



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

# The U.S. High Energy Physics Program in a Global Vision of Particle Physics

*DPF Meeting  
August 8, 2015*

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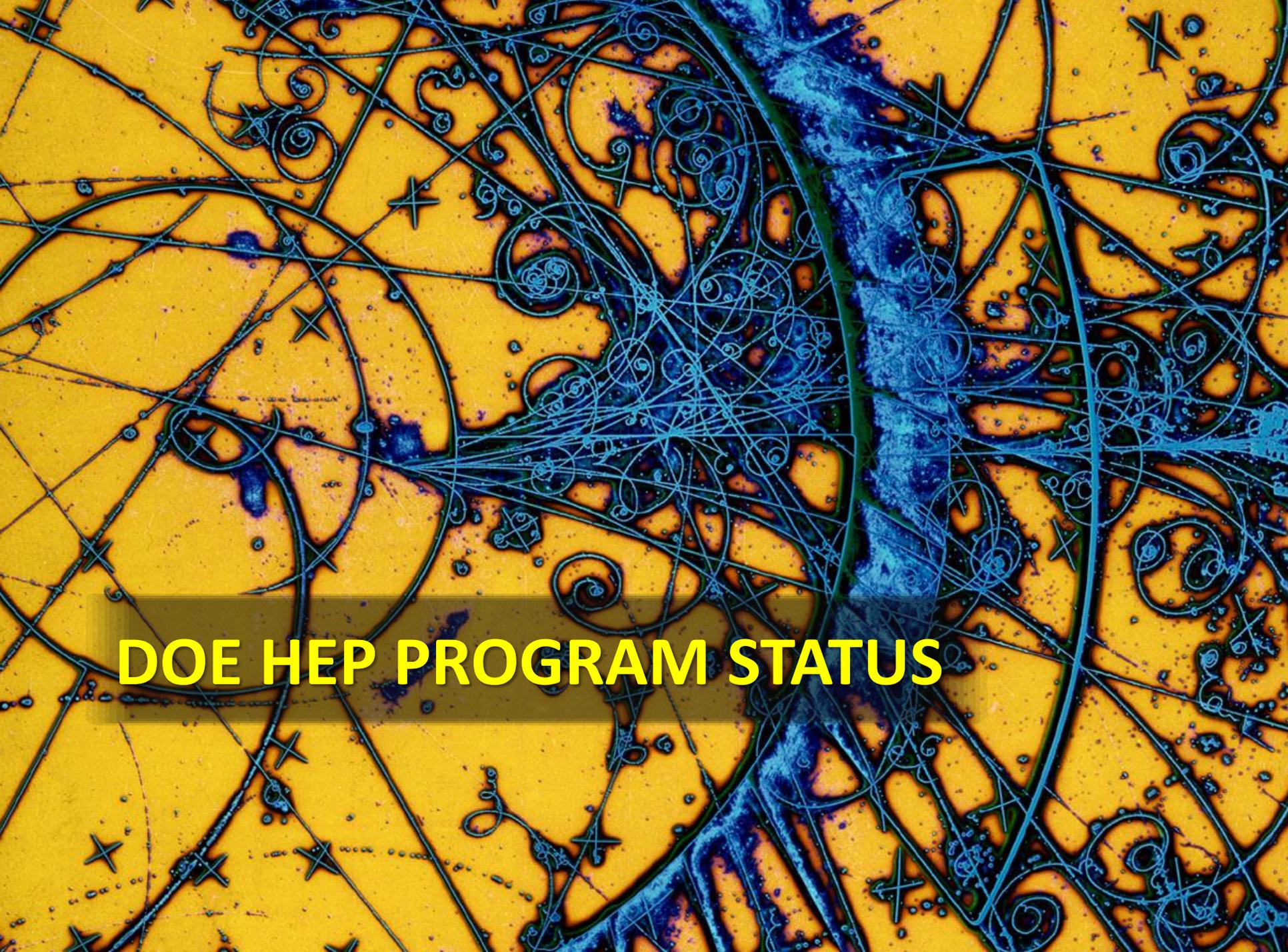
**A GLOBAL VISION FOR HEP**

# U.S. Particle Physics is Advancing

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- **The P5 report continues to have a large impact on U.S. particle physics**
  - HEP is receiving strong support from the administration, legislators, and the global particle physics community
  - Rapid progress continues to be made in implementing the P5 strategy:
    - Major international agreements already signed, with more in the works
    - Strong domestic and international interest in establishing a U.S.-hosted megascience facility has led to rapid progression of LBNF/DUNE
    - New projects starts were successfully approved by appropriators
- **The keys to success of the P5 report strategy have been:**
  - Presents a clear, global vision for an exciting science program
  - Strategy is executable within the reality of current fiscal environment
  - Plan has strong community support
- **Continuing progress and achieving the P5 vision will require sustained effort and continued support from the U.S. particle physics community**





# DOE HEP PROGRAM STATUS

# P5 Headline: Particle Physics is Global

- The P5 report emphasized the global nature of particle physics
- U.S. HEP plan is embedded in the context of a global HEP effort
  - P5 states, “The scientific program required to address all of the most compelling questions of the field is beyond the finances and the technical expertise of any one nation or region.”
- International partnerships of growing importance in U.S. science, particle physics seen as a leader of this trend
  - U.S. involvement in LHC at CERN seen as a successful example of international collaboration



# International Partnerships

*Successful partnerships key to implementing U.S. long-term strategy*

**DOE-Italy Agreement on High Energy, Astroparticle and Nuclear Physics Research**  
**Signed July 17, 2015**

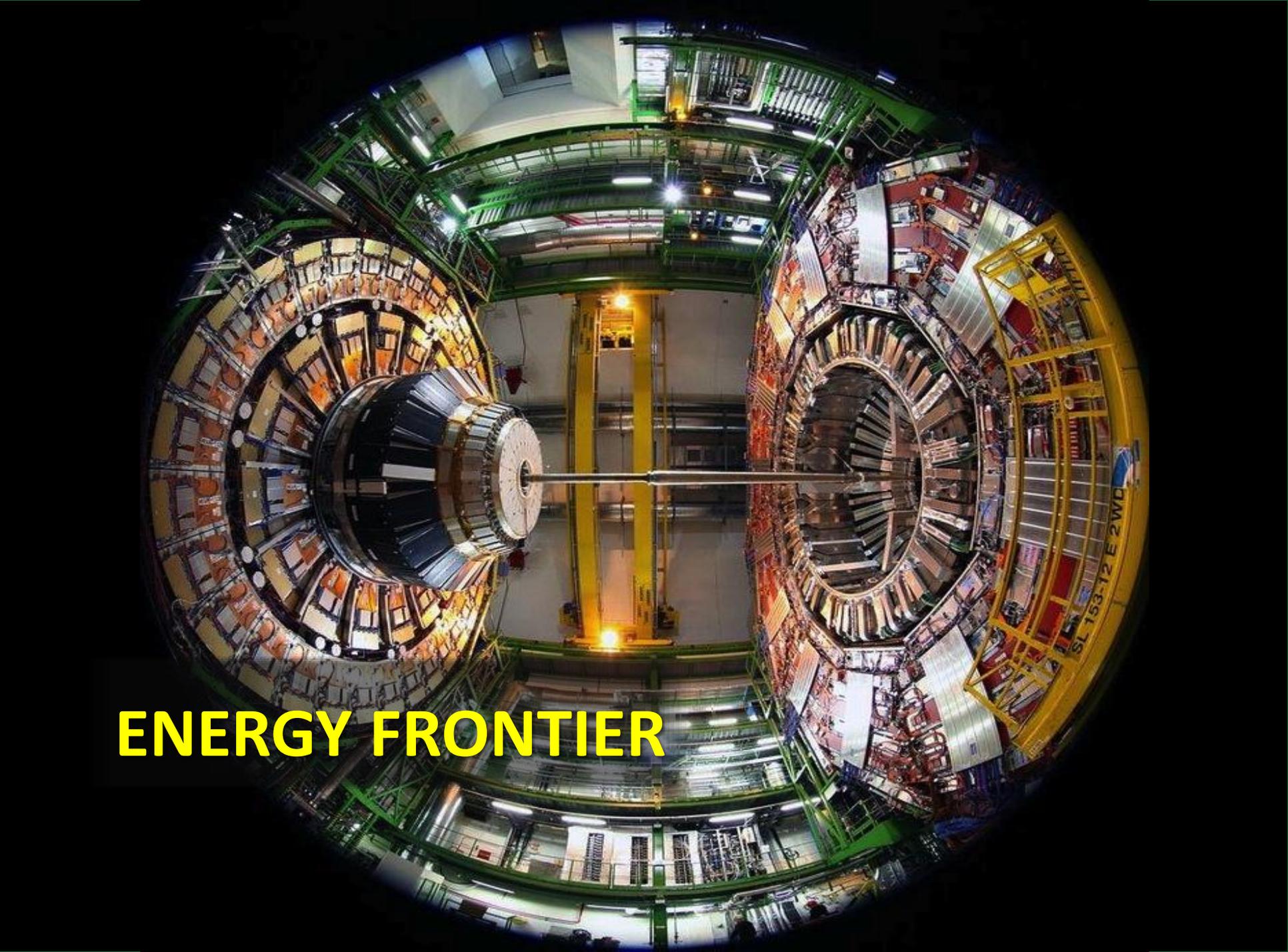


***New Bilateral U.S.-CERN Agreement***  
***Signed May 7, 2015***



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**ENERGY FRONTIER**

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# Energy Frontier Highlight:

## LHC Run II Has Begun

- LHC Run II began on June 3, 2015, with collisions at 13 TeV!



- Higher energy collisions at 13 TeV will increase the reach into search for new physics in high-impact topics:
  - SUSY, dark matter, 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
  - Phase-1 U.S. CMS/ATLAS upgrades received CD-2/3 approval Nov. 12, 2014



# Energy Frontier Strategy

- 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
    - HL-LHC upgrades will increase LHC luminosity by a factor of 10 beyond its design value and significantly extend its discovery potential
    - NSF will be an important partner in realizing the continued success of the U.S. LHC program through the Phase-2 upgrades. We are actively coordinating with NSF on HL-LHC detector upgrade plans.
  - U.S. leadership in superconducting magnet technology in general, and with 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 U.S. laboratories, BNL, FNAL, LBNL, and SLAC
      - Planned accelerator upgrades for HL-LHC aims to realize the technology advances from LARP and therefore maximize the full discovery potential of U.S. investments in the LHC
- 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



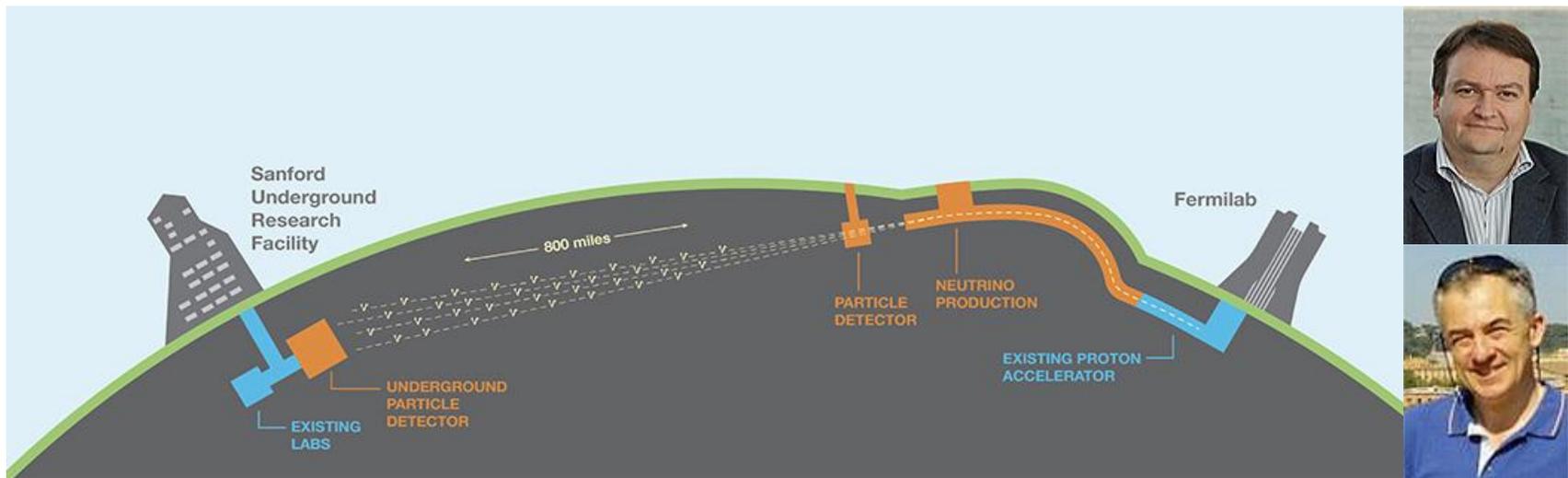


**INTENSITY FRONTIER**

# Intensity Frontier Highlight:

## LBNF/DUNE Proceeding Rapidly

- An international collaboration has been established for the Deep Underground Neutrino Experiment (DUNE)
  - Includes 770 scientists from 150 institutions across 23 countries in Asia, Europe, and North and South America
  - André Rubbia (ETH Zurich) and Mark Thomson (University of Cambridge) serving as spokespersons of the international collaboration
- Fermilab and DOE working with the International LBNF/DUNE to develop the organizational structure
  - Governance based on successful model of LHC: IAC, RRB, Finance Board, etc.
- LBNF/DUNE held successful CD-1 Refresh Review July 14-16 at Fermilab



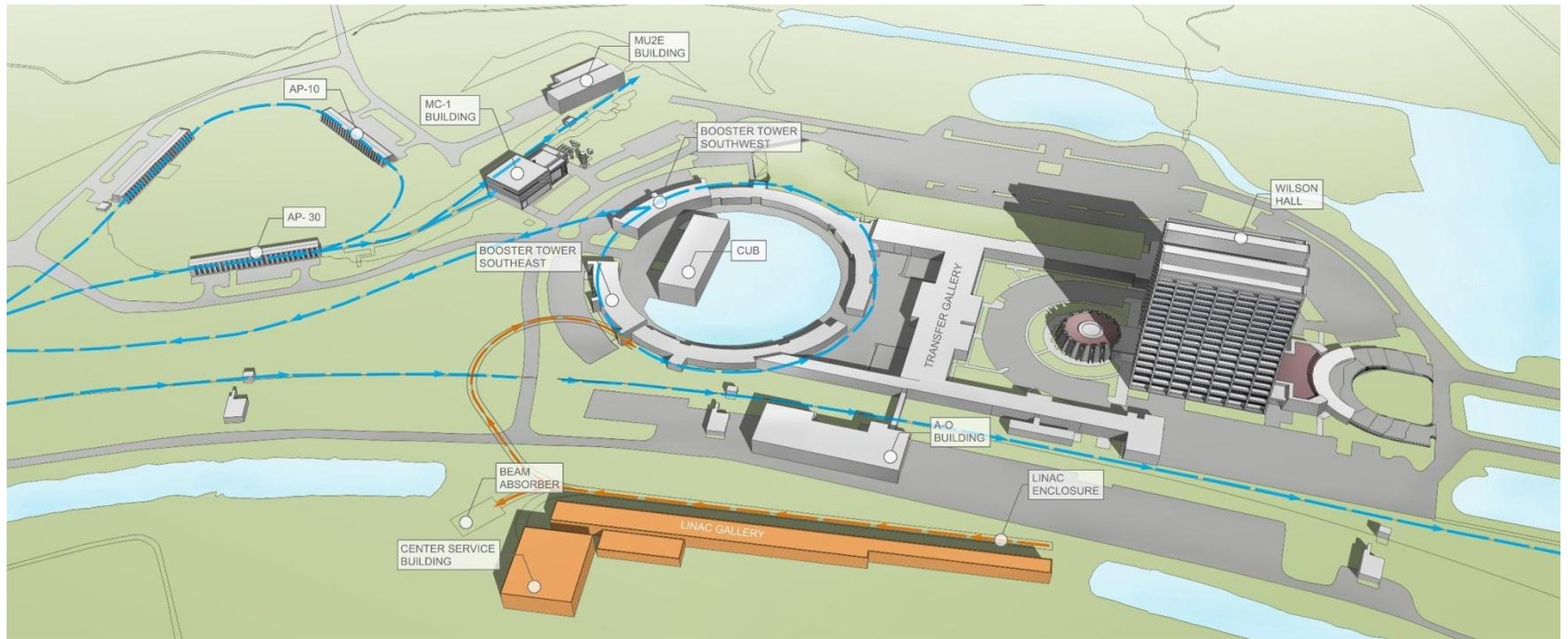
# Intensity Frontier Strategy

- 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
- Funding Opportunity Announcement (FOA) for the Intermediate Neutrino Program was issued July 14, 2015
  - Letters of Intent were due July 29, 2015; Final proposals due Sep. 2, 2015

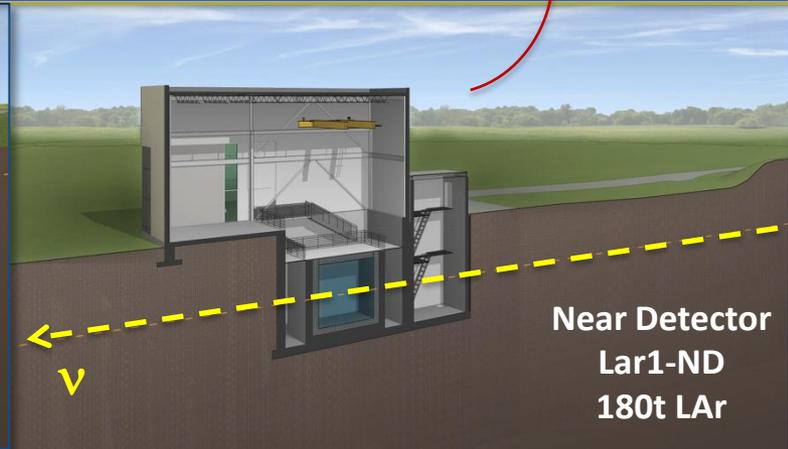
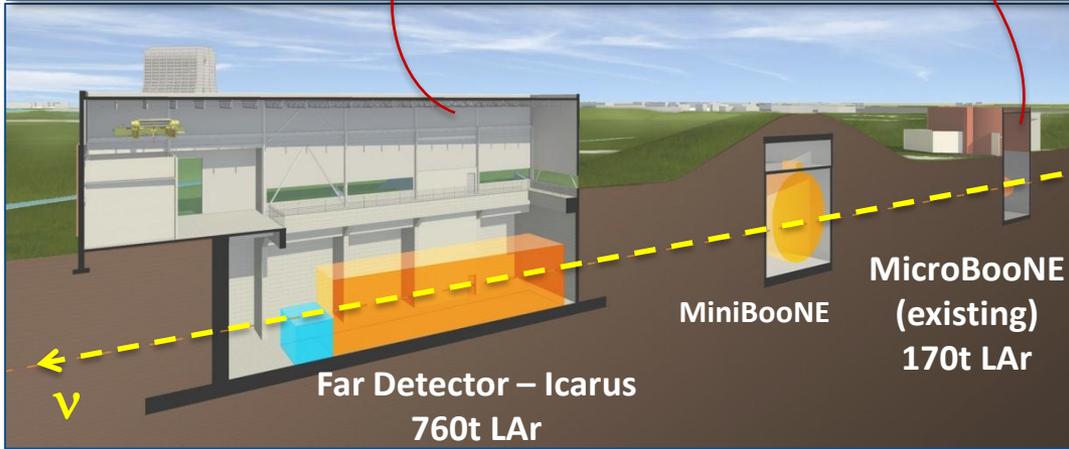
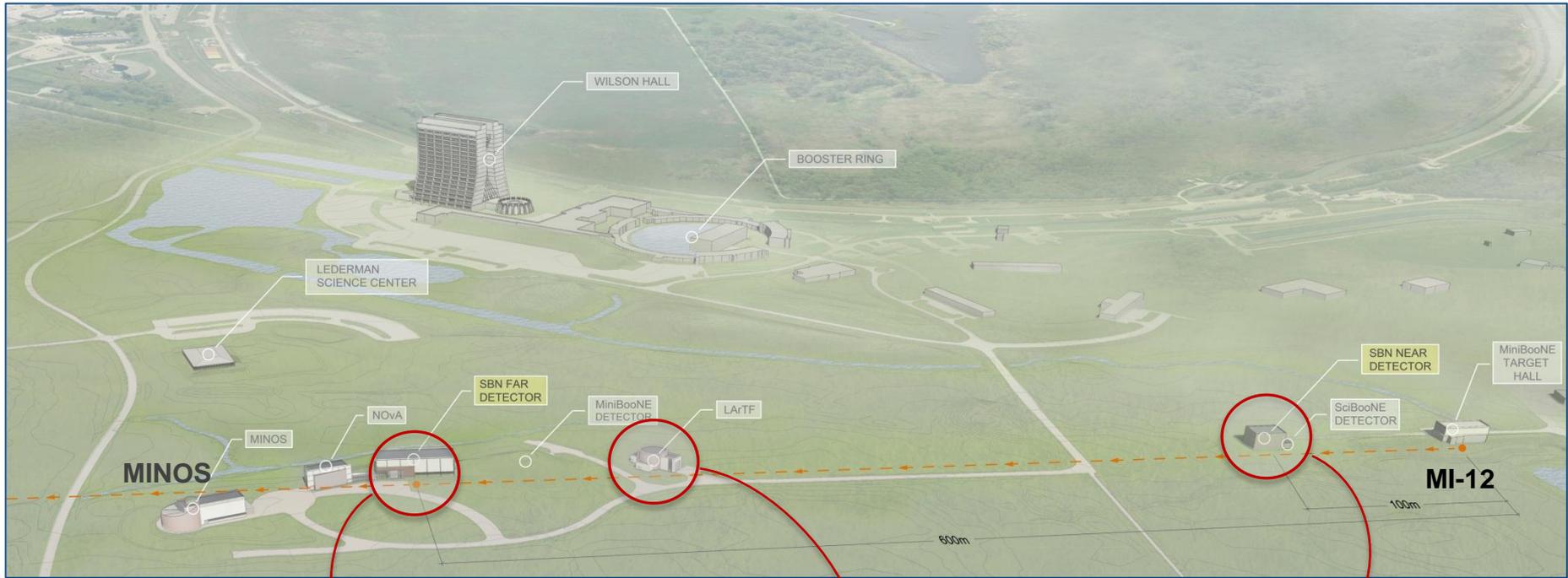


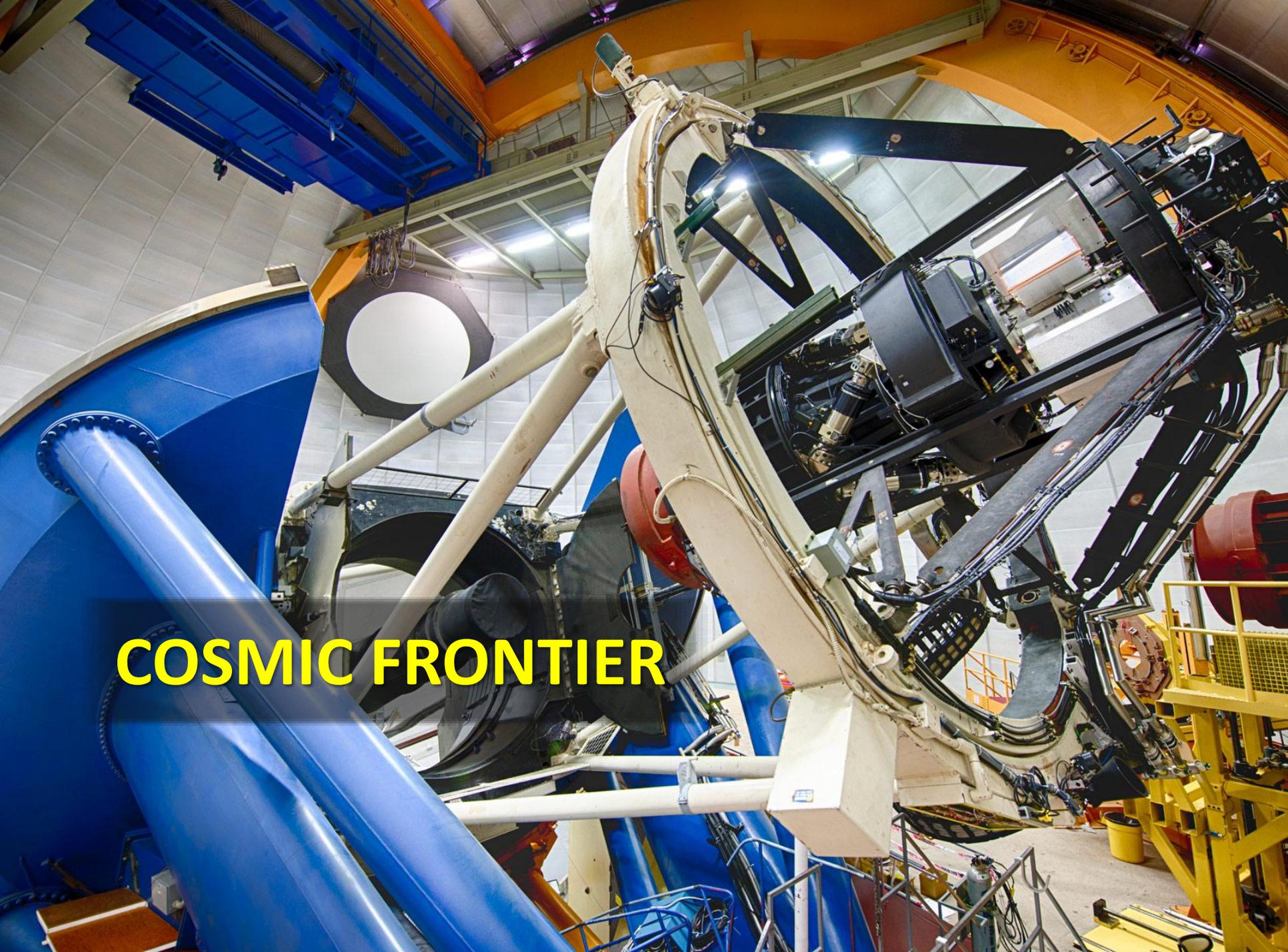
# Proton Improvement Plan II (PIP-II)

- PIP-II supports longer term physics research goals by providing increased beam power to LBNF while providing a platform for the future
- Infrastructure and workforce development due to LCLS-II work at Fermilab will be leveraged in support of PIP-II, further advancing SRF capabilities



# FNAL Short Baseline Neutrino Program



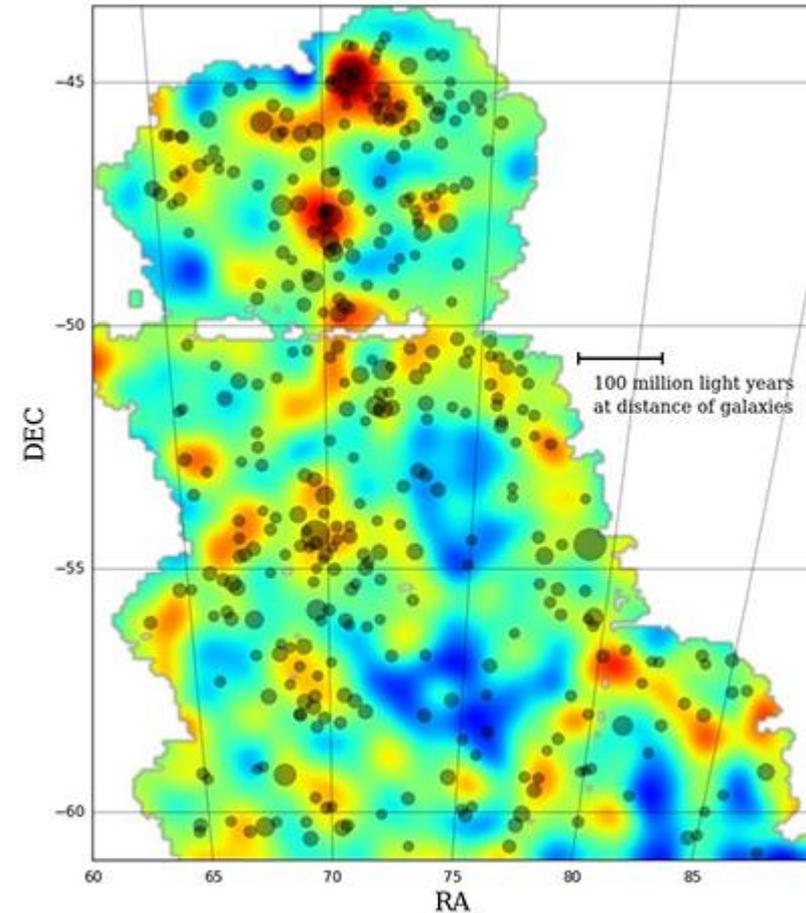


**COSMIC FRONTIER**

# Cosmic Frontier Highlight:

## DES Releases its First Map of Dark Matter

- The Dark Energy Survey and the 570-megapixel DECam continue to move science forward
  - Partnership with NSF
  - DECam mounted on the 4-meter Victor Blanco Telescope in the Chilean Andes
- Scientists on the Dark Energy Survey have released the first in a series of dark matter maps of the cosmos
  - Weak lensing mass map based on galaxy shape measurements in the 139 deg<sup>2</sup> SPT-E field from the Dark Energy Survey Science Verification data
  - Map covers only about 3% of the sky area DES will document over its five-year mission
  - Tests of analysis tools and studies of systematics performed in this analysis will benefit future DES science program



[http://www.fnal.gov/pub/presspass/press\\_releases/2015/Mapping-The-Cosmos-20150413.html](http://www.fnal.gov/pub/presspass/press_releases/2015/Mapping-The-Cosmos-20150413.html)



# Cosmic Frontier Strategy

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- 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 and SuperCDMS-SNOlab expected to begin fabrication in FY 2016
- 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)
  - LSST baseline was approved in January 2015
  - DESI is approved for fabrication start in 2015
  - Ramping up as rapidly as possible within constraints of FY 2015 funding
- P5 recommended an advanced cosmic microwave background (CMB) experiment sensitive to the early expansion phase of the universe
  - Community planning towards a “Stage 4” CMB experiment continues





**ADVANCED TECHNOLOGY R&D**

# Accelerator R&D Program

- Following P5, the Accelerator R&D Subpanel 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 continue to refine implementation
  - HEP-GARD Magnet Workshop held July 28, 2015
  - Advanced Accelerator Concepts workshop early '16
- CD-0 for FACET-II is nearing completion
- Next opportunity for high-level discussions on ILC will be at the U.S.-Japan Joint High Level Committee Meeting on October 6, 2015



	Intensity Frontier Accelerators	Hadron Colliders	$e^+e^-$ Colliders
Current Efforts	PIP	LHC	
	PIP-II	HL-LHC	ILC
Next Steps	Multi-MW proton beam	Very high-energy $pp$ collider	1 TeV class energy upgrade of ILC*
Further Future Goals	Neutrino factory*	Higher-energy upgrade	Multi-TeV collider*

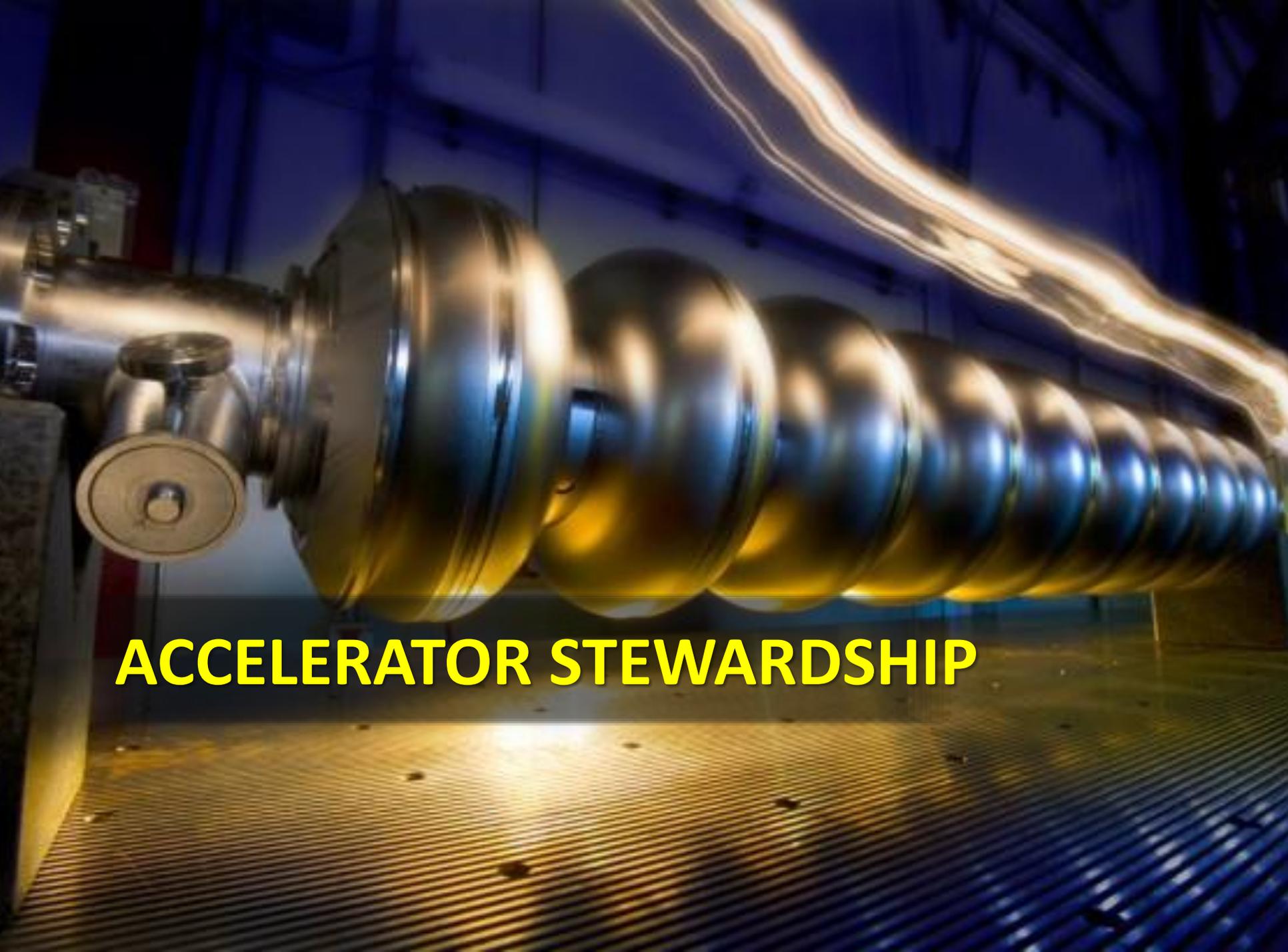
*\*dependent on how physics unfolds*



# 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 and ILC**
  - Funding Agencies for Large Colliders (FALC) can be the forum for this discussion among agencies
  - Labs and agencies need to lead the discussion in order that the formal planning process does not slow the scientific community
  - Regional and national planning needs global coherence
- **Current DOE HEP priority is investment in the enabling technologies for future machines**





**ACCELERATOR STEWARDSHIP**

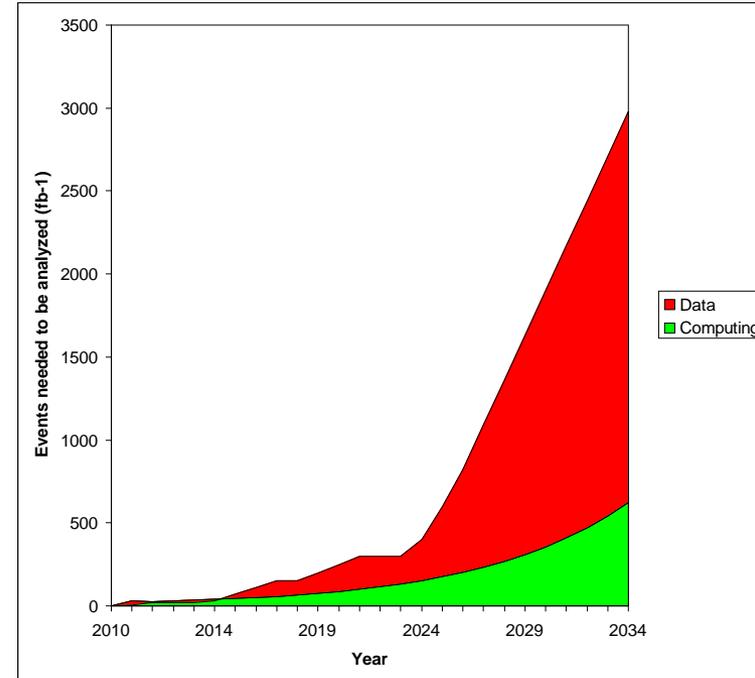
# Stewardship Activities

- **The Accelerator Stewardship Test Facility Pilot Program is launching after a delay due to appropriations**
  - The seven participating SC labs are conducting public outreach events through April–June and will propose collaborative R&D with industry to HEP for funding in FY 2015
  - The ANL/FNAL outreach event alone drew 95 registered participants
- **An Energy & Environmental Applications of Accelerator Basic Research Needs workshop was held June 23-26 at ANL**
  - The goal was to identify accelerator technology R&D opportunities that, if developed, could enable high-impact solutions for current E&E challenges. Three working groups addressed:
    - **WG-1: High power, low-energy e-beam systems for treating potable and waste water, removing pollutants from stack gases;**
    - **WG-2: High power, medium-energy e-beam systems for sterilization of sludges and solid wastes; mobile e-beam systems for environmental remediation;**
    - **WG-3: Superconducting magnet technologies for wind generators, enhanced magnetic separation of material streams, and other industrial processes.**
  - For more information contact Eric Colby ([eric.colby@science.doe.gov](mailto:eric.colby@science.doe.gov))



# HEP & Exascale Computing

- HEP computing needs by 2025 anticipated to be ~10-100x current HEP infrastructure
  - Driven by enhanced precision, higher luminosity, increased event complexity of planned experiments and advanced simulations
- HEP partnership with Advanced Scientific Computing Research (ASCR), including through the Forum for Computational Excellence, will help address issues facing HEP computing needs
- ASCR expects exascale-class facilities will be available in early 2020s
  - Office of Science Exascale Requirements Reviews began with HEP-ASCR on June 10–13, 2015
    - <https://www.nersc.gov/science/hpc-requirements-reviews/exascale/HEP/>
  - Review emphasized the need to address future computing as an integrated environment that includes data, software, and networking



**Estimated ATLAS Computing Requirements**

*The green assumes 15% growth per year from Run 1, and that Run 1 had exactly enough capacity.*

# Achieving the Global Vision for HEP

- **P5** provides the science drivers and recommended strategic priorities, particularly project priorities under various budget scenarios
- **HEPAP** is the “keeper” of the plan and reviews implementation and progress
- The **agencies**, as the stewards of the program, receive the advice and try to implement the plan as best they can with the actual budgets
- Strong **community** support continues to be crucial to achieving the P5 vision:
  - Coherent community message in support of vision gets noticed by appropriators
  - Focused community effort required to crisply execute the plan and flawlessly complete projects

