



U.S. DEPARTMENT OF
ENERGY

Office of
Science

High Energy Physics Program Status

Jim Siegrist

**Associate Director for High Energy Physics
Office of Science, U.S. Department of Energy**

Advancing the P5 Vision

- **HEP, in partnership with NSF, is implementing the global vision for particle physics set forth in the community-supported strategic plan presented in the May 2014 Particle Physics Project Prioritization Panel (P5) report**
 - P5 strategy continues to receive strong support from Administration and Congress
- **The FY 2017 HEP budget reflects the way that implementing the P5 strategy has evolved as the U.S. and international community has adopted and responded to it**
 - LBNF/DUNE has been reconfigured and is gaining international support much more rapidly than anticipated in the P5 strategy
 - Administration and Congress strongly support establishing LBNF/DUNE as the first U.S.-hosted international science facility
 - This presents an opportunity to advance the P5 strategy on a shorter time scale than originally envisioned



FY 2017 HEP Budget Strategy

- **The strategy for the HEP FY 2017 budget is to advance the P5 strategy on a shorter time scale through additional funding: “Scenario B+”**
 - As the highest priority in the near-term, the HL-LHC accelerator and detector upgrades are the foundation of our program planning
 - Support all other projects in P5’s Scenario B
 - DOE SC policy is to support the planned funding profiles of baselined projects
 - Maintain balance between Research, Operations, and Projects
 - Aim for no further Research reductions, but future increases will be targeted
 - See Glen Crawford’s HEPAP talk for more detailed discussion of Research program
 - Additional funding beyond the above priorities would support accelerating the implementation of LBNF/DUNE
 - Important to sustain momentum in community and with Administration, Congress
 - HEP investments will help solidify crucial international partnerships
- **FY 2017 priorities include:**
 - Start the HL-LHC accelerator and detector projects
 - Solidify international partnerships to establish LBNF/DUNE
 - Complete existing projects, including suite of dark matter and dark energy experiments
 - Maintain balance between research, facility operations, and projects





HEP FY 2017 BUDGET

HEP FY 2017 Budget Overview

- **Energy Frontier: Continue to support leadership roles in highly successful LHC program**
 - Initial LHC detector upgrade project funding ends in FY 2017
 - Scope being determined for High Luminosity (HL)-LHC, P5's highest priority near-term project; CD-0 in 2016
 - The 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 FY 17 supports key P5 recommended Cosmic Frontier projects to study dark matter and dark energy: LSSTcam, DESI, SuperCDMS-SNOlab, LZ



HEP FY 2017 Budget Highlights I

- **FY 2017 request (\$818M) continues the successful implementation of the P5 strategy**
 - Investing in portfolio of high-priority projects at the small, medium, and large cost scales
 - Request is carefully balanced between support for projects (\$212M), facility operations (\$252M), and scientific research (\$354M) in order to produce scientific results while “building for discovery”
- **The High Luminosity Large Hadron Collider (HL-LHC) accelerator and detector upgrade projects will significantly extend the discovery reach of the world’s highest energy collider**
 - P5 recognized LHC upgrades as the highest priority near-term large project
 - MIE start (\$2.5M) necessary to allow critical U.S. contributions to be delivered on schedule for global LHC program
- **The U.S.-hosted international Long Baseline Neutrino Facility and Deep Underground Neutrino Experiment (LBNF/DUNE) has made rapid progress in the past year and attracted the interest of international partners**
 - P5 recognized LBNF/DUNE as the highest priority project in its time frame
 - Construction funding (\$45M) enables necessary engineering design, site preparation and long-lead procurement for LBNF/DUNE to meet newly revised schedule, and will help solidify international partnerships
- **As recommended by P5, a complementary suite of projects will address dark matter and dark energy**
 - Planned fabrication funding increase supports LSSTcam (\$45M), DESI (\$10M), LZ (\$10.5M), and SuperCDMS-SNOLab (\$4M)



HEP FY 2017 Budget Highlights II

- **Facility for Advanced Accelerator Experimental Tests II (FACET-II) will enable continued R&D in the promising area of beam-driven plasma wake field acceleration**
 - Will sustain the momentum of excellent achievements in the program and maintain U.S. leadership globally in this area
 - MIE start (\$8M) essential to support FACET-II efforts during critical construction window during Linac Coherent Light Source II (LCLS-II) installation
- **Accelerator Stewardship will advance U.S. competitiveness in accelerator technology**
 - Funding collaborative R&D (\$13.7M) to put accelerator technology to work for better cancer treatment, pollution reduction, national security, and making unique test facilities available to industry



FY 2017 HEP Funding by Activity

HEP Funding Category (\$ in K)	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	Explanation of Changes (FY17 vs. FY16)
Research	334,225	327,389	331,123	Sustain support for research program
Facilities	264,634	254,979	252,037	Overall operations support reductions due to scheduled completion of projects
Projects	99,373	107,620	108,516	<i>*Other Project Costs (OPC) includes CDR, project-specific R&D, prototyping and testing, installation and commissioning/pre-operations before CD-4</i>
<i>Energy Frontier Projects</i>	<i>15,000</i>	<i>19,000</i>	<i>18,967</i>	<i>Initial ATLAS/CMS upgrades complete in FY17; OPC* begins for HL-LHC detector upgrades</i>
<i>Intensity Frontier Projects</i>	<i>48,170</i>	<i>17,685</i>	<i>9,349</i>	<i>Reduction from ramp down of g-2 & end of LBNF/DUNE OPC*; SBN Program increases</i>
<i>Cosmic Frontier Projects</i>	<i>45,203</i>	<i>66,835</i>	<i>70,200</i>	<i>Planned ramp up supports fabrication of LSSTcam, DESI, SuperCDMS-SNOlab, LZ</i>
<i>Other Projects</i>	<i>1,000</i>	<i>4,100</i>	<i>10,000</i>	<i>Increase to support the FACET-II project</i>
Construction (Line Item)	37,000	84,115	103,741	Request engineering design, site preparation and long-lead procurement for the LBNF/DUNE; planned profile for Mu2e
SBIR/STTR	20,768*	20,897	22,580	
Total	766,000*	795,000	817,997	

* SBIR/STTR added to FY 2015 for comparison to FY 2016/2017

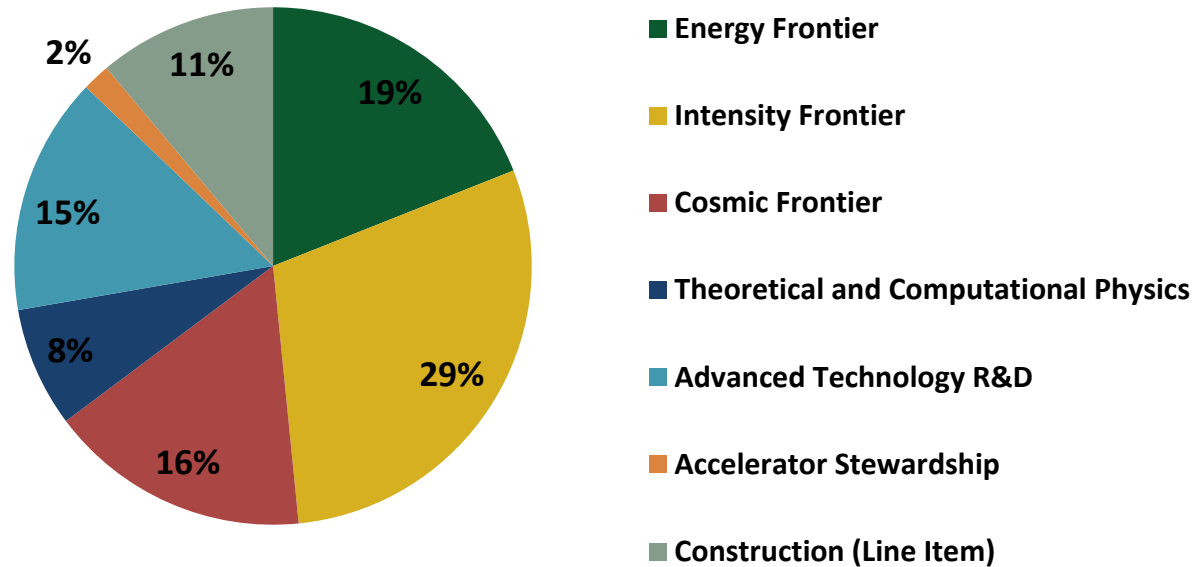
FY 2017 HEP Funding by Subprogram

HEP Funding Category (\$ in K)	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	Explanation of Changes (FY17 vs. FY16)
Energy Frontier	146,040	150,723	150,998	LHC initial detector upgrades complete; HL-LHC detector upgrade activities begin; research slightly reduced to support projects
Intensity Frontier	259,750	243,121	234,144	LBNF/DUNE OPC ramps down; SBN, NuMI ops, and accelerator refurb. supported at Fermilab; research increases; SRF R&D/ops activities move to ATR&D
Cosmic Frontier	106,507	130,582	130,069	MIE projects (LSSTcam, DESI, LZ, SuperCDMS-SNOLab) ramp up according to profile
Theoretical and Computational Physics	61,848	59,083	59,656	Research slightly reduced; Lattice QCD project held constant as in planned profile
Advanced Technology R&D	124,087	115,494	118,285	LARP increases to complete prototype magnets LHC upgrade; FY17 is last funding year for MAP as MICE deliverables complete
Accelerator Stewardship	10,000	9,000	13,744	Research increases; BNL ATF upgrade continues
Construction (Line Item)	37,000	66,100	88,521	Request engineering design, site preparation and long-lead procurement for the LBNF/DUNE; planned profile for Mu2e
SBIR/STTR	20,768*	20,897	22,580	
Total	766,000*	795,000	817,997	

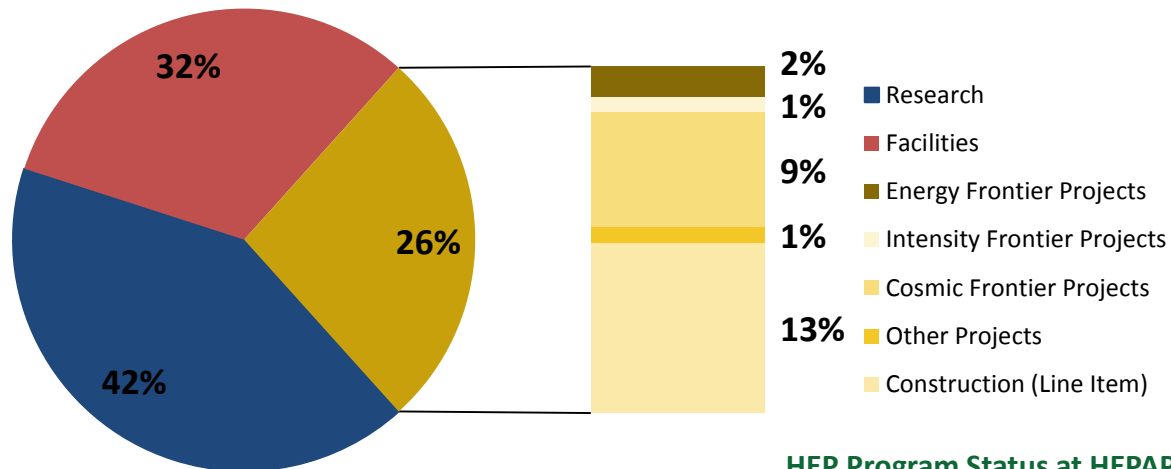
* SBIR/STTR added to FY 2015 for comparison to FY 2016/2017

FY 2017 HEP Budget Request Overview

FY 2017 HEP Request by Subprogram



FY 2017 HEP Request by Activity





DOE HEP PROGRAM STATUS



ENERGY FRONTIER

SL 153-12 E 2 WD

Energy Frontier Highlight:

LHC Experiments Search for New Physics

- Both ATLAS and CMS see an excess of data near 750 GeV in two photon events

- ATLAS results:

- Local significance: 3.6σ
- Global significance: 2.0σ

- CMS results:

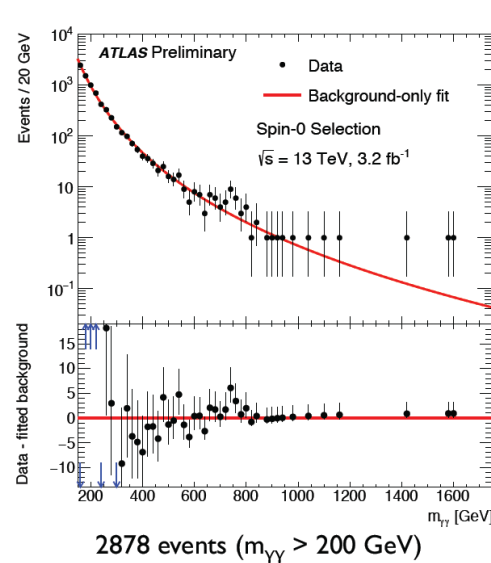
- Local significance: 3.4σ
- Global significance: 1.6σ

- LHC will continue 13 TeV collisions in 2016

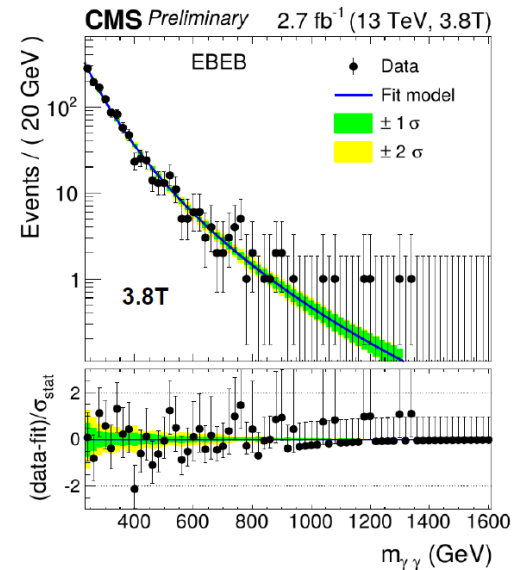
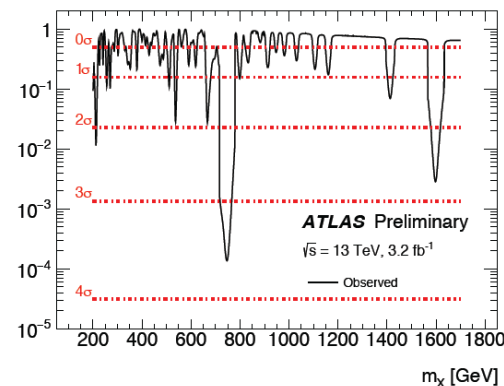
- Injection of first proton beams took place on Friday March 25, 2016

- Goal is to reach 25 fb^{-1} in 2016, up from 4 fb^{-1} achieved in 2015

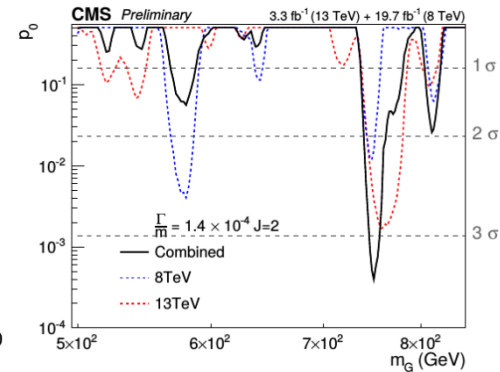
- New data will allow researchers to further explore nature of Higgs boson and continue search for new physics



ATLAS Results



CMS Results



Energy Frontier

Energy Frontier Experimental Physics	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	Explanation of Changes (FY17 vs. FY16)
Research	77,370	77,270	76,811	Reduced to support current and future experimental capabilities; some research staff redirected to complete LHC detector upgrade projects and begin leading HL-LHC upgrade projects
Facility Operations and Experimental Support	53,670	54,453	55,220	Some detector maintenance personnel redirected to complete LHC detector upgrade projects and begin leading HL-LHC upgrade projects
Projects	15,000	19,000	18,967	Initial ATLAS/CMS upgrades complete in FY17; OPC begins for HL-LHC detector upgrades
Total	146,040	150,723	150,998	

- **LHC continues Run II operations at 13+ TeV**
- **Phase-1 LHC Detector upgrade projects receive final funding in FY 2017, are on track to reach CD-4 in 2019**
- **As part of international process, HL-LHC detector upgrade efforts begin in FY 2017**



Energy Frontier Status

Current program

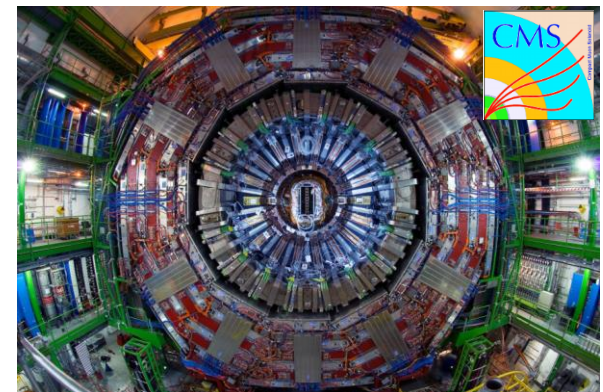
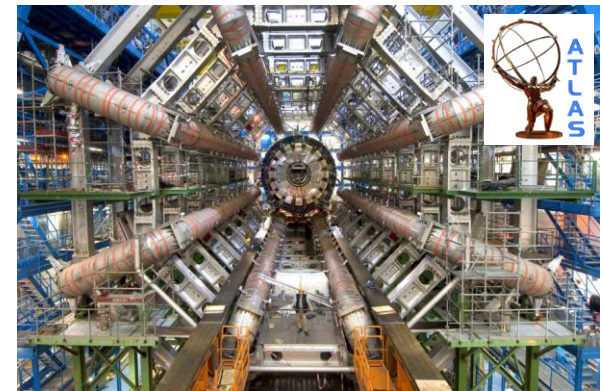
- 500+ LHC Run 1+2 papers submitted by *each* of the ATLAS and CMS Collaborations
- The U.S. will continue to play a leadership role in LHC discoveries and is actively executing the initial upgrades (Phase-1) to the LHC detectors

Planned program

- **High-luminosity LHC upgrades in 2024-2026 will extend the discovery reach**
 - Increase luminosity by 10 times LHC design value to explore new physics at TeV energies
 - DOE/HEP actively working with US-CMS and US-ATLAS to begin mounting upgrade projects
 - Mission-Need (CD-0) anticipated in 2016; CD-1 in 2017
 - International ATLAS/CMS TDRs expected in 2016-2017, resulting in baselining of upgrades by the international experiments and the LHC Resources Review Boards (RRB)
 - Long-lead procurement of silicon sensors for inner tracker — as part of the DOE project scope (CD-3a) — planned for December 2017
- **Very modest investments in R&D for future options**
 - Lepton colliders and very high energy hadron colliders

Science Laboratories Infrastructure (SLI) at BNL

- *The Core Facility Revitalization project will provide new space for RHIC and ATLAS computing, as well as future computing needs at Brookhaven*



LHC Strategy

Initial LHC detector upgrade funding ends and HL-LHC upgrade efforts begin in FY 17

- P5 report identified LHC upgrades as the **highest priority near-term large project** and specifically recommends:
 - Complete “Phase-1” (2019) upgrades of ATLAS and CMS experiments
 - Continue collaborations with the “Phase-2” (High-Luminosity LHC, 2024-26) upgrades of the accelerator and the ATLAS and CMS experiments to extend discovery potential
- The next important step for HL-LHC is *finalizing* the international scope of accelerator and detector upgrades and determining the U.S. contributions
 - CERN’s approval at October 2015 LHC RRB for ATLAS and CMS to proceed in developing subsystem-specific TDRs for upgrades
 - NSF will be an important partner in realizing the continued success of the U.S. LHC program through the HL-LHC upgrades
 - We are actively coordinating with NSF and the experiments the HL-LHC detector upgrade schedule and plans
 - DOE HL-LHC ESAAB (Agency decision) for CD-0 scheduled for April 13, 2016



International Linear Collider Strategy

- **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
 - Report emphasized that support for these efforts would ensure a strong position for the U.S. within the ILC global project
- **DOE is maintaining modest investments in ILC R&D efforts during the Japanese decision making process**
 - An interim report of the ILC Advisory Panel to the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) recommends monitoring LHC Run II results closely for potential impact on the science achievable with the ILC
 - This establishes a time scale for a decision on ILC by Japan

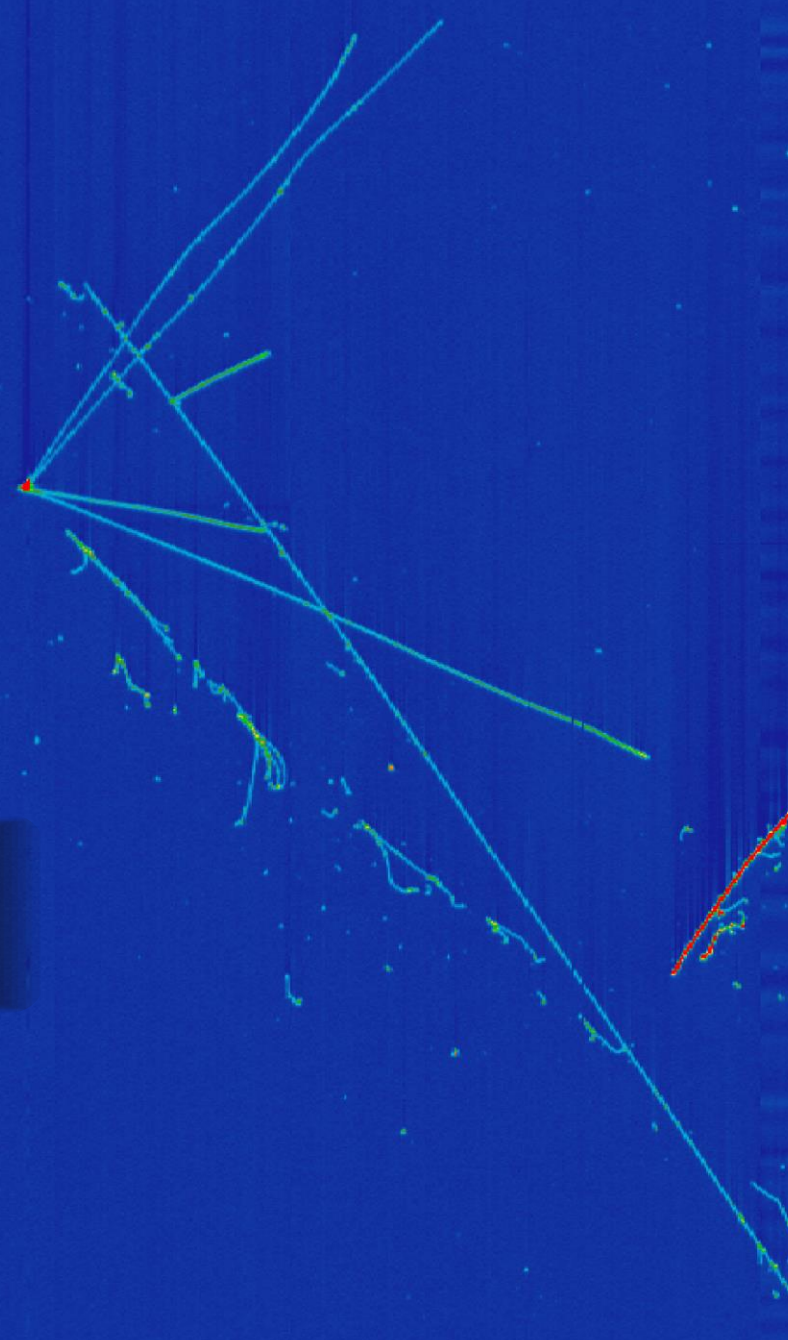


Global Coordination of Future Energy Frontier Machine Planning

- **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.”
- **China & Europe are studying and initiating R&D for future circular colliders**
 - P5 said that U.S. should be counted among the potential host nations
- **There is a pressing need for a global discussion among regions regarding the Energy Frontier program to follow the HL-LHC**
 - Regional and national planning needs global coherence
 - Labs and agencies need a coordinated discussion in order that the formal planning process does not slow the scientific community
 - Funding Agencies for Large Colliders (FALC), coordinated with major partner institutions, may become a forum for this discussion among agencies
- **Current priority in the General Accelerator R&D portfolio is investment in the enabling technologies for future machines**

μ BooNE

INTENSITY FRONTIER



Intensity Frontier Highlight:

KEKB First Turns and U.S. Belle II Project Status

- **KEKB upgrade will deliver 100x luminosity of PEP-II**
 - On Feb 10, 2016 SuperKEKB made first turns and stored a positron beam, 4 GeV in its 3km ring
 - 7 GeV electron beam followed on Feb 26
 - “Phase II” running with the superconducting final focus and the Belle II outer detector expected in fall 2017
- **Belle II now installing and commissioning the U.S.-led iTOP detector system**
 - Belle II is a collaboration of 650 members from 23 countries and 99 institutes
 - Lead U.S. role in iTOP particle identification detector, scintillator based K-long/muon (KLM) upgrade, BEASTII accelerator background commissioning, & distributed computing & data management
 - On track to close out (CD-4) in June 2016



Accelerator background commissioning detector is installed and working at the IP



First iTOP module arriving at Tsukuba Hall, the site of the Belle II detector



Intensity Frontier

Intensity Frontier Experimental Physics	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	Explanation of Changes (FY17 vs. FY16)
Research	54,122	56,104	56,509	Increase supports current and future experimental capabilities; some research staff redirected to lead the internationalization of LBNF/DUNE or development of SBN Program
Facility Operations and Experimental Support	158,658	151,317	153,066	Reduction primarily from completion of four AIP projects in Fermilab MC complex in FY 16
Projects	46,970	35,700	24,569	Reduction from ramp down of g-2 & end of LBNF/DUNE OPC; SBN Program increases
Total	259,750	243,121	234,144	

- **Active research program will take advantage of new data from:**
 - NOvA, MicroBooNE, Belle II
- **Site preparation and excavation of caverns begins at SURF for LBNF/DUNE**
- **R&D will continue on SBND and ICARUS for the Short-Baseline Neutrino (SBN) Program**
- **Fabrication continues on Muon g-2, Mu2e**



Intensity Frontier Status

Exploring the unknown through precision measurements

- **Development of muon-beam based program at Fermilab continues:**
 - *Muon g-2*: Successfully tested SC magnet in June 2015, received CD-2/3 August 20, 2015
 - *Mu2e*: Reached CD-2/3 on March 4, 2015; CD-3C review scheduled for June 2016
- **Collaborating with Japan on *K* meson, *c/b* quark, and τ lepton precision studies:**
 - *Belle II* on track to close out (CD-4) in June 2016; *KOTO* had physics data taking in 2015

Identify the physics of dark matter

- ***APEX* and *Heavy Photon Search* performing particle beam based searches for DM**
 - *Heavy Photon Search (HPS)* recorded initial data in Jefferson Lab Hall B; physics to follow

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, *SBND* installation in 2018
 - *MicroBooNE* recorded first neutrino candidates from neutrino beam in October, 2015
 - Next step in the non-Fermilab neutrino program will be determined by outcome of review of proposals to the Intermediate Neutrino Research Program FOA (closed 9/2/15)
 - *DUNE* established as international long-baseline neutrino experiment



Intensity Frontier Strategy

Aim to solidify international partnerships for LBNF/DUNE with FY 2017 investments in site preparation and excavation of caverns

- The P5 report recommended completing the Muon g-2 and Muon-to-electron Conversion (Mu2e) experiments at Fermilab, which provide complementary ways of exploring the unknown for signs of new particles and interactions
- P5 recommended substantial investments in the U.S. neutrino program in order to develop, with international partners, a coherent short- and long-baseline neutrino program hosted at Fermilab
 - The swift establishment of the international Deep Underground Neutrino Experiment (DUNE) is a strong indication of the high level of interest from the neutrino community in achieving this global vision
 - The Fermilab Proton Improvement Plan II (PIP-II) program of updates to the accelerator complex will provide proton beams with power >1 MW by the time of first operation of DUNE
 - A coordinated set of short-baseline neutrino experiments will address the observed anomalies in current neutrino experiments while advancing the R&D necessary for LBNF and DUNE



Progress on Developing LBNF/DUNE

- **The international effort on LBNF/DUNE made impressive progress in 2015**
 - An international collaboration 800 physicists from 26 countries has formed
 - The experimental design has been enhanced to deliver more physics on a faster time scale
 - DOE has an signed agreement with CERN to cooperate on LBNF/DUNE, and CERN has allocated significant support in their 2015 financial plan
 - First international science “megaproject” hosted in the U.S.
- **The new design was evaluated by an independent project review and was found to meet mission need**
 - CD-1 for this new design was approved by DOE in November 2015
 - The DOE LBNF/DUNE cost range at CD-1 is \$1,260 to \$1,860 million with international in-kind contributions adding another ~30%
 - If successful, this may become the largest project ever undertaken by SC
 - Continued support from community, Administration, and Congress needed to succeed
- **Preparation of the site has begun to allow excavation to start in late FY 17**
 - Another independent project review evaluated the readiness of the project to begin excavating detector halls at the Homestake Mine in South Dakota
 - The review panel found the project ready to proceed with underground excavation
- **Aim is to optimize construction schedule for LBNF/DUNE to enable first data from DUNE in late 2024 and first neutrino beam data in late 2026**



Science Laboratories Infrastructure (SLI)

“In 10 years, Fermilab with international and national partners will have successfully built a new billion-dollar class neutrino facility and will have a modern, centralized campus catering to a large international user community.” *– Nigel Lockyer, Fermilab Director*



The Integrated Engineering Research Center at Fermilab will consolidate engineering functions from across the laboratory into the core campus near Wilson Hall



COSMIC FRONTIER

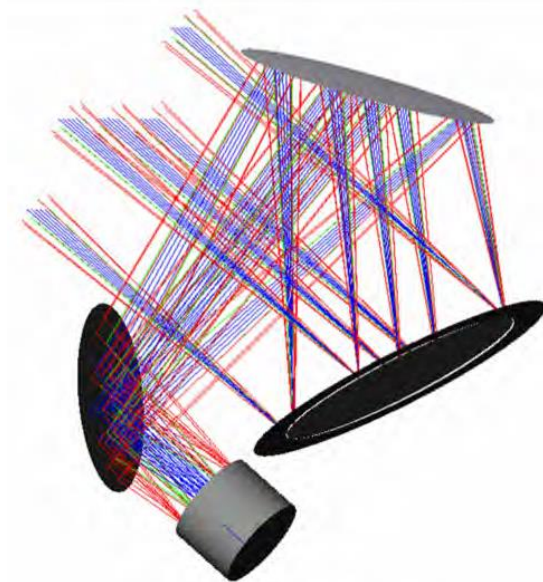
Cosmic Frontier Highlight:

CMB-S4 Collaboration Workshop

- As recommended by P5, HEP is planning to participate in a CMB Stage 4 (CMB-S4) experiment
 - HEP will coordinate efforts within HEP program and consider possible HEP roles
 - Will work with NSF to coordinate planning and a path forward
- *Cosmology with CMB-S4 Collaboration Workshop* was held March 7-9, 2016, at LBNL
 - 180 participants
 - Produced first draft Science Book (149 pages)
 - https://cosmo.uchicago.edu/CMB-S4workshops/index.php/Main_Page
- Community-based planning aiming towards ground-based experiment to:
 - Gain insight into the inflationary epoch
 - Probe dark energy and neutrino properties from CMB lensing
 - Map B-mode polarization power spectrum
 - Probe high energy environment of early universe
- Notional CMB-S4 experiment is array of several telescopes with on the order of 0.5 M detectors total in Chile and South Pole
 - Involving ANL, FNAL, LBNL, SLAC, universities
 - Partnership may include NSF-AST, NSF-PLR, NSF-PHY, international agencies
 - Technology ready, but needs scale-up of detector fabrication, testing, and readout
 - Cost models under development with considerations for possible international contributions



CMB-S4 Collaboration Workshop Participants



Prototype Large Aperture Telescope design with 10x mapping speed improvement (Niemack 2016)



Cosmic Frontier

Cosmic Frontier Experimental Physics	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	Explanation of Changes (FY17 vs. FY16)
Research	48,777	49,910	49,934	Research slightly increases to support: planning for calibration, simulation, and operation of new projects; data analyses for operating or recently completed experiments
Facility Operations and Experimental Support	11,327	13,837	9,935	Facilities activities decrease for Working Capital Fund costs; increased support for early operations planning activities for future experiments, particularly LSST
Projects	46,403	66,835	70,200	Planned ramp up supports fabrication of LSSTcam, DESI, SuperCDMS-SNOLab, LZ
Total	106,507	130,582	130,069	

- **Research activities continue for ongoing experiments:**
 - AMS-2, HAWC, FGST, DES, eBOSS, SPT
- **Ramp up in project support for fabrication efforts on:**
 - 2nd generation dark matter experiments LZ and SuperCDMS-SNOLab
 - Dark energy experiments DESI and LSSTcam



Cosmic Frontier Status

Dark Energy: Staged program of complementary suite of imaging and spectroscopic surveys

- *BOSS* final results out soon; *eBOSS*, *DES* continue operations
- *Large Synoptic Survey Telescope (LSST)* received CD-3 in August 2015
- *Dark Energy Spectroscopic Instrument (DESI)* received CD-2 in September 2015
 - Received Congressional “MIE start” approval in FY 2015
- Have MOA’s with NSF-AST for LSST partnership & DESI cooperation

Dark Matter (direct detection): Staged program of current and next-generation experiments with multiple technologies

- Completing operations on current DM-G1 experiments in FY 2016
- Progress continues on DM-G2 experiments: *ADMX-G2*, *LZ*, *SuperCDMS-SNOlab*
 - LZ & SuperCDMS-SNOlab projects received Congressional “MIE starts” approval in FY 2015
 - LZ received CD-1/3A in May 2015; SuperCDMS-SNOlab received CD-1 December 2015

Cosmic-ray, Gamma-ray

- *Fermi/GLAST*, *AMS*, and *HAWC* continue operations
 - HAWC gamma-ray observatory began full science operations in early 2015
- 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* begins operations in December 2016; partnership with NSF
- Community planning proceeding for CMB-S4 experiment



Cosmic Frontier Strategy

Fabrication funding ramp up in FY 17 supports key P5 recommended Cosmic Frontier projects:

- **LSSTcam, DESI, SuperCDMS-SNOlab, and LZ**
- **P5 recommended proceeding immediately with a broad second-generation (G2) dark matter direct detection program and R&D towards third generation experiments**
 - Three G2 experiments jointly selected by DOE and NSF in July 2014
 - ADMX-G2, LZ, and SuperCDMS-SNOlab
 - LZ scheduled for CD-2 review in April 2016
 - SuperCDMS-SNOlab anticipates CD-2 review in FY 2017
- **P5 supported advancing the dark energy program from current generation of experiments to the Large Synoptic Survey Telescope (LSST) and the Dark Energy Spectroscopic Instrument (DESI)**
 - LSSTcam received CD-3 approval in August 2015
 - DESI received Congressional “MIE start” in 2015; CD-3 review in May 2016
 - LSSTcam and DESI expected to continue fabrication in FY 2017
- **P5 recommended an advanced cosmic microwave background (CMB) experiment sensitive to the early high energy phase of the universe**
 - HEP is planning to participate in CMB-S4
- **Use P5 criteria to determine appropriate DOE scope and level of support for experiments that may have interest to broader astrophysics community**
 - Optimize our resources and science return by partnering or coordinating with other U.S. agencies (NSF, NASA) and international partners



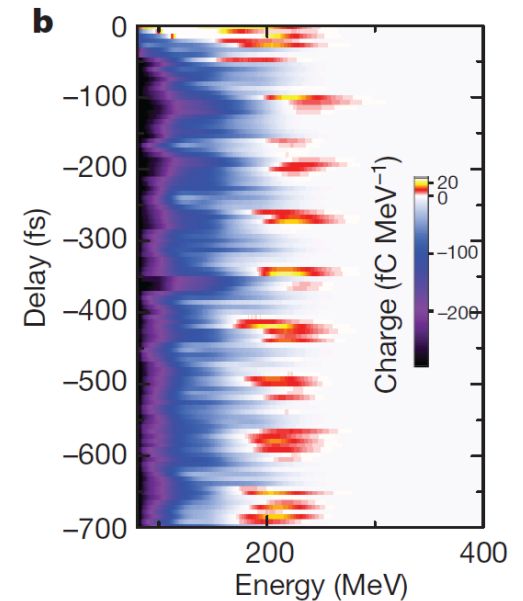
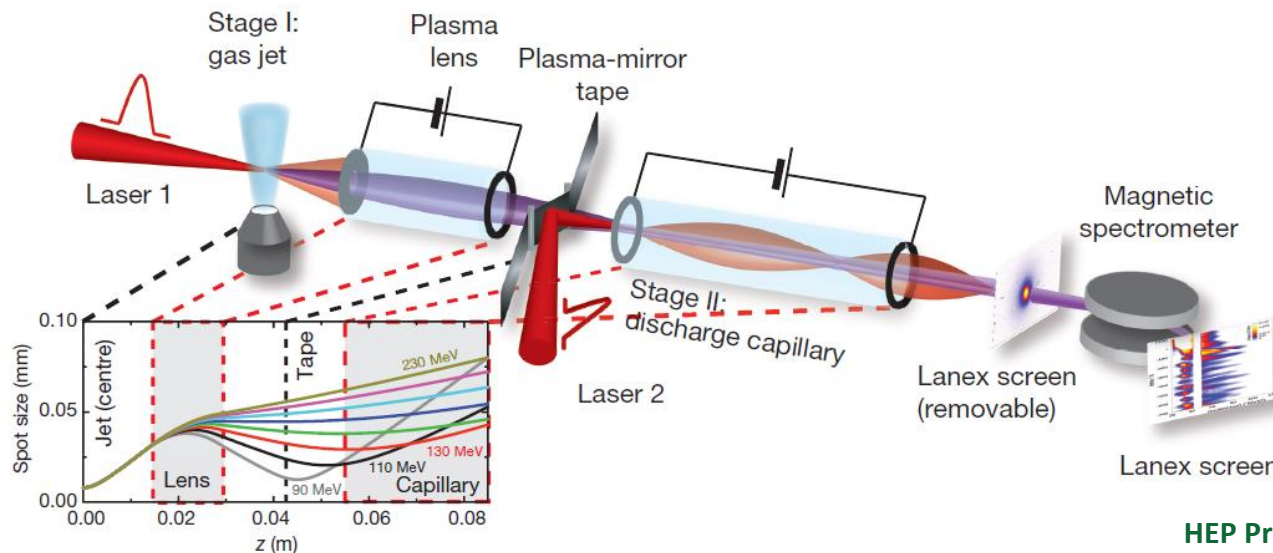
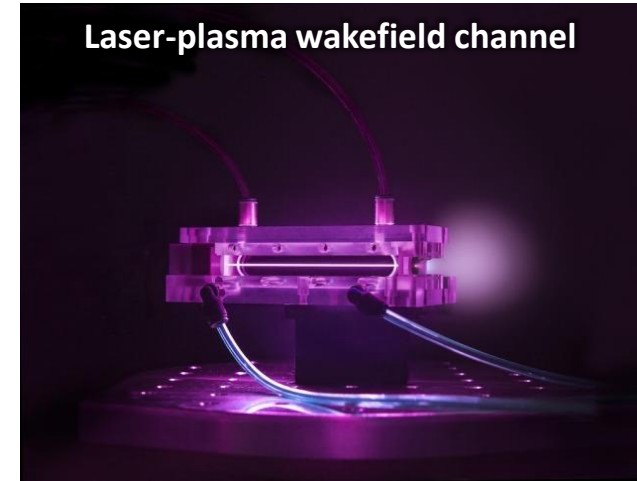


ADVANCED TECHNOLOGY R&D

Advanced Technology R&D Highlight:

BELLA Demonstrates Plasma Accelerator Staging

- **BELLA has previously demonstrated single-stage Laser-plasma Particle Accelerators (LPA)**
 - Using world-record petawatt output laser, delivering 40 femtosecond pulses at 1 Hz
 - World-record gradient achieved in 2014 with 4.25 GeV acceleration in 9 cm laser-plasma channel
- **The Berkeley Lab Laser Accelerator (BELLA) at LBNL has successfully demonstrated two-stage laser-induced plasma wakefield acceleration**
 - Staging is a key step towards realizing future LPA colliders
- **Two LPA stages were coupled over a short distance by a plasma mirror**
 - After 1st stage acceleration to 200 MeV, acceleration by 2nd stage detected via energy gain of 100 MeV for subset of the electron beam
 - Results indicate that fundamental limitation to energy gain from laser depletion can be overcome using staged acceleration
- **Results published in Nature 530, 190–193 (11 February 2016)**



Beam Energy after 2nd Stage LPA vs. Laser Pulse Delay Time

Accelerator R&D Program

- **Following P5, the Accelerator R&D Subpanel (ARDS) was charged to identify the most promising accelerator research areas to support the advancement of HEP**
 - ARDS plan provides prioritization in an R&D roadmap towards the Next Steps and Further Future accelerators
- **Workshops will provide roadmaps to guide research for the GARD Thrusts**
 - HEP-GARD Magnet Workshop held July 28, 2015
 - A nascent Magnet Development Program, led by Steve Gourlay, is in the process of coordinating the R&D activities in superconducting magnets and materials
 - Advanced Accelerator Concepts Research Roadmap Workshop held February 2-3, 2016
 - AAC Research Roadmap report in final preparation stage
 - GARD RF Acceleration Technology Workshop planned for late FY 2016
- **FACET II CD-1 approved December 21, 2015**

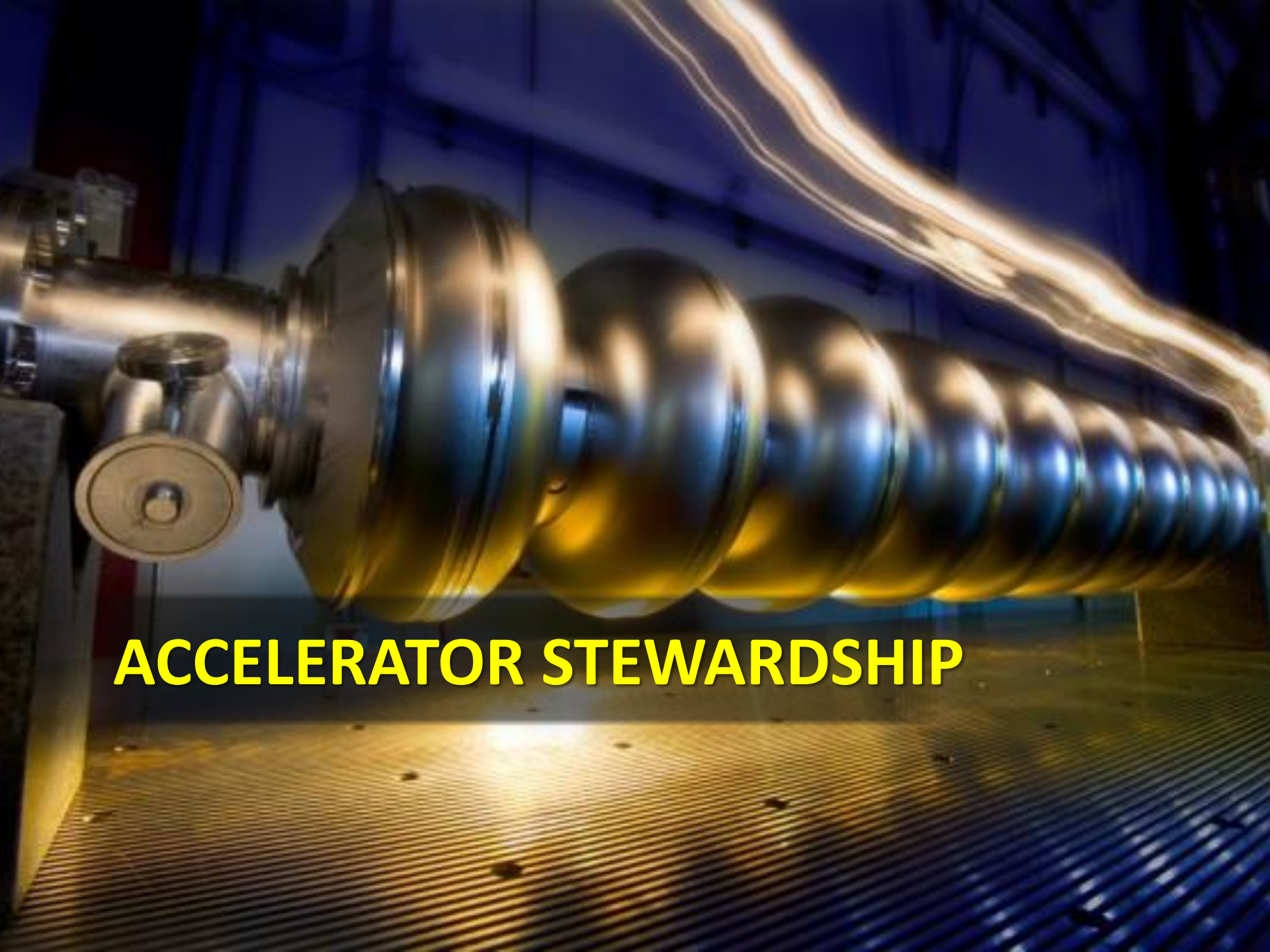


Advanced Technology R&D

Advanced Technology R&D	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	Explanation of Changes (FY17 vs. FY16)
Research	88,217	83,644	83,360	
<i>General Accelerator R&D</i>	<i>45,903</i>	<i>46,722</i>	<i>44,510</i>	<i>Focus on high priority areas in SC magnets, SRF, and high-power beam targets; \$1M of funding to initiate traineeship activity</i>
<i>Directed Accelerator R&D</i>	<i>23,000</i>	<i>20,640</i>	<i>21,500</i>	<i>Reductions from MAP ramp down offset by increase in LARP SC magnet effort to meet schedule for delivery of magnet prototypes</i>
<i>Detector R&D</i>	<i>19,314</i>	<i>16,282</i>	<i>17,350</i>	<i>Modest detector R&D support while focus remains on high priority R&D identified by P5</i>
Facility Operations and Experimental Support	35,870	29,750	26,925	Reduction dominated by end of operations funding for FACET
Projects	0	2,100	8,000	Increase to support the FACET-II project
Total	124,087	115,494	118,285	

- Advanced Technology Traineeship Activity will revitalize education and innovation in the physics of particle accelerators for the benefit of HEP and other SC programs that rely on these enabling technologies**





ACCELERATOR STEWARDSHIP

Accelerator Stewardship

Accelerator Stewardship	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	
Research	4,891	3,378	6,853	Research increased to handle full breadth of translational R&D challenges in the laser, medical, and energy & environmental application areas
Facility Operations and Experimental Support	5,109	5,622	6,891	Increases as the BNL-ATF relocation to a larger building reaches a peak year of activity; Accelerator Stewardship Test Facility Pilot Program is expanded
Total	10,000	9,000	13,744	

- **Continue support for research activities at laboratories, universities, and in industry for technology R&D areas such as laser, ion-beam therapy, and accelerator technology for energy and environmental applications**
- **Support ATF relocation and user facility operations and the expansion of the Accelerator Stewardship Test Facility Pilot Program**



Accelerator Stewardship Strategy

Address high-impact translational R&D challenges in laser, medical, energy & environmental, and national security applications, continue the ATF-II User Facility upgrades, and implement the Test Facility Pilot Program

- **Improve access to national laboratory accelerator facilities**
 - Finish the expansion of the Brookhaven ATF-II User Facility and begin first user operations
 - Double the user experiment space, 2x beam energy, 100x laser energy
 - Implement the Accelerator Stewardship Test Facility Program
 - Evaluate the Pilot Program results in 2016, formulate the full program and implement in 2017
 - Continued lab outreach, seed funding to catalyze joint R&D with industry, others
- **Develop innovative solutions to critical problems**
 - Support R&D on more performant, lower cost accelerators for medicine
 - First compact gantry magnet prototype should be tested in 2017
 - Support R&D on 1000x speedup of laser-based sciences
 - First demonstration of highly scalable fiber laser technology in 2017
 - Support R&D on accelerator technologies for Energy & Environmental applications
 - Initial design and feasibility studies for megawatt-class accelerators completed in 2017
 - Push megawatt-class accelerator power source efficiency and capability
 - Basic R&D on new concepts, materials, and methods in accelerator technology
 - FY 2016 review process is underway; awards will be announced in April
- **Broaden and strengthen the community**
 - RFIs and community workshops will continue, bringing accelerator scientists, application scientists, and industrialist together to address high-impact challenges
 - **Lead a Basic Research Needs workshop** on one of: active interrogation sources for national security, EUV sources for next-gen semiconductor lithography, THz and millimeter-wave sources for material science & communication, ...
 - **Strengthen workforce preparation** for accelerator science needs of the DOE National Laboratories

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu}$$

$$+ i \bar{\psi} \not{D} \psi + \text{h.c.}$$

$$+ \bar{\psi}_i \gamma_{ij} \psi_j \phi + \text{h.c.}$$

THEORETICAL AND

COMPUTATIONAL PHYSICS

$$+ \frac{1}{2} m^2 \phi^2 - V(\phi)$$

Theoretical and Computational Physics

- Provides the mathematical, phenomenological, and computational framework to understand and extend our knowledge of the dynamics of particles and forces, and the nature of space and time
 - Theoretical research essential for proper interpretation and understanding of the experimental research activities in other HEP subprograms
 - Advanced computing tools necessary for designing, operating, and interpreting experiments and scientific simulations that enable experimental discovery research
- **The P5 report recognized the importance of theory and computing:**
 - “The U.S. has leadership in diverse areas of theoretical research in particle physics. A thriving theory program is essential for both identifying new directions for the field and supporting the current experimental program.”
 - Recommended strengthening global cooperation among laboratories and universities to address computing and scientific software needs and provide efficient training in next-generation hardware and data-science software relevant to particle physics



Theoretical and Computational Physics

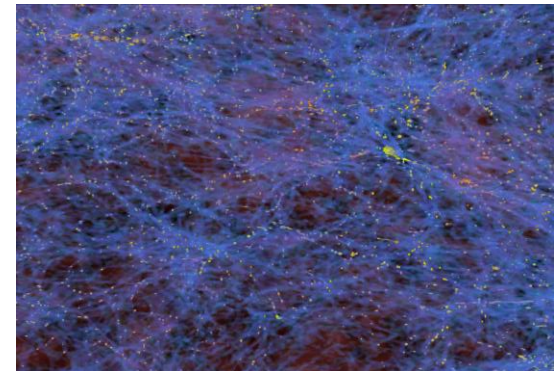
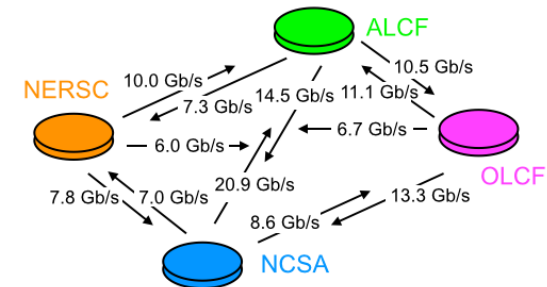
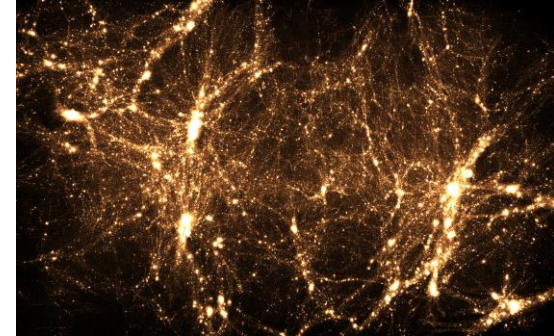
Theoretical and Computational Physics	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	Explanation of Changes (FY17 vs. FY16)
Research	60,848	57,083	57,656	
<i>Theory Research</i>	<i>52,323</i>	<i>48,465</i>	<i>49,620</i>	<i>Slight increase to maintain a thriving theory program as recommended in the P5 report</i>
<i>Computational Research</i>	<i>8,525</i>	<i>8,618</i>	<i>8,036</i>	<i>HEP expanding cooperation with ASCR on multiple computational projects and will rely less on the SciDAC program</i>
Projects	1,000	2,000	2,000	LQCD funded according to planned profile
Total	61,848	59,083	59,656	

- **SciDAC will be re-competed in FY 2017 in partnership with ASCR**
 - New partnership with ASCR results in a lower level of funding necessary for SciDAC
- **LQCD plan includes acquisition of new hardware as well as continued operations**

Computational Physics Strategy

Leverage partnerships to address computing challenges identified by P5

- HEP is strengthening and expanding its computing partnerships with ASCR through Computational HEP
- Along with the SciDAC Program, HEP partners with the ASCR Research Division and with Facilities through:
 - The HEP FCE -> HEP Center for Computational Excellence
 - Data Movement and Mini App projects
 - Extreme Analysis Systems (EASy)
 - Data sharing and movement
 - SENSE: SDN for End-to-End Networks for Extreme-Scale Science
 - Potential new international pilot projects and
- HEP-ASCR Exascale Requirements Review Report will be available soon
- Barb Helland's HEPAP talk later today will touch on some of these partnerships as well as on DOE's ASCR-led role in the national computing scene



HEP Connections

- **HEP Connections activities and related presentations at HEPAP, point to the value of coordinated pursuit of techniques and technology within the Office of Science and at the DOE and Interagency level**
 - Quantum Information Science and the Entanglement Frontier
 - Quantum Field theory across disciplines
 - Technology shared across disciplines
- **HEP has organized several joint Round Tables and Study Groups within SC for Connections activities**
 - Most recently, a Round Table on Quantum Sensors
- **HEP will partner with ASCR on the post-Moore algorithms, technologies, and QIS test beds**

The background of the image is a complex astronomical chart or star map. It features a yellow background with a network of blue lines representing celestial paths or constellations. The chart includes various symbols such as stars, crosses, and spirals. A prominent feature is a large, dark blue, textured band that runs vertically through the center-right of the image, possibly representing a specific celestial feature or a data series. The overall appearance is that of a historical or scientific map.

PROJECTS

HEP MIE Project Status

Subprogram	TPC (\$M)	CD Status	CD Date
INTENSITY FRONTIER			
Long Baseline Neutrino Facility (LBNF) / Deep Underground Neutrino Experiment (DUNE)	1,260 - 1,860	CD-1(R)	November 5, 2015
Muon g-2	46	CD-2/3	August 20, 2015
Mu2e	273	CD-2/3	March 4, 2015
Next Generation B-Factory Detector Systems (BELLE-II)	15	CD-2/3	April 23, 2014
ENERGY FRONTIER			
LHC ATLAS Detector (Phase-1) Upgrade	33	CD-2/3	November 12, 2014
LHC CMS Detector (Phase-1) Upgrade	33	CD-2/3	November 12, 2014
HL-LHC ATLAS Detector (Phase-2) Upgrade	150	Pre-CD-0	CD-0 ESAAB on April 13, 2016
HL-LHC CMS Detector (Phase-2) Upgrade	150	Pre-CD-0	CD-0 ESAAB on April 13, 2016
COSMIC FRONTIER			
LZ	46-59	CD-1/3A	April 28, 2015
SuperCDMS-SNOlab	16-21	CD-1	December 21, 2015
Dark Energy Spectroscopic Instrument (DESI)	56	CD-2	September 17, 2015
Large Synoptic Survey Telescope Camera (LSSTcam)	168	CD-3	August 27, 2015
ADVANCED TECHNOLOGY R&D			
Facility for Advanced Accelerator Experimental Tests II (FACET-II)	TBD	CD-1	December 21, 2015
Proton Improvement Project (PIP-II)	TBD	CD-0	November 12, 2015
HL-LHC Accelerator Upgrade	200	Pre-CD-0	CD-0 ESAAB on April 13, 2016

Construction

Accelerator Stewardship	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	Explanation of Changes (FY17 vs. FY16)
11-SC-40, LBNF/DUNE	12,000	26,000	45,021	TEC funding increased to continue site preparation and start excavation of caverns for the neutrino detectors and cryogenic infrastructure
11-SC-41, Mu2e Experiment	25,000	40,100	43,500	Funding increases according to planned funding profile as construction continues
Total	37,000	66,100	88,521	

- **LBNF/DUNE:**

- TEC funding is requested to continue technical design of the facility and the experiment
- The design of cryogenic infrastructure is the next part of the facility design that needs to be completed
- Funding is also needed to continue site preparation and start excavation of the large caverns for the neutrino detectors, as long-lead procurement

- **Mu2e:**

- Construction funds are requested to finish civil construction and continue fabrication of technical components (solenoid magnets and particle detectors)





OFFICE NEWS AND MISCELLANY

HEP Program Status Updates

- **Comings and Goings**

- Petros Rapidis began as Program Manager for Intensity Frontier in January 2016
- Our new budget team is Erin Cruz (began September 2015, focus on formulation) and Michelle Bandy (began February 2016, focus on execution)

- **New Assignments and Opportunities**

- New permanent position for Theory PM (vice Simona) planned in 2016
- Interested in new IPA/detailee for Energy Frontier starting ~Summer/Fall 2016
- *Interested parties should contact HEP management!*



HEP Laboratory Sustainability

- **HEP is working with the laboratories to improve the long-term sustainability of the HEP program**
 - Exercise looks ahead 7 years, attempting to account for:
 - Expected modest growth of Research funding
 - Expected costs of Operations
 - Expected participation in Projects
- **Process is ongoing and has not yet reached an outcome, but progress is being made**
 - Laboratory leadership are discussing the HEP program across laboratory boundaries, exploring:
 - Unique capabilities brought by each laboratory to HEP mission
 - Best way to leverage unique capabilities in future program
 - Prioritization of where to invest resources to maintain a healthy, sustainable program in the long term



Best Practices in Media Communication

- A “Best Practices in Media Communication” meeting was held for spokespersons of HEP experiments on January 19, 2016
 - Talks by Jim Siegrist, Steve Ritz, Lynn Cominsky, and Katie Yurkewicz
 - Aimed to:
 - Inspire renewed focus on best practices in media communications within each collaboration
 - Start a conversation that will continue within the community as you work to implement your media plans
- Will follow up with spokespersons soon for feedback, including:
 - Outcome of collaboration’s review of their media plan
 - Request to provide DOE PM and Michael Cooke with contact information for collaboration’s media coordinator
 - Encourage community to host & attend communications training talks
- HEP further requests that collaborations give advanced notice before big announcements via two paths:
 - Media coordinators, to help plan appropriate collaboration press rollout
 - DOE via PM and Michael Cooke, to help ensure that the agency has an opportunity to coordinate with the collaboration’s announcement



Community Materials

- Steve Ritz has lead a community effort to produce materials to help maintain the visibility of the P5 report
 - Initial materials are available at: <http://www.usparticlephysics.org/>
 - Steve plans to continue working with the community to update the material as needed
- Users' Groups report that Steve's material was helpful during their March visit to Washington, DC
- Spokespersons should consider using Steve's messages as part of their media interaction strategy

Building for Discovery

U.S. Particle Physics Strategy Education and Outreach Site

Particle physics is a dynamic, successful, and global field. The U.S. particle physics community has come together to develop a clear vision for the future. These carefully chosen investments will enable discovery and maintain U.S. leadership in key areas.

The Science Drivers

Building for Discovery

Pursue the physics associated with neutrino mass.

Building for Discovery

The P5 Report provides a strategy and the priorities for U.S. investments in particle physics for the coming decade.

The top four priorities this year

Start the High-Luminosity LHC (HL-LHC) accelerator and injector upgrade projects so the U.S. can deliver its critical contributions on time. This is PS's highest priority near-term large project.

Complete the existing construction projects in particle physics, including the ATLAS and CMS upgrades, LSS1, DUNE, Mu2e, Belle II, L2, ADAM-CX, and SuperCDMS-SNO+.

Balance scientific research with facility operations and the carefully selected portfolio of small, medium, and large projects that together facilitate the success of the community's strategic vision.

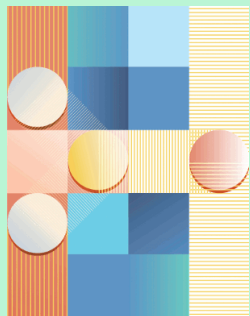
These carefully chosen investments will enable a steady stream of exciting new results for many years to come and will maintain U.S. leadership in key areas.

Particle Physics is both Global and Local. Scientists, engineers, and facilities are spread across the globe. The U.S. has a unique advantage in that it is a global leader in particle physics. The U.S. has the resources, talent, and infrastructure to lead in high-tech research and development. Particle physics is a key area where the U.S. offers a unique and significant contribution to the world.



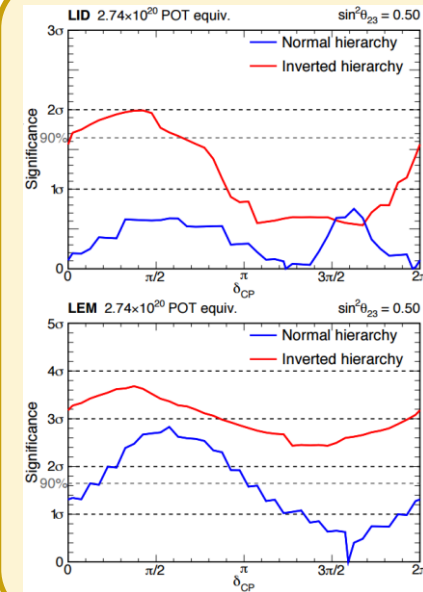
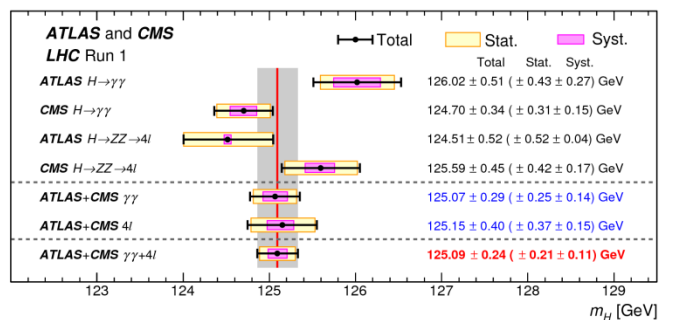
Addressing Compelling Questions in HEP

Science Highlights from the Past Year

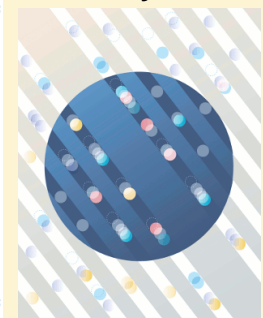


Higgs boson

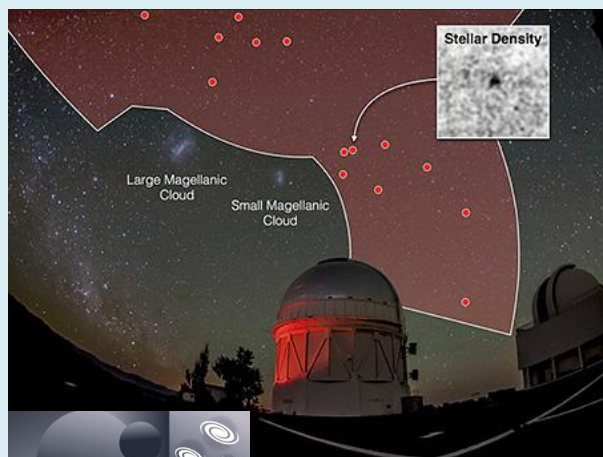
ATLAS and CMS Higgs boson mass combination (0.19% precision!):
 $m_H = 125.09 \pm 0.21$ (stat.) ± 0.11 (syst.) GeV



NOvA results using the first 7.6% of the total planned neutrino beam exposure slightly favor the Normal Mass Hierarchy

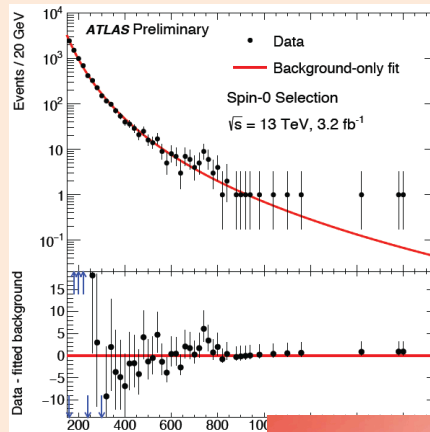


Neutrino Mass

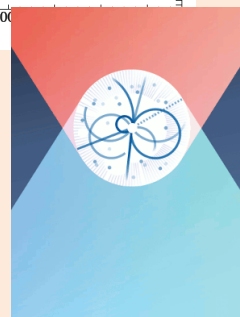


DES discovered 17 dwarf galaxy candidates during 2015, providing excellent laboratories to study properties of dark matter

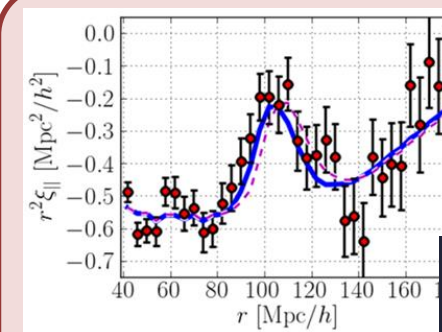
Dark matter



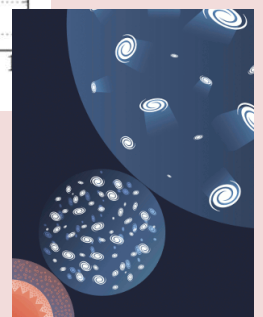
ATLAS and CMS beyond the Standard Model searches show a slight excess at 750 GeV in two photon events



Explore the Unknown



BOSS measured the expansion rate in the young Universe with an unprecedented 2% precision



Cosmic acceleration 51

Fulfilling the HEP Mission: Enabling Discovery

The P5 plan enables discovery in particle physics

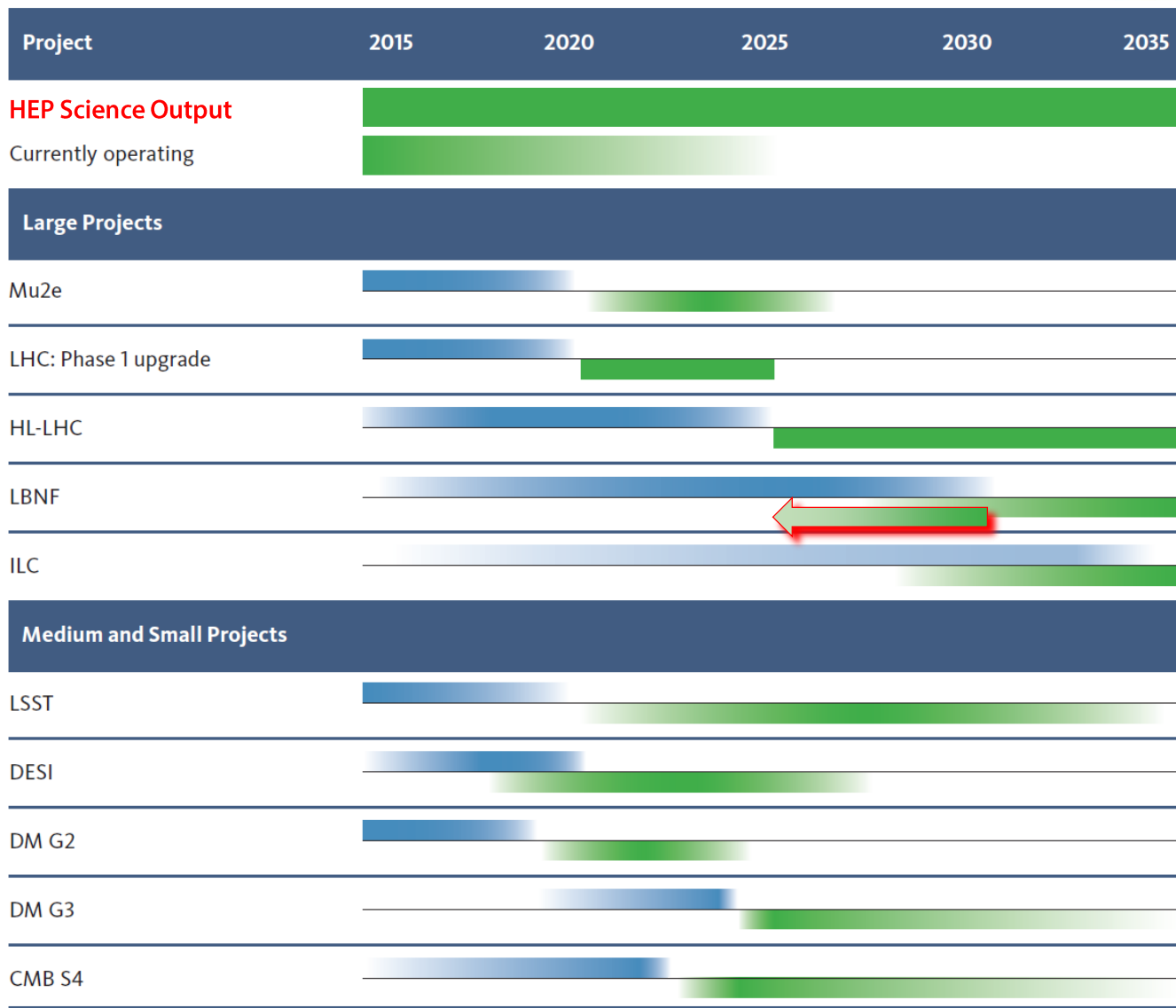
- Pursues the most important science opportunities wherever they are: on- and off-shore
- Coordinates time-phased project execution
- Incorporates projects of different scales
- Balances across experimental Frontiers

“Scenario B+” aims to advance the LBNF/DUNE timeline

- First DUNE data late 2024, first beam data late 2026

P5 strategy produces continuous physics output

- Any science driver across the Frontiers could lead to discovery
- Historic opportunities await us!



Advancing the P5 Vision

- **The FY 2017 budget continues the implementation of the P5 global vision for particle physics**
 - Strong community support has been crucial to the successful implementation of the P5 strategy so far
 - Continued community support is necessary to maintain our momentum with the Administration and Congress
- **Our strategy is to implement P5's plan for Scenario B while pursuing an opportunity to accelerate the establishment of the first U.S.-hosted international science facility, LBNF/DUNE**
 - HL-LHC accelerator and detector upgrades are the foundation of our implementation and we will support all other projects in P5's Scenario B
 - Our implementation maintains balance between Research, Operations, and Projects
 - Additional funding supports accelerating the implementation of LBNF/DUNE, which has received strong support from the Administration, Congress, and interested international partners

