



U.S. DEPARTMENT OF
ENERGY

OFFICE OF
SCIENCE

Report from the DOE Office of High Energy Physics

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Office of Science, US Department of Energy

LHC Users' Meeting, October 18-20, 2012

Outline

- **A Year of Discovery !**
- **HEP Strategic Plan**
- **Budget**
- **The LHC Program in the US**
- **News from the Office**

A Year of Discovery!



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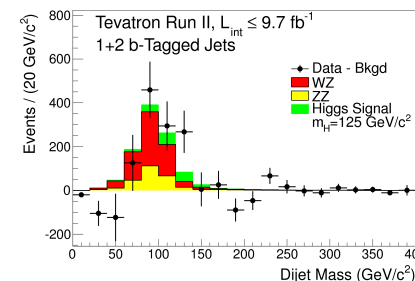
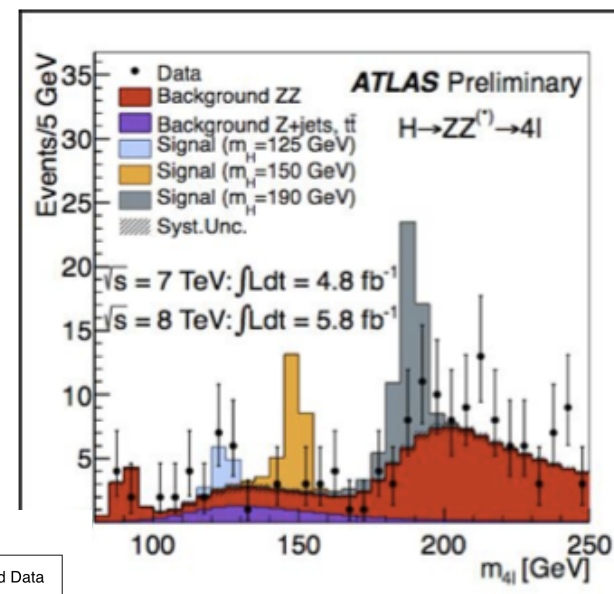
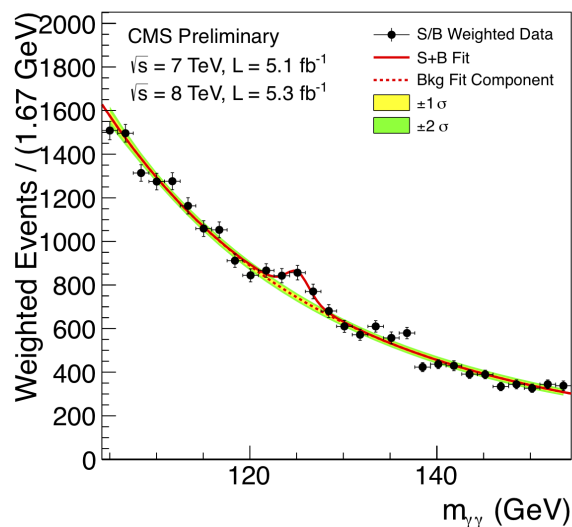
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Simona Rolli, LHC Users' Meeting, October 20 2012

Year of Discovery: Energy Frontier

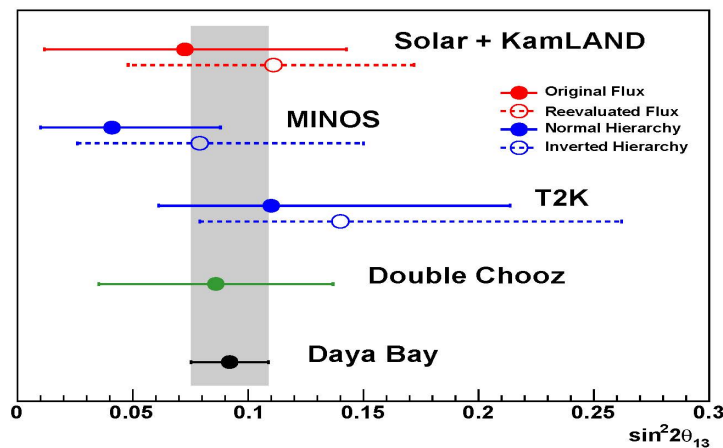
A particle that looks like the Higgs Boson has been seen at CERN

- Mass of $125 \text{ GeV}/c^2$
- Seen by two experiments each in two decay modes.
- Each experiment has $>5\sigma$ signals.
- Complementary evidence at the Tevatron.
- FY 2013: Will search for more signals and check the properties against the Standard Model.

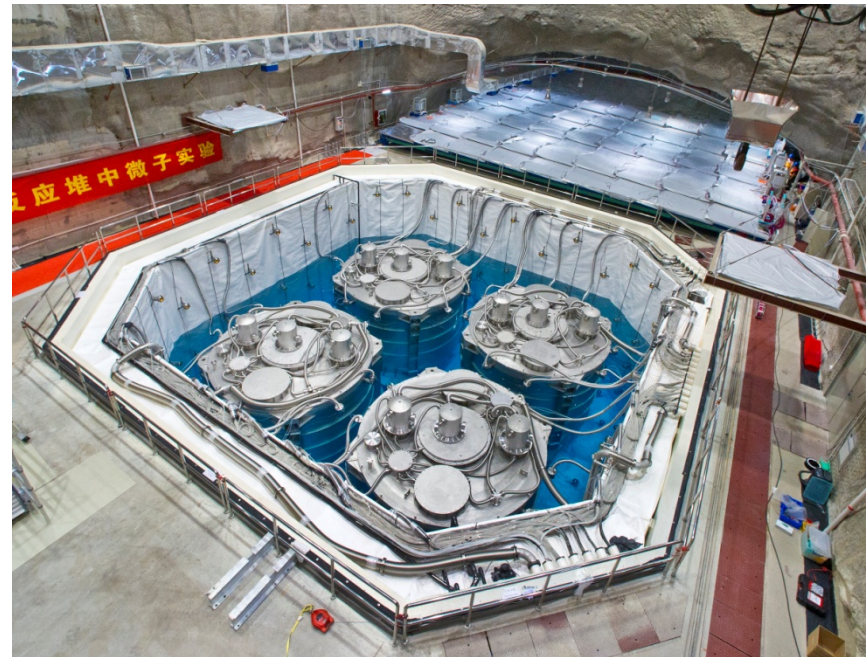


Year of Discovery: Intensity Frontier

- **Daya Bay reactor neutrino experiment definitively shows that the unmeasured neutrino mixing is large (of order 10^0)**
 - Done with 6 of the 8 detectors operating; Very valuable info for LBNE redesign

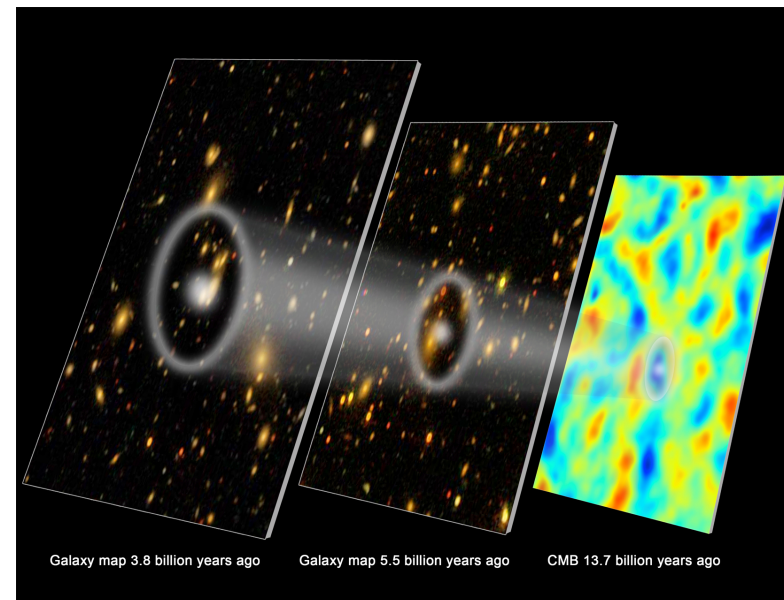
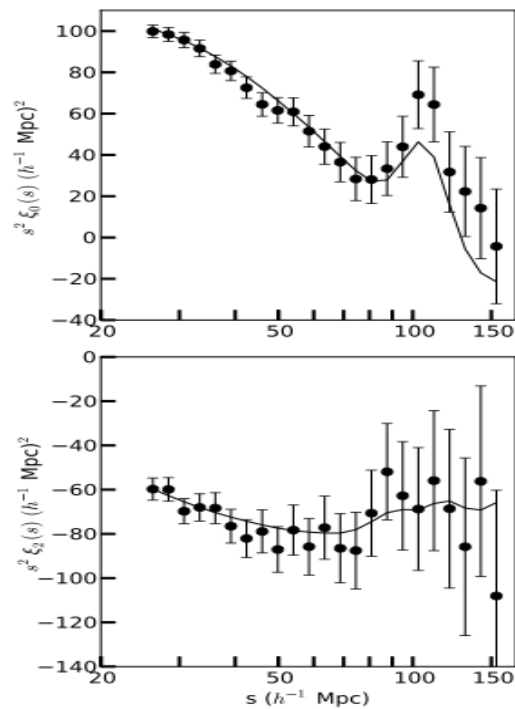


Far Detector Hall with 4 neutrino detectors



Year of Discovery: Cosmic Frontier

- 2011 Nobel Prize awarded for the measurement of the acceleration of the Universe: Permuter, Schmidt, and Riess.
- BOSS has measured the characteristic length scale of the universe, with a definitive detection of BAO peak.



Year of Discovery: Fruit of Investments

- **The U.S. began involvement in the LHC in 1994 and real investments started in 1997.**
 - Higgs discovery culminates a 48 year search for EWSB mechanism.
- **The Daya Bay project started in 2006.**
 - It was designed to provide guidance for the development neutrino program by being sensitive to values of θ_{13} at the 1% level.
 - The very rapid result was nature's choice to be kind to neutrino physicists ☺
- **The discovery of dark energy in the late 90s has completely changed the field of cosmology.**
 - New tools have been developed to study the problem.
 - BOSS started operations in 2009 and has now firmly established the predicted presence of a standard ruler for cosmology.

This discoveries are important in their own right, but also point us to new measurements to better understand the universe.

HEP Strategic Plan

The HEP Mission

- **The High Energy Physics program's mission is to understand how our universe works at its most fundamental level.**
 - discovering the most elementary constituents of matter and energy,
 - probing the interactions between them,
 - exploring the basic nature of space and time itself.
- **To enable these discoveries, HEP supports**
 - theoretical and experimental research in both –
 - elementary particle physics and
 - fundamental accelerator science and technology.

HEP Strategic Plan

Plan is based on the HEPAP (P5) report from 2008, which was affirmed and updated in 2009 and 2010.

Progress in achieving the goals of particle physics requires advancements at the

- Energy, Intensity and Cosmic Frontiers
- Each provides a unique window for insight about the fundamental forces and particles of nature
- The U.S. should have a strong, integrated research program at all three frontiers.

HEP at its core is an accelerator-based experimental science.

- Support accelerator and detector R&D to develop new technologies
 - that are needed by the field
 - that benefit the nation



P5 Recommendations

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**.

The panel recommends funding for **measurements of rare processes** to an extent depending on the funding levels available... (Mu2e, g-2)

The panel recommends support for the study of **dark matter and dark energy** as an integral part of the US particle physics program.

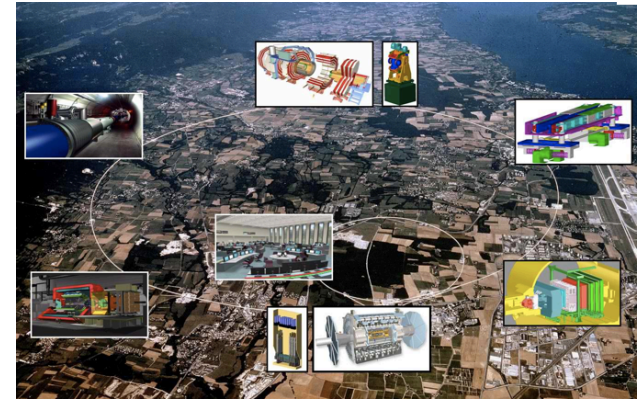
The panel recommends a **broad strategic program in accelerator R&D**, along with support of **basic accelerator science**.

Planning

- **HEP is putting in place a comprehensive program across the three frontiers.**
 - In five years,
 - NOvA, Mu2e, g-2 will be running on the intensity frontier.
 - The CMS and ATLAS upgrades will be installed at CERN.
 - DES will have finished and the Midscale Dark Energy Spectroscopic will be about to start.
 - The two big initiatives LSST and LBNE will be well underway.
- **Need to start planning now for what comes next.**
 - Intensity Frontier workshop last year;
 - DPF-sponsored community planning process that will conclude next summer (Snowmass 2013).
 - Prioritization process (P5) will that input.
 - Start the agency process to propose new initiatives as the current initiatives finish.
 - Any plan should exhibit compelling science as well as **technical and fiscal realism**

The Energy Frontier

- **Science goals**
 - Explore the TeV scale. Is there anything there but a SM-like Higgs?
- **Recent results**
 - There is a Higgs-like boson at 125 GeV.
 - SM or BSM?
 - Measurement of precision properties
 - Windows to new physics?
- **Near term**
 - Continued LHC running through early 2013.
 - Repair splices in LHC magnets in 2013/2014. – Resume running at ~ 14 TeV in 2014.
- **No new facilities under construction at this time**
- **Planned program of major projects:**
 - LHC Phase 1 Detector Upgrades: (2017-18) to cope with increased data rates (CD-0 approved)
 - Participate in the LHC-High Luminosity upgrade with installation ~ 2022 .
 - Renewal of the CERN Cooperation Agreement



The 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**
 - **Daya Bay** reactor neutrino experiment definitively shows that the unmeasured neutrino mixing is large
Valuable info for LBNE restructuring
- **New facilities under construction:**
 - **NuMI upgrade + NOvA** progressing well
- **Planned program of major projects:**
 - **Mu2e** to explore charged lepton mixing (CD-1 approved July)
 - **LBNE** to make definitive measurements of neutrino properties
- Aiming for CD-1 by the end of the year.



The 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 :**
 - **2011 Nobel Prize** awarded for the measurement of the acceleration of the Universe: Permuter, Schmidt, and Riess.
 - **BOSS** has measured the characteristic length scale of the universe using baryon acoustic oscillations.
- **New facilities under construction:**
 - **Dark Energy Survey** commissioning.
- **Planned program of major projects:**
 - **Large Synoptic Survey Telescope** is the longer-term centerpiece of this program; aims to make definitive ground-based Dark Energy measurements using “weak lensing”. DOE CD-1 approved,



Theory and Computing

■ Theory:

- Investigate the general notion that as the scale of NP gets higher, the flavor sector becomes more important .
- A single intensity frontier experiment may point to NP, but we need a set of measurements to narrow down the nature of the NP on the intensity frontier.
 - Is there possible an analysis of a what a comprehensive intensity frontier program would look like?
- Higgs naturalness or hierarchy problem?
- What is the physics gained from more precise/full knowledge of Higgs branching fractions at the LHC vs dedicated Higgs Factory?

■ Computing

- Is the current LHC computing model robust into the future? How far?
- Are other computing models needed to support the other frontiers, or can ‘one size fit all’?
- Are there new architectures that need to be developed to help with the DAQ/triggering problem?

Accelerator Stewardship

- **HEP conducted a workshop in 2010**
 - Accelerators for America's Future
 - Looked at what types of accelerator research was needed for:
 - Energy and Environment
 - Medicine
 - Industry
 - Security and Defense
 - Discovery Science
- **Accelerator Stewardship Strategic Plan is ready to go to Congress.**
- **Reclassified a small number of efforts in Advanced Technology R&D to Accelerator Stewardship.**

Budget and the Energy Frontier

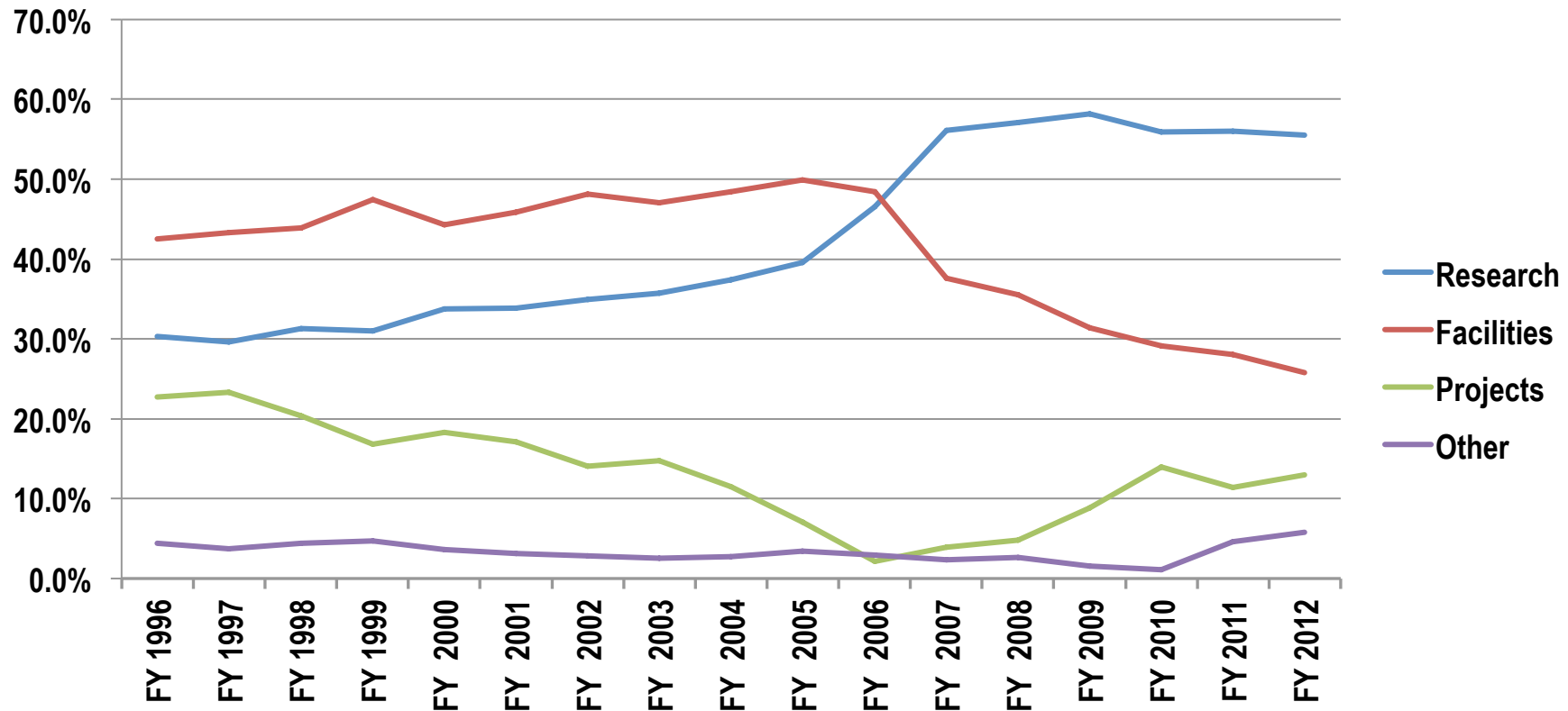
Budget

	FY 2012 Enacted	FY 2013 Request	FY 2013 House Mark	FY 2013 Senate Mark
Energy Frontier Experimental Physics	159,130	160,736	151,223	151,154
Intensity Frontier Experimental Physics	284,048	280,743	287,448	289,448
Cosmic Frontier Experimental Physics	72,390	84,946	82,086	82,086
Theoretical and Computational Physics	67,031	65,018	64,585	64,585
Advanced Technology R&D	157,084	141,588	131,841	134,757
Accelerator Stewardship	2,850	2,900	2,900	2,900
SBIR/STTR	20,327	20,590	20,438	20,591
Construction	28,000	20,000	36,000	36,000
High Energy Physics	790,860	776,521	776,521	781,521

New Investments

- **HEP has finished three projects in FY 2012.**
 - Daya Bay, Dark Energy Survey, and FACET have all received CD-4 and are operating.
 - BELLA will be completed this calendar year.
- **Balance the investments across the three frontiers.**
 - **Five new MIEs have received CD-0 approval**
 - Energy Frontier
 - LHC ATLAS Detector Upgrade, \$22–34M
 - LHC CMS Detector Upgrade, \$22–34M
 - Intensity Frontier
 - New Muon g–2 Experiment, \$30–60M
 - Cosmic Frontier
 - Second-generation Dark Matter Experiments, \$20–38M
 - Midscale Dark Energy Spectroscopic Instrument, \$25–42M
 - **Should carry us through FY 2017-2018**
 - Need to have case for new projects ready in the 2015-2016.

Funding History



Fraction of the budget in new investments has fallen since the building of B-factory and the Main Injector. Starting to recover now, but we still are not where we need to be.

Recent Functional Breakdown

	FY 2012	FY 2013 Request	FY 2013 House	FY 2013 Senate
Research	391,871	383,607	370,187	373,418
Facilities	248,954	262,024	262,159	263,775
Projects	101,708	90,300	87,737	87,737
SBIR/STTR	20,327	20,590	20,438	20,591
Construction	28,000	20,000	36,000	36,000
HEP Total	790,860	776,521	776,521	781,521

- Research is down to support an increase in construction.
- Facilities are up to support new muon campus infrastructure at Fermilab and a slight increase in Homestake.
- Non-line item construction is ~flat.

Implementing the Priorities

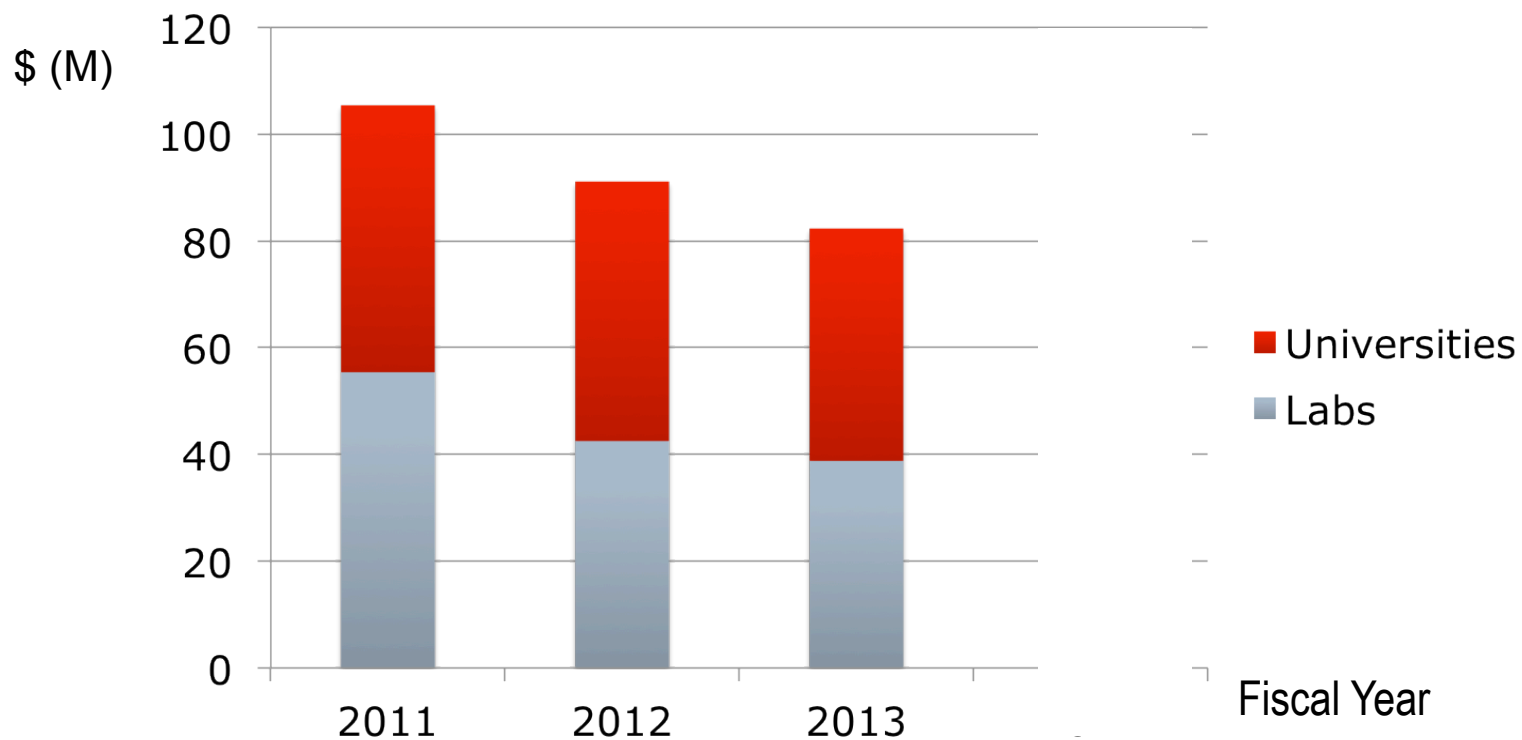
- **Research funding will decrease for the next several years.**
 - Program priorities and comparative reviews will be used to optimize the resources
 - Different programs will “suffer” differently
- **Both the universities and the laboratories will be affected.**
 - Comparative lab reviews in Energy Frontier and detector R&D this year
 - Cosmic and Intensity Frontiers next year; Accelerator Science TBD
- **Operations funding approximately flat-flat**
 - CD-0 approval for mid-scale projects at all frontiers;
 - CD-1 approved for LSST; CD-1 review for LBNE in one week
- **Embarking on the Snowmass community planning process.**
 - APS Division of Particle and Fields is organizing it.
 - Preparatory Meeting last week
 - Working groups meeting now.
 - Major meeting next summer.

Energy Frontier

	FY 2012	FY 2013 Request	FY 2013 House	FY 2013 Senate
Energy Frontier	159,130	160,736	151,223	151,154
Research	91,477	97,667	90,428	90,428
Facilities	67,653	63,069	60,795	60,726
Projects	0	0	0	0

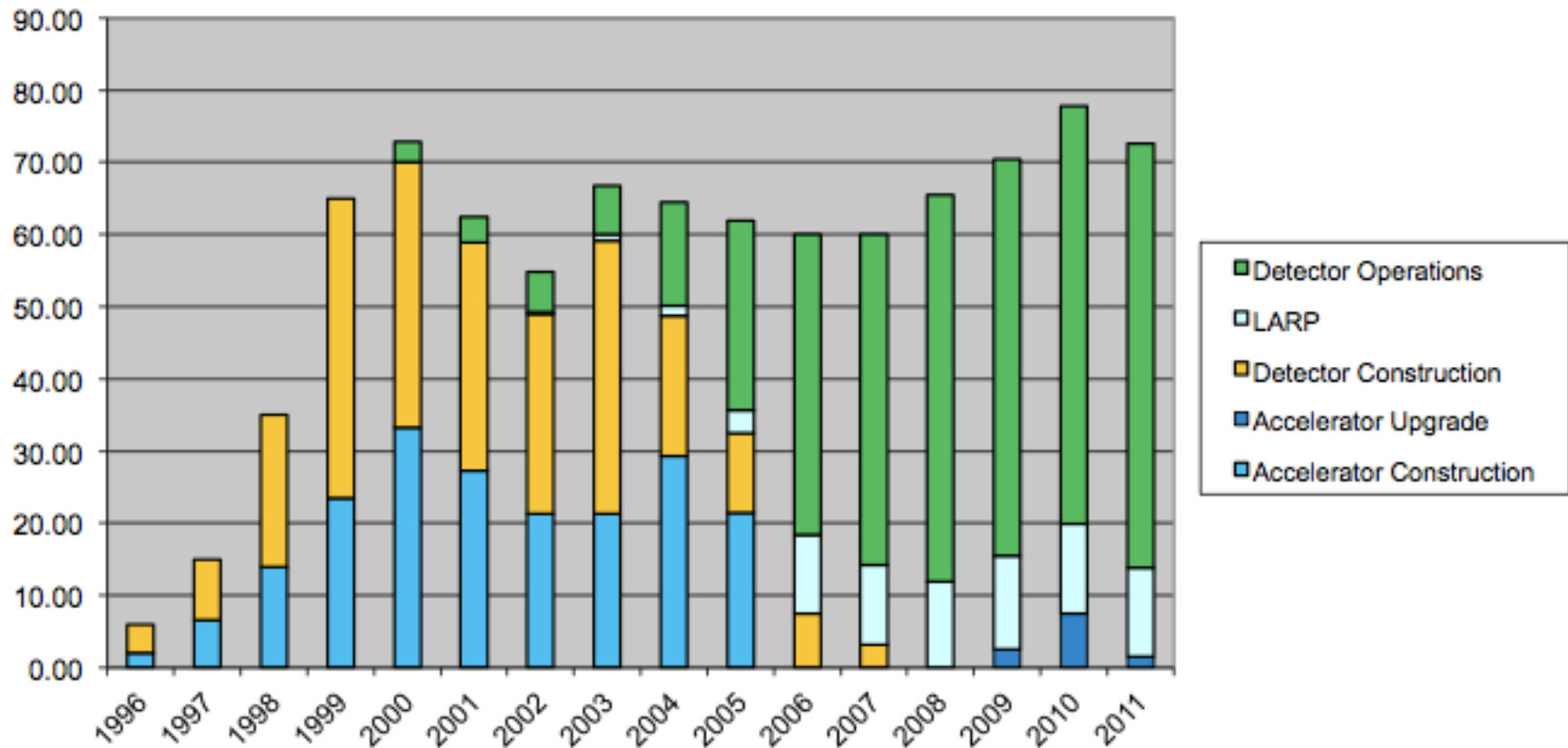
- The LHC will be shutdown for part of 2013 and most of 2014.
 - Researchers will be concentrating on analyzing data taken in 2012.
 - Computing expenses are down as the data set is not growing.
- Participation in the LHC is still the highest priority to HEP.
- New MIEs are started to support upgrades to the CMS and ATLAS detectors.
 - These are aimed at handling the higher data rates expected by FY 2018.
- Research is reduced as the Tevatron efforts continue to ramp down.
 - **In FY 2013, the House and Senate moved \$16,000,000 from research to LBNE PED.**
 - **Biggest impact of this comes in Energy Frontier research.**

Energy Frontier Budget – Core Research



Energy Frontier Budget - Operations

Funding / FY (in \$M)



Planned Funding & Schedule for LHC ATLAS and CMS Detector Upgrades

Critical Decisions (CD)	Fiscal Year
CD-0, Approve Mission Need	FY 2012
CD-1, Approve Alternative Selection and Cost Range	FY 2013
CD-2, Approve Performance Baseline	FY 2013
CD-3, Approve Start of Construction	FY 2014
CD-4, Approve Project Completion	FY 2018

DOE Cost Range
for **ATLAS-CMS** Upgrade: \$22-34 M
NSF Contribution: ~\$10 M

Each project will be independently tailored at
CD-1
CD-4 Date & TPC will remain fixed

Planned Funding in \$ Millions						
	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	Total
TPC	*	3.5 3	8 8.5	11	9.5	32
* The no funds in the FY 2013 PRB because CD-0 was not approved. The program plans to provide up to \$2M for OPC for each project in FY 2013; these funds will become part of the TPC.						

The LHC Program in the U.S.

The LHC: View from HQ

- **The LHC is a real success story**
 - Technical: Machine and detectors performing exceptionally well
 - Scientific : Lots of papers, huge training ground for future generation
 - *True international endeavor*: U.S. fully integrated at all levels in the collaborations
- **All advisory groups, panels, and studies have stated that the LHC is a high priority activity for the U.S.**
 - DOE-HEP is committed to maximal exploitation of U.S. investment
 - Level of DOE funding for LHC activities reflect the high priority, especially in tight budget times
- **The U.S. does not host an Energy Frontier Facility anymore**
 - However, we follow the science opportunities, and the LHC program is and will remain a high priority within the Office of Science
 - We should be mindful that the long-term health of HEP depends on whether we can build a diverse portfolio of science investments that include world-leading particle physics facilities in the U.S.
 - We must therefore strike the right balance between offshore investments and a domestic program built around the intensity frontier.

A Healthy U.S. LHC Program

- **We are entering a 20-year program and we need to make it robust and fiscally defensible**
- **We now have experience through all stages of the program**
 - R&D, fabrication, commissioning
 - Operations, computing, analysis
 - Activities both at CERN and in the US (LSP, ASCs)
- **What can we do better?**
 - Manage exposure to exchange rate
 - COLAs – need to be folded into cost of doing business
 - Develop ways to be as effective as possible while working in the US – whether at the LPC/ASC or at the home institution
 - Recognizing contributions from individuals
- **We have been clarifying program roles and responsibilities along research, operational, and project lines – policies on**
 - “Category A” costs ;
 - COLA;

Operations
Core Research
Upgrades

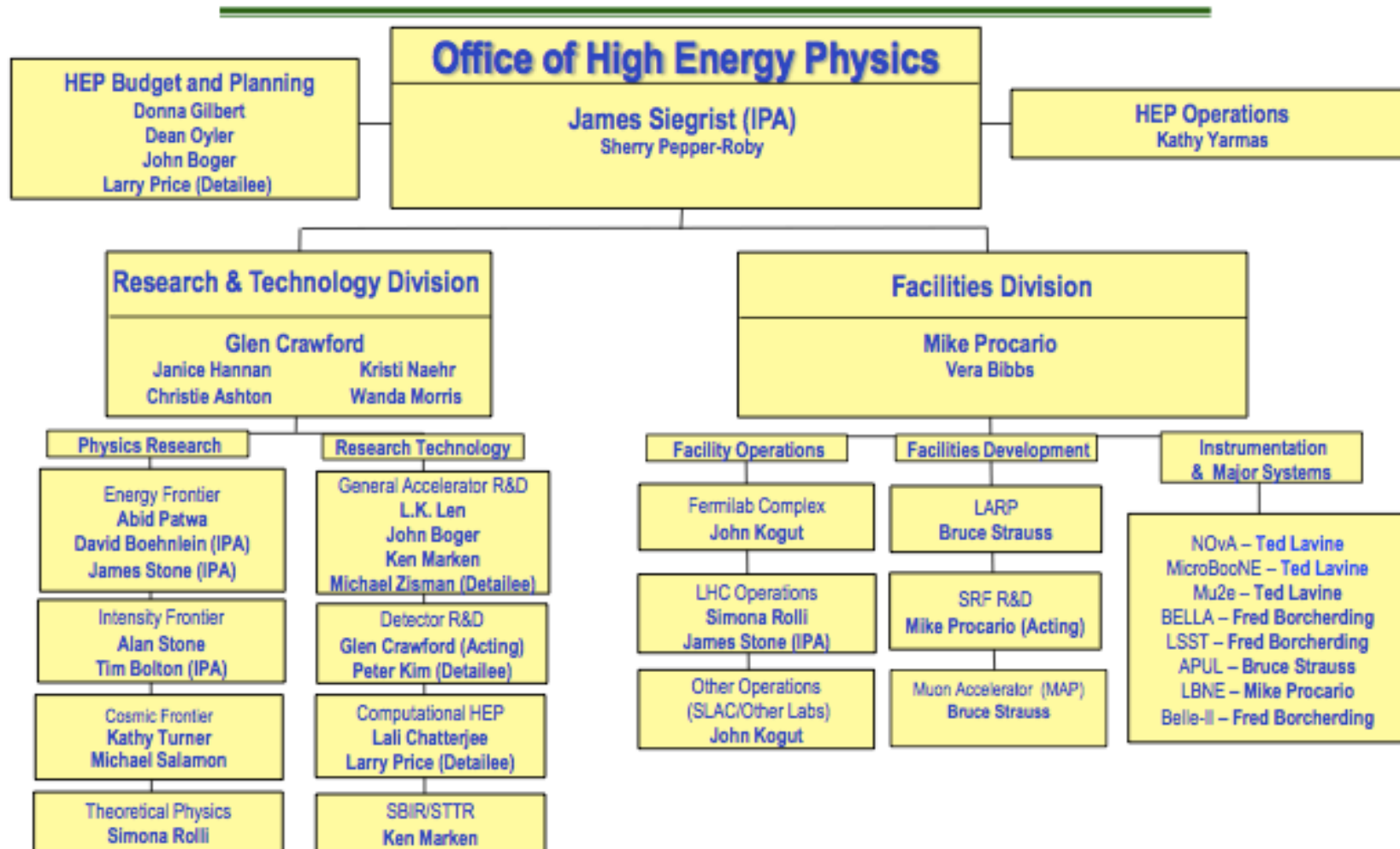
Operations
Core Research
Upgrades

Future Relations with CERN

- **We have 5 years to develop and sign a new cooperation agreement**
 - Must have a good idea of what future US-CERN relationship will look like before we negotiate post-2017 commitments
- **CERN Council is phasing out the Observer State status, which was granted as part of the US-CERN agreement for the LHC**
 - Through 2017, we see no need to alter the U.S.-CERN Observer relationship.
- **As new initiatives of mutual interest are considered and initiated, we favor the institution of stakeholder and collaborative approach on a project-by- project basis**
 - We welcome CERN participation in future global projects both at CERN and elsewhere that will leverage global resources to obtain the best overall science
- **Care must be taken to balance the location and leadership of these global projects so that regional programs remain healthy, vital, and can support one another**

News From the Office

Org Chart



News From the Office

Departures

- Eli Rosenberg returned to Iowa State after 4 years of meritorious service as an IPA

Arrivals

- Peter Kim (SLAC) started detail in Aug : Detector R&D
- Abid Patwa (formerly at BNL) joined as Fed program manager for Energy Frontier
- Jim Stone (BU) joined as an IPA : Energy Frontier, LHC Ops
- Tim Bolton (Kansas State) joined as an IPA : Intensity Frontier

Transitions

- Fred Borcherding now full-time on Projects
- Simona Rolli transitions from (Energy Frontier + LHC Ops + Theory) to (LHC Upgrades + Theory)

Miscellanea

- HEP Budget restructuring along Frontiers basis approved for FY2013

Summary

- **Budgets are very tight so we need to invest wisely**
 - Build a world-class domestic program centered on the intensity frontier
- **Many opportunities in particle physics**
 - Cosmic
 - Neutrino experiments
 - LHC
- **The P5 Strategic Plan is still our roadmap.**
 - Balanced program across the three frontiers.
 - Near-term implementation understood and moving forward on all Frontiers
 - Updates and revisions to P5 plan for longer-term starts with Snowmass process
- **Although the LHC is very exciting right now, it is important to remain engaged with the domestic program – a healthy US LHC program needs a diverse US HEP program**
 - We are developing and implementing policies aimed at strengthening the US LHC program

Congratulations on the excellent performance of the LHC and the great work done by the experiments in this exciting year of discovery!

Backup

Comparative Reviews

- **Strategic reductions in research funding are in our plan, while providing support for the top researchers**
- **We have been conducting comparative reviews of our national laboratory research programs for four years.**
- **In FY 2012 we completed the first round of comparative review of the HEP university grants program.**
 - All grants up for renewal ($\sim 1/3$) were comparatively reviewed by subprogram.
 - All energy frontier proposals were compared with each other by an expert panel.
 - Similarly for intensity frontier, cosmic frontier, theory, and accelerator science proposals.
 - Panel reviews supplemented by mail review where necessary.
- **Outcomes:**
 - 106 applications received, 13 withdrawn or declined w/o review
 - 58 proposals funded, 35 declined. Total first-year funding \$21.4M
 - 237 individual (co)PIs applied, including 64 who did not have previous DOE support. Success rate was 78% for those with prior funding, 42% for “new” PIs
 - There were 34 applications from new Jr faculty, 16 of which were funded.

Brief History of U.S. @ CERN

- **A U.S.-CERN cooperation agreement was signed by the Secretary of Energy, the Director of NSF, Director General of CERN, and the President of CERN Council.**
- **The U.S. was granted Observer Status at CERN.**
- **Experiments and Accelerator protocols were also signed by the Director of the Office of Energy Research, DOE, the Assistant Director of MPS, NSF, and the CERN DG.**
- **The scope of the agreement is limited to LHC activities**
- **The accelerator portion of the agreement concluded in 2007, the detector portion remains in force until 2017.**
- **A new instrument for LHC cooperation will have to be negotiated so that it can be in place in 2017**



Washington DC, December 8, 1997



CERN, December 19, 1997

US Contributions to LHC

- **The cooperation agreement set the overall scale of U.S. contributions to the LHC project at \$531M (\$450M for DOE, \$81M for NSF); The protocols defined the U.S. participation**
 - DOE Contributions to the LHC Accelerator: \$200M (~3% of LHC)
 - DOE and NSF Contributions to ATLAS and CMS: \$331M (~25% of each detector)
- **DOE and NSF then set up a joint LHC Detector Operations Program to coordinate U.S. contributions**
 - Manage the common fund contributions for U.S. physicists working on CMS and ATLAS.
 - Maintain detector systems and subsystems that are U.S. responsibility.
 - Carry out directed R&D needed to maintain and eventually upgrade the detectors.
 - Provide computing and data storage needed for physics analysis.
- **Research support (salaries for physicists, student support, travel, etc.) is handled separately through our peer review funding process**
- **The main goal is to enable U.S. physicists to fully and successfully participate in LHC physics.**

SC and HEP Funding Trends

- **Budget climate not conducive to increases in any discretionary spending area.**

