DOE HEP Budget and Planning

or

Message from The Funding Frontier

Intensity Frontier Workshop

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Alan L. Stone
Program Manager
Office of High Energy Physics
Office of Science, U.S. Department of Energy

Outline

Introduction

Mission

Budget and Issues

Strategic Planning and Community Process

Intensity Frontier Planning

Summary

Take-Away Messages

- The U.S. HEP program is following the strategic plan laid out by the previous HEPAP/P5 studies
- Though some of the boundary conditions have changed, we are still trying to implement that plan within the current constraints
  - FY2014 request generally supports this, though funding constraints have led to delays in some key projects
  - Need to maintain progress with projects currently "on the books"
  - Working to attract partnerships that will extend the science impact
- Actively engaged with community in developing new strategic plan
- Increased emphasis on broader impacts via accelerator stewardship
- Our only hope to maintain leadership in the long-term is to out-innovate the competition, and exploit unique capabilities
  - Focus on areas where US can have leadership
  - "High-risk, high-impact" as opposed to incremental advances
  - Note this is not an <u>either/or</u> proposition, we need both with appropriate balance

DOE HEP MISSION

Office of

High Energy Physics

Fundamental

to the

Frontiers of

Discovery

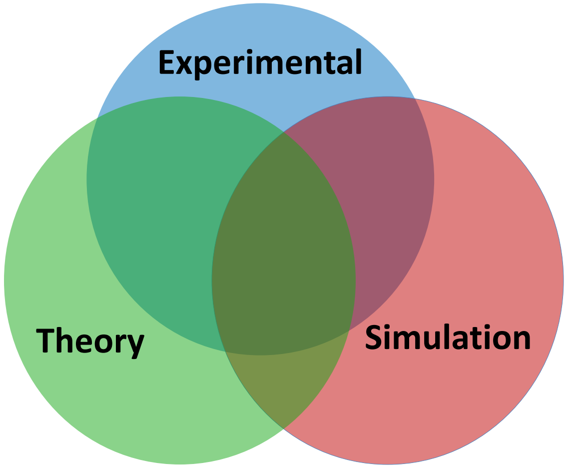
HEP's Mission: To explore the most fundamental questions about the nature of the universe at the Cosmic, Intensity, and Energy Frontiers of scientific discovery, and to develop the tools and instrumentation that expand that research.

HEP seeks answers to Big Questions:

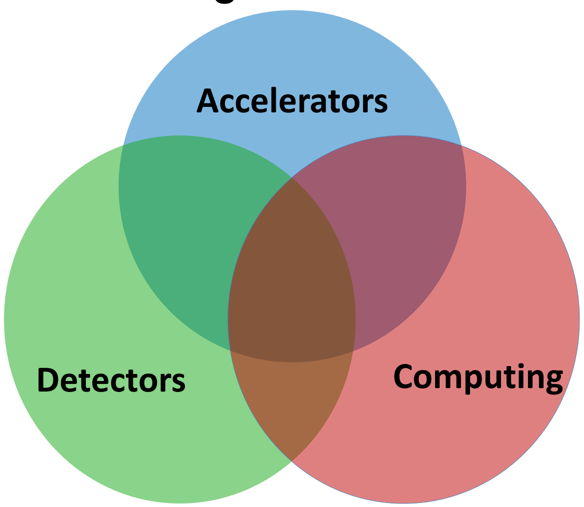
How does mass originate?
Why is the world matter and not anti-matter?
What is dark energy? Dark matter?
Do all the forces become one and on what scale?
What are the origins of the Universe?

HEP offers high-impact research opportunities for small-scale collaborations at the Cosmic and Intensity Frontiers to full-blown international collaborations at the Energy Frontier. More than 20 physicists supported by the Office of High Energy Physics have received the Nobel Prize.

HEP Physics and Technology



Along Three Paths



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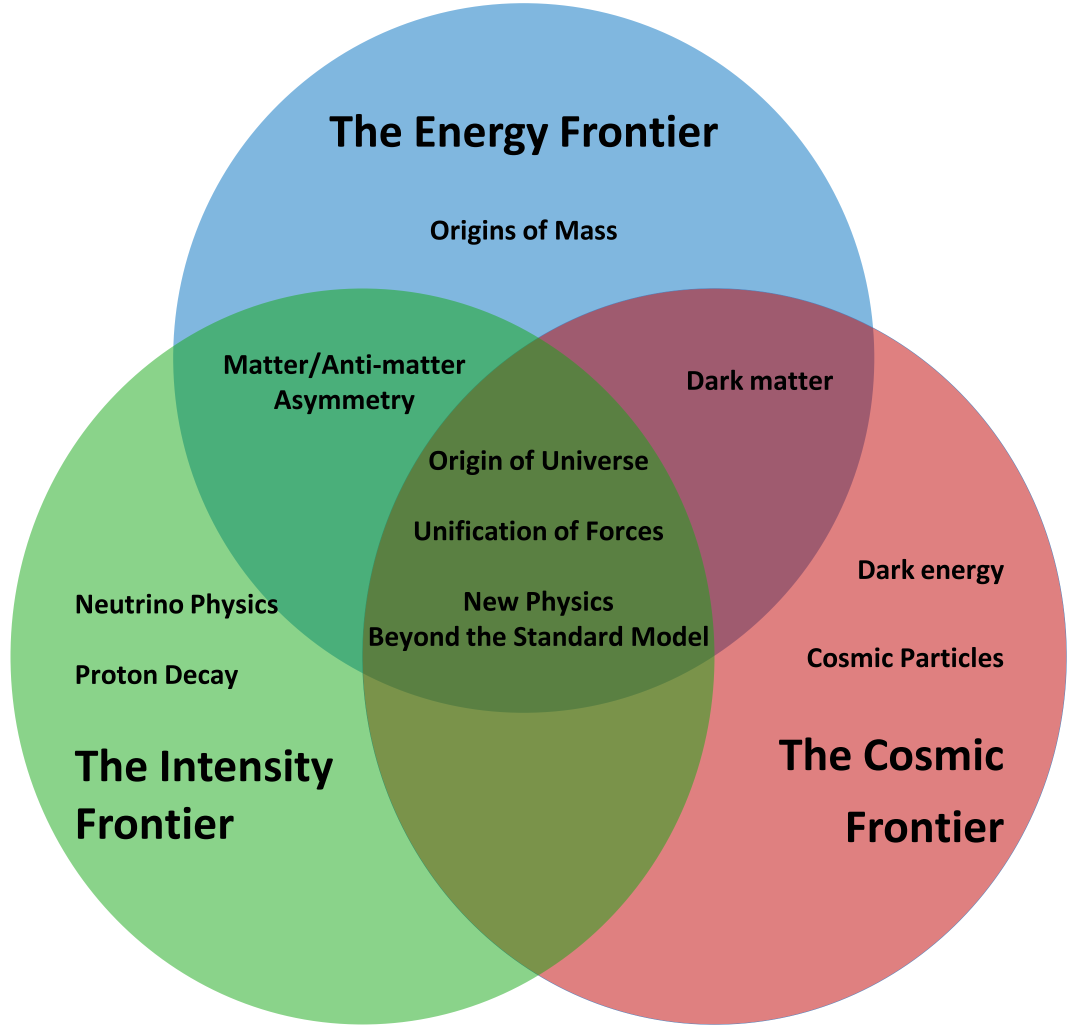
Advanced Technologies in:



Physics Frontiers

The Common Goal

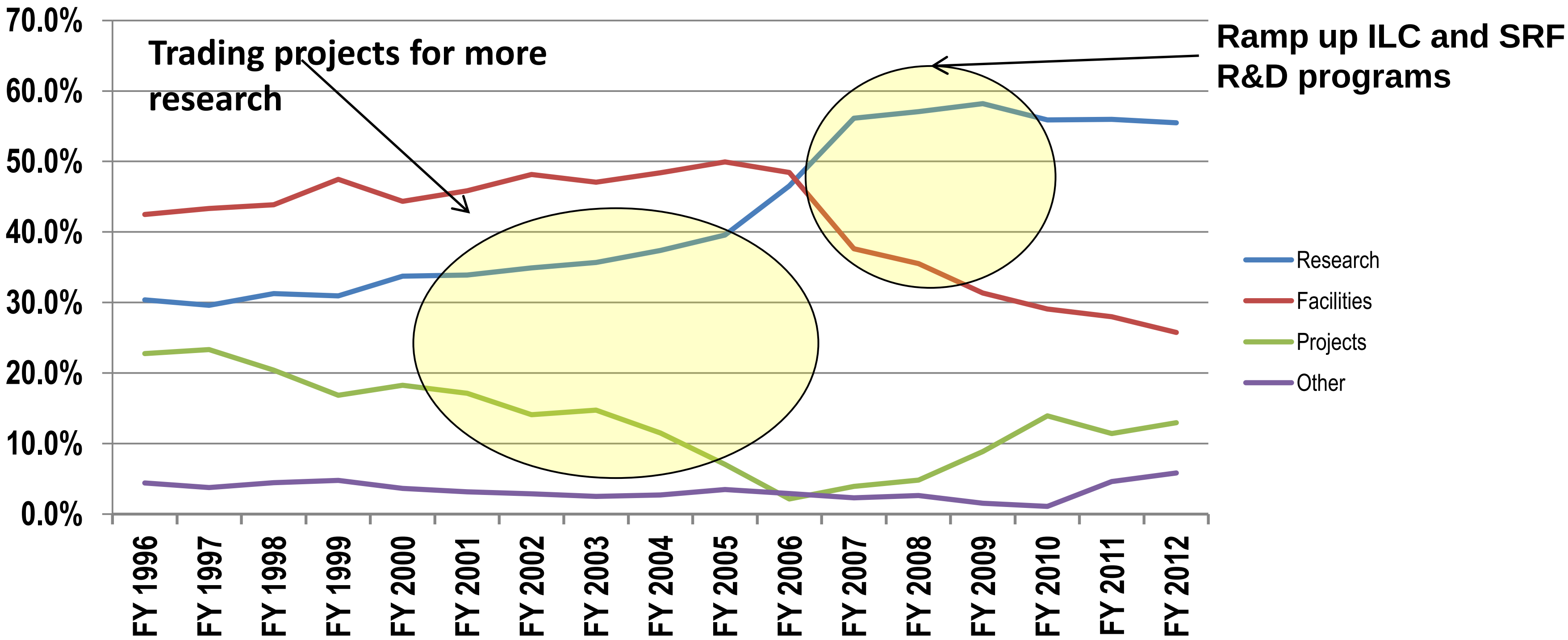
- **A realistic, coherent, shared plan for US HEP**
  - Enabling world-leading facilities and experiments in the US while recognizing the global context and the priorities of other regions
  - Recognizing the centrality of Fermilab while maintaining a healthy US research ecosystem that has essential roles for both universities and multi-purpose labs
  - Articulating both the value of basic research and the broader impacts of HEP
  - Maintaining a balanced and diverse program that can deliver research results consistently

HEP BUDGET

HEP Budget Overview

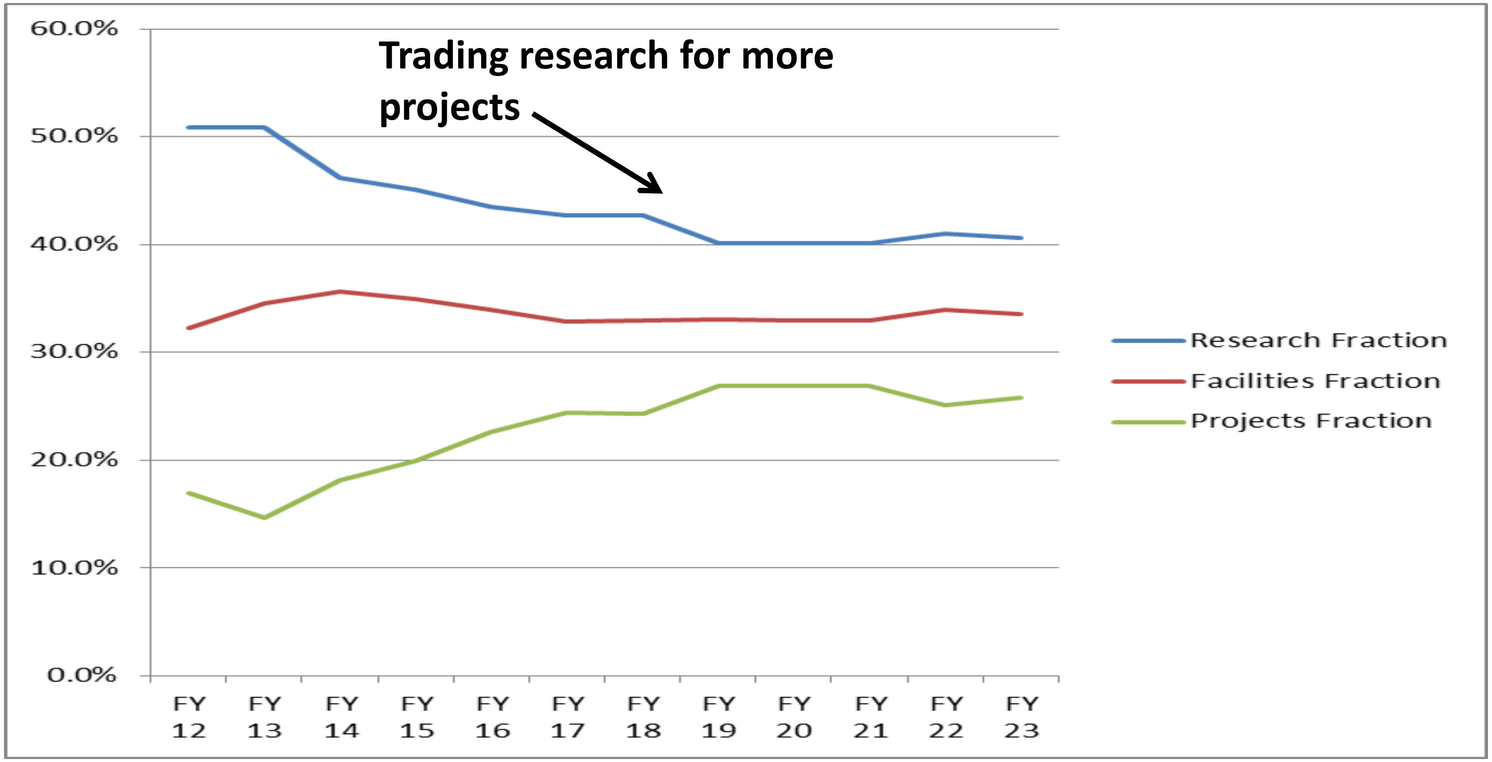
- **FY2014 budget philosophy was to enable new world-leading HEP capabilities in the U.S. through investments on all three frontiers**
  - **Accomplished through ramp-down of existing Projects and Research**
  - **When we were not able to fully implement this approach, converted planned project funds to R&D: Research → ~~Projects~~ → Research**
  - **Therefore the FY14 Request shows *increases* for Research which are driven by this R&D "bump", while Construction/MIE funding is only slightly increased**
  - **Details in following slides**
- **Impact of these actions:**
  - **Several new efforts are delayed: LBNE, LHC detector upgrades, 2nd Generation Dark Matter detectors**
  - **US leadership/partnership capabilities will be challenged by others**
  - **Workforce reductions at universities and labs**
- **Key areas in FY2014 Request**
  - **Maintaining forward progress on new projects via Construction and Research funding lines**

Recent Funding Trends



- In the late 90's the fraction of the budget devoted to projects was about 20%.
- Progress in many fields require new investments to produce new capabilities.
- The projects started in 2006 are coming to completion.
- New investments are needed to continue US leadership in well defined research areas.
- Possibilities for future funding growth are weak. Must make do with what we have.

One Possible Future Scenario



- **About 20% (relative) reduction in Research fraction over ~5 years.**
  - ***In order to address priorities, this will not be applied equally across Frontiers.***
- **This necessarily implies reductions in scientific staffing. Some can migrate to Projects but other transitions are more difficult.**
- **We have requested labs to help manage this transition as gracefully as possible.**

FY 2014 High Energy Physics Budget
(Data in new structure, dollars in thousands)

Description	FY 2012 Actual	FY 2014 Request	Explanation of Change
Energy Frontier Exp. Physics	159,997	154,687	Ramp-down of Tevatron
Intensity Frontier Exp. Physics	283,675	271,043	Completion of NOvA (MIE), partially offset by Fermi Ops
Cosmic Frontier Exp. Physics	71,940	99,080	Ramp-up of LSST
Theoretical and Computational Physics	66,965	62,870	Continuing reductions in Research
Advanced Technology R&D	157,106	122,453	Completion of ILC R&D
Accelerator Stewardship	2,850	9,931	FY14 includes Stewardship-related Research
SBIR/STTR	0	21,457	
Construction (Line Item)	28,000	35,000	Mostly Mu2e; no LBNE ramp-up
Total, High Energy Physics	**770,533***	**776,521**	**Down -1.8% after SBIR correction**
Office of Science	**4,873,634**	**5,152,752**	

***The FY 2012 Actual is reduced by $20,327,000 for SBIR/STTR**

HEP Intensity Frontier

Funding (in $K)	FY 2012 Actual	FY 2014 Request	Comment
Research	**53,261**	**53,562**	Ramp-down of Bfactory research offset by increased support for new initiatives
Facilities	**143,844**	**180,481**	
Expt Ops	6,615	7,245	Offshore and offsite Ops
Fermi Ops	119,544	156,438	Accelerator and Infrastructure improvements
Bfactory Ops	10,031	4,600	Completion of BaBar D&D
*Homestake**	5,478	10,000	
Other	2,176	2,198	GPE and waste mgmt
Projects	**86,750**	**37,000**	
Current	73,770	27,000	NOvA + MicroBooNE rampdown
Future R&D	12,880	10,000	
TOTAL Intensity Frontier	**283,675**	**271,043**	

***Per interagency MOU, HEP provided LHC Detector Ops funding during FY12 CR to offset NSF contributions to Homestake dewatering activities.**

Current LBNE Strategy

- We are trying to follow the reconfiguration (phased) plan for LBNE, though it has hit some snags
  - Out year budgets are challenging
  - Some members of the community objected that the phased LBNE was not what P5 (or they) had in mind
- The plan, as it currently stands:
  - Use time before baselining to recruit partners (international and domestic) that expand scope and science reach
  - Working to get more of the community on board
- It seems clear this is necessary. Will it also be sufficient?
  - Need to get agreement on what is required for success

MIE Issues

- We were not able to implement (most) new MIE starts in FY14 request
  - Muon g-2 experiment is the only new start in HEP
- This upsets at least 2 major features of our budget strategy:
  - Strategic plan : “Trading Research for Projects”
  - Implementation of facilities balanced across Frontiers

HEP Physics MIE Funding

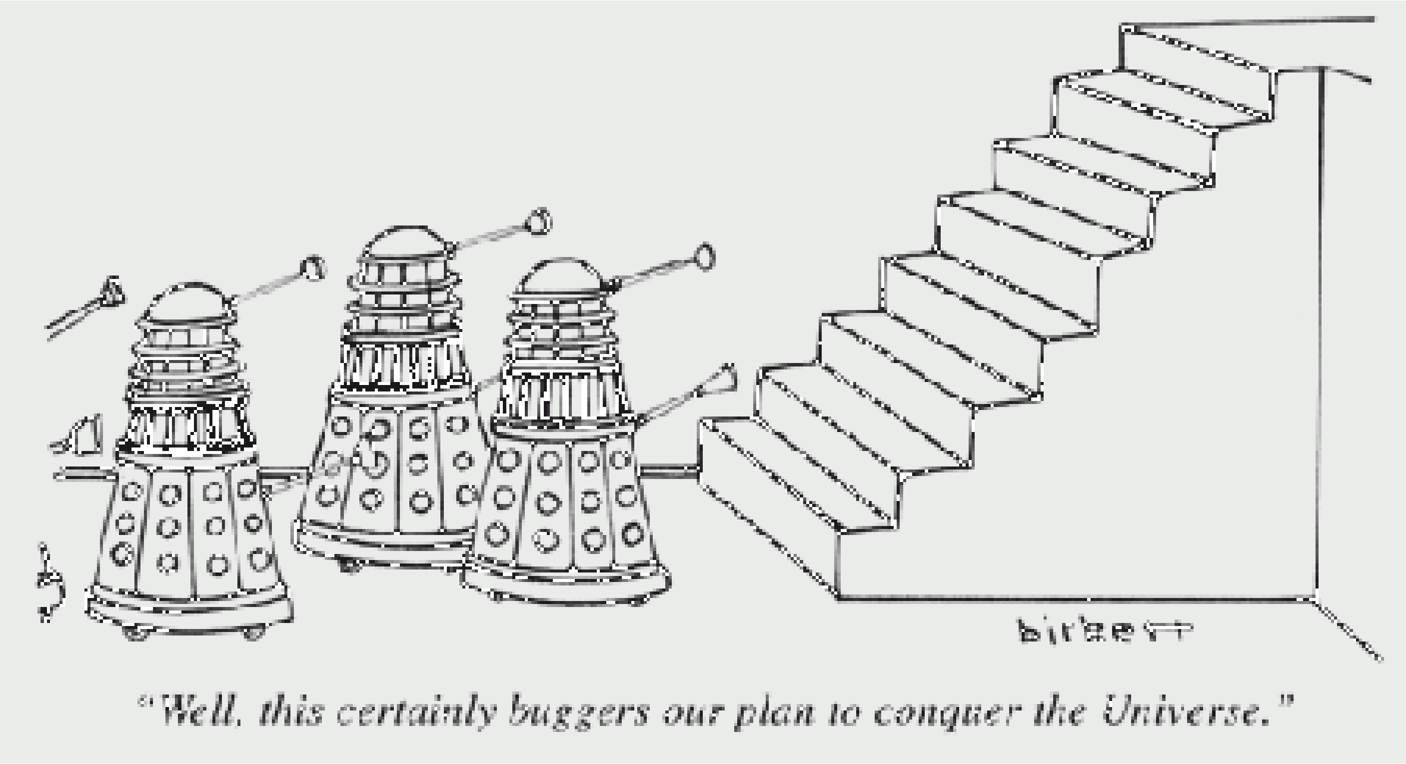
Funding (in $K)	FY 2012 Actual	FY 2014 Request	Description
MIE's	**55,770**	**39,000**	
Intensity Frontier	41,240	0	NOvA ramp-down
Intensity Frontier	6,000	0	MicroBooNE
Intensity Frontier	500	0	Reactor Neutrino Detector at Daya Bay
Intensity Frontier	1,030	8,000	Belle II
Intensity Frontier	0	9,000	Muon g-2 Experiment
Cosmic Frontier	1,500	0	HAWC
Cosmic Frontier	5,500	22,000	Large Synoptic Survey Telescope Camera
TOTAL MIE'S	**55,770**	**39,000**	

HEP Physics Construction Funding

Funding (in $K)	FY 2012 Actual	FY 2014 Request
Construction	**53,000**	**45,000**
Long Baseline Neutrino Experiment	**21,000**	**10,000**
TEC	4,000	0
OPC	17,000	10,000
TPC	21,000	10,000
Muon to Electron Conversion Experiment	**32,000**	**35,000**
TEC	24,000	35,000
OPC	8,000	0
TPC	32,000	35,000

HEP Project Status

Subprogram	TPC ($M)	CD Status	CD Date
INTENSITY FRONTIER			
Long Baseline Neutrino Experiment (LBNE)	TBD	CD-1	December 10, 2012
Muon g-2	40	CD-0	September 18, 2012
Mu2e	249	CD-1	July 11, 2012
Next Generation B Factory Detector Systems (BELLE II)	16	CD-3a	November 8, 2012
NuMI Off-Axis Electron Neutrino Appearance Exp't (NOvA)	278	CD-3b	October 29, 2009
Micro Booster Neutrino Experiment (MicroBooNE)	19.9	CD-3b	March 29, 2012
Main INjector ExpeRiment for v-A (MINERvA)	16.8	CD-4	June 28, 2010 [Finished]
Daya Bay Reactor Neutrino Experiment	35.5	CD-4b	August 20, 2012 [Finished]
ENERGY FRONTIER			
LHC ATLAS Detector Upgrade	TBD	CD-0	September 18, 2012
LHC CMS Detector Upgrade	TBD	CD-0	September 18, 2012
COSMIC FRONTIER			
Dark Matter (DM-G2)	TBD	CD-0	September 18, 2012
Large Synoptic Survey Telescope (LSST)	173	CD-1	April 12, 2012
Dark Energy Survey (DES)	35.1	CD-4	June 4, 2012 [Finished]
ADVANCED TECHNOLOGY R&D			
Accelerator Project for the Upgrade of the LHC (APUL)	11.5	CD-2/3	July 29, 2011
Berkeley Lab Laser Accelerator (BELLA)	27.2	CD-4	January 17, 2013 [Finished]
Facility for Advanced Accelerator Experimental Tests (FACET)	14.5	CD-4	January 31, 2012 [Finished]



STRATEGIC PLANNING AND COMMUNITY PROCESS

Major Recommendations of 2008 Advisory Panel (P5)

- The panel recommends that the US maintain a leadership role in world-wide particle physics. The panel recommends a strong, integrated research program at the three frontiers of the field: the Energy Frontier, the Intensity Frontier and the Cosmic Frontier.
- **The panel recommends support for the US LHC program, including US involvement in the planned detector and accelerator upgrades (highest priority)**
- The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.
  - LBNE CD-0 received Jan 2010, and CD-1 received Dec 2012.
- The panel recommends funding for measurements of rare processes to an extent depending on the funding levels available… (Mu2e at FNAL, U.S. Belle II detector upgrade).
  - Mu2e CD-0 received Nov 2009, and CD-1 received July 2012.
  - Belle II CD-0 received Aug 2011, and CD-1 received July 2012.
- **The panel recommends support for the study of dark matter and dark energy as an integral part of the US particle physics program.**
- **The panel recommends a broad strategic program in accelerator R&D, including work …, along with support of basic accelerator science.**
- **These are still relevant, and this is still the plan.**

Strategic Planning

- **The HEP budget puts in place a comprehensive program across the three frontiers.**
  - In five years:
    - NOvA, Belle II, Muon g-2 will be running on the Intensity Frontier
    - Mu2e will be commissioning for first data taking
    - The CMS and ATLAS detector upgrades will be installed at CERN
    - DES will have completed its science program and new mid-scale spectroscopic instrument and DM-G2 should begin operation
    - The two big initiatives, LSST and LBNE, will be well underway
- **Need to start planning now for what comes next.**
  - Engaging with DPF community planning process that will conclude this summer.
  - Will set up a prioritization process (a la P5) using that input.

Customized Implementation Strategies

- **Energy Frontier**
  - US has a leading role in LHC physics collaborations but is not the driver
    - The issue is the scope and scale of US involvement. Requires US-CERN negotiation.
    - Could also be true for Japanese-hosted ILC but requires *deus ex machina*
- **Intensity Frontier**
  - US is a (the?) world leader and needs new facilities and/or upgrades of existing facilities to maintain its position
    - Has the potential to attract new partners to US-led projects if we can get going
    - Portfolio of experiments and science case is diverse. This complicates the case. The scale of the projected investments is a big challenge
- **Cosmic Frontier**
  - US HEP has a leading role in a competitive, multidisciplinary environment
    - Technologies are diverse but HEP physics case is simple and compelling. Only question is how far one needs to go in precision/setting limits.
    - DOE is a technology enabler, not a facilities provider (see NSF, NASA)
      - Analogous to LHC but the HEP physics goals are not those of the facility owners
    - DOE supports particle physics goals and HEP-style collaborations
      - Astronomy and astrophysics is not in our mission nor our *modus operandi*

Agency Letter to the Community

- Fundamentally…[planning] is a multi-step process with several important milestones over the coming year, and each step will inform and prepare for the next.
  1. HEP Facilities Subpanel: Advise DOE/SC mgmt. on the scientific impact and technical maturity of planned and proposed SC Facilities, in order to develop a coherent 10-yr SC facilities plan
     - Subpanel can add or subtract from initial facilities list
     - Does not exclude/pre-empt later additions
  2. DPF/CSS2013 "Snowmass": identify compelling HEP science opportunities over an approximately 20 year time frame.
     - Not a prioritization but can make scientific judgments
  3. HEPAP/P5: Develop new strategic plan and priorities for US HEP in various funding scenarios, using input from #1 and 2 above (among others)

Goals for the P5 Process

- The P5 process takes the science vision of the community and turns it into plan that is feasible and executable over a ~10 year timescale
- HEP MUST have a planning and prioritization process that the community can stand behind and support once the P5 report is complete
- We also need a process that repeats at more less regular intervals (5 years?)
  - We also want to allow for less comprehensive updates to the plans along the way (a la P5 updates in 2009, 2010)
- Key elements envisioned for the P5 process:
  - Revisit the questions we use to describe the field (e.g. *Quantum Universe*, updated and corrected)
  - Decide on the project priorities within budget guidance (in detail for the next 10 years, in broad outline beyond that)
  - Propose the best way to describe the *value* of HEP research to society
  - Build on the investment in the Snowmass process

What P5 Is (and Is Not)

P5 will prioritize HEP projects over a 10-20 year timeframe within reasonable budget assumptions and position the U.S. to a be a leader in some (but not all) areas of HEP.

- **This will include an explicit discussion of the necessity (or not) of domestic HEP facilities in order to maintain such a world leadership position.**
- **Necessarily this will involve consideration of technical feasibility as well as plausible timescales and resources for future projects.**
- **There will be budget "fixed points" for projects already under construction and other prior commitments**

The charge to P5 will NOT include explicit examination of

- **Agency review processes**
- **Roles, responsibilities and funding of labs versus universities**
- **Relative funding of experimental HEP vs. theory vs. technology R&D**

DRAFT New P5 Process (for discussion)

Based on adopting "best practices" from our colleagues in Nuclear Physics and Astrophysics, we are considering the following enhancements to the P5 process for this iteration:

- **Greatly enlarged P5 panel (~50 members)**
  - **Nominations will be sought from HEP and related communities through a Dear Colleague letter**
- **Several "town meetings" as public forums not only to advocate for particular science opportunities but also to *prioritize***
  - **Each sub-group of the community should be able to prioritize the most important science within its specialty. P5 will recommend priorities across the entire field.**
  - **Project-specific white papers will be solicited (in addition to Snowmass white papers)**
- **Separate working group updating the *Quantum Universe* questions in parallel with science priority discussion**
- **Separate working group elucidating HEP benefits to society**

Draft Proposed Town Meetings (1)

- **First meeting on the overall strategy, questions to describe the field, and discussion of how technology development priorities and other crosscutting issues should be covered in the P5 report**
  - **Start with the current P5 plan and possible alternatives as well as global strategy considerations.**
    - **Open discussion of issues so the community can better understand the constraints, and hopefully reach broader agreement.**
  - **Fundamental questions for the field and how to unify and connect the Frontiers framework will also be discussed**
    - **Input from the Theory community will be especially important in this area**
  - **Technology support will NOT be a main focus of P5, but the panel will benefit from wisdom in the community in this area.**
    - **E.g., Do we have a coherent technology R&D plan that dovetails with the science opportunities? If not, how do we get there?**
    - **Note that 'Accelerator Stewardship' is an Office of Science wide initiative managed by the HEP office, so should be discussed for information, but will not be modified by P5.**

Draft Proposed Town Hall Meetings (2)

- **Subsequent meetings will focus on open community discussion of project priorities on each of the frontiers: Intensity, Energy, and Cosmic.**
  - **The expected outcome will be advice to P5 on a *prioritized project list* by frontier. Each meeting will focus on one frontier, not flaws in the plan of the other frontiers.**
  - **The process will be moderated by P5 itself, and based on input from Snowmass whitepapers and project whitepapers updated from the facility panel, Snowmass, or just for this purpose.**
  - **P5 will see to it that the meetings do not descend into a shouting contest**
  - **The budget guidance to P5 will be public as part of its Charge, so proponents will have a good idea of the total budget envelope that can be considered and can debate what is a "reasonable" budget profile.**
- **Based on the results of the first 4 meetings, we will consider a 5th meeting to 'wrap up' and discuss any broad matters arising.**

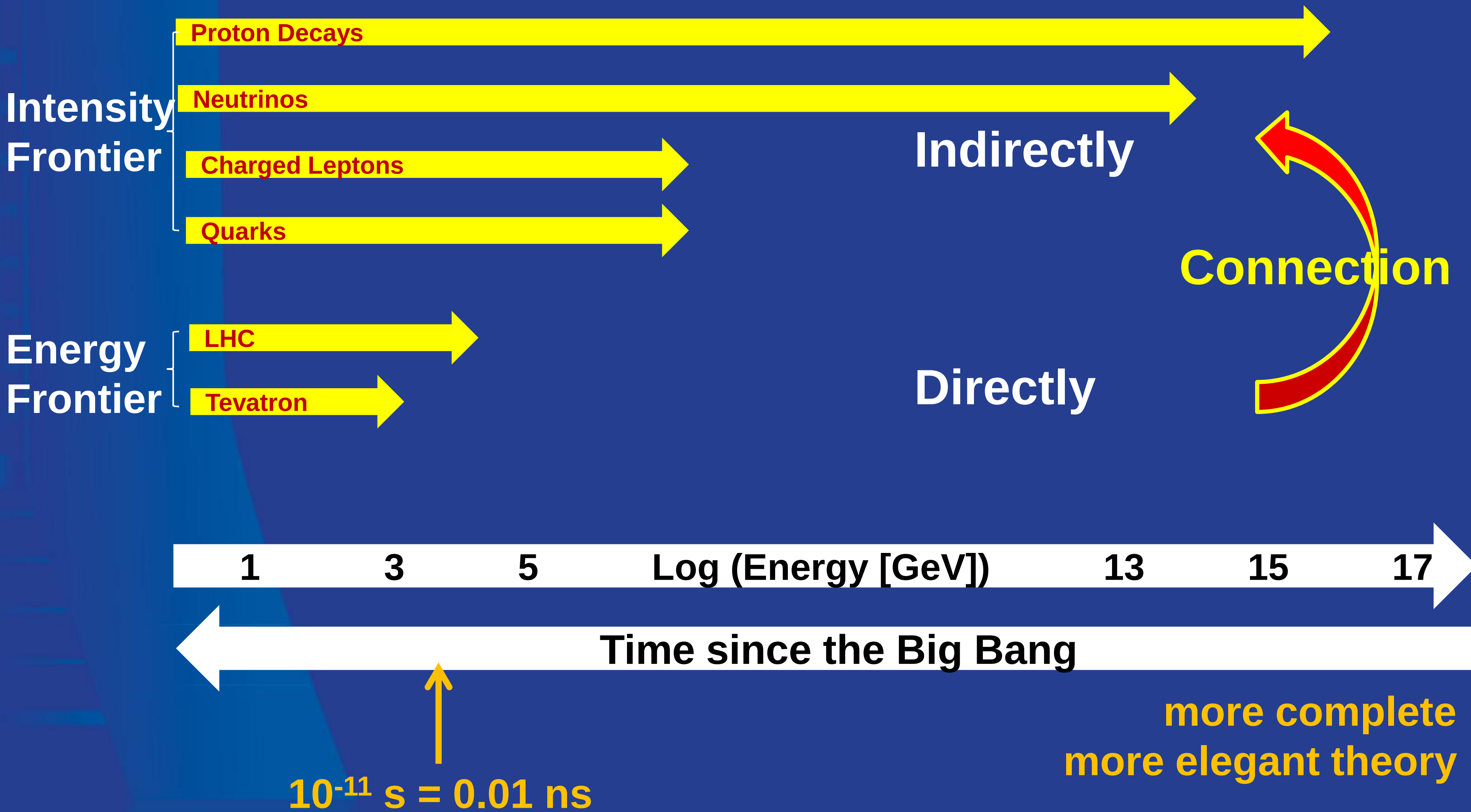
Next Steps

- The agencies welcome input from the community on the shape of the P5 process.
- Expect to see a ‘Dear Colleague’ letter soon on P5 membership nomination.
- We have until the end of Snowmass to modify our P5 plans, and the agencies plan a series of talks at the Snowmass meetings to solicit further input about the P5 process.
- The agencies expect that our community is capable of adult behavior, and look forward to vigorous and open discussions of our challenges and opportunities.

Intensity Frontier

Intensity Frontier

The strategy and experimental reach



Fermilab

HEP Intensity Frontier Experiments

Experiment	Location	Status	Description	#US Inst.	#US Coll.
Belle II	KEK, Tsukuba, Japan	Physics run 2016	Heavy flavor physics, CP asymmetries, new matter states	10 Univ., 1 Lab	55
CAPTAIN	Los Alamos, NM, USA	R&D; Neutron run 2015	Cryogenic apparatus for precision tests of argon interactions with neutrinos	5 Univ., 1 Lab	20
Daya Bay	Dapeng Peninsula, China	Running	Precise determination of θ_{13}	13 Univ., 2 Lab	76
Heavy Photon Search	Jefferson Lab, Newport News, VA, USA	Physics run 2015	Search for massive vector gauge bosons which may be evidence of dark matter or explain g-2 anomaly	8 Univ., 2 Lab	47
KOTO	J-PARC, Tokai , Japan	Running	Discover and measure $K_L \rightarrow \pi^0 \nu\nu$ to search for CP violation	3 Univ.	12
LArIAT	Fermilab, Batavia, IL	R&D; Phase I 2013	LArTPC in a test beam; develop particle ID & reconstruction	11 Univ., 3 Lab	38
LBNE	Fermilab, Batavia, IL & Homestake Mine, SD, USA	CD1 Dec 2012; First data 2023	Discover and characterize CP violation in the neutrino sector; comprehensive program to measure neutrino oscillations	48 Univ., 6 Lab	336
MicroBooNE	Fermilab, Batavia, IL, USA	Physics run 2014	Address MiniBooNE low energy excess; measure neutrino cross sections in LArTPC	15 Univ., 2 Lab	101
MINERvA	Fermilab, Batavia, IL, USA	Med. Energy Run 2013	Precise measurements of neutrino-nuclear effects and cross sections at 2-20 GeV	13 Univ., 1 Lab	48
MINOS+	Fermilab, Batavia, IL & Soudan Mine, MN, USA	NuMI start-up 2013	Search for sterile neutrinos, non-standard interactions and exotic phenomena	15 Univ., 3 Lab	53
Mu2e	Fermilab, Batavia, IL, USA	First data 2019	Charged lepton flavor violation search for $\mu N \rightarrow eN$	15 Univ., 4 Lab	106
Muon g-2	Fermilab, Batavia, IL, USA	First data 2016	Definitively measure muon anomalous magnetic moment	13 Univ., 3 Lab, 1 SBIR	75
NOvA	Fermilab, Batavia, IL & Ash River, MN, USA	Physics run 2014	Measure ν_μ-ν_e and ν_μ-ν_μ oscillations; resolve the neutrino mass hierarchy; first information about value of δ_{cp} (with T2K)	18 Univ., 2 Lab	114
ORKA	Fermilab, Batavia, IL, USA	R&D; CD0 2017+	Precision measurement of $K^+ \rightarrow \pi^+ \nu\nu$ to search for new physics	6 Univ., 2 Lab	26
Super-K	Mozumi Mine, Gifu, Japan	Running	Long-baseline neutrino oscillation with T2K, nucleon decay, supernova neutrinos, atmospheric neutrinos	7 Univ.	29
T2K	J-PARC, Tokai & Mozumi Mine, Gifu, Japan	Running; Linac upgrade 2014	Measure ν_μ-ν_e and ν_μ-ν_μ oscillations; resolve the neutrino mass hierarchy; first information about value of δ_{cp} (with NOvA)	10 Univ.	70
US-NA61	CERN, Geneva, Switzerland	Target runs 2014-15	Measure hadrons production cross sections crucial for neutrino beam flux estimations needed for NOvA, LBNE	4 Univ., 1 Lab	15
US Short-Baseline Reactor	Site(s) TBD	R&D; First data 2016	Short-baseline sterile neutrino oscillation search	6 Univ., 5 Lab	28

HEP Program Planning – Intensity Frontier

Issues and questions we will need to deal with when laying out longer term plan – and to be able to execute & defend the program

- **Which are the most important science areas &/or projects that need to be emphasized to make significant advances towards HEP goals? Which areas of phase space do we emphasize? Are there efforts that need to be ramped down or terminated?**
- **In addition to looking for next steps following current program, are there gaps in the current program or other projects that need to be done in the future to fully exploit our program?**
- **Are there branch points where we choose a certain direction?**
- **How far do we need to go in precision &/or setting limits in each area, i.e. when do we stop going in a certain direction?**
- **What are other theory, computational resources and simulations needed?**
- **Need to build case with other Frontiers for the importance of Intensity Frontier**

Intensity Frontier Research & Development

- Intensity Frontier R&D activities reviewed case by case
  - Target of opportunities: fast, cheap and compelling (<u>discovery potential</u>)
- What constitutes Intensity Frontier R&D?
  - Perform simulations and physics studies in support of the conceptual and preliminary design of a future experiment or project
  - Develop and demonstrate the technical feasibility of novel detectors or systems
  - Design, construct, commission, and operate a prototype experiment
- What are the ground rules?
  - There is not a separate pot of money. All funding comes out of research. Be thrifty. Be reasonable. R&D proposals should be mainly for technical support.
  - Form a strong & credible collaboration. Partnerships with labs and universities are preferred. International participation is encouraged.
  - Socialize with the funding agencies AND lab management at the earliest opportunity.
    - Briefings to DOE (or NSF). PAC(s) should have a voice.
    - How and when does this activity fit within the HEP mission and Intensity Frontier portfolio?
  - Technical proposal will be reviewed. Research will be reviewed. Separately.

Current Intensity Frontier R&D Efforts

Experiment	Location	Status	Description	#US Inst.	#US Coll.
CAPTAIN	Los Alamos, NM, USA	R&D; Neutron run 2015	Cryogenic apparatus for precision tests of argon interactions with neutrinos	5 Univ., 1 Lab	20
Heavy Photon Search	Jefferson Lab, Newport News, VA, USA	Physics run 2015	Search for massive vector gauge bosons which may be evidence of dark matter or explain g-2 anomaly	8 Univ., 2 Lab	47
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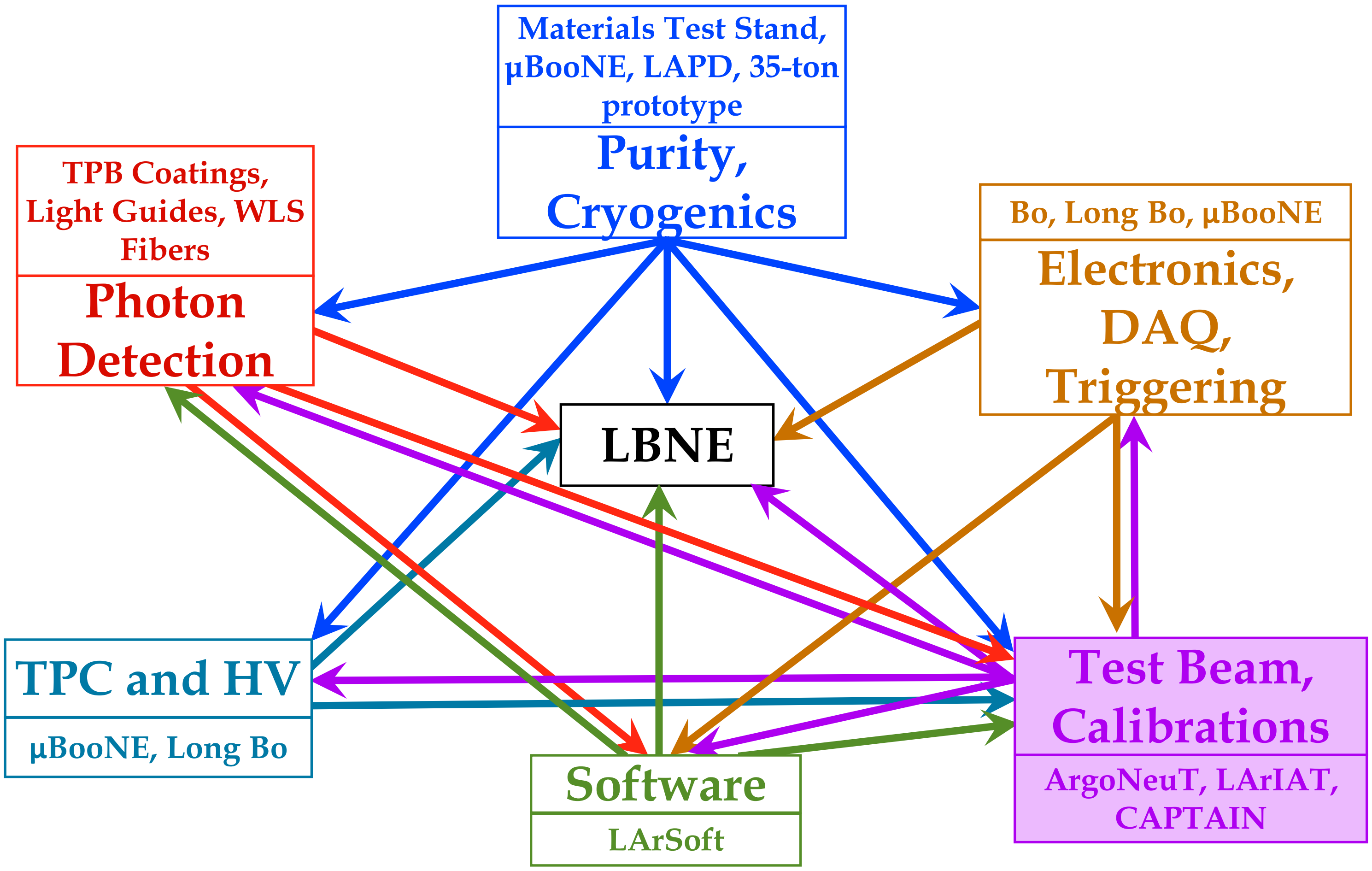
US Short-Baseline Reactor	Site(s) TBD	R&D; First data 2016	Short-baseline sterile neutrino oscillation search	6 Univ., 5 Lab	28

- **Heavy Photon Search: Feb 2013 DOE Briefing; July 11, 2013 DOE Panel Review**
  - **Determine whether to fund the design, construction, commissioning, and operation of the first phase of the experiment for the period of FY14-FY16**
- **nEXO R&D: Monthly DOE HEP/NP Phone Calls; July 12, 2013 DOE Panel Review**
  - **Determine whether to fund the 5 ton LXe TPC R&D program for the period of FY13-FY16**
- **US Short-Baseline Reactor: Monthly DOE Phone Calls; Apr 2013 DOE Briefing**
- **LArIAT: Monthly DOE Phone Calls; Apr 2013 DOE Briefing**
- **ORKA: May 2012 DOE Briefing; FNAL Stage 1**
- **CAPTAIN: Feb 2012 LANL Review (DOE Observer); Monthly DOE Phone Calls**
- **nuSTORM: Monthly DOE Phone Calls; Proposal to FNAL PAC in June 2013**
- **US-NA61: ?**

A Few Words on LAr R&D



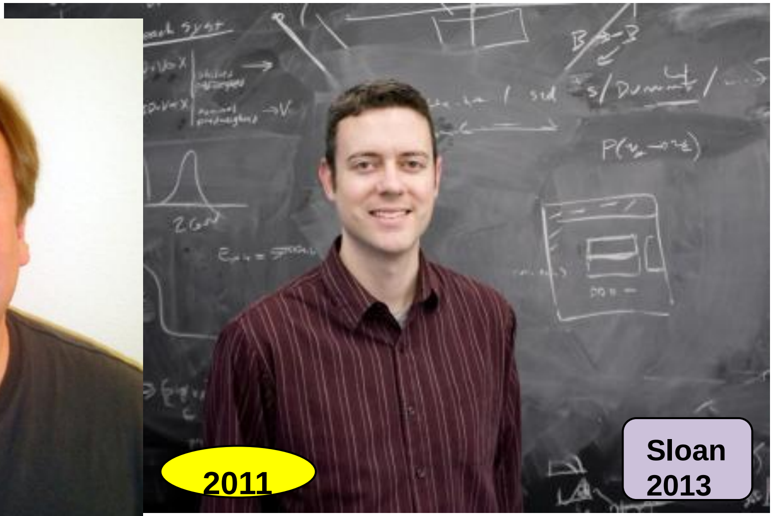
- Provides relevant input to many of the necessary items that will help make LBNE successful.
- Coordination and cooperation among LAr R&D efforts is essential!
- Roadmap(s): Scientific, Technical, Computational.

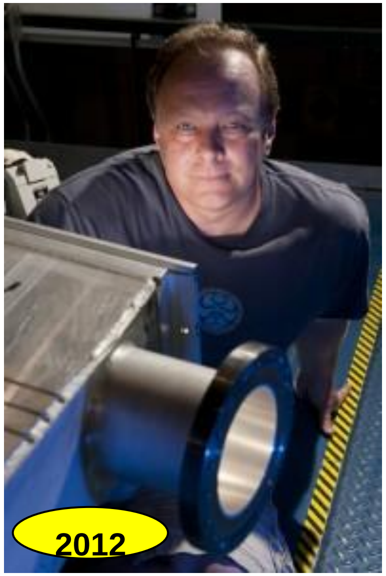
Intensity Frontier – Final Remarks

- In a very competitive HEP research environment, we suspect everyone* may need to up their game
- Some things we often hear, for example:
  - R&D experiments must produce and publish results in a timely fashion
  - Physics studies need full reconstruction of fully simulated events
  - The HEP and NP theory communities need to be engaged in producing better event generators and other simulation tools
  - Software needs to be developed and managed "more like ATLAS, CMS, and Daya Bay"

*With possible exceptions - see next slide.

Intensity Frontier
Early Career Awardees





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2013

SUMMARY

Take-Away Messages

- The U.S. HEP program is following the strategic plan laid out by the previous HEPAP/P5 studies
- Though some of the boundary conditions have changed, we are still trying to implement that plan within the current constraints
  - FY2014 request generally supports this, though funding constraints have led to delays in some key projects
  - Need to maintain progress with projects currently "on the books"
  - Working to attract partnerships that will extend the science impact
- Actively engaged with community in developing new strategic plan
- Increased emphasis on broader impacts via accelerator stewardship
- Our only hope to maintain leadership in the long-term is to out-innovate the competition, and exploit unique capabilities
  - Focus on areas where US can have leadership
  - "High-risk, high-impact" as opposed to incremental advances
  - Note this is not an <u>either/or</u> proposition, we need both with appropriate balance

BACKUP

BROADER IMPACTS OF HEP

The Accelerator R&D Stewardship Program

- The mission of the HEP long-term accelerator R&D stewardship program is to support fundamental accelerator science and technology development of relevance to many fields and to disseminate accelerator knowledge and training to the broad community of accelerator users and providers.

- Strategies:
  - Improve access to national laboratory accelerator facilities and resources for industrial and for other U.S. government agency users and developers of accelerators and related technology;
  - Work with accelerator user communities and industrial accelerator providers to develop innovative solutions to critical problems, to the mutual benefit of our customers and the DOE discovery science community;
  - Serve as a catalyst to broaden and strengthen the community of accelerator users and providers
- Strategic plan sent to Congress in October 2012
- Incorporated into FY2014 Budget Request as new subprogram in HEP

Connecting Accelerator R&D to Science and to End-User Needs

DOE R&D Program Thrust	Science Goal "Push": Particle Beam Quality	Photon Beam Quality	Beam Intensity	Compact or High Energy	Application "Pull": Industry	Medicine	Energy and Environment	Defense and Security	Discovery Science
Superconducting RF	●	●	●	●	●		●	●	●
Accelerator, Beam, Computation	●	●	●	●		●	●	●	●
Particle Sources	●	●	●	●	●		●	●	●
RF Sources			●	●	●		●	●	●
Beam Inst. & Controls	●	●	●	●		●	●	●	●
NC High-gradient Accel. Structures	●	●		●	●	●		●	●
New Accelerator Concepts				●		●		●	●
Superconducting Magnets	●	●	●	●	●	●			●

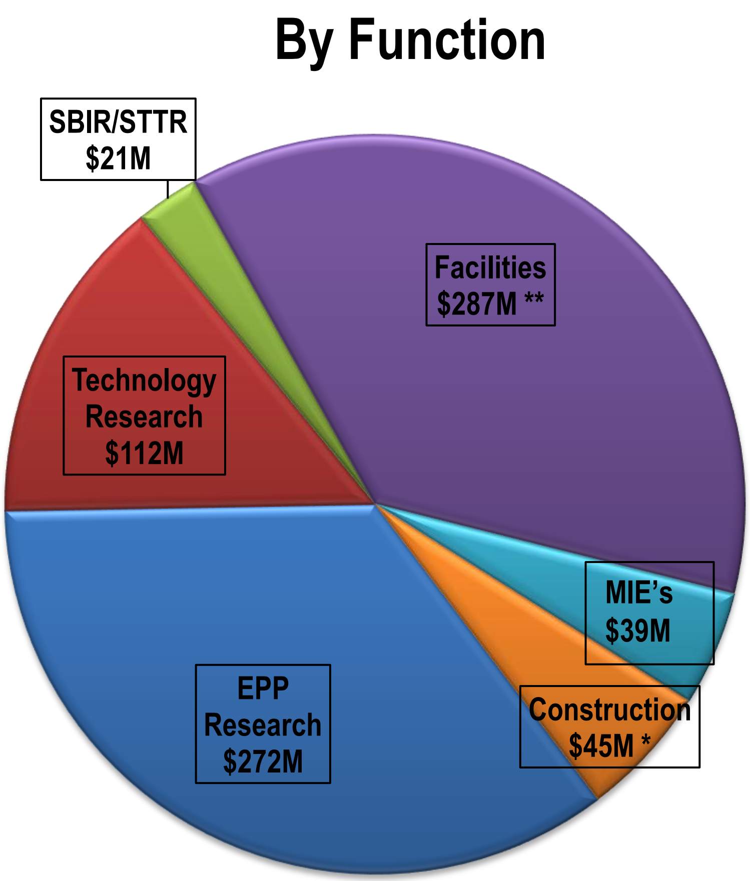
BUDGET BACKUP

HEP Physics Funding by Activity

Funding (in $K)	FY 2012 Actual	FY 2014 Request	Change from FY 2012
Research	**391,329**	**383,609**	Reduction mostly ILC R&D
Facility Operations and Exp't Support	**249,241**	**271,561***	NOvA ops start-up and infrastructure improvements
Projects	**129,963**	**99,894**	
Intensity Frontier	86,570	37,000	NOvA ramp-down, start Muon g-2
Cosmic Frontier	12,893	24,694	LSST
Other	2,500	3,200	LQCD hardware
Construction	28,000	35,000	Mu2e and LBNE
SBIR/STTR	**0**	**21,457**	
TOTAL HEP	**770,533**	**776,521**	

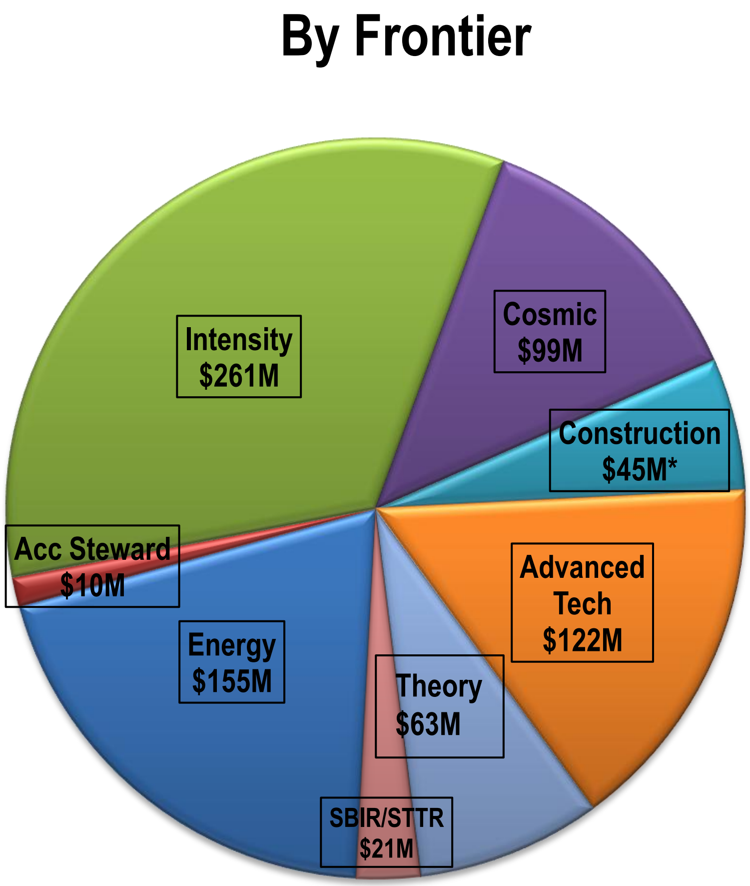
*** Includes $1,563K GPE**

FY 2014 Request Crosscuts



*Includes Other Project Costs (R&D) for LBNE

**Includes $15.9M Other Facility Support



* Includes Other Project Costs (R&D) for LBNE

HEP Energy Frontier

Funding (in $K)	FY 2012 Actual	FY 2014 Request	Comment
Research	**91,757**	**96,129**	Tevatron ramp-down offset by R&D for LHC detector upgrades
Facilities	**68,240**	**58,558**	
*LHC Det Ops**	64,846	56,774	LHC down for maintenance
Other	3,394	1,784	IPAs, Detailees, Reviews
TOTAL Energy Frontier	**159,997**	**154,687**	

*****Per interagency MOU, HEP provided LHC Detector Ops funding during FY12 CR to offset NSF contributions to Homestake dewatering activities.

HEP Cosmic Frontier

Funding (in $K)	FY 2012 Actual	FY 2014 Request	Comment
Research	**47,840**	**62,364**	R&D for G2 Dark Matter
Facilities	**11,207**	**12,022**	Offshore and offsite Ops
Projects	**12,893**	**24,694**	
Current	9,153	23,200	LSSTcam fabrication begins
Future R&D	3,380	1,484	Dark energy and dark matter projects move to conceptual design
TOTAL Cosmic Frontier	**71,940**	**99,080**	

HEP Theory and Computation

Funding (in $K)	FY 2012 Actual	FY 2014 Request	Comment
Research	**64,465**	**59,670**	
Theory	55,929	51,196	Follows programmatic reductions in Research
Computational HEP	8,536	8,474	
Projects	**2,500**	**3,200**	Lattice QCD hardware
TOTAL Theory and Comp.	**66,965**	**62,870**	

HEP Advanced Technology R&D

Funding (in $K)	FY 2012 Actual	FY 2014 Request	Comment
Research	**134,006**	**105,303**	
General Accel R&D	59,280	57,856	Selected long-term R&D moves to Accel Stewardship
Directed Accel R&D	46,587	23,500	Completion of ILC R&D
Detector R&D	28,139	23,947	Funding for liquid argon R&D is reduced
Facility Operations	**23,100**	**17,150**	Completing SRF infrastructure at Fermilab
TOTAL Advanced Technology	**157,106**	**122,453**	

Accelerator Stewardship

Funding (in $K)	FY 2012 Actual	FY 2014 Request	Comment
Research	**0**	**6,581**	Recast of Accelerator R&D activities relevant to broader impacts
Facility Operations	**2,850**	**3,350**	Incremental FACET ops for stewardship research
TOTAL Accel. Stewardship	**2,850**	**9,931**	

NEUTRINO BACKUP

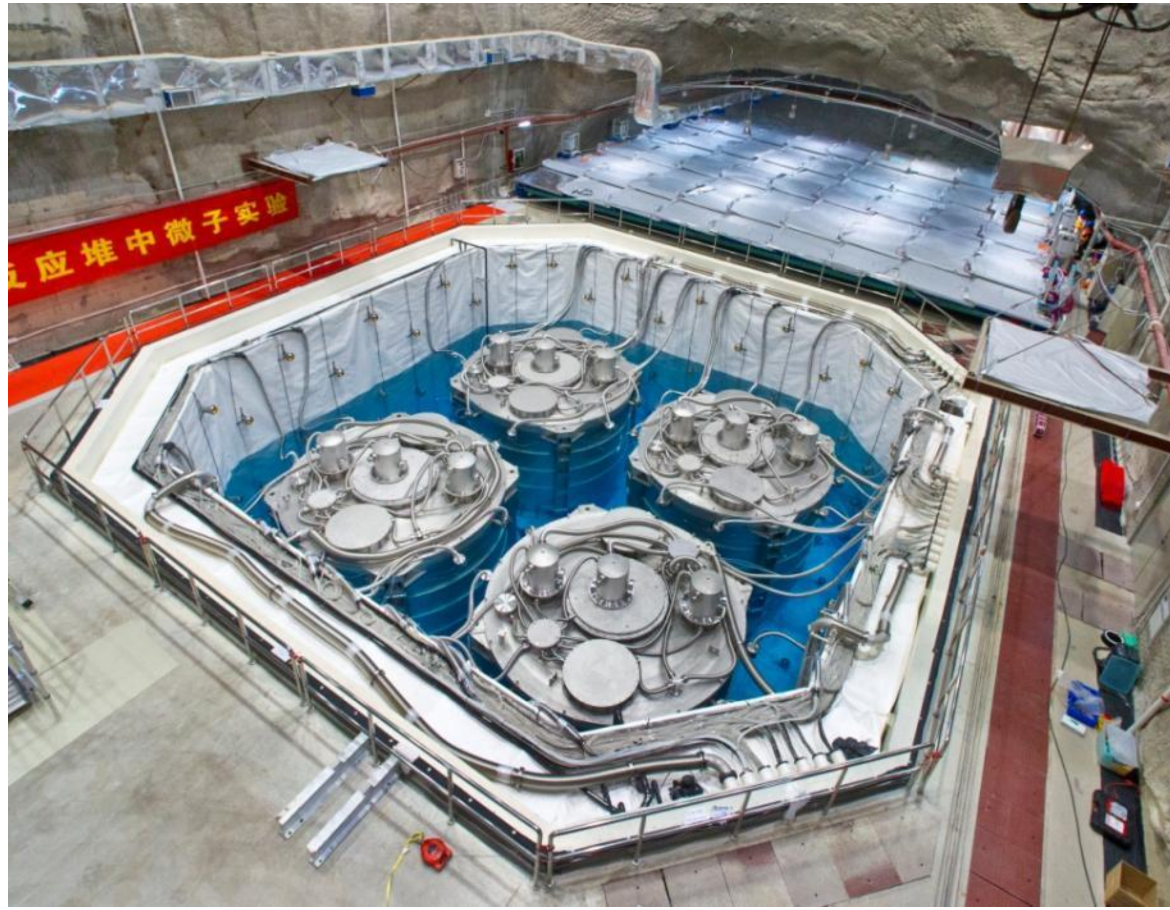
Why Study Neutrinos?

- **Neutrinos are the least understood and most abundant constituents of matter.**
  - **They are everywhere, but they hardly interact at all. More than 10 million are inside every person on earth. You don't notice.**
  - **Neutrinos are very, very, very light.**
    - **Less than one-millionth the mass of an electron, so light no one has actually been able to measure the mass yet (but we know its not = 0).**
  - **Neutrinos come in three "flavors" (types) that can change from one kind to another.**
- **Neutrinos are also very important to our existence.**
  - **They are vital to how stars shine and how they produce all the elements beyond hydrogen, including the carbon and oxygen that makes up people.**
  - **They may play a key role in why there is any matter at all in the universe.**
    - **The Big Bang should have produced equal amounts of matter and antimatter, which should have annihilated into pure energy. Yet almost all the antimatter seems to have vanished and matter is still here.**

Recent Major Accomplishment

Daya Bay Reactor Neutrino Experiment makes the first definitive measurement of the remaining unknown neutrino mixing angle.

In China, the Daya Bay collaboration led by U.S. and Chinese physicists reported a measurement of the mixing angle responsible for changing muon neutrinos to electron neutrinos. This result means that in the current neutrino oscillation model, the possibility of matter-antimatter asymmetry, and a hierarchy of neutrino masses, can be definitively tested with new experiments.



Daya Bay Far Detector Hall with 4 neutrino detectors

Intensity Frontier Status

Current program: MINERvA, NOvA, T2K, MicroBooNE, Daya Bay, EXO-200

- **NOvA and MicroBoone will complete construction in FY 2014 (see below + next slide), others taking data**

Planned program: 4 projects in design/R&D phase; fabrication not approved yet

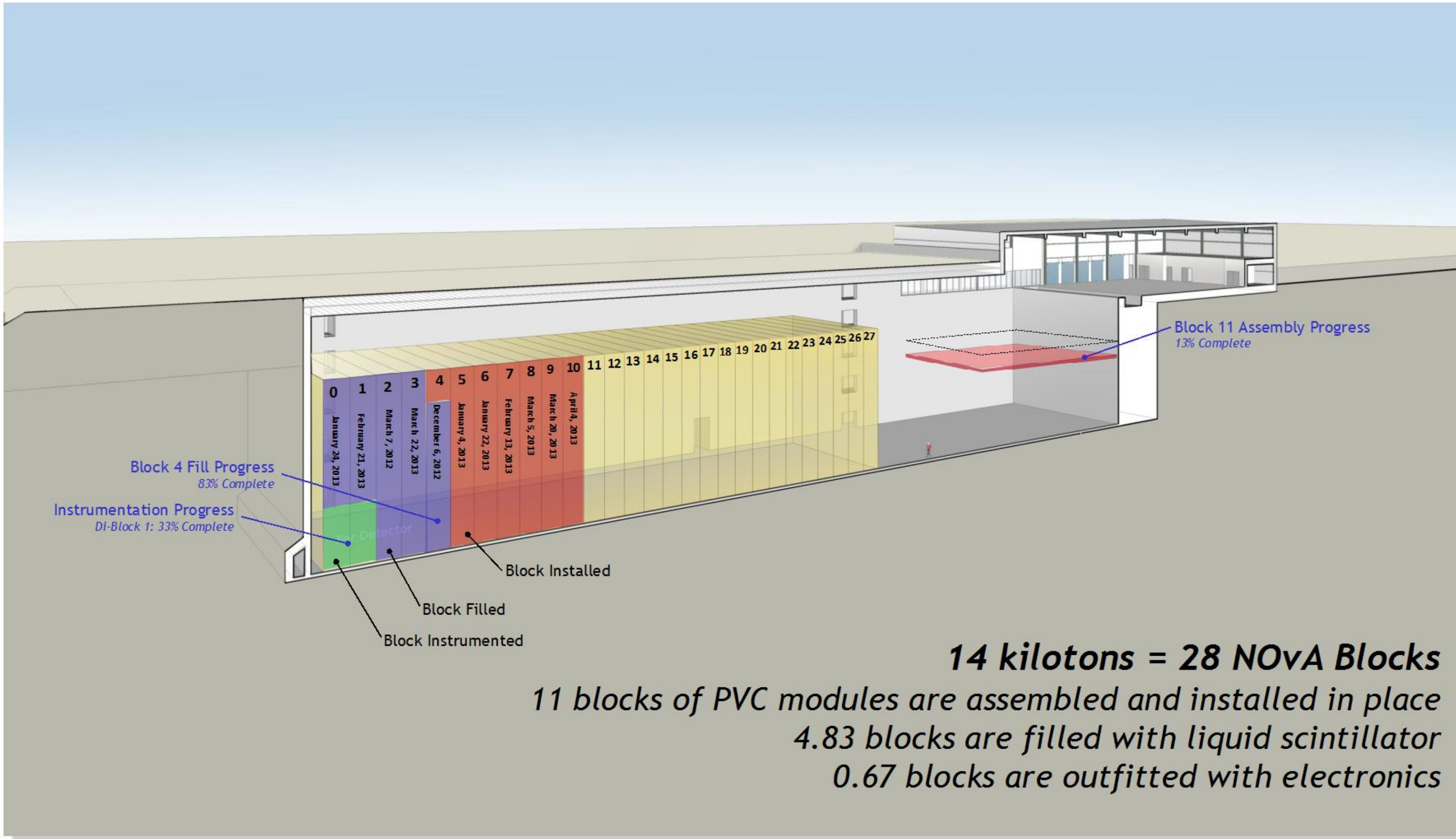
- **Belle-II**
- **Mu2e**
- **LBNE**
- **Muon g-2**

Physics Status

- **Daya Bay, T2K, NOvA, et al. will usher in the era of precision neutrino physics with few % measurements**
  - **1st steps in a comprehensive program**

MicroBooNE cryostat delivered →

NOvA Far Detector Assembly Progress



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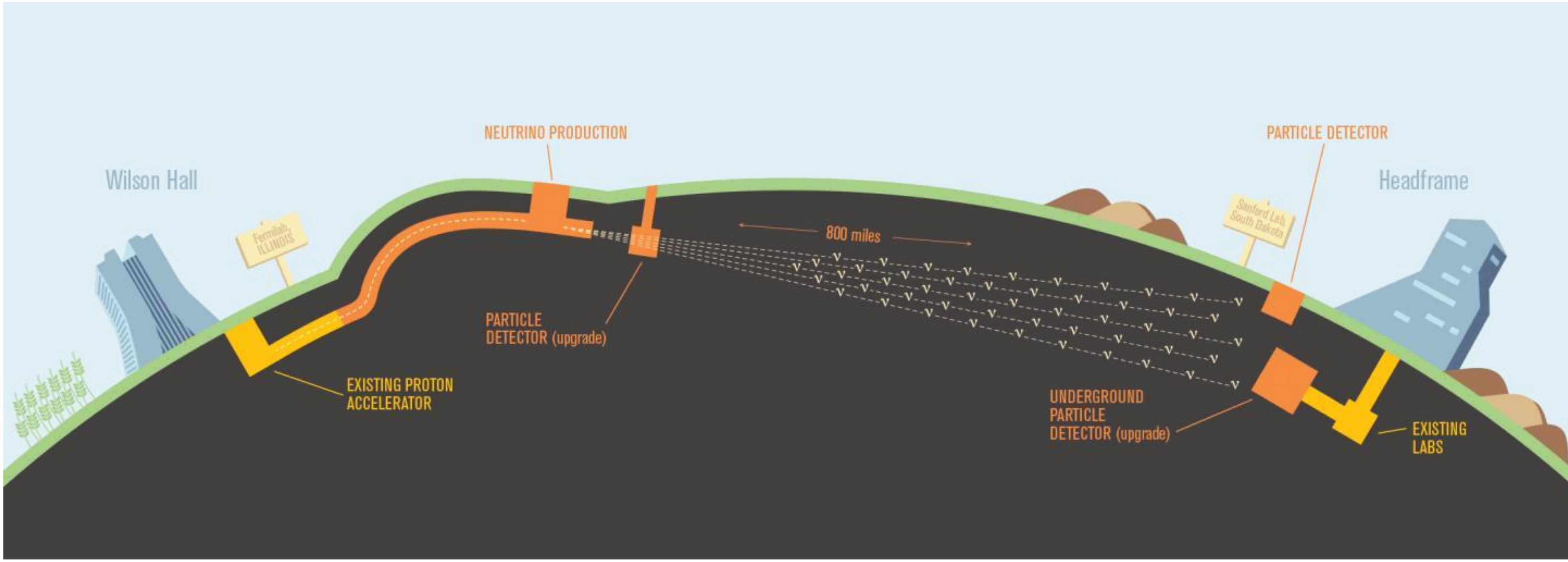
The Long Baseline Neutrino Experiment



- **Neutrino beam from Fermilab travels ~800 miles to large detector at the Sanford Lab (old Homestake Mine) in Lead, SD. On the way there, some of the neutrinos change type and some interact with matter in the earth. The large detector counts how many neutrinos survive and what type they are. These studies can address many of the key questions about neutrinos.**
- **LBNE is currently has CD-1 approval and is seeking additional domestic and international partners to enhance the physics reach of its initial configuration**

The Questions - The Neutrino Program

- **Key remaining questions:**
  - Where did all the antimatter go ?
  - Why are there so many different types (“flavors”) of neutrinos?
  - What is the ordering of neutrino masses?
  - Are there hidden phenomena we have not yet discovered ?

reactor

high energy ν

low energy ν

Experiment	Anti-matter	Flavors	Mass Order	Hidden Sector	Technology R&D
Daya Bay		***	-	-	*
MINOS		**	-	*	*
T2K	*	**	-	*	*
NOνA	**	***	*	**	*
LBNE	***	****	***	***	***
MiNERvA	--	---	---	*	*
MicroBooNE	--	--	---	**	**

Intensity Frontier

Discover the nature of massive known & NEW particles indirectly by intense beams of charged leptons and quarks

Quantum Fluctuation

High-intensity

particle beam

Top

W, Z

….

NEW

Rate for rare transition

Uncertainty Principle

$$E = Mc^2$$

Limit ~10^4 TeV

What Makes HEP Unique?

- Collaboration/teamwork
- Ambition/"big science"
- A long-term view
- We invent our own tools

"Americans seem to work very well, only they obviously insist on making everything as big as possible."

—German physicist Franz Simon's impression upon a visit to the US in 1932.

LBNL Staff in 1939

What Are HEP's limitations?

- Middle-aged field
- Technology plateau
  - (At least at Energy Frontier)
- Not a national priority
  - Increased competition for science funding
- Long timescale and high threshold for new experiments
- Over-reach?
- Reliance on international partners