U.S. DEPARTMENT OF ENERGY

OFFICE OF SCIENCE

High Energy Physics Program

Presentation to HEPAP
March 12, 2012

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

Outline

HEP Plans and Priorities

Important Recent Results

FY 2013 Request

Technology Stewardship

HEP PLANS AND PRIORITIES

HEP Strategic Plan

Plan is based on High Energy Physics Advisory Panel "P5" report

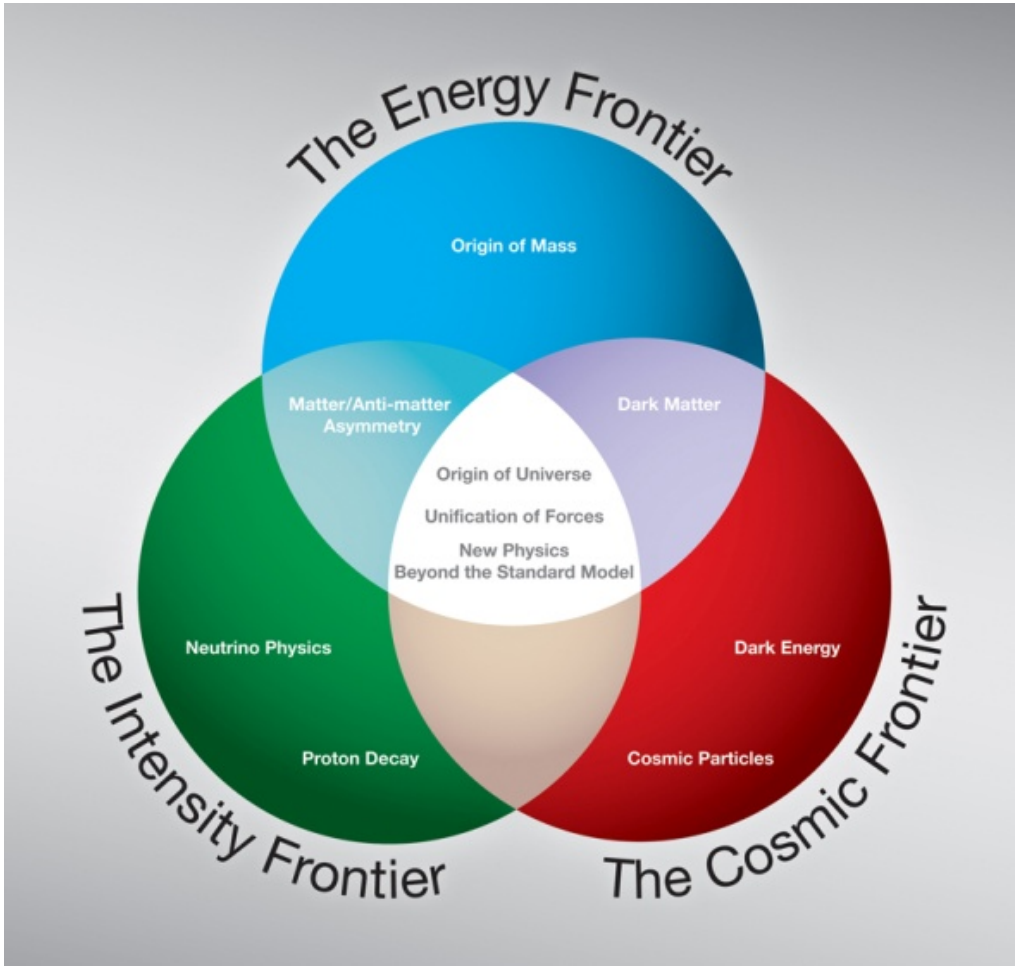
This is still the plan.

Implementation at the Energy and Cosmic Frontiers is clear

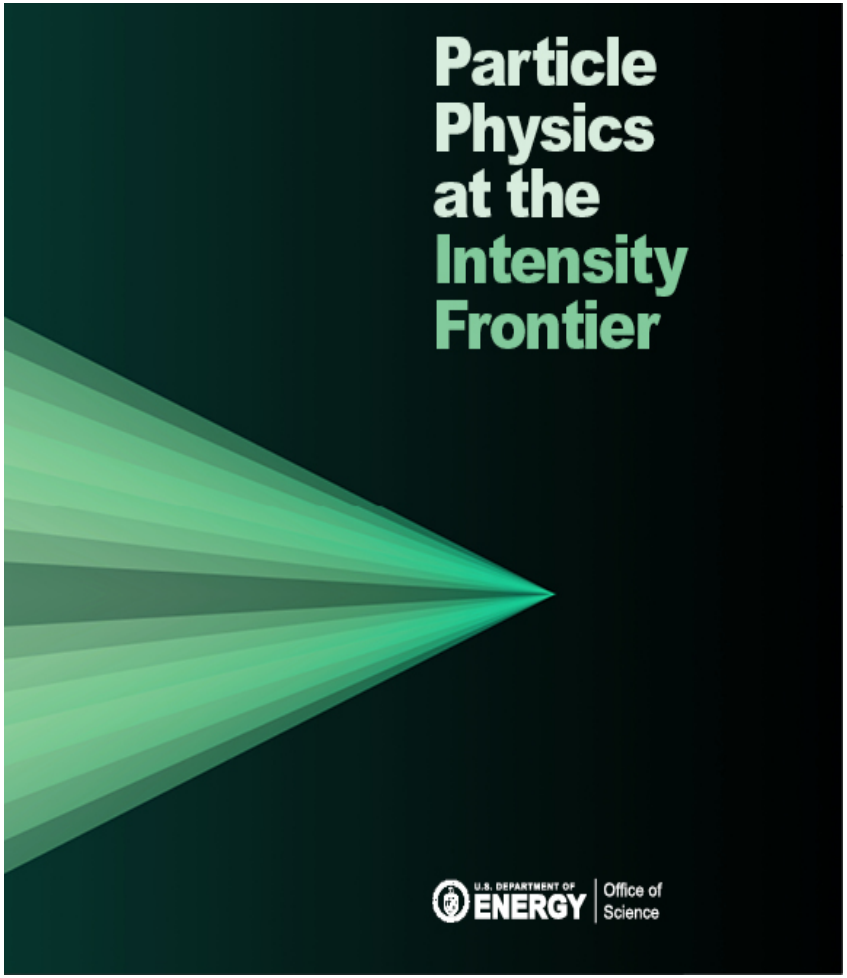
- End of Tevatron
- LHC (+upgrades)
- Dark Matter + Dark Energy

Implementation at the Intensity Frontier has been more challenging

- Funding levels at lower end of P5 Scenarios
- CR uncertainties + "no new starts"
- DUSEL difficulties



Vision for Program Development



- Our domestic program is the world leader in 'Intensity Frontier' area, and we need to increase investments there, while keeping a balance with the other frontiers
- Community is engaged on further developing the science case on all 3 frontiers – we need a healthy portfolio of construction ideas supported by compelling science drivers at achievable budget levels
  - Will need more help from the community here; see also talks tomorrow
- Our program will deliver science now, in the near term, and in the long term on all 3 frontiers

HEP Priorities for the Next 12 Months

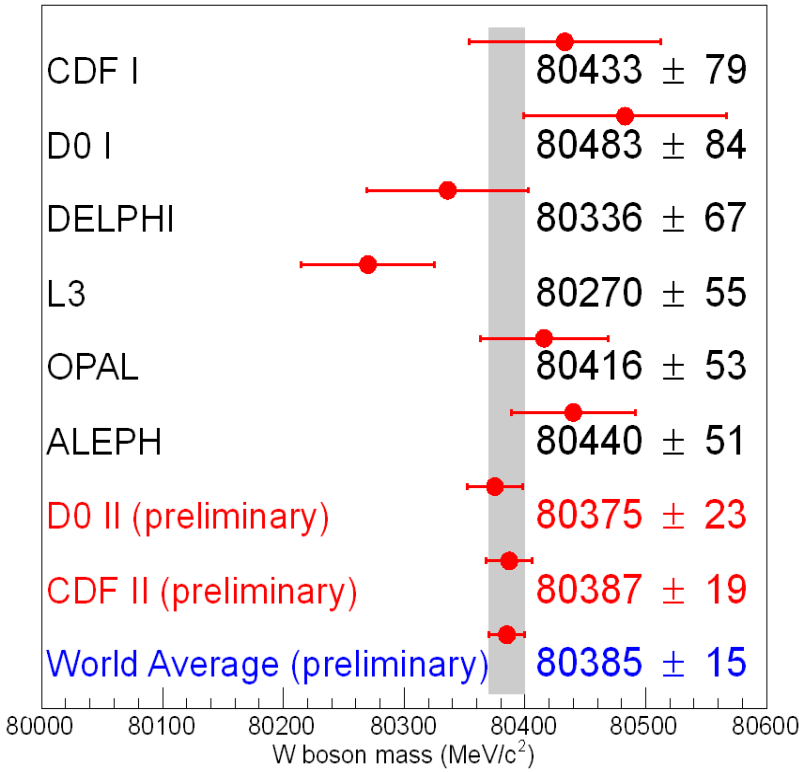
- Develop Mission Need statement for US participation in LHC detector upgrades
- Make critical decisions on Long Baseline Neutrino Experiment
- Issue solicitation for R&D leading to Next Generation Dark Matter Experiments and make selections
- Develop strategic plans for Intensity Frontier and Accelerator R&D programs

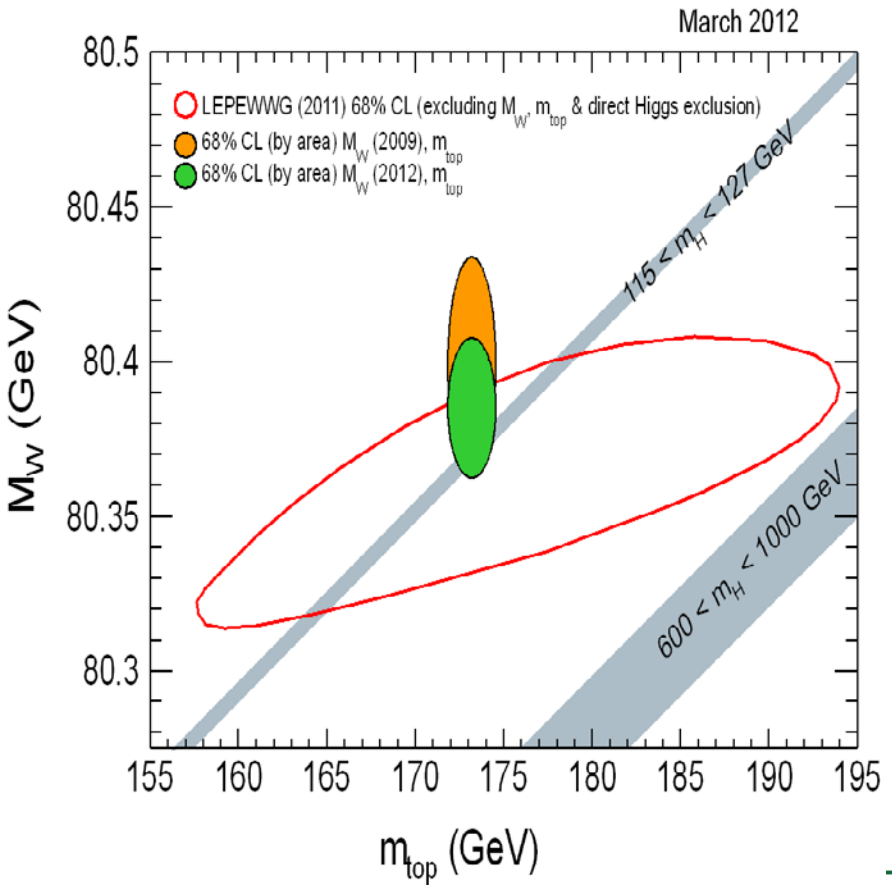
Energy Frontier

- **Near-term Science goal :**
  - Discover the Higgs or whatever takes its place. Is there just one?
- **Recent results (see following slides)**
  - **LHC + Tevatron** have ruled out most of the interesting Higgs mass range
  - **Tevatron** run is completed, final data analyses are underway
  - **LHC** will run thru 2012, then shutdown to achieve full energy (14 TeV)
- **No new facilities under construction at this time**
- **Planned program of major projects:**
  - **LHC Upgrades Phase I** : (2017-2018) to cope with increased data rates
  - **LHC Upgrades Phase II: (**2021+) factor of 10 increased luminosity
  - Future evolution (>2025) will depend on results in the next few years:
    - *If New Physics can be accessed at ~TeV energy*, **e+e- or mu+mu- collider (?)**
    - *If not,* long program of LHC exploitation (+ **LHC energy upgrade?**)

Tevatron: W Boson Mass

- **New results by CDF and DZero: W boson mass now known to 0.02%**
- **Factor of 2-3 improvements compared with the previous Tevatron measurements**



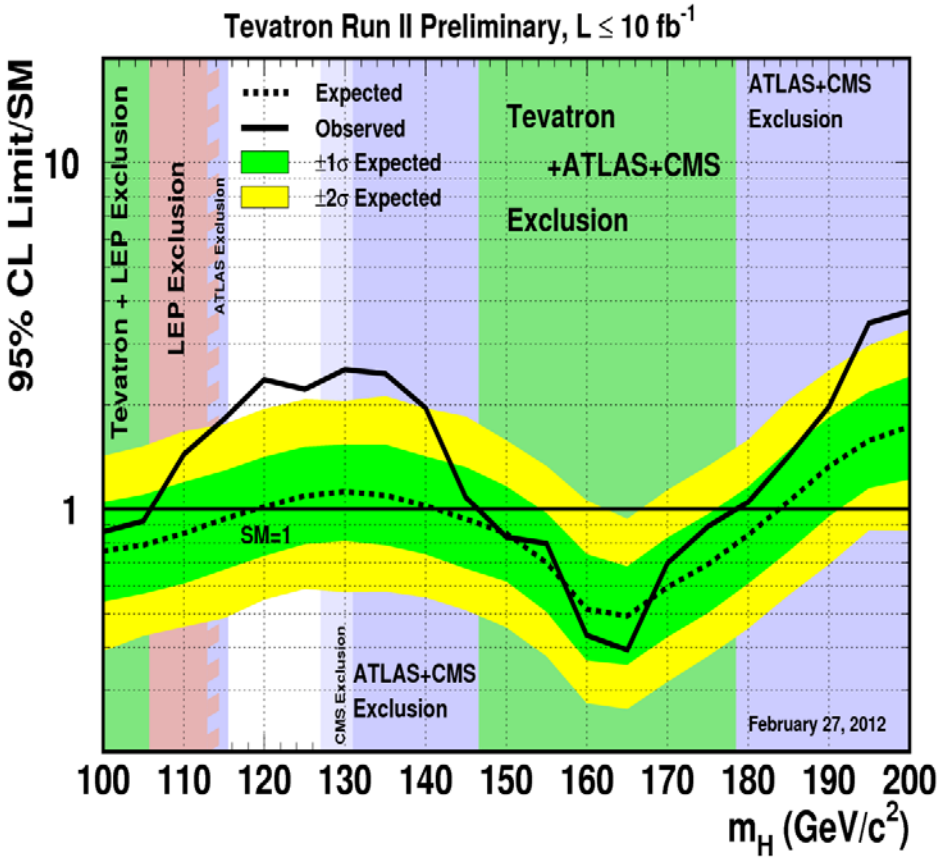


Tevatron: Higgs Boson

- **The data appear to be incompatible with the background.**

- **All channels combined**
  - global p-value: 2.2σ
  - local p-value: 2.7σ

- **H → bb only**
  - global p-value: 2.6σ
  - local p-value: 2.8σ

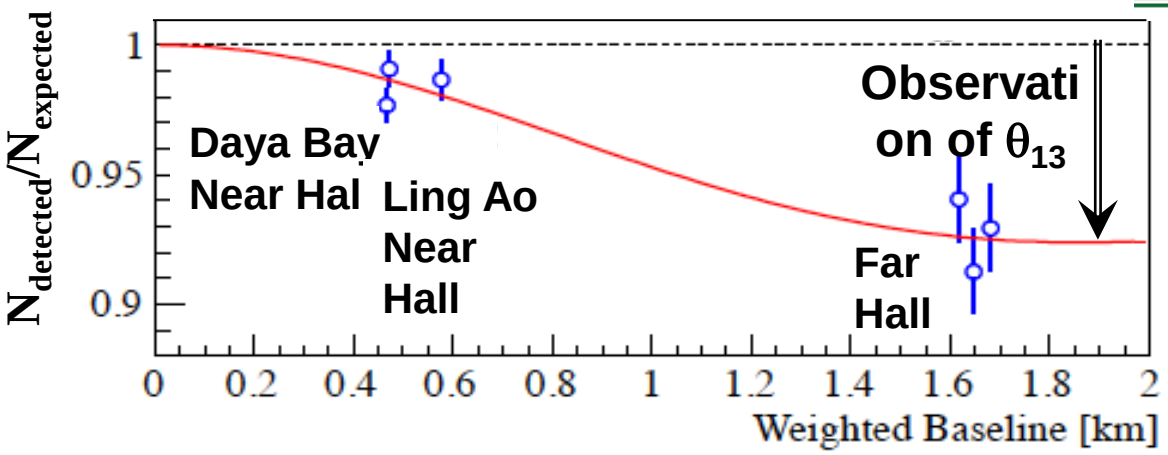


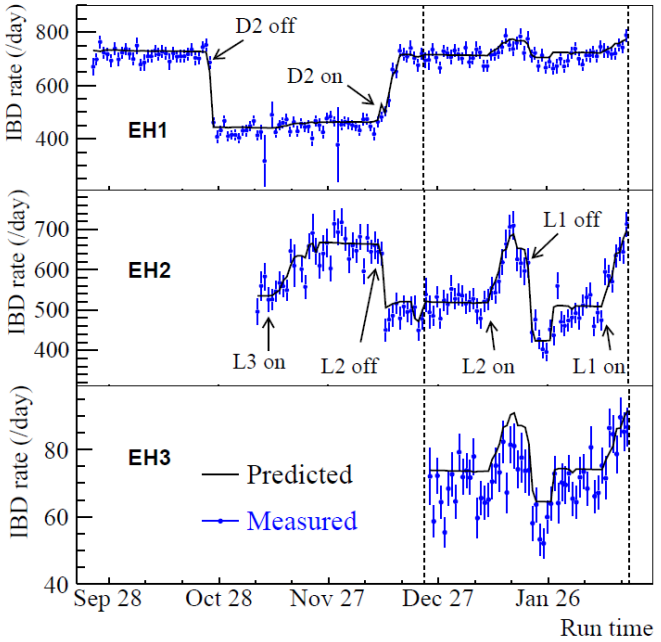
- **Further analysis improvements to come in the near future**

Intensity Frontier

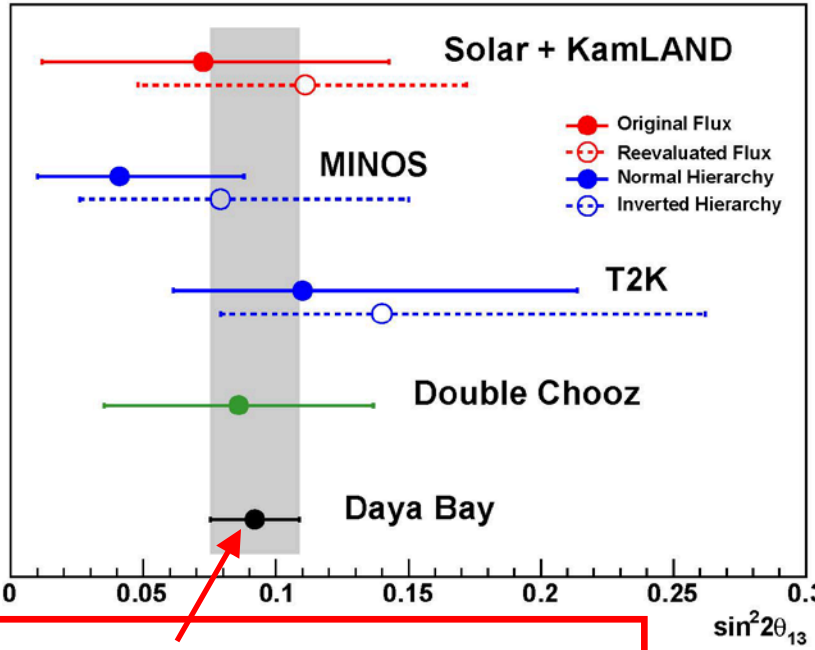
- **Near-term Science goals :**
  - Implement comprehensive program to understand neutrino mixing
  - Deliver much improved limits (measurements?) of charged lepton mixing and hidden sector phenomena
- **Recent results (see following slide)**
  - **Daya Bay** discovers third kind of neutrino mixing (and its large!)
  - Various "hints" of additional neutrino species, anomalous interactions?
  - Faster-than-light neutrinos?!?
- **New facilities under construction:**
  - **NuMI** upgrade + **NOvA**; **reactor experiments** commissioning
- **Planned program of major projects:**
  - **Mu2e** to explore charged lepton mixing (2018-2022)
  - **LBNE** to make definitive measurements of neutrino properties (2021+)

Daya Bay θ_{13} Result





- **Discovery of reactor electron antineutrino disappearance at ~2 km.**
- **Neutrino mixing angle θ_{13} is non-zero at 5.2σ**
- **Non-zero θ_{13} enables a clear path forward towards measuring leptonic CP violation.**
- **LBNE will be able to measure the mass hierarchy and CP violating phase, regardless of its value, and search for new physics.**



$$\sin^2 2\theta_{13} = 0.092 \pm 0.016(\text{stat}) \pm 0.005(\text{syst})$$

Cosmic Frontier

- **Near-term Science goals :**
  - Discover (or rule out) the particle(s) that make up Dark Matter
  - Advance understanding of Dark Energy
- **Recent results :**
  - Various controversial evidence for Dark Matter from both direct and indirect searches
  - Demonstration and prototyping of several Dark Energy measurements
- **New facilities under construction:**
  - **Dark Energy Survey** commissioning
- **Planned program of major projects:**
  - **Large Synoptic Survey Telescope** (2018-2023+) will make definitive ground-based Dark Energy measurements using “weak lensing”
  - **3rd-Generation** (ton-scale) **Dark Matter** experiments (2021?) to reach ultimate background limits

FY 2013 HEP REQUEST

Leading HEP Budget Issues

- **ILC R&D efforts zeroed out**
  - 5 year R&D plan successfully completed; no project on near horizon
  - Plan to continue involvement with international planning at very low level
    - Physics case needs to be re-examined in light of LHC results
    - Be prepared if foreign gov't comes with high-level request for partnership
  - Working with HEP labs to minimize damage to accelerator core competencies
- **LBNE construction not included**
  - Revised project plan not ready in time for FY2013 Budget
  - Finish developing LBNE case with the Administration
  - Homestake dewatering effort maintained at reduced scope
- **Lack of new facilities for science threatens the future of the program**
  - To exert leadership we need not only to fully exploit current research infrastructure but also to develop new facilities and infrastructure.
  - Current scientific landscape indicates the ripe opportunities are at the Intensity and Cosmic Frontiers:
    - Mu2e, LBNE, BELLE-II
    - LSSTcam, dark matter detection

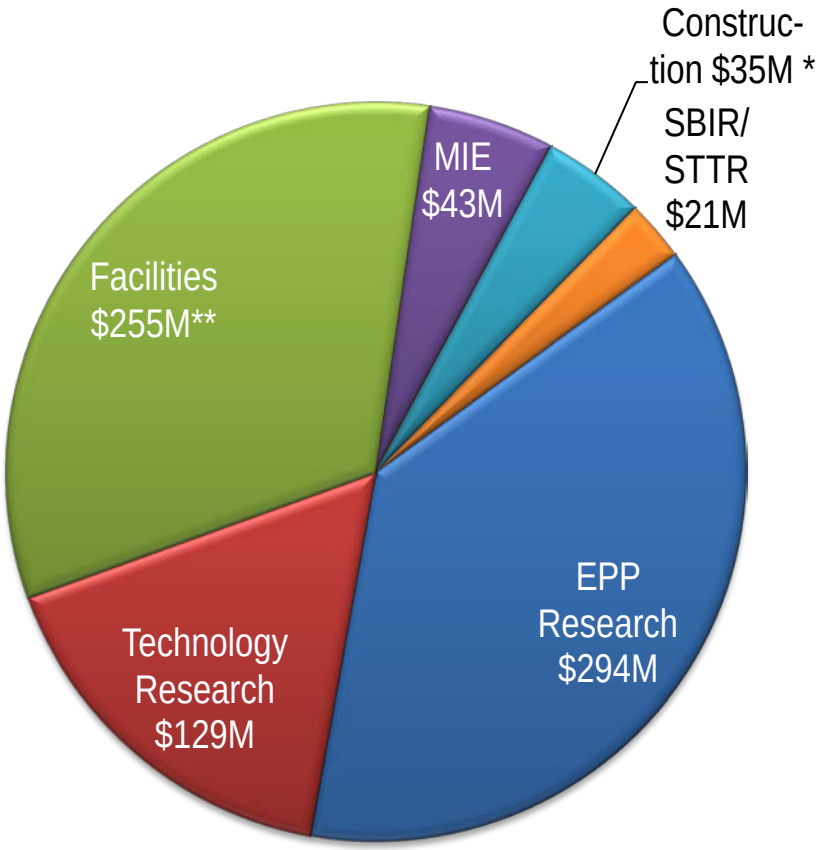
FY 2013 High Energy Physics Budget Request

(Dollars In Thousands)	FY 2012	FY 2013 Request	FY 2013 vs. FY 2012
Proton Accelerator-Based Physics	421,594	411,532	-10,062
Electron Accelerator-Based Physics	23,025	29,146	+6,121
Non-Accelerator Physics	84,062	97,425	+13,363
Theoretical Physics	66,850	68,522	+1,672
Advanced Technology R&D	167,329	149,896	-17,433
Subtotal, Research and Operations	762,860	756,521	-6,339
Construction	28,000	20,000	-8,000
Total, High Energy Physics	790,860*	776,521	-14,339

*The FY 2012 appropriation is reduced by $840,000 for the High Energy Physics share of the DOE-wide $73,300,000 rescission for contractor pay freeze savings. The FY 2013 budget request reflects the FY 2013 impact of the contractor pay freeze.

FY 2013 Request Crosscuts

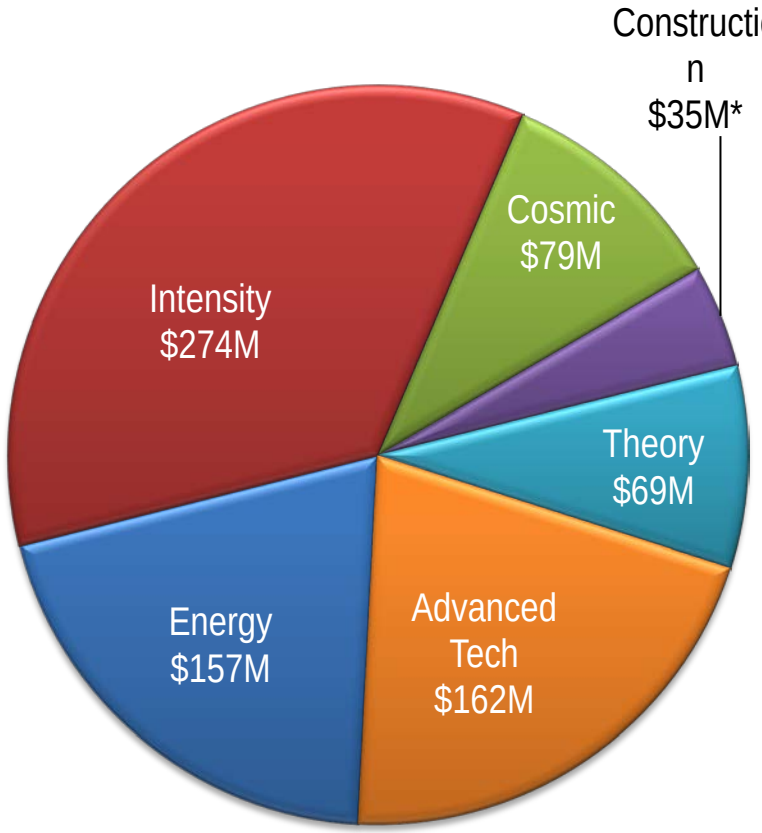
By Function



*Includes Other Project Costs (R&D) for LBNE and Mu2e

**Includes $17.6M Other Facility Support

By Frontier



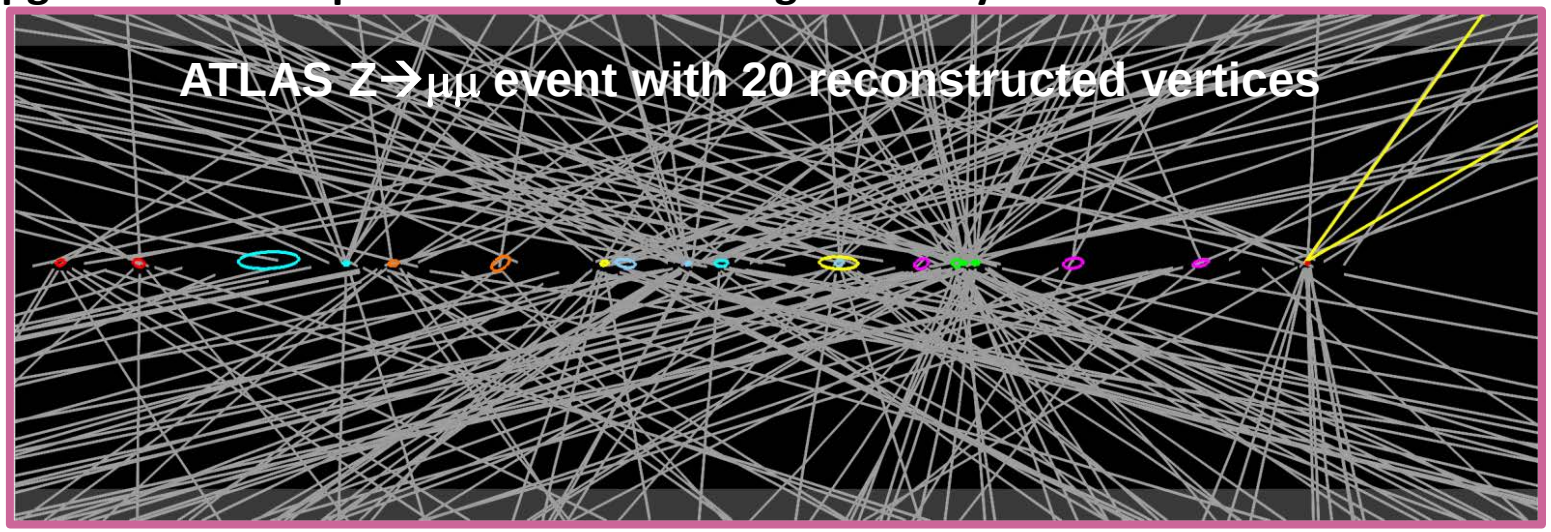
*Includes Other Project Costs (R&D) for LBNE and Mu2e

Major Changes in FY2013

- **Funds are shifted from Facility Operations and Technology R&D to**
  - Support planned funding profiles for projects (Mu2e) and new MIEs (LSSTcam, Belle-II)
  - Conduct targeted R&D for future Intensity and Cosmic frontier projects
  - Maintain key research efforts needed for future program
- **The Fermilab proton accelerator complex will run for 20 weeks to support the neutrino program.**
  - Operations funding increases from $103M in FY 2012 to $107M in FY 2013 .
  - Complete installation, and commission the accelerator upgrade components of NOvA.
    - Beam power will go from 400kW to 700kW.
- **The NOvA Project completes its funding profile.**
  - From $41 M in FY 12 to $19M in FY13.
  - Detector commissioning (with partially complete detector) starts in 2013.
- **Net effect on Fermilab is a large reduction in total HEP funding.**
  - From $382M in FY12 to $359M in FY13

Priorities: Developing a Mission Need Statement

- **HEP will work with the collaborations and CERN to understand the impact of the CERN LHC upgrades on detectors:**
  - What are the critical needs for detector upgrades?
  - What responsibilities does CERN want the US to take on?
  - In what technical areas does the US possess leading or unique capabilities?
- **Analyze the schedule needed to deliver upgraded detector components.**
- **Develop a cost estimate and plan to have the funding available in the HEP budget.**
- **Goal is to complete a Mission Need Statement in FY 2012 for the near-term upgrades that keep the detectors running smoothly**



Proton Accelerator Based Physics

(Dollars In Thousands)	FY 2012	FY 2013 Request	FY 2013 vs. FY 2012
Proton Accelerator Based Physics	**421,594**	**411,532**	**-10,062**
Research	122,894	125,394	+2,500
Facilities	298,700	286,138	-12,562
Complex Operations	102,376	107,201	+4,825
Complex Support	21,865	27,088	+5,223
Facility Projects	84,640	59,252	-25,388
Current Facility Projects	70,240	40,337	-29,903
NOvA	41,240	19,480	-21,760
MicroBooNE	6,000	5,857	-143
Mu2e (OPC)	6,000	5,000	-1,000
LBNE (OPC)	17,000	10,000	-7,000
Future Facility R&D	14,400	18,915	+4,515
Large Hadron Collider Support	73,144	73,414	+270
Other Facilities	16,675	19,183	+2,508

• Reduction in Facilities funding mostly reflects completion of current projects, somewhat offset by restart of neutrino operations for NOvA and other experiments.

Priorities : LBNE Decisions

- **The Office of Science charged a review to examine cost-effective options to do underground science.**
- **Report was delivered in June 2011. Main findings relative to LBNE:**
  - Cost estimates need more work.
  - Making a technology choice should be done soon to reduce costs of developing two technologies.
- **Project team was charged to develop a technology choice and refine the cost estimates.**
  - The project team has recommended a technology.
  - Fermilab and DOE concurred with that recommendation.
- **Make a go/no go decision by the end of Q2 FY2012.**
  - If go then make a technology decision for CD-1 by the end of Q3 FY 2012.
  - If no-go then explore alternatives to achieve a significant fraction of the science goals of LBNE in a different configuration with significantly reduced cost.

Electron Accelerator-based Physics

(Dollars In Thousands)	FY 2012	FY 2013 Request	FY 2013 vs. FY 2012
Electron Accelerator-Based Physics	**23,025**	**29,146**	**+6,121**
Research	12,550	13,946	+1,396
Grants Research	4,754	6,150	+1,396
National Laboratory Research	7,738	7,738	0
University Service Accounts	58	58	0
Facilities	10,475	15,200	+4,725
Complex Operations	8,925	8,925	0
Complex Support	900	275	-625
Current Facility Projects—Belle-II	650	6,000	+5,350

- The SLAC B-factory analysis is mostly complete in FY2012, moves to archival phase in FY2013. This decrease is offset by a ramp-up in R&D associated with US participation in planned Japanese B-factory upgrade (Belle-II)
- Decommissioning of the Babar detector is completed in FY2013, and D&D of the PEP-II accelerator begins
  - HEP is investigating giving accelerator components to Italy for their use. This would be less expensive than disposing of them.

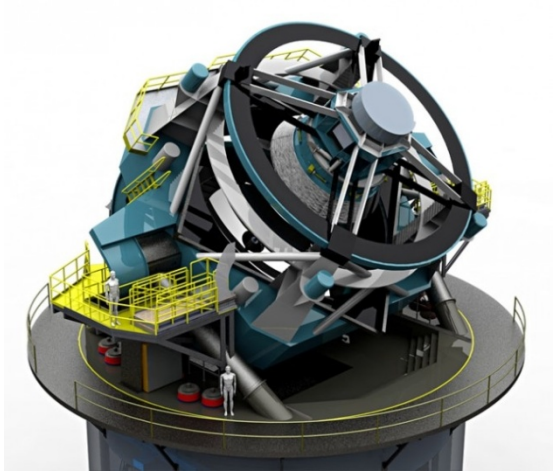
Non-accelerator Physics

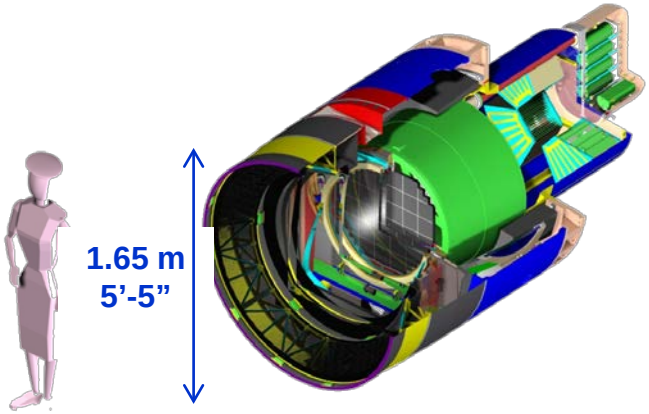
(Dollars In Thousands)	FY 2012	FY 2013 Request	FY 2013 vs. FY 2012
Non-Accelerator Physics	**84,062**	**97,425**	**+13,363**
Research	69,562	70,962	+1,400
Grants Research	19,330	19,730	+400
National Laboratory Research	50,232	51,232	+1,000
Projects	14,500	26,463	+11,963
Current Projects	7,500	11,500	+4,000
Reactor Neutrino, Daya Bay	500	0	-500
HAWC	1,500	1,500	0
LSST	5,500	10,000	+4,500
Future Projects R&D	7,000	14,963	+7,963

- Funding is increased primarily for the LSSTcam MIE and support of second-generation dark matter experiments (under Future Projects R&D)
- Research is maintained at approximately the FY2012 level-of-effort.

Cosmic Frontier : LSST

- Dark Energy is one of the high priority science questions for HEP, and particle physicists want to lead that scientific effort →partnerships
  - The study of Dark Energy requires telescopes, and an understanding of astrophysical backgrounds.
- The Astro2010 decadal survey by the National Academies made recommendations relevant to HEP.
  - The Large Synoptic Sky Survey (LSST)was the highest ranked ground-based initiative.
    - HEP to provide the advanced CCD camera
    - NSF to build the telescope, data management
- NSF Astronomy is pursuing LSST as a new project
  - NSF will be the lead agency with DOE partnership
  - Requesting National Science Board approval this year
- The FY 2013 request includes funding to begin fabrication of LSSTcam.
  - Working with NSF to align project schedules
  - DOE CD-0 was approved June 2011, CD-1 imminent
  - Estimated DOE TPC range $120-160M





LSST telescope (above) and camera

Priorities: Develop Cosmic Program Plans

- **Dark Matter:**
  - **Funding Opportunity for R&D on 2nd Generation direct detection experiments:** https://www.fedconnect.net/FedConnect/?doc=DE-FOA-0000597&agency=DOE .
  - Aug 2012 – community workshop to get input on strategy for dark matter research, particularly coordination and complementarity of different methods (e.g. direct detection vs. indirect gamma-ray searches vs. LHC)
- **Dark Energy:**
  - Pro-actively developing a balanced, robust dark energy program in HEP – our own independent plan
    - With near term and low cost options
    - Using multiple methods
  - What facilities are required and how do we obtain access to do our experiments?
  - Plan HEP community workshop this summer, then broaden the discussion
- **Computing**
  - What do Cosmic Frontier experiments actually need? How well integrated are they with emerging national Computational Cosmology collaboration?
    - Planning meeting with all parties this summer

Theoretical Physics Research

(Dollars In Thousands)	FY 2012	FY 2013 Request	FY 2013 vs. FY 2012
Theoretical Physics	**66,850**	**68,522**	**+1,672**
Research	66,850	68,522	+1,672
Grants Research	28,222	29,072	+850
National Laboratory Research	23,778	24,501	+723
Computational HEP	10,963	10,963	0
SciDAC	5,735	5,735	0
Scientific Computing	5,228	5,228	0
Other	3,887	3,986	+99

- Program is maintained at approximately the FY2012 level-of-effort
- Some computational support activities have moved into (or out of) Computational HEP to Facilities Ops based on internal reorganization

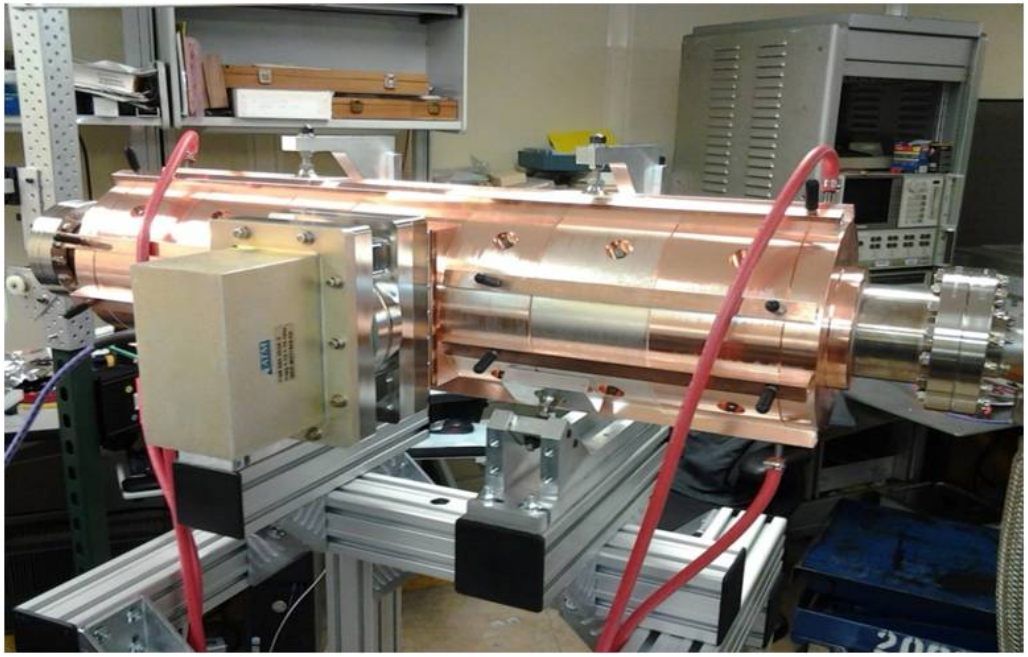
Advanced Technology R&D

(Dollars In Thousands)	FY 2012	FY 2013 Request	FY 2013 vs. FY 2012
Advanced Technology R&D	**167,329**	**149,896**	**-17,433**
Accelerator Science	44,150	46,850	+2,700
Grants Research	11,007	11,307	+300
National Laboratory Research	33,143	35,543	+2,400
Accelerator Development	75,400	52,600	-22,800
General Accelerator Development	27,900	27,900	0
Superconducting RF R&D	13,500	13,500	0
Muon Accelerator Program	12,000	11,200	-800
International Linear Collider R&D	22,000	0	-22,000
Other Technology R&D	27,739	29,856	+2,117
Detector Development, Grants Research	6,646	3,763	-2,883
Detector Development, National Laboratory	21,093	26,093	+5,000
SBIR/STTR	20,040	20,590	+550

• Reduction dominated by the completion of the ILC R&D activity, offset by an increase to support detector R&D needs of Cosmic and Intensity frontier experiments.

Accelerator R&D Highlights

- First production model of an advanced accelerator component for test accelerator at ANL that worked “out of the box” and was much cheaper to produce than previous versions because delicate, labor-intensive modifications were not required.
- The reason this works is that the SLAC national accelerator lab has developed an advanced simulation code for these components that is then converted into code that runs the precision milling machines that make the parts.
- It is a major step forward in building cheaper accelerators and may have broad applications.



TECHNOLOGY STEWARDSHIP

Accelerator Stewardship

- The FY2012 Senate report specifies that

  "The Committee directs the Department to submit a 10-year strategic plan by June 1, 2012 for accelerator technology research and development to advance accelerator applications in energy and the environment, medicine, industry, national security, and discovery science."

- HEP has charged a community task force to provide input on promising R&D areas, pros and cons of current technology transfer models, and potential challenges of implementation
  - Report from task force to DOE SC February 13. N. Holtkamp talk at this mtg.
- This will be significant effort to implement and is not without risk. We have positive feedback from other SC offices and other agencies. Industry has given many constructive suggestions
  - HEP is not expecting any immediate changes associated with this, just some modest redirection and stability for our support to accelerator science
  - Community report will form the basis of the strategic plan and inform FY2014 formulation. We are working on a reorganization of our accelerator R&D efforts aligned with the strategic plan