescope Array (CTA) based on P5 recommendation and program priorities.**

Cosmic Microwave Background (CMB)

- **Operating:** South Pole Telescope polarization (**SPTpol**)
- **Fabrication:** Starting for **SPT-3G** experiment, assuming successful Sept. 2014 review
- **Planning:** Community planning for a **CMB Stage IV** experiment

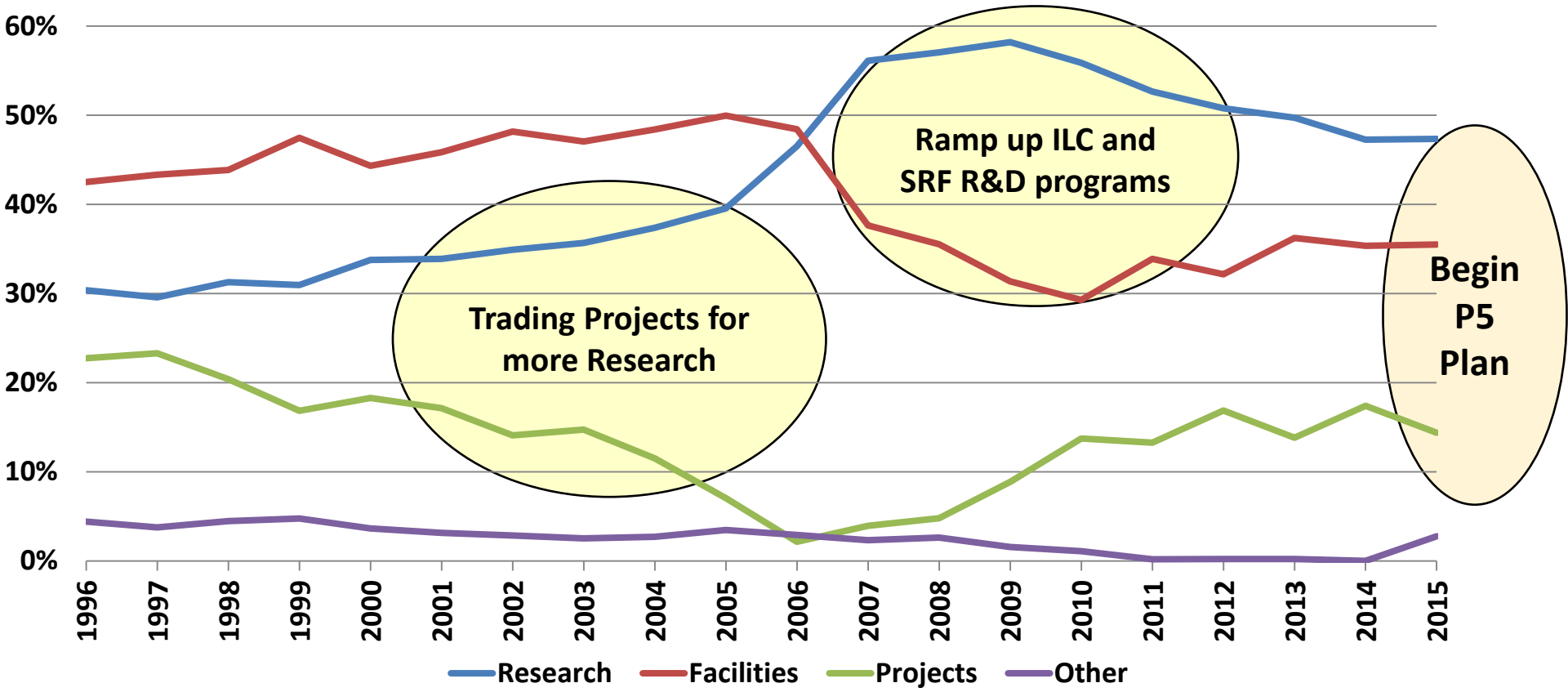
Accelerator Stewardship

- **Authorized for the first time in FY 2014 as a redirection of funds**
  - An initial Stewardship program was identified in discussions with SC/BES and SC/NP composed of 10 existing university grants, the BNL-ATF program, and the Facilities Pilot Program
- **Program elements for FY 2015 awaiting appropriations**
  - First Accelerator Stewardship call for proposals for FY 2015
    - Three applied R&D topic areas recommended by the Accelerator Task Force, and developed by subsequent workshops
      - Particle Beam Therapy Improvements
      - Ultrafast Laser R&D
      - Energy Efficiency Improvements for SC Accelerators
    - A basic R&D category for long-term generic accelerator R&D
    - Merit review process underway now
    - Awards subject to available funding
  - Accelerator Test Facility Pilot Program for FY 2015
    - Will gauge demand and nature of “outside” uses of SC accelerator R&D infrastructure
    - Defining agreement signed this summer. Will implement in FY 2015, subject to available funding

HEP BUDGET AND ISSUES

Funding Trends by Fiscal Year

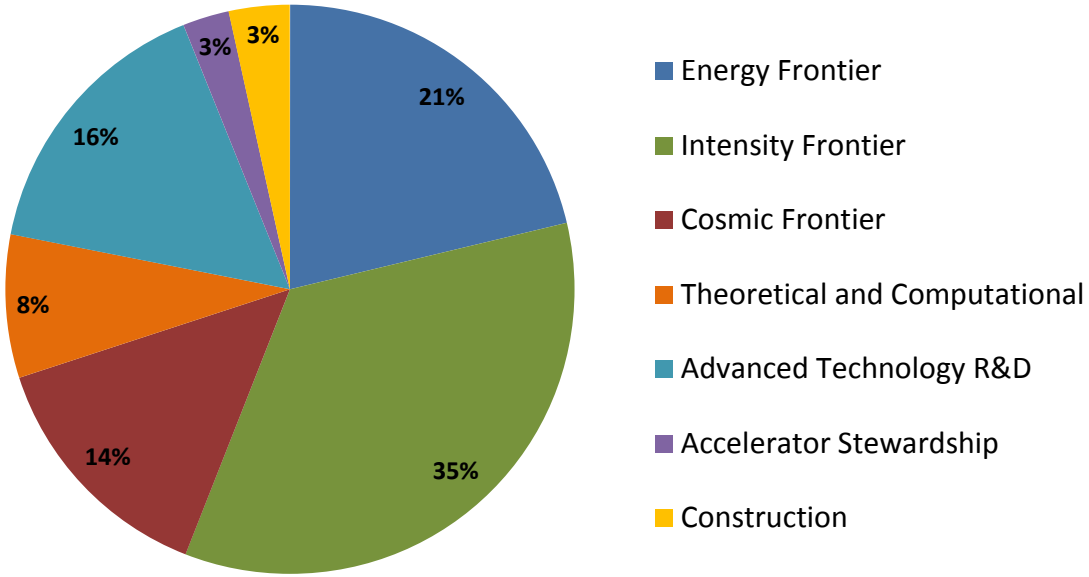
(FY2015 shows President's Request)



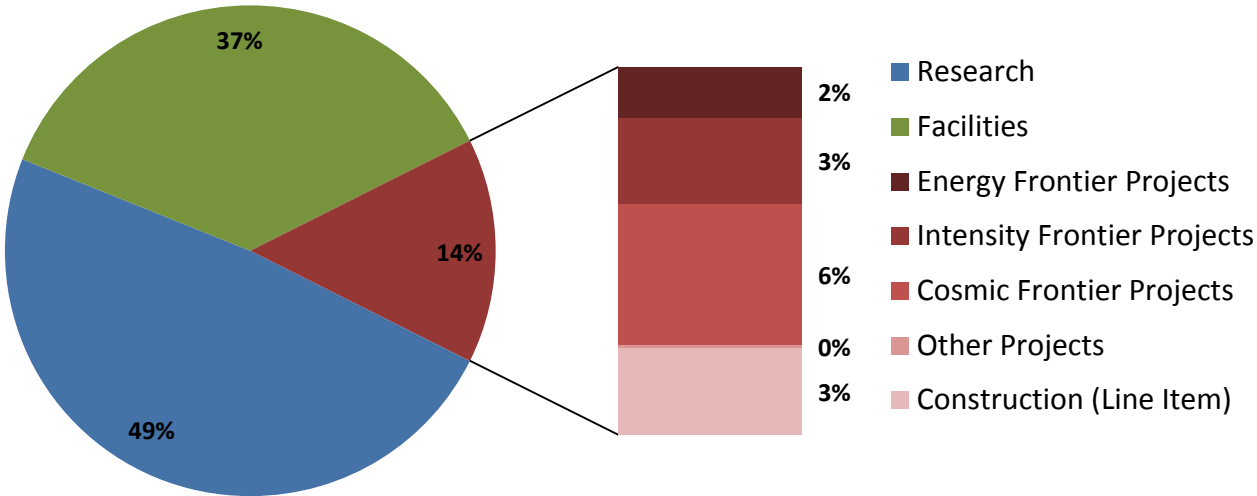
- **P5 report recommendation suggests increasing the project budget fraction to 20%–25%**
  - "Addressing the [science] Drivers in the coming and subsequent decades requires renewed investment in projects."
- **Impacts of P5 report strategy should begin to become evident in FY 2016 DOE budget**

FY 2015 HEP Budget Request Overview

HEP FY15 Request Funding by Subprogram



HEP FY15 Request Funding by Activity



FY 2015 High Energy Physics Budget

HEP Funding Category *($ in K)*	FY 2013 Current	FY 2014 Current	FY 2015 Request	Explanation of Changes (FY15 vs. FY14)
Energy Frontier	149,446	154,687	153,639	Reduction for Tevatron completion offset by LHC upgrade activities
Intensity Frontier	274,412	275,043	251,245	Reductions for NOvA project completion, Belle-II offset by increase for beam line ops & refurbishment at FNAL
Cosmic Frontier	80,063	99,080	101,245	Ramp-up of LSSTcam
Theoretical and Comp.	66,398	62,870	58,850	Reduced to offset investments in future facilities
Advanced Technology R&D	142,291	122,291	114,242	Reduced to offset project increase, shift towards directed R&D
Accelerator Stewardship	3,132	9,931	19,184	Support new R&D efforts, open accelerator test facilities to industry
Construction	11,781	51,000	25,000	Mu2e on profile; LBNE reduced in FY15 req. (req. made during P5 report development)
SBIR/STTR	0	21,619	20,595	
Total	**727,523**	**796,521**	**744,000**	

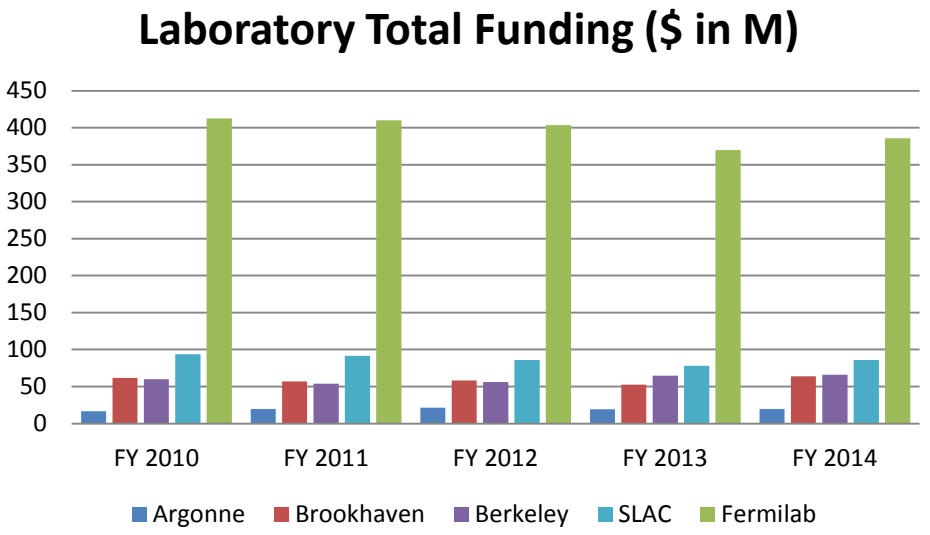
FY 2015 HEP Funding by Activity

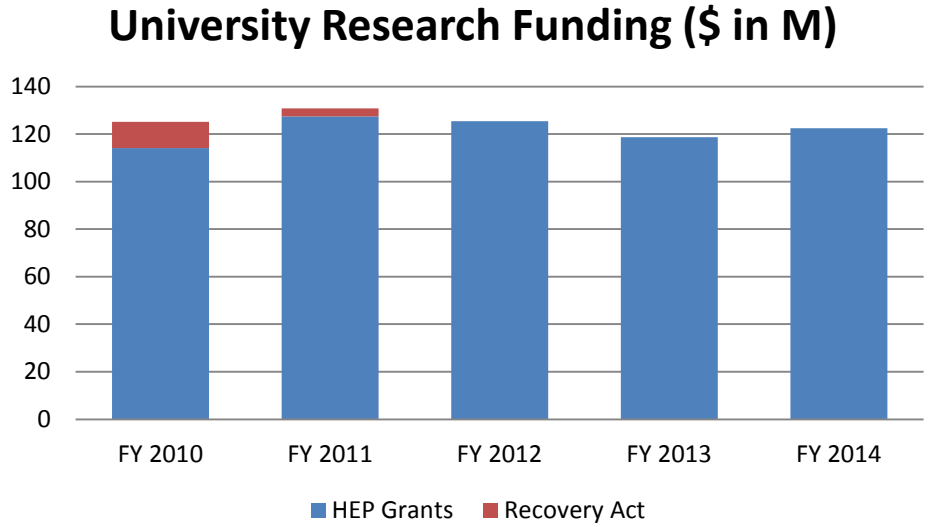
HEP Funding Category *($ in K)*	FY 2013 Current	FY 2014 Current	FY 2015 Request	Explanation of Changes (FY15 vs. FY14)
Research	364,766	382,447*	352,227	Research reductions support project investments
Facilities	265,123	276,561	264,208	Small decrease in CF operations as some experiments ramp down
Projects	85,853	64,894	81,970*	
Energy Frontier Projects	*0*	*0*	*15,000*	*LHC detector upgrade MIEs*
Intensity Frontier Projects	*63,494*	*37,000*	*24,970*	*Belle-II ramp down, FNAL acc. upgrade R&D reduction*
Cosmic Frontier Projects	*19,159*	*24,694*	*41,000*	*LSSTcam fabrication support and R&D related project costs*
Other Projects	*3,200*	*3,200*	*1,000*	*Lattice QCD hardware project completion*
Construction (Line Item)	11,781	51,000	25,000	Mu2e on profile; LBNE reduced in FY15 request (request made during P5 report development)
SBIR/STTR	0	21619	20595	
Total	**727,523**	**796,521**	**744,000**	

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

HEP Funding Trends

- **University funding level has been constrained in recent years**
  - Full funding requirements affect resource allocations
- **Investments in Laboratory projects are being supported by reductions in Laboratory research**





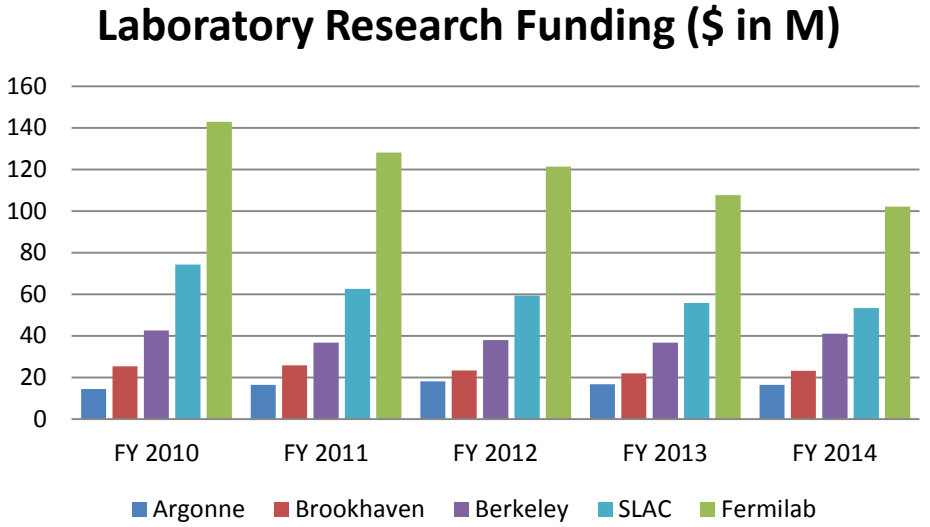


Table of FY15 Request vs. Senate & House

Funding in $K	FY 2014 Current	FY 2015 Request	FY 2015 House Mark	FY 2015 Senate Mark
Energy Frontier	151,926	153,639	157,888	156,069
Intensity Frontier	251,032	251,245	266,691	244,939
Cosmic Frontier	101,371	101,245	103,056	106,641
Theoretical and Computational	64,298	58,850	60,670	60,416
Advanced Technology R&D	147,124	114,242	125,605	119,638
Accelerator Stewardship	8,169	***19,184***	***3,000***	***19,184***
Construction	51,000	25,000	37,000	47,000
SBIR/STTR	0	20,595	21,090	20,595
Total	**774,920**	**744,000**	**775,000**	**774,482**

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

HEP Budget Scenario

- **"Are we in Scenario A or B of the P5 report?"**
  - Based on the House and Senate markups of the **appropriation bills**, we anticipate that we will be able to implement **Scenario B**
  - However, the **continuing resolution** (currently in effect through Dec. 11) is at a level **below Scenario A**
- **This complicates planning for HEP, but we will respect the P5 priorities:**
  - Projects that are baselined or nearly baselined will be fully funded
    - This includes the LHC Phase I upgrades, Mu2e, and LSST
  - High-priority near-term efforts like second generation dark matter experiments will get enough funding to keep the going through the CR and we will try to enhance their funding after an appropriation is passed
  - We will seek opportunities to reduce funding for efforts with large carryovers in order to get us through this period within minimal impacts
  - Decisions on how to fund longer term investments like Future Circular Collider studies or ILC R&D will be delayed until the budget situation is better known
- **To the greatest degree possible the laboratories should defer costs**
  - Consider delaying new hires or making major commitments until after budget situation has clarified
  - Some laboratories may have funding shortfalls that are great enough to require layoffs
    - These should be considered in light our hopes to carry the Scenario B P5 vision
- **University research will also be impacted**
  - At continuing resolution budget, 3-5% reductions in university grant support expected
  - Will try to restore this to "flat cash" in event of appropriation near Congressional marks

Projects Not Recommended by P5 Report

- **A number of projects were not recommended in any scenario**
  - Additional efforts beyond this list have been or will be curtailed based on agency priorities (e.g. CTA)
  - Working with the Labs on redirection of resources from these projects/activities

	Scenarios			Science Drivers					
Project/Activity	FY 2013 Appropriated Budget baseline: flat for 3 yrs, then +2% per yr. Scenario A	FY 2014 President's Request baseline: flat for 3 yrs, then +3% per yr. Scenario B	Unconstrained Budget Scenario C	Higgs	Neutrinos	Dark Matter	Cosm. Accel.	The Unknown	Technique (Frontier)
Large Projects (>$200M)									
NuSTORM	N	N	N		✓				I
RADAR	N	N	N		✓				I
Medium Projects ($50M - $200M)									
ORKA	N	N	N					✓	I
MAP	N	N	N	✓	✓	✓		✓	E,I
CHIPS	N	N	N		✓				I
LAr1	N	N	N		✓				I

Ramp Down of MAP-MICE

- **Following P5 recommendations HEP proposed a ramp down budget of $9, $6, and $3 million for the fiscal years FY15 through FY17**
  - Optimize investments in U.S. and UK
  - Optimize science return
  - Protect graduate students and post docs
- **HEP conducted a review of the MAP-MICE program at BNL on August 12-14, 2014**
  - Committee determines that Step V does not fit
  - Project proposes alternate configuration
    - Eliminates high risk coupling coil
    - Less complex lattice
    - Better fit to funding profile
    - Detailed plans due to DOE by September 30, 2014
- **As a result of that review the MAP-MICE program submitted a plan that has been accepted by DOE to ramp down the program**
  - Almost all hardware presently delivered
  - Plan accepted by DOE
  - Plan accepted by STFC-UK


HEP FUNDING OPPORTUNITIES

Funding Opportunity Announcement Status

- **The HEP research FY2015 Funding Opportunity Announcement (FOA) is now closed and we are preparing for the comparative review process**
  - Opened on July 22, closed on September 23
- **The Accelerator Stewardship FOA is now closed**
  - Opened June 13, closed on September 4
  - Focused on two distinct activities:
    - Applied R&D focused on developing a prototype in response to a specific technical challenge
      - Particle Therapy Beam Delivery Improvements
      - Ultrafast Laser Technology Program
      - Energy Efficiency Improvements for SC Accelerators
    - Basic research that broadly impacts many accelerator applications
- **Early Career Research Program FOA is open**
  - Pre-proposals have been submitted; encourage/discourage coming soon
  - Final proposals due November 20, 2014 at 5 PM Eastern

Office of Science (SC) Digital Data Management Statement

- **Data management involves all stages of the digital data life cycle including capture, analysis, sharing, and preservation. The focus of the SC Digital Data Management is the sharing and preservation of digital research data.**
  - Dr. Laura Biven will present a more detailed talk on SC Digital Data Management at this HEPAP meeting
  - Funding Opportunity Announcements (FOAs) issued after October 1, 2014, will require a Data Management Plan (DMP) and compliance with the SC Statement
  - Requirements for DMPs and guidelines are available at: http://science.energy.gov/funding-opportunities/digital-data-management/
- **Additional HEP-specific guidance on DMPs is available**
  - http://science.energy.gov/hep/funding-opportunities/digital-data-management/
  - HEP will be working with the DOE National Laboratories to make available accessory information about individual experiments and projects led by respective laboratories
  - For more information please contact Dr. Lali Chatterjee and/or your Program Manager


OFFICE NEWS AND MISCELLANY

HEP Program Status Updates

- **New Assignments**
  - Alan Stone is taking on additional duties in budget and planning

- **Comings and Goings**
  - Tim Bolton (Intensity Frontier IPA) returned to KSU in August
  - New IPAs (Cosmic, Theory) coming on in late 2014
  - David Boehnlein (Energy Frontier IPA), Peter Kim (Detector R&D Detailee), and Larry Price (Computing Detailee) finish their terms in early 2015
  - Additional help welcome to aid with P5 implementation!
    - Interested parties should contact HEP management

HEP Science & Technology Connections Thrust

P5 noted the importance of our Benefits and Connections to Society

- **HEP has initiated discussions internally with some of the other SC Programs to start building stronger connections**
  - **Explore new experimental systems and techniques**
  - **Exploit transformative capabilities available in adjacent scientific disciplines**

  With aims to advance HEP science drivers, test our models and contribute to our S&T environment

- **Thanks to those who submitted Nominations for an HEP Connections Committee**
  - **We are not forming this HEP specific committee at this time**
  - **We will keep your nominees in mind as planning progresses with potential partner communities**
- **For more information contact Lali Chatterjee: lali.chatterjee@science.doe.gov**

HEP Forum for Computational Excellence (FCE)

- **HEP-FCE is a pilot project to strengthen scientific computing within our field as part of DOE HEP's response to P5 Recommendations on Computing**
  - Explore next-generation hardware and data-science software and foster more cross-laboratory and university-laboratory collaboration
  - Current website: http://press3.mcs.anl.gov/hepfce/
- **FCE Roles**
  - Computing planning input
  - R&D portfolio focused on cross-cutting tasks
  - Computational support for smaller experiments
  - Cross-cutting knowledge/capability base
  - Training/Workshop activities
  - Data archiving/curation/management contact point
  - Strategic connectivity for DOE HEP program
  - Build HEP-FCE community hub
- **FCE Organization**
  - Directors: S. Habib (ANL) and R. Roser (FNAL)
  - Advisory Panel Members: D. Asner (PNNL), P. Avery (Florida), A. Boehnlein (SLAC), C. Tull (LBNL), T. Wenaus (BNL), + Additional University Members.
- **Currently, three FCE working groups are looking at cross-cutting HEP computing needs**

Take-Away Messages

- **P5 plan is a compelling, unified vision for HEP**
  - Five intertwined science drivers define the big issues
  - Widespread community support not seen for 20+ years
- **A balanced approach is critical**
  - Another important reason the P5 plan enjoys such widespread HEP community support is that it takes a balanced approach to planning:
    - Time-phased, projects of different scales, balanced across Frontiers, on- and off-shore
  - DOE implementation strives to maintain that balance
- **HEP is global**
  - P5 strategic plan explicitly recognizes this fact, as does DOE implementation
  - Highest priority major projects are LHC upgrades (near-term) and LBNF (mid-term).
    - LBNF will be the first truly international experiment hosted by the US, with management modeled after the successful LHC scheme
- **We share the community's enthusiastic response to the P5 strategic plan**
  - We are moving forward with implementation in targeted areas
  - But given the current fiscal environment, **full** implementation of the plan will take some time


BACKUP

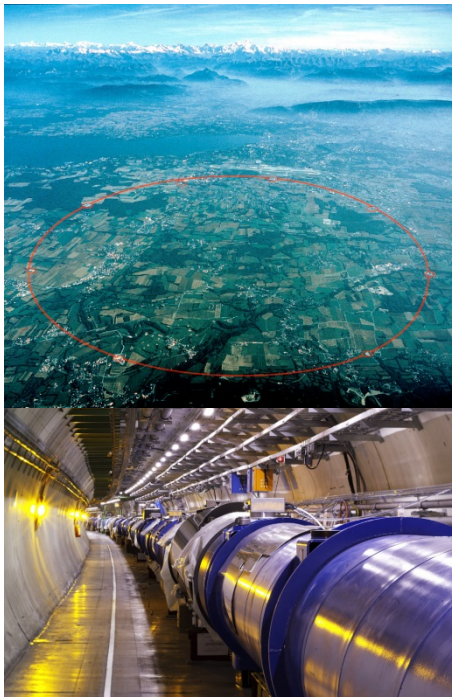
The Science Drivers of Particle Physics

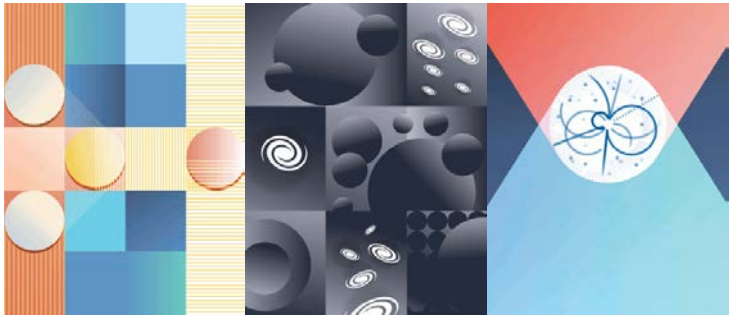
The P5 report identified five intertwined science drivers, compelling lines of inquiry that show great promise for discovery:

- **Use the Higgs boson as a new tool for discovery**
- **Pursue the physics associated with neutrino mass**
- **Identify the new physics of dark matter**
- **Understand cosmic acceleration: dark energy and inflation**
- **Explore the unknown: new particles, interactions, and physical principles**

Enabling Discovery at the Energy Frontier

- **Energy Frontier researchers accelerate particles to the highest energies ever made by humanity and collide them to produce and study the fundamental constituents of matter**
  - The LHC, 17 miles in circumference, accelerates and collides high-energy protons while sophisticated detectors, some the size of apartment buildings, observe newly produced particles that provide insight into fundamental forces of nature and the conditions of the early universe
- **The Energy Frontier pursues these science drivers:**
  - Use the **Higgs boson** as a new tool for discovery
  - Identify the new physics of **dark matter**
  - **Explore the unknown**: new particles, interactions, and physical principles





Higgs boson | Dark matter | Explore the Unknown

Enabling Discovery at the Intensity Frontier

- **Intensity Frontier researchers use intense particle beams and highly sensitive detectors to make precise measurements and search for new physics**
  - Precise measurements of particle properties and studies of the rarest particle interactions predicted by the Standard Model could uncover new physics
  - Measuring the mass and other properties of neutrinos may have profound consequences for understanding the evolution and fate of the universe
- **The Intensity Frontier pursues these science drivers:**
  - Pursue the physics associated with **neutrino mass**
  - Identify the new physics of **dark matter**
  - **Explore the unknown**: new particles, interactions, and physical principles

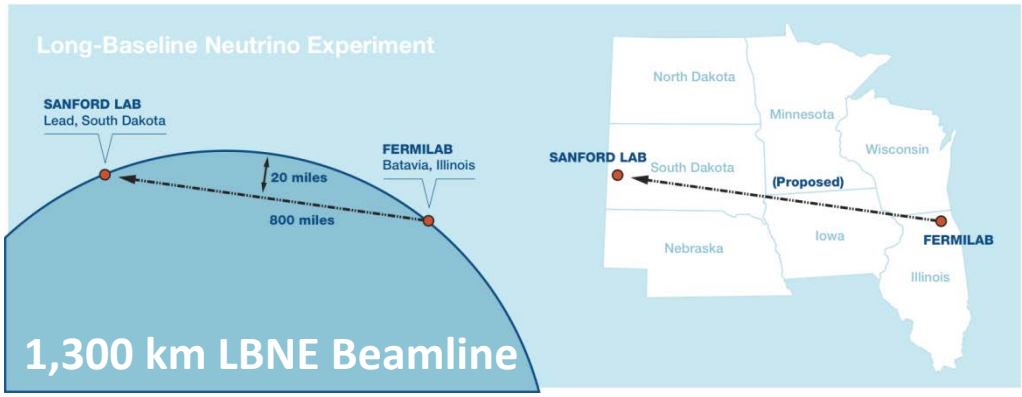
Neutrino Mass | Dark matter | Explore the Unknown

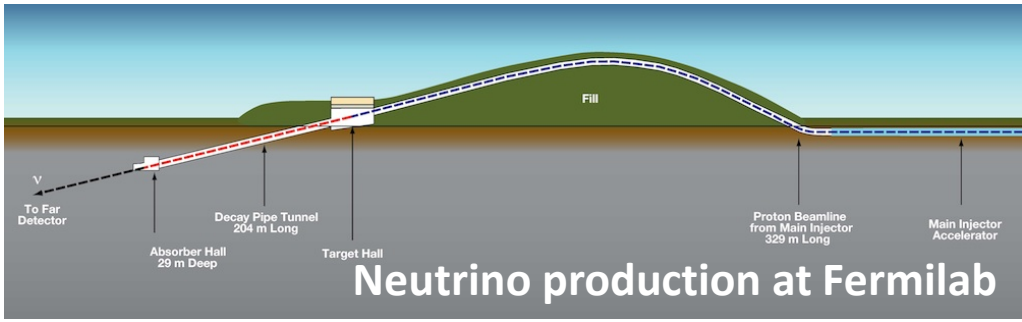
Measuring Neutrino Properties

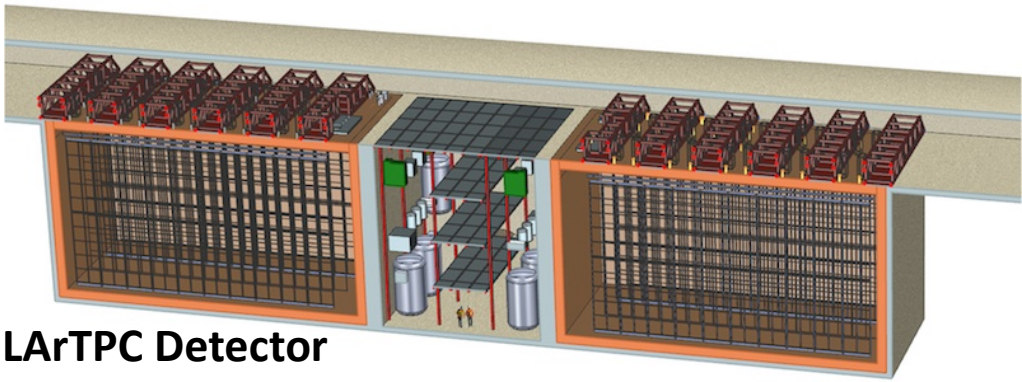
- **Neutrinos are neutral and only interact via the weak force**
  - Experiments need to generate a huge number of neutrinos
    - Nuclear power plants produce antineutrinos in all directions
    - Powerful accelerators can produce copious amounts of neutrinos and antineutrinos in a directed beam to a neutrino detector
  - Experiments need very large and sensitive detectors
    - Hundreds to thousands of tons of mass help allow a neutrino interaction
    - High detector sensitivity helps record rare interactions, when they occur
- **Neutrinos are known to change types as they travel and it is not clear if there is a difference in the way neutrinos and antineutrinos interact**
  - It takes some time (distance) for neutrinos to change types (oscillate)
    - Optimal distance depends on the properties of the neutrino source
    - Some measurements require hundreds of miles between source and detector
  - Accelerators required to study difference between neutrino & antineutrino
- **Understanding the complex physics of neutrinos requires a complementary set of experiments with different sources and detectors**

LBNE Project Status

- **P5 recommendation:**
  - "Form a new international collaboration to design and execute a highly capable **Long-Baseline Neutrino facility (LBNF)** hosted by the U.S. To proceed, a project plan and identified resources must exist to meet the minimum requirements in the text. **LBNF is the highest-priority large project in its timeframe.**"
- **CD-1 approval on 12/10/2012**
  - Baseline cost $867M
- **Option currently under consideration by community:**
  - New neutrino beam at Fermilab
  - 1,300 km distant Liquid Argon Time Projection Chamber (LArTPC) detector at Homestake mine in South Dakota
- **Potential foreign collaborators encouraged to bring alternative ideas for consideration**
  - Interim International Executive Board formed to organize efforts
- **LBNE proceeding with a plan based on international partnerships to deliver:**
  - High-power neutrino beam
  - High-resolution near detector
  - Far detector with ≥10 kt fiducial mass in cavern that can accommodate 35 kt det.

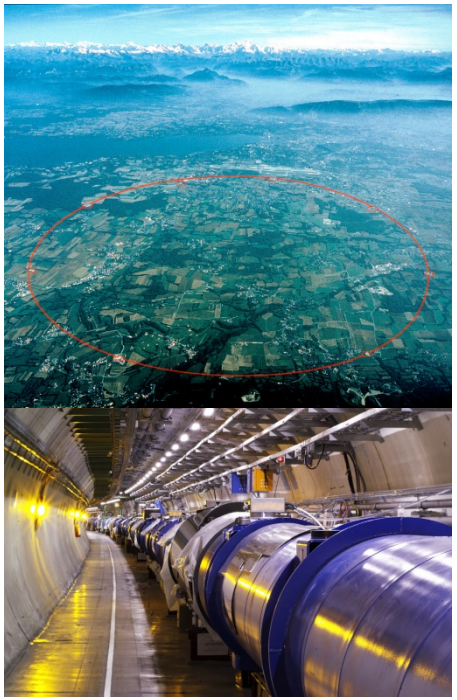


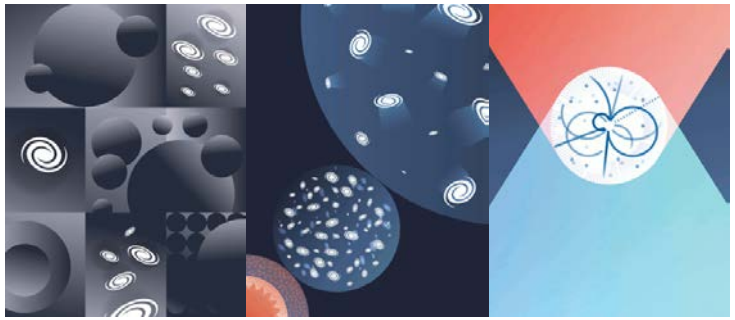




Enabling Discovery at the Cosmic Frontier

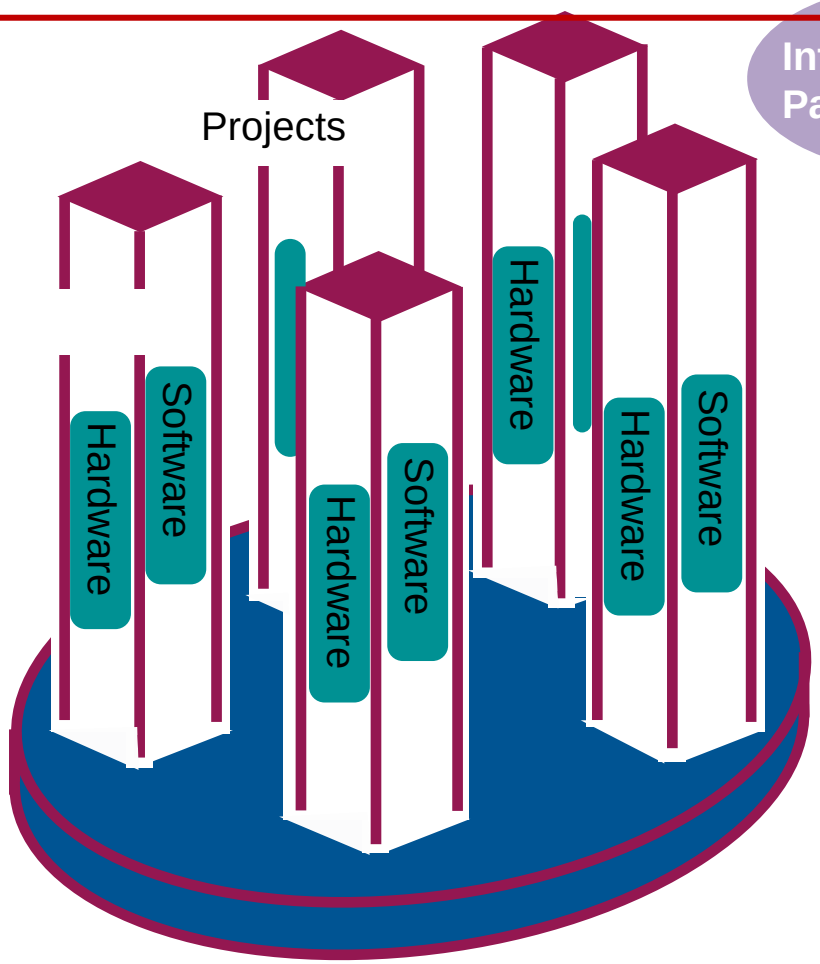
- **Cosmic Frontier researchers seek to reveal the nature of dark matter and dark energy by using naturally occurring particles to explore new phenomena**
  - The highest-energy particles ever observed have come from cosmic sources
  - Ancient light from distant galaxies allows the distribution of dark matter to be mapped and perhaps the nature of dark energy to be unraveled
  - Ultra-sensitive detectors deep underground may glimpse the dark matter passing through Earth
- **The Cosmic Frontier pursues these science drivers:**
  - Identify the new physics of **dark matter**
  - Understand **cosmic acceleration**: dark energy and inflation
  - **Explore the unknown**: new particles, interactions, and physical principles
  - Aspects of "Pursue the physics associated with **neutrino mass**"





Dark matter | Cosmic acceleration | Explore the Unknown

Computing Lives Vertically in Projects



FCE: HEP-Internal Partnerships

International Partnerships

Major Projects

Lab/University Partnerships

.....

Science Software

Tools/ Libraries

Systems

.....

Forum for Computational Excellence

DOE ASCR

NSF

Industry

.....

FCE: Promoting Cross-Cuts and Use of Common Resources and Solutions to Tackle Next-Generation Hardware and Exponential Increase in Data Collection

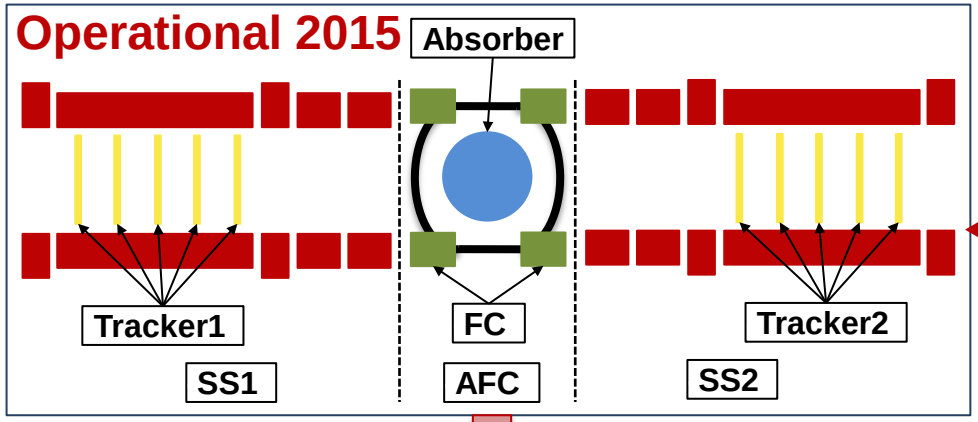
FCE: HEP-External Partnerships

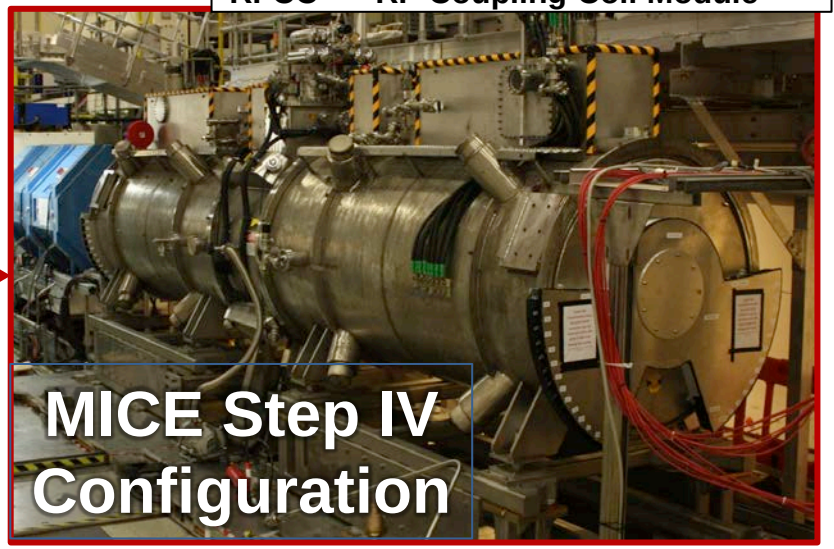
MICE Steps IV & V

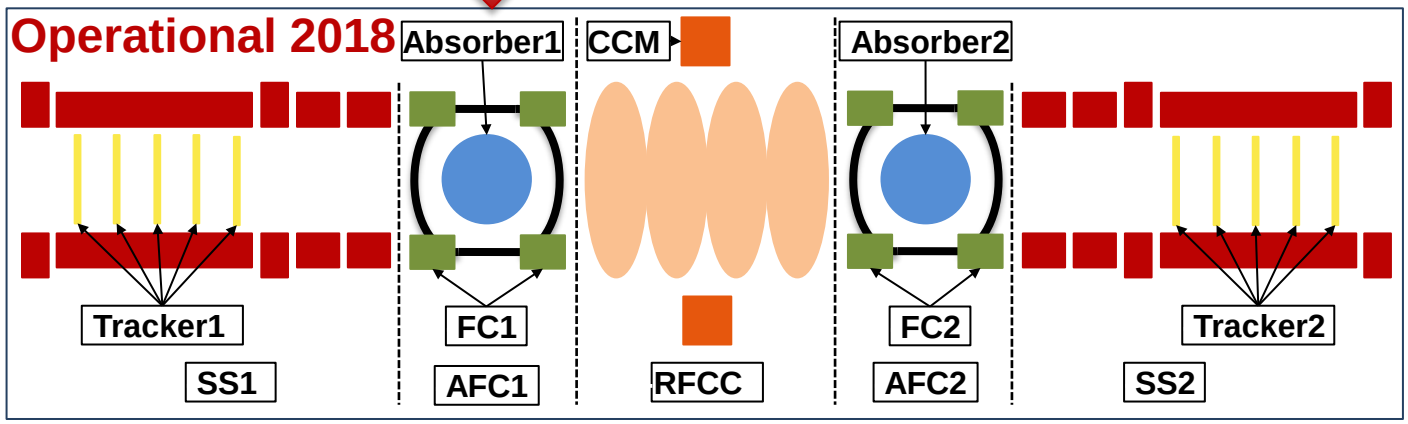
Plan endorsed by MICE Project Board in April 2014

Legend:

SS	=	Spectrometer Solenoid
FC	=	Focus Coil
AFC	=	Absorber-Focus Coil Module
CCM	=	Coupling Coil Magnet
RFCC	=	RF-Coupling Coil Module





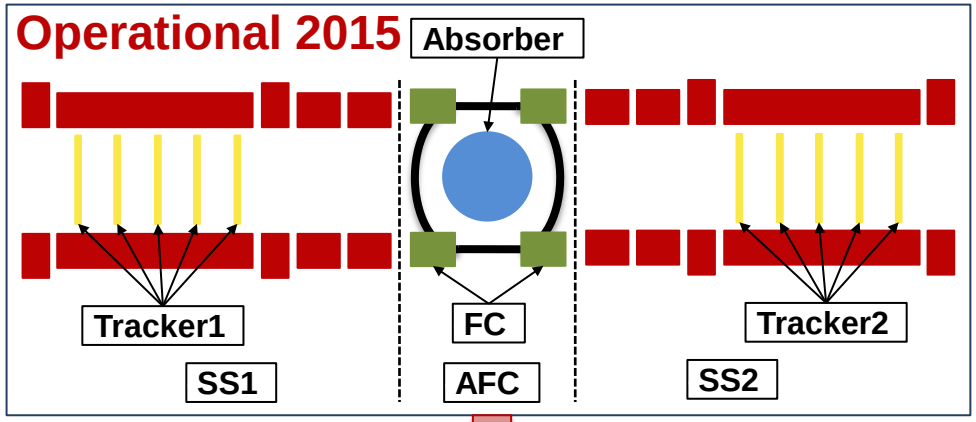


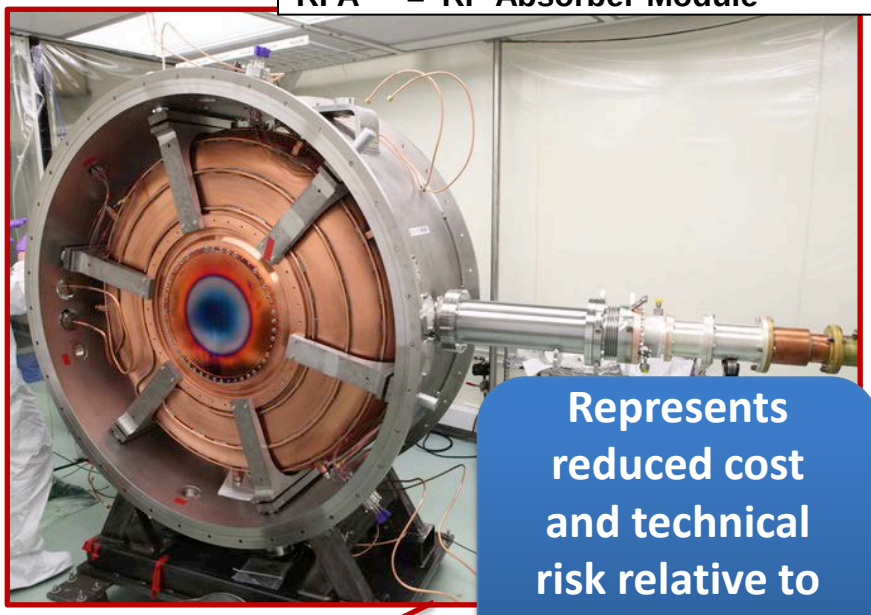
MICE Step V Configuration

Expedited Muon Cooling Demonstration

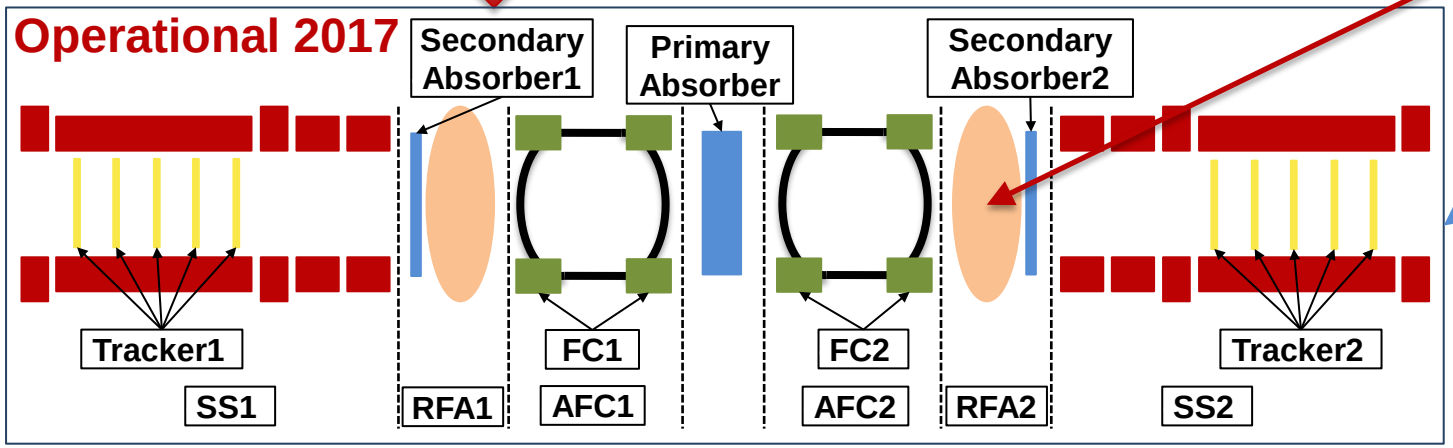
Plan developed in response to P5 recommendations

Legend:
SS = Spectrometer Solenoid
FC = Focus Coil
AFC = Absorber-Focus Coil Module
RFA = RF-Absorber Module





Represents reduced cost and technical risk relative to MICE Step V



NEW **Expedited MICE Final Configuration**