HEP Game Plan

Lab Intensity Frontier Research Review

May 23, 2013

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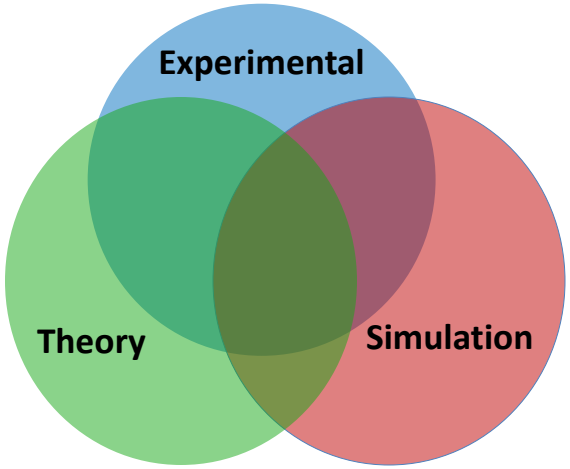
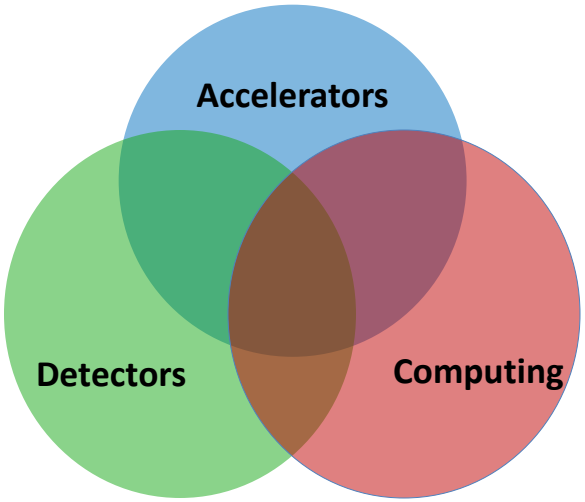
Take-Away Messages

- **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**

HEP Physics and Technology



Along Three Paths



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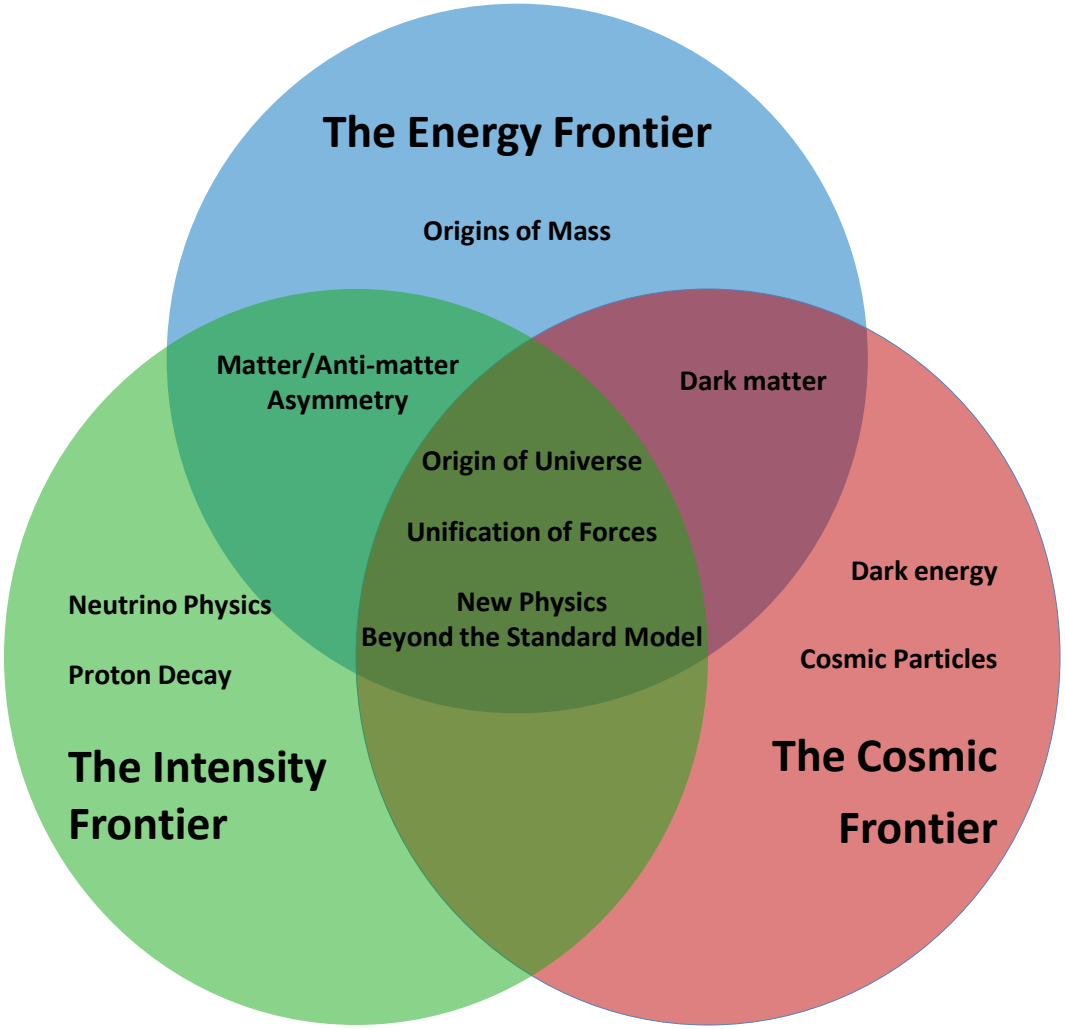


Physics Frontiers

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

Intensity Frontier

Intensity Frontier

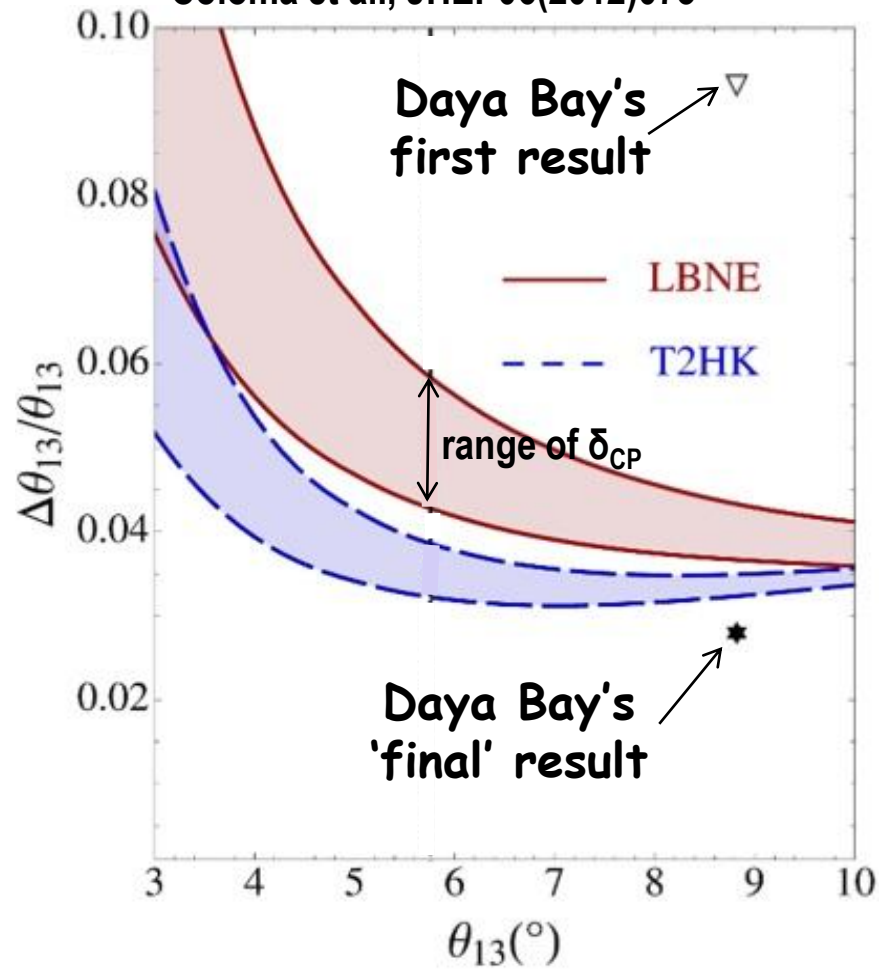
HEP Intensity Frontier Experiments

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
BES III	IHEP, Beijing, China	Running	Precision measurements charm, charmonium, tau; search for and study new states of hadronic matter	6 Univ	26
CAPTAIN	Los Alamos, NM, USA	R&D; Test run 2015	Cryogenic apparatus for precision tests of argon interactions with neutrinos	5 Univ, 1 Lab	20
Daya Bay	Dapeng Penisula, 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
K0TO	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 testbeam; 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 & Soudain 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 $N \rightarrow eN$	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 hadron 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

Daya Bay

- **Motivation and scientific goals:**
  - Precise determination of θ_{13}
  - Determination of Δm^2_{ee}
  - Precise measurement of reactor ν_e flux and energy spectrum (addressing reactor ν_e anomaly)
- **Status:**
  - Installed and commissioned the last two of (eight) antineutrino detectors (ADs) in the summer of 2012
  - Carrying out rate-plus-spectrum analyses
- **Schedule:**
  - Data taking with 8 ADs since Oct 19, 2012
  - **Plan to run full experiment for three years with expected precision of ~0.003**

Coloma et al., JHEP06(2012)073



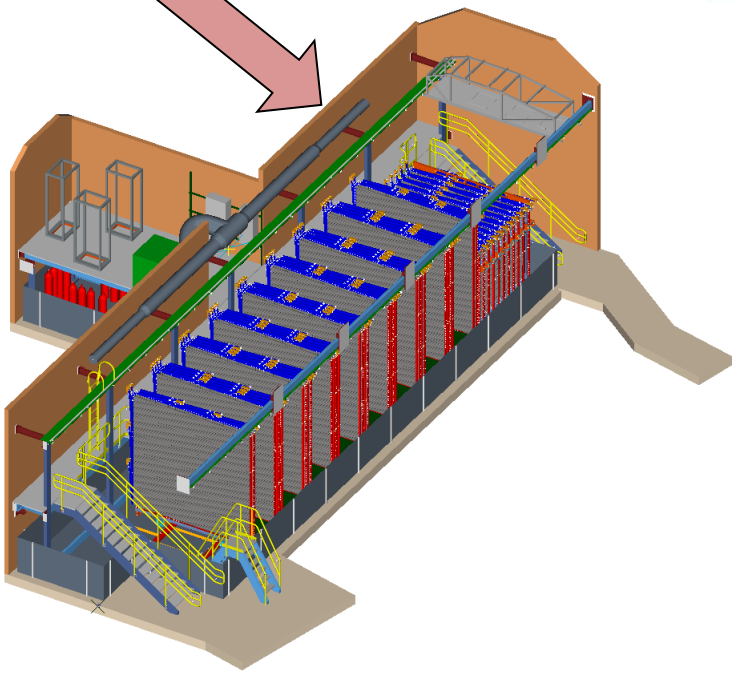
Observed non-zero $\sin^2 2\theta_{13}$ at >7σ with **0.089±0.010(stat)±0.005(syst)**.

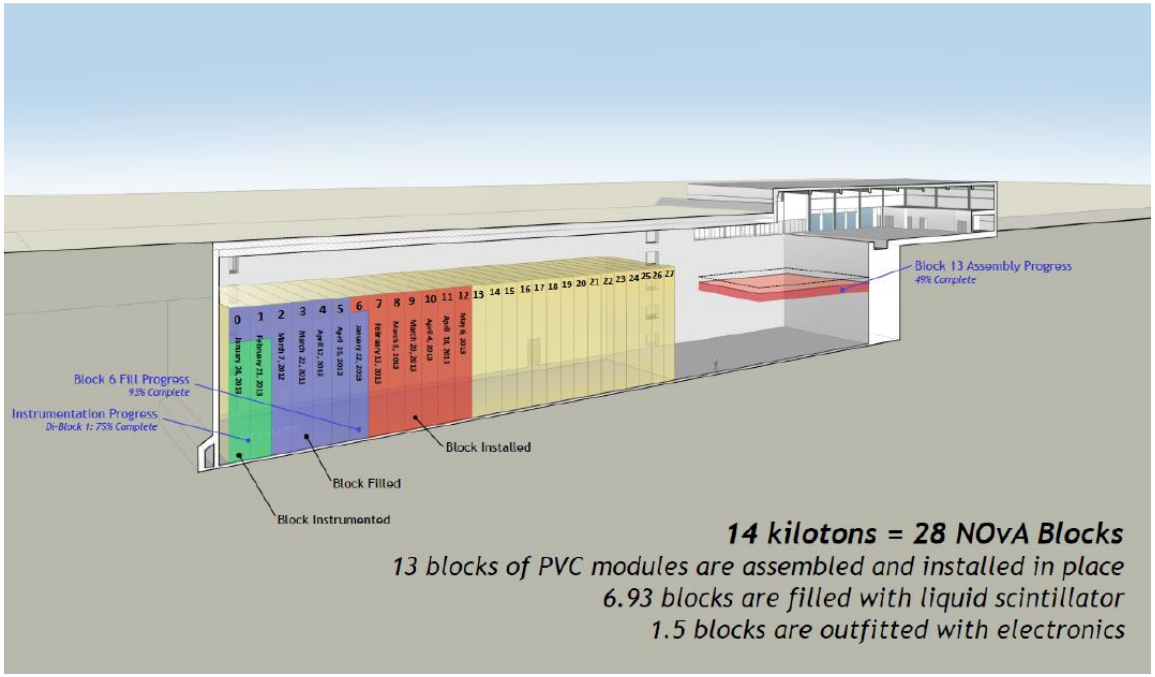
http://dayawane.ihep.ac.cn/twiki/bin/view/Public/

NOvA

NOvA beam starts by July with ~3 kilotons fully instrumented
Measured NuMI electron neutrinos in prototype near detector
Expect 3-5 ν_μ–ν_e signal during first year depending on hierarchy
Beneficial occupancy of Near Detector cavern May 10th
Produce the muon catcher modules plus half of the Near detector by early July

- **This allows construction of half the Near Detector this summer and fall**





MicroBooNE

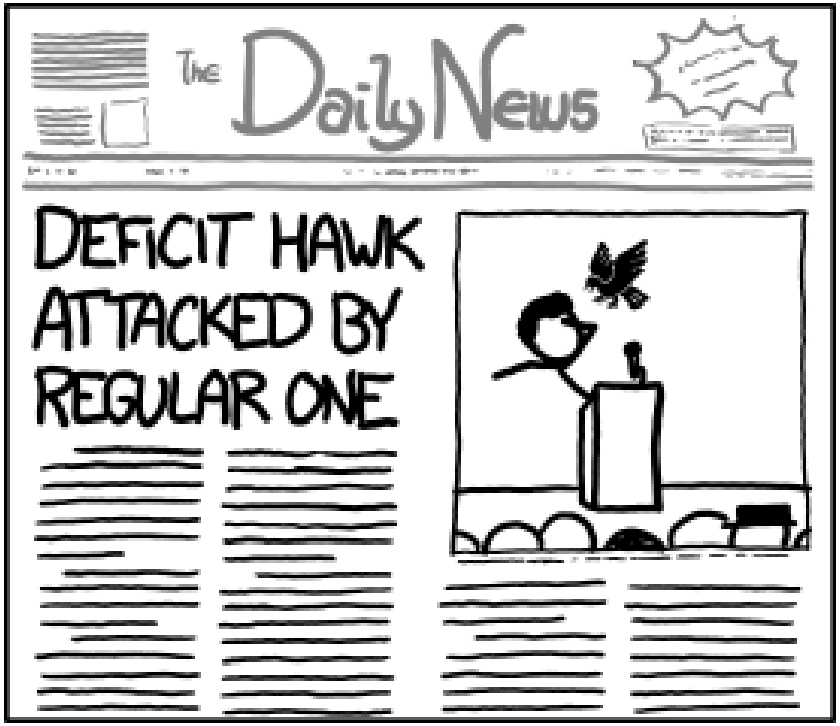
MicroBooNE cryostat arrival – March 8, 2013

Wire stringing completed 2 weeks ago. All 3 wires planes installed.

- **170 ton (total) Liquid Argon TPC will be largest LAr TPC in the U.S.**
- **Important step towards large scale LAr TPCs for long-baseline ν physics**
- **Physics goals:**
  - ***address MiniBooNE low energy excess***
  - ***measure ν cross sections on argon***
- **R&D goals:**
  - ***argon fill without evacuation***
  - ***cold front-end electronics***
  - ***long drift (2.5m)***
  - ***near surface operation***
  - ***reconstruction development (e/g)***

Beneficial occupancy of LArTF early May.

- **MicroBooNE just entered the last year of project construction**
- **Experiment will begin data-taking in the Fermilab Booster Neutrino beam in 2014**



http://xkcd.com/1062/

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**
- **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**

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

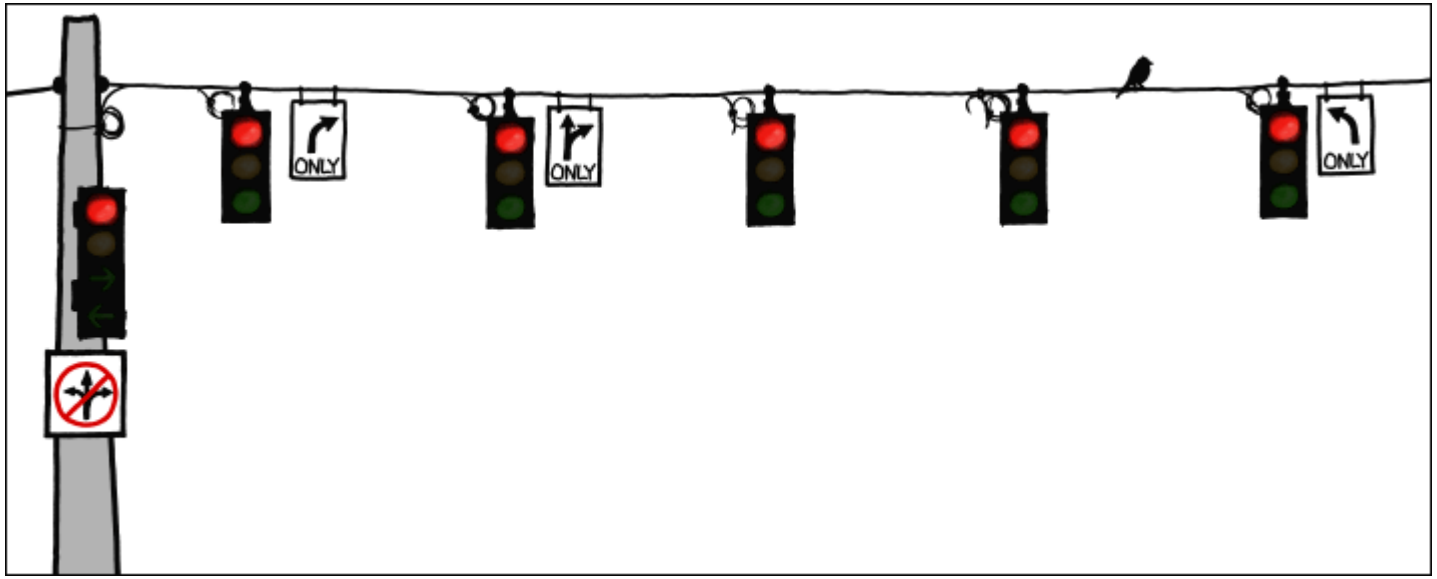
Funding (in $K)	FY 2012 Actual	FY 2014 Request	Description
MIE's	**55,770**	**39,000**	
Intensity Frontier	41,240	0	NOvA ramp-down
Intensity Frontier	6,000	0	MicroBooNE
Intensity Frontier	500	0	Reactor Neutrino Detector at Daya Bay
Intensity Frontier	1,030	8,000	Belle II
Intensity Frontier	0	9,000	Muon 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]



http://xkcd.com/1116/

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**
- **Intensity Frontier**
  - **US is a 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**
    - **HEP component of the physics case is simple and compelling. Only question is how far one needs to go in precision/setting limits on, e.g., dark matter.**
    - **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***

Joint 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": community identifies compelling HEP science opportunities over an approximately 20 year time frame.**
     - **Not a prioritization but can make scientific judgments**
  3. **HEPAP/P5: Advises agencies on new strategic plan and priorities for US HEP in various funding scenarios, using input from #1 and 2 above (among others)**

Snowmass / P5 Interface

What we hope to see from Snowmass:

- What are the most compelling science questions in HEP that can be addressed in the next 10 to 20 years and why
- What are the primary experimental approaches that can be used to address them? Are they likely to answer the question(s) in a "definitive" manner or will follow-on experiments be needed?
- What are the "hard questions" (science, technical, cost…) that a given experiment or facility needs to answer to respond to perceived limitations in its proposal?

These topics should be covered in the Snowmass reports and white papers. P5 will use these reports and white papers as its starting point.

- We expect to have the P5 panel selected and a formal charge issued by the time of the September HEPAP meeting

Goals for the P5 Process

DOE/NSF met in early May to kickoff P5 process and agree on goals:

- **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**

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). Previous P5 had 21 members.**
  - **Nominations will be sought from HEP and related communities through a Dear Colleague letter**
  - **Snowmass output (reports, white papers) as a starting point, but may solicit additional material on specific projects**
- **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.**
- **Working subgroup for updating the *Quantum Universe* questions in parallel with science priority discussion**
- **Separate working group elucidating HEP benefits to society**

DRAFT New P5 Timeline

May: DOE/NSF agree on outlines of P5 process and inform community via presentations and "dear colleague" letter

June: Call for nominations to P5

July: Agencies draft P5 charge. HEPAP Chair reviews P5 nominations and begins selection process

August : Snowmass meeting concludes, reports issued. P5 charge sent to HEPAP Chair.

Sept : HEPAP Meeting. P5 charge and membership formally announced. Timeline for P5 meetings announced.

Fall 2013 : Town Meetings (4 or 5, venues and topics TBD)

Winter/Spring 2014 : P5 meetings (phone in and face to face)

Spring/Summer 2014 : P5 report(s) due. Exact dates and deliverables to be spelled out in P5 charge.

Next Steps on Snowmass / P5

- **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.**

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**

Take-Away Messages, Redux: Laboratories and the Intensity Frontier

For labs, the need to lead:

- **Sharpening the science case.**
  - **Better quantifications of goals, outputs, and impacts?**
  - **Heightening the rigor. More theory support?**
  - **Does the broader community "get it"? More visibility needed?**
- **Execution and delivery**
  - **Do we have enough of the right people? Recruitment from other frontiers?**
  - **Is Fermilab the world center for intensity frontier physics?**
  - **Do we have the right model to work through and with Fermilab? And vice versa?**
  - **How can we bring valuable assets from all labs to the intensity frontier? A national intensity frontier operations program a la ATLAS, CMS?**

Summary

- Enable world-leading facilities and experiments
- Attract partnerships that will extend the science impact

http://xkcd.com/955/

- Maintain progress and deliver on current portfolio of projects
- Discover new physics