Report from the Office of High Energy Physics

LHC Users Organization Annual Meeting
September 26, 2009

Glen Crawford
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Office of High Energy Physics

U.S. DEPARTMENT OF ENERGY

Outline

- Following the P5 Roadmap
- The Program and the Budget
- The Subprograms
- The Office of High Energy Physics

Following the P5 Roadmap

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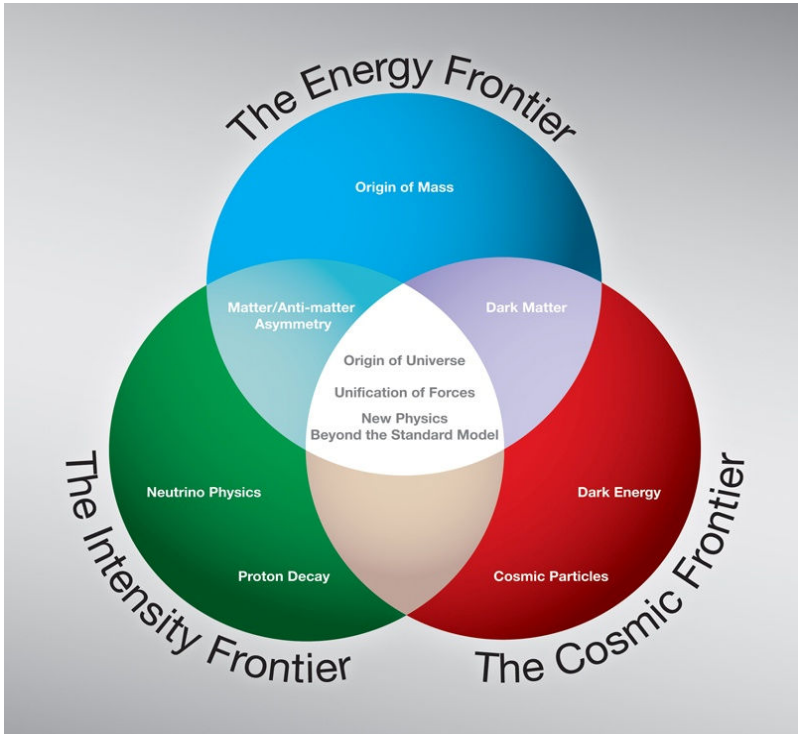
Particle Physics Today
Three Scientific Frontiers

- ***The Energy Frontier,*** **powerful accelerators are used to create new particles, reveal their interactions, and investigate fundamental forces;**

- ***The Intensity Frontier,*** **intense particle beams and highly sensitive detectors are used to pursue alternate pathways to investigate fundamental forces and particle interactions by studying events that occur rarely in nature; and**

- ***The Cosmic Frontier,*** **ground and space-based experiments and telescopes are used to make measurements that will offer new insight and information about the nature of dark matter and dark energy, to understand fundamental particle properties and discover new phenomena.**



The three frontiers have been excellent framework for our discussions of the program with the Office of Science, DOE, OMB, and Congress.

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The P5 Roadmap

- **Following the reductions in the FY 2008 HEP budget, DOE/NSF requested that P5 develop a new roadmap for HEP.**

- **HEPAP (Particle Physics Project Prioritization Panel (P5)) seriously addressed the charge given by DOE/NSF:**
  - to examine the scientific opportunities and options
  - for mounting a world class particle physics program
  - at different funding levels

- **Lays out what the nation will get with different investments**
  - Scenario A (FY 2008 Approp + COL) – unable to mount productive, world-class programs at all three frontiers
  - Scenario B (FY 2007 Approp + COL) – programs at all three frontiers
  - Scenario C (FY 2007 doubling (+6.5%/yr)) – leadership programs – partner in TeV-scale facility
  - Scenario D (additional above C) – the funding to host next TeV-scale facility

Report submitted 2 June 2008,
www.science.doe.gov/hep/files/pdfs/P5_Report%2006022008.pdf

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HEPAP (P5) Report
The Guidance

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**

Energy Frontier

- Continued support for the Tevatron Collider program for next 1-2 years
- LHC program has the highest priority, including US involvement in planned upgrades
- Accelerator and detector R&D program for next generation lepton collider

Intensity Frontier

- Recommends a world class neutrino program as core component
- Long term vision includes a large detector at DUSEL and high-intensity neutrino source at Fermilab.
- Program of rare decays (e.g.: muon to electron conversion – Mu2e)

Cosmic Frontier with an emphasis on dark energy and dark matter

- Joint Dark Energy Mission (JDEM) in collaboration with NASA
- Large Synoptic Survey Telescope (LSST) in collaboration with NSF
- Direct dark matter search experiments

HEP at its core is an accelerator based experimental science.

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

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The U.S. HEP program is at a crossroad

U.S. has not made investments in onshore HEP research capabilities

- Number of U.S. accelerator user facilities has been reduced to one
- Investments have not implemented a sustainable U.S. program
  - Major investment over last decade has been offshore (LHC)
  - Proposed onshore initiatives have not materialized (BTeV, ILC,….)

Foreign nations have made (are planning to make) investments in HEP research capabilities

▪ Europe	→ CERN/LHC (Phase I &II)	Energy Frontier
▪ Japan	→ J-PARC / S- BELLE	neutrinos /rare decay/ e^+-e^- collider
▪ China	→ BES-II / Daya Bay	electron beams / neutrinos
▪ Italy	→ (Super-B)	e^+-e^- collider

If the U.S. wants to remain among the leaders investments need to be made

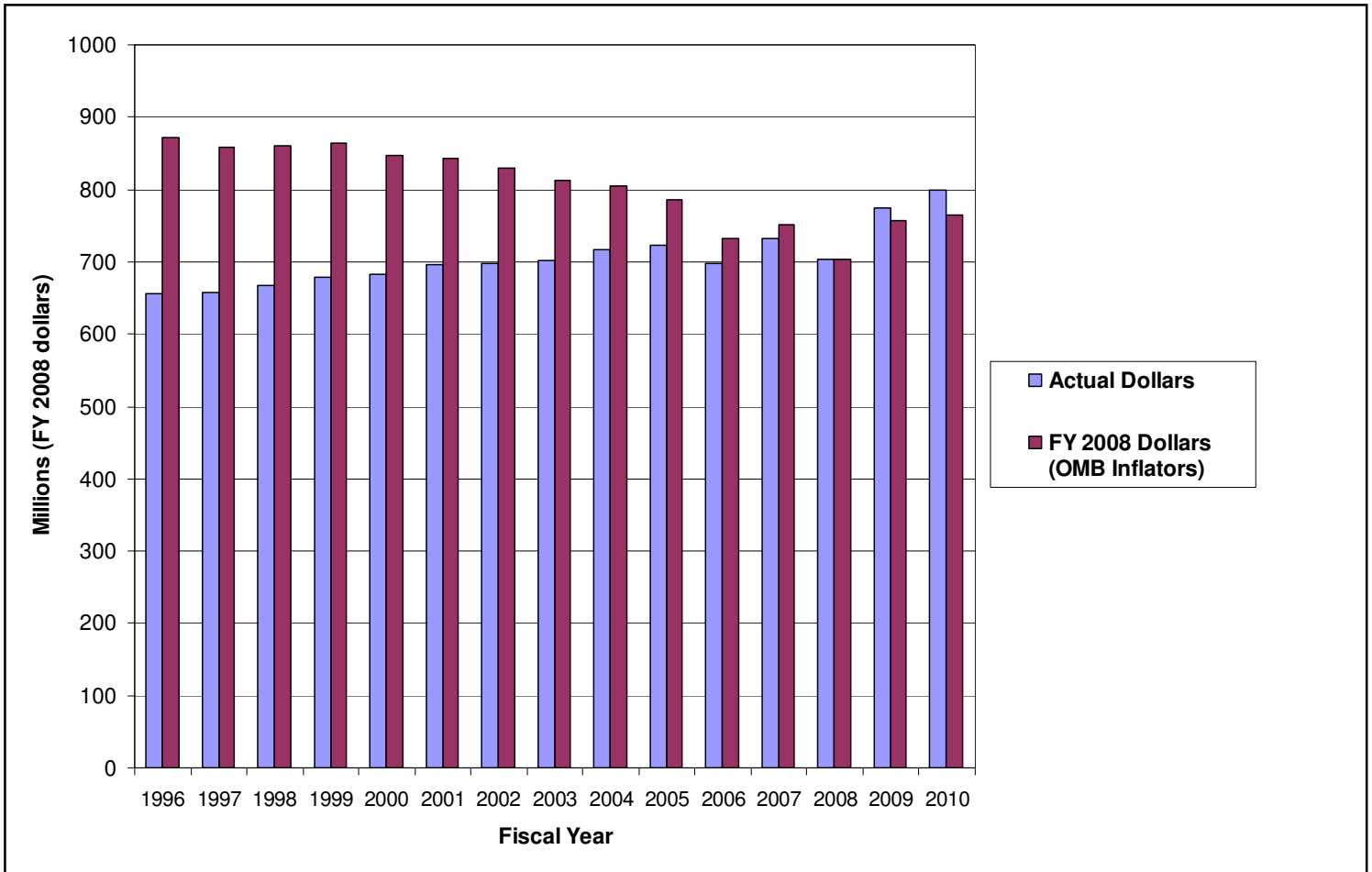
- **A realistic strategic plan has been developed that will position the U.S. to play a leadership role**
  - Develop research infrastructure in the U.S. that produces outstanding science and a technology foundation
  - Provides a role for U.S. scientists in campaigns at all three scientific frontiers
  - Positions the U.S. for a productive, sustainable program in the future

- **Leadership in HEP is important to the Nation**
  - Delivers new knowledge/discoveries about the world we live in - that have significant impact on other scientific fields
  - Attracts and trains a next generation of scientists for the Nation's scientific workforce
  - Develops advanced technologies that are important for the Nation's security and competitiveness

FY 2009 Funding & FY 2010 Request change trend but need for above COL to implement the Plan

- HEP funding has been eroded by inflation: FY 2008 / FY 1996 ~ 20 % (OMB COL)

- HEP FY 2009 funding is +10 % compared to FY 2008 and above OMB Cost-of-Living (COL) from FY 2007
- HEP received 220.0 million in Recovery Act funding (additional $16.5 million Early Career)
- HEP FY 2010 Request is above OMB COL (+2.9 %) compared to FY 2009



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Building the tools to deliver the science

- **Projects under construction**
  - Dark Energy Survey (cosmic)
  - Daya Bay (intensity)
  - NOvA (intensity)
  - MINERvA (intensity)
- **Projects in design**
  - BELLA (accelerator R&D)
  - FACET (accelerator R&D)
  - Accelerator Project for the Upgrade of the LHC (energy)
- **Projects where we are working on Mission Need**
  - Long Baseline Neutrino Experiment (intensity)
  - Muon to Electron Conversion Experiment (intensity)
  - Joint Dark Energy Experiment (cosmic)
  - MicroBoone (intensity)
- **Large Projects that are being considered for the future.**
  - LHC detector upgrades (energy)
  - Large Synoptic Sky Survey (cosmic)
  - Project X (intensity)

Limited to projects with TPC over $5 million.

The Program and the Budget

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FY 2009 Budget Overview

HEP Functional Categories	FY 2007	FY 2008	Diff vs FY08	FY 2009	Diff vs FY08	Diff vs FY07
Fermilab Accelerator Complex Operations	145.1	151.0	11.8	162.8	7.8%	12.2%
LHC Detector Support/Operations	56.8	65.6	3.8	69.4	5.8%	22.1%
SLAC Accelerator Complex Operations	79.0	36.5	-21.2	15.3	-58.0%	-80.6%
Facility Operations	**280.9**	**253.1**	-5.6	**247.5**	-2.2%	-11.9%
EPP Research	249.1	264.5	20.2	284.7	7.6%	14.3%
Advanced Technology R&D	167.7	138.1	29.0	167.2	21.0%	-0.3%
Core Research	**416.8**	**402.6**	49.2	**451.9**	12.2%	8.4%
Project - NOvA	12.5	12.0	15.7	27.8		
Project - Minerva	4.0	7.2	-2.3	4.9		
Project - T2K	0.6	2.5	-1.5	1.0		
Daya Bay	1.0	6.9	7.1	14.0		
LHC Detectors	3.2	0.0	0.0	0.0		
LHC Accelerator Upgrade Phase I	0.0	0.0	2.5	2.5		
DES	1.4	5.5	4.2	9.7		
Super CDMS	0.0	0.0	1.0	1.0		
FACET	0.0	0.0	0.0	0.0		
BELLA	0.0	0.0	8.0	8.0		
Projects	**22.6**	**34.1**	34.7	**68.9**	101.8%	204.4%
Other (GPP/GPE/SBIR/STTR)	**31.5**	**31.5**	-4.0	**27.5**	-12.8%	-12.7%
High Energy Physics	**751.8**	**721.3**	74.4	**795.7**	10.3%	5.8%

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FY 2009
American Recovery and Reinvestment Act (ARRA)

	FY 2009 ARRA
Fermilab Accelerator Complex Operations	15.0
Facility Operations	**15.0**
Proton Research	6.6
Electron Based Research	0.3
Non-Accelerator	1.4
Theory	2.9
EPP Research	**11.2**
Accel Science	0.4
General Accel Development	6.0
Superconducting RF	52.7
Advanced Tech SRF R&D	9.0
Detector Development	8.4
Advanced Technology R&D	**76.5**
Core Research	**87.7**
Project - NOvA	55.0
FACET	13.0
BELLA	20.7
Projects	**88.7**
Other (GPP/GPE/SBIR/STTR)	**28.6**
High Energy Physics	**220.0**

	HEP ARRA Projects
15.0	**University Enhancement & Infrastructure**
52.7	**SRF Infrastructure (Fermilab & Industry)**
20.0	**Advanced Technologies (Universities & Labs)**
15.0	**Long Baseline Neutrino Experiment (LBNE) R&D**
55.0	**NOvA (Univ. Minnesota and Fermilab)**
33.7	**Advanced Plasma Accelerator Facilities (LBNL/SLAC)**
25.0	**GPP Fermilab**
3.6	**SBIR/STTR**
220.0	

DOE Early Career Research Program

- **A new funding opportunity for early career researchers in universities and DOE national laboratories.**
  - Five-year awards : approx. $500k/yr for lab researchers, $150k/yr for universities
  - Competitive peer-reviewed proposals, replaces Outstanding Junior Investigator (OJI) program in HEP starting in FY 2010.
  - Expect ~12 awards in HEP in 1st year from ~150 proposals (about 3X typical OJI pool)
  - Supported by Recovery Act funds in the first year, will be adopted by SC programs over the following 4 years.
- **Proposals were due September 1.**
  - Proposals are no longer being accepted. All proposals are currently under review within our program offices. **We need peer reviewers!**
  - Current plan is to make awards in Spring 2010. Due to overwhelming response to this program, it will be challenging to meet this goal.
  - Please be advised that our program managers **cannot discuss** specific pending proposals.
- **Questions? See : http://www.science.doe.gov/SC-2/early_career.htm**

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DOE SC HEP
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High Energy Physics	**751.8**	**721.3**	**795.7**	23.3	**819.0**	2.9%	5.8%

The Subprograms

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Proton Accelerator Based Physics
Energy Frontier – Significant Activities

- **Tevatron Program**
  - With the delay in the LHC there is an increasingly strong case for running the Tevatron in FY 2011
  - Funding had not been allocated in the HEP plan for a FY 2011 Tevatron run
    - **HEP now plans to request funding in FY 2011 to run the Tevatron**

- **LHC Program**
  - CERN established a Working Group to examine possible geographic and scientific enlargement of CERN
  - U.S (DOE and NSF) provided input the CERN WG deliberations on September 3, 2009
  - **U.S. proposes that its relations with CERN remain basically the same as now**
    - Project stakeholder/CERN-Observer (not CERN Member State)
    - Will participate in the LHC program until end of US-CERN MOU (2017)
      - This includes detector/accelerator "replacement"/"modest upgrades" (Phase I LHC upgrades)
    - Will decide what its role might be for LHC major upgrade (sLHC or Phase II)
      - CERN has not yet made a decision on Phase II proposed x10 upgrade
      - U.S. position is that we will not pay LHC facility operating costs

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Proton program at a glance

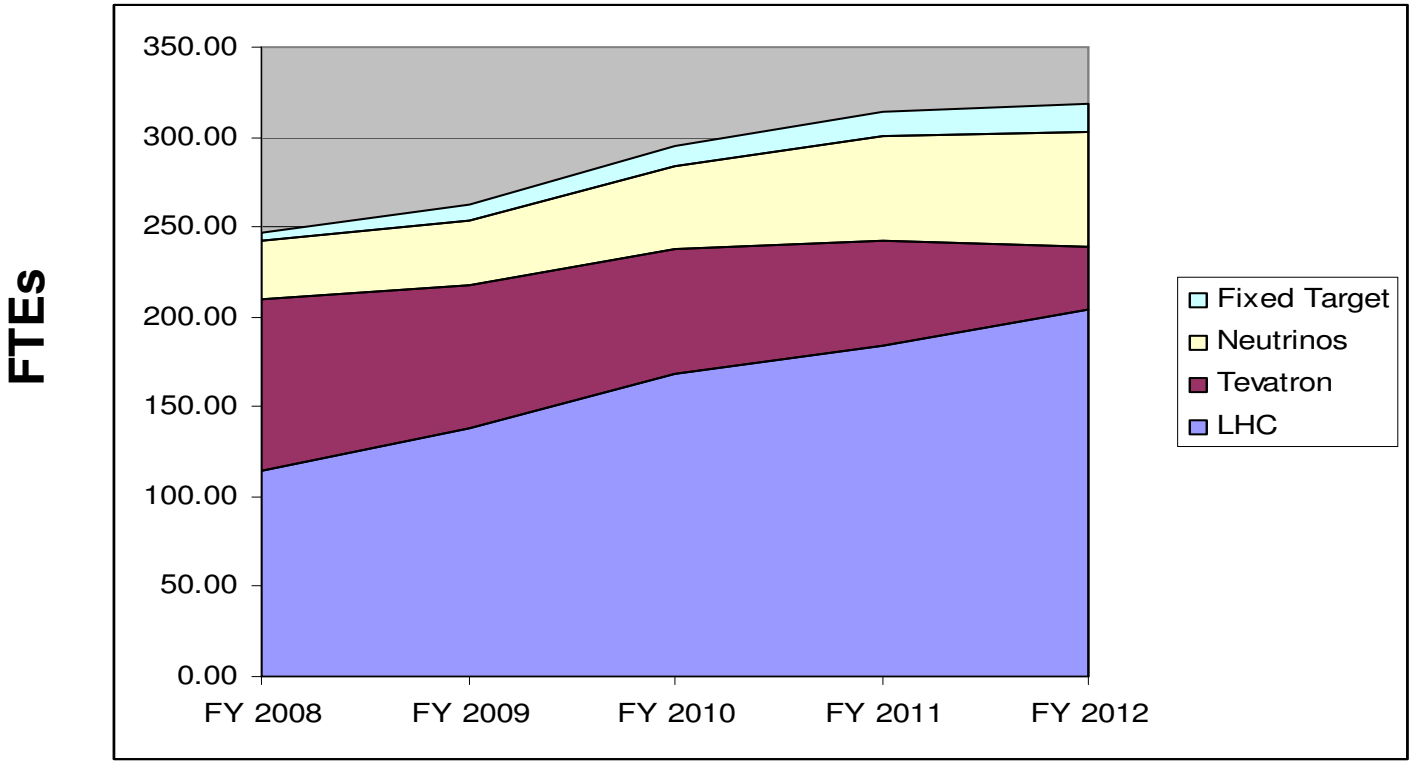
FY 2008	Labs		Universities		Total	
	FTE	Funding	FTE	Funding	FTE	Funding
Tevatron	95	$19M	185	$10M	247	$29M
LHC	115	$31M	505	$38M	629	$69M
Neutrinos	33	$9M	115	$7M	137	$16M
Fixed target	4	$1M	10	$1M	42	$2M
Total	247	$60M	815	$56M	1062	$116M

>Plus LHC Detector Operations ($56M) and LHCNet ($2M) for Tier 1, M&O, R&D, software, computing, etc.

>In FY09, 46 Tier 3 centers funded through ARRA ($2M)

TOTAL DOE: ~$130M/yr (not incl. LHC Accelerator upgrades, LARP)

US LHC Program



- **All DOE labs presented plans to expand their LHC research programs at the Proton Research review earlier this summer (see graph above)**
- **The Review committee, while supporting the priority of the US LHC program, did not find these plans sustainable in the long-term**
- **Furthermore, there is a need to establish a strong national program at the Intensity Frontier – which will require resources and people.**

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Intensity Frontier
Neutrino Physics

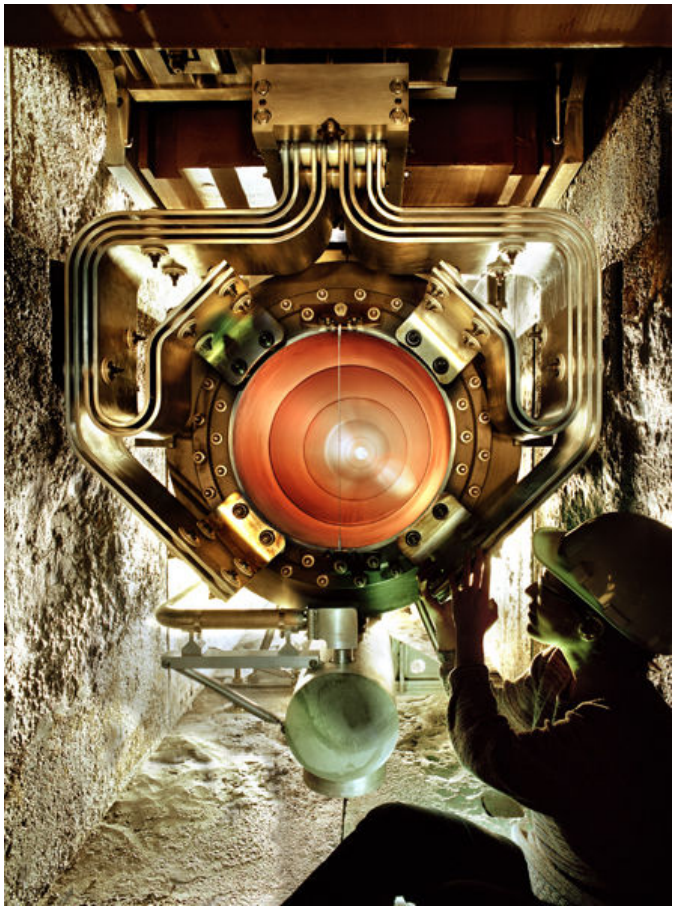
- **Goals for the next phases of the experimental program in neutrino oscillations:**
  - The mixing angles
  - The ordering of the neutrino mass states.
  - The extent of CP violation in neutrino sector.

- **There is a worldwide effort to address these questions**

DOE Program @Fermilab:

Accelerator-based Neutrino Oscillations

  - Running: MiniBooNe, SciBooNE, MINOS
  - Under construction: Minerva, NOvA
  - In planning stages: Long Baseline Neutrino Exp. (LBNE)
  - Supported by a series of phased beam upgrades



NuMI Horn

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Intensity Frontier
Fermilab Neutrino Program

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Proton Accelerator Based Physics
Intensity Frontier – Significant Activities

- **HEPAP envisioned "world-class" intensity frontier program entails evolution of Fermilab program**
  - MINOS/Minerva → NOvA (700kW) → LBNE (700kW) → SLBNE (2000 kW) --> Energy Frontier ?
  - The accelerator infrastructure allows: SLBNE → neutrino factory → muon collider

- **Envisioned intensity frontier program also entails development of an underground detector**
  - LBNE needs a large underground detector (~100-300 ktons)
  - A large detector (~300 kton) at the right depth (~5000 ft) detector can also do proton decay

- **Goals are ambitious and will take significant combined (DOE, NSF, other countries) resources**
  - NSF is proposing a Deep Underground Science and Engineering Laboratory (DUSEL) with a suite of experiments that includes a large detector (for neutrino oscillations and proton decay)
  - Other regions (Europe, Asia) are also interested in the science

- **DOE and NSF have had discussion with OMB and OSTP on how to coordinate planning**
  - NSF is supporting the conceptual design of the DUSEL facility and a suite of experiments
  - DOE HEP is seeking Mission Need (CD-0) approval for LBNE that includes the neutrino beam and a large underground detector
  - DOE and NSF will work together closely to coordinate their efforts, avoid duplication, and optimize their investments; see recent joint statement by DOE (Koonin) and NSF (Bement)
  - See later talk by J. Reidy for more details

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Electron Accelerator Based Physics
Intensity Frontier - Significant activities

- **B-Factory / BaBAR**
  - BaBAR data need to be analyzed and archived (new structure that could be become model for future)
  - Disposal of PEP II components await Italian decision on proposed SuperB

- **Proposed SuperB Facility (Italy)**
  - **Italians (INFN) proposing a next generation ~10 GeV electron-positron collider facility**
    - Decision by Italian government is expected by the end of calendar 2009.
    - CERN Council (responsible for European Particle Physics Strategic Plan) also needs to weigh in
  - **INFN has requested that all the PEP II components be provided for this facility**
    - The estimated value is 130 million Euros (no significant U.S. need for components foreseen)
    - U.S. scientists are interested in participating
  - **U.S. participation in SuperB would influence international HEP relations**
  - **OHEP will need to make a decision in FY 2010**
    - OHEP is requesting that SLAC do an assessment of options (costs, benefits, etc.) for U.S. involvement before the end of the calendar year.

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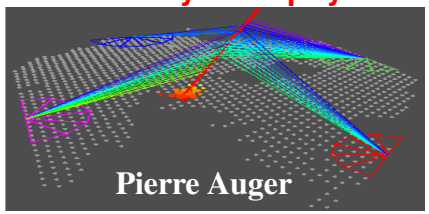
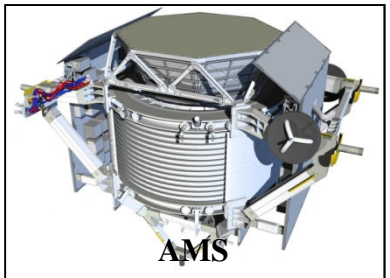
DOE OHEP
Cosmic Frontier Projects

Gamma-ray Astrophysics

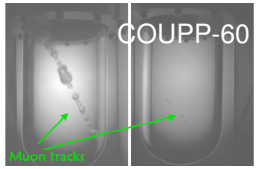
Cosmic Ray Astrophysics



Anti-matter, Dark Matter

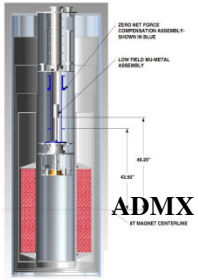


Dark Matter (WIMPs)

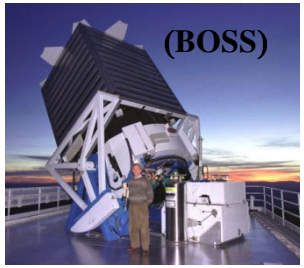


LUX

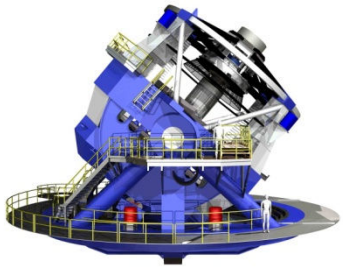
Dark Matter (axions)



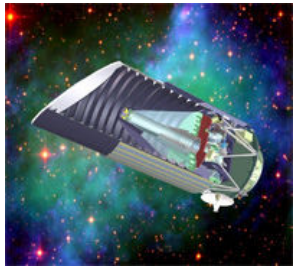
Dark Energy (ground-based)



LSST - proposed



Dark Energy (space-based)



JDEM - proposed

Non-Accelerator Physics
Significant activities

DOE/NSF Joint Dark Energy Mission (JDEM)

- Long history!
- Took a year (Nov 2007 to Nov 2008) to negotiate a MOU (signed November 2008)
- Over the last year formed project offices, Figure of Merit Science Working Group (started June 2008 and finished their study (Dec. 2008), Science Coordination Group (formed Sept. 2008; reported April 2009), and developed two pre-conceptual reference missions (JDEM/IDECS and OMEGA)
- DOE/OHEP and NASA/Astrophysics:
  - Agreed in principle on working relationship
  - Jointly presented two reference missions to National Academies Decadal Survey (June)
  - Jointly decided on need to consider a cost-constrained “JDEM-Probe” concept due to budget constraints.
- Working to identify a mission and work shares that are mutually agreeable and within allowable funding levels

Particle Astrophysics Scientific Advisory Group

DOE/NSF has charged to HEPAP for a review of the Particle Astrophysics program

- In response to recommendations in the May 2008 P5 report
- To identify the scientific opportunities that should be pursued by the U.S. program at various funding levels in the out-years.
  - **Similar to the P5 charge.**
- To better clarify what constitutes "particle astrophysics" and what this contributes to the mission of particle physics and to the fields of astrophysics and astronomy and what our role should be in experiments that overlap areas
- Report is to be submitted to HEPAP for their meeting on October 22, 2009.

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Advanced Technology R&D
Significant activities

- **Historically the U.S. has been a leader in the development of advanced accelerators.**
  - The developments have been largely driven by the HEP program, and supported by the DOE OHEP, in the quest for higher energies and intensities and more demanding beam properties.

- **U.S. leadership in this area is being challenged by efforts in other regions and countries**
  - Investments have been made and are being made in new forefront HEP accelerator facilities
  - A recognition by governments of the importance of accelerator competency and infrastructure
  - Industrial capabilities have been nurtured in Europe/Japan and are now preferred vendors for specialized accelerator components

- **OHEP has begun to address this technology gap**
  - Started in FY 2007 to nurture the development critical accelerator capabilities (e.g.; SRF cavities) in the U.S.
  - Participating in the international ILC R&D effort
  - Significant Recovery Act funding is being directed towards accelerator R&D and in particular industrialization

- **OHEP will be sponsoring an Accelerator R&D Workshop in 2009**
  - To make a more direct connection between fundamental accelerator technology and applications
  - To obtain guidance on the needs of federal programs and the private sector

Accelerators for America's Future

Symposium: Accelerators for America's Future, October 26, 2009

- ***Sponsored by Office of High Energy Physics***
- ***Chairs: Walter Henning (ANL) and Charles Shank (LBNL)***
- ***The symposium will examine the challenges for developing and deploying accelerators to meet the nation's needs in***
  - *Discovery Science*
  - *Medicine and Biology*
  - *Energy and Environment*
  - *National Security*
  - *Industrial Applications and Production*
- ***Poster session and white papers will solicit views from a broad range of stakeholders***

Workshop, October 27-28, 2009

- ***Invited experts in the above areas will meet to draft a report to the Office of Science and the Office of High Energy Physics***
- ***Report to be used as planning document for possible future OHEP activities***

For more information and to register, please visit

www.acceleratorsamerica.org

The Office of High Energy Physics

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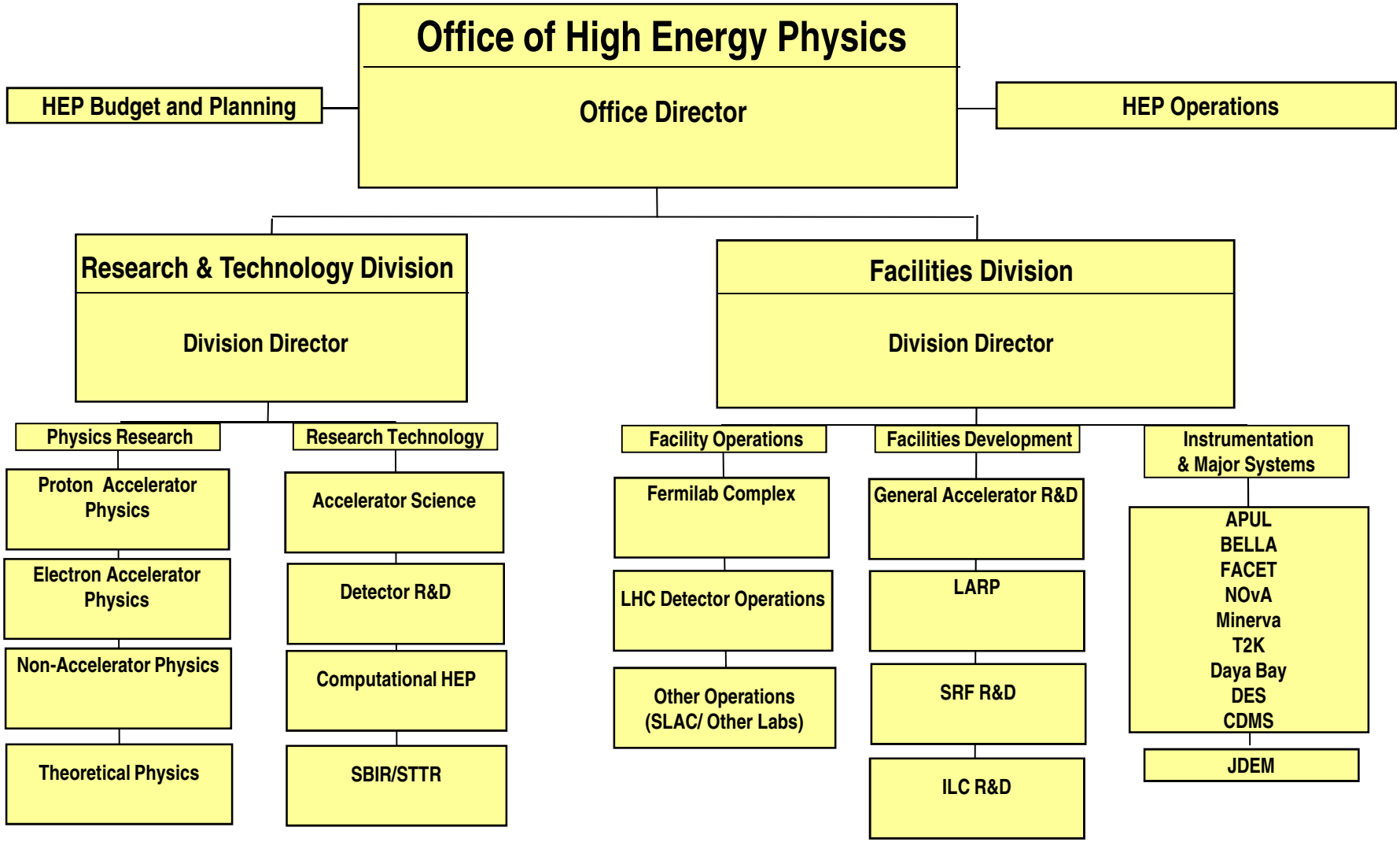
New OHEP Organization Chart



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OHEP Positions

- **Currently have 13 Federal employees who are physicists, 6 visiting physicists, and 8 administrative employees.**
- **Research and Technology Division**
  - Currently open and closes 10/30/09
    - Theory Program Manager
    - Non-Accelerator Program Manager
  - Near Future
    - Interdisciplinary Computer Scientist/Physicist (Computational HEP)
- **Facilities Division**
  - Currently open and closes 10/30/09
    - Interdisciplinary General Engineer/Physicist (Instrumentation and Major Systems)
  - Near Future
    - FNAL Program Manager

Backup

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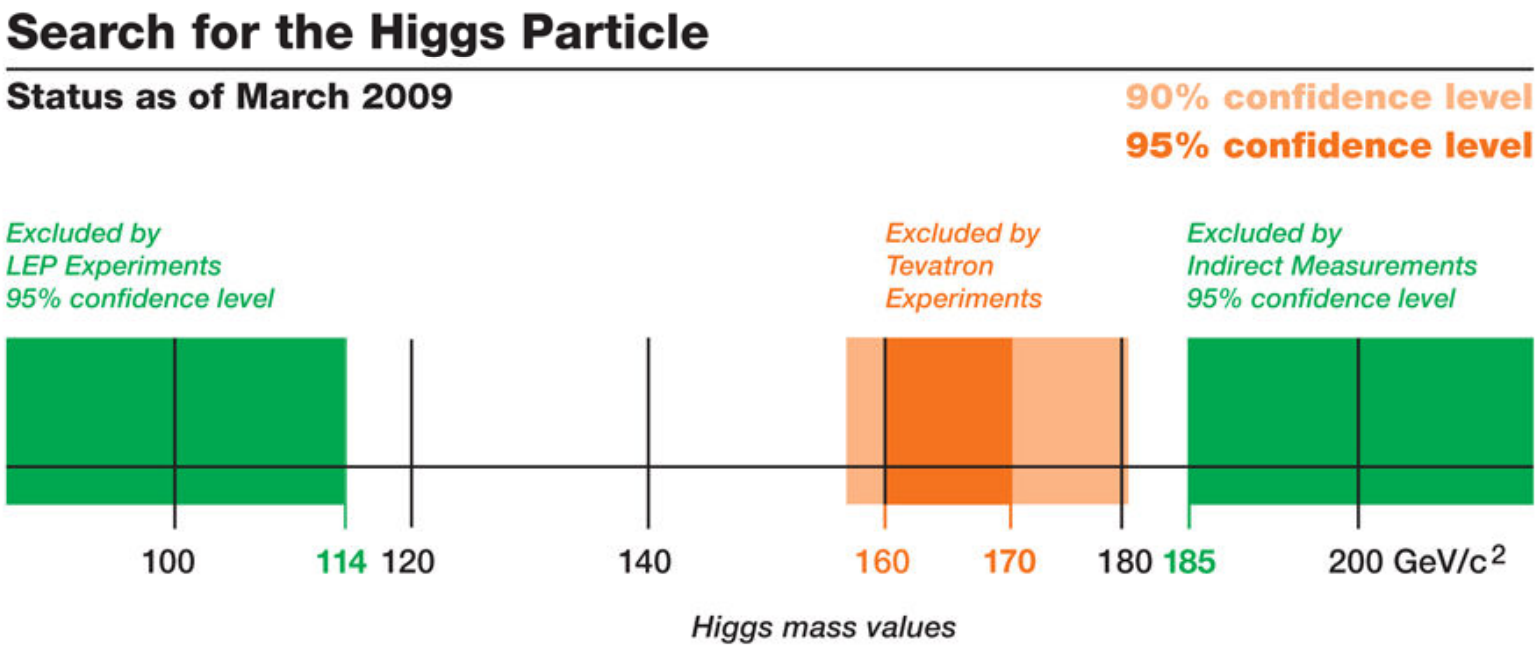
With the delay in the LHC program the Tevatron has an opportunity

Tevatron Experiments:

- D0 and CDF are now treading unexplored territory: First direct limits on Higgs Boson since 2000, when LEP collider at CERN shut down
- As more data is collected at Fermilab, either the exclusion region will expand or first hints of the Higgs boson will appear
- Tevatron has a real competitive advantage over the LHC for first Standard Model Higgs exclusion or observation



LHC Status and Plans

Status of LHC Machine:

- All magnets are in place with three out of eight sectors cooled-down
- All 10,000 magnet interconnects have been tested; The remaining sectors will be cooled once all consolidation work is completed.
- Current schedule calls for all sectors cold and ready by early November 2009.
- CERN strategy is to run the machine conservatively to prevent a recurrence of the September 2008 incident.

LHC Run plans for CY 2009 – CY 2011:

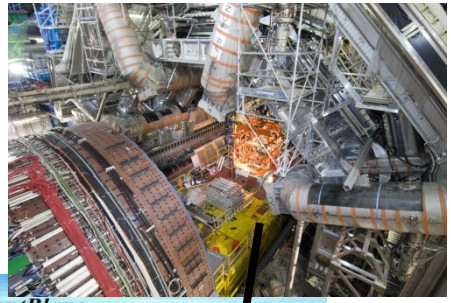
- Circulate beam at 450 GeV (1/2 of Tevatron energy) by mid-November 2009, verifying that the new protection systems are working properly
- First collisions with 3.5 TeV beams (3.5x Tevatron energy) by December 2009
- Ramp up to 5 TeV beam energy in mid-2010 after initial running experience
- Integrate 200 pb^{-1} before first run ends in late-2010 at 5 TeV beam energy
- Restart in late-2011 at 7 TeV beam energy (design energy)

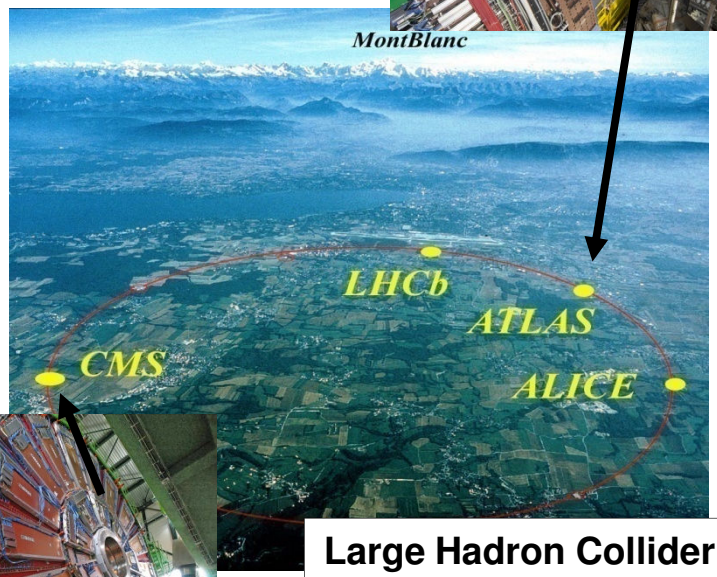
Impact of new LHC run plan on Physics:

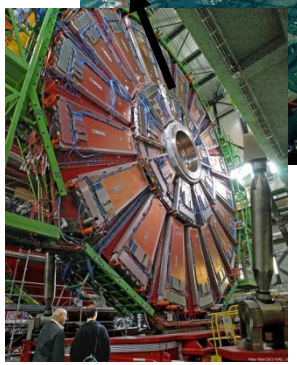
- Diminished physics reach due to lower expected luminosity and lower initial energy through 2010
- Physics goals of 2010 run are to understand the performance of the detectors in the LHC environment, to "re-discover" the Standard Model, and to look for new high cross section phenomena in the new energy regime
- There is potential for discoveries at the LHC in 2010 – but not for a Standard Model Higgs in the currently-favored mass region

U.S. DEPARTMENT OF ENERGY

Proton Facilities

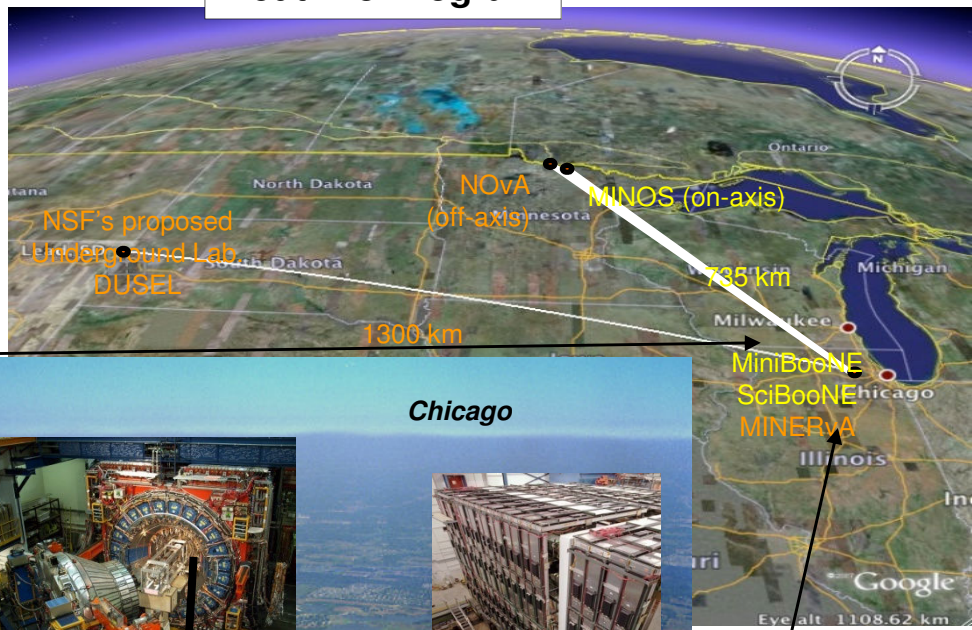


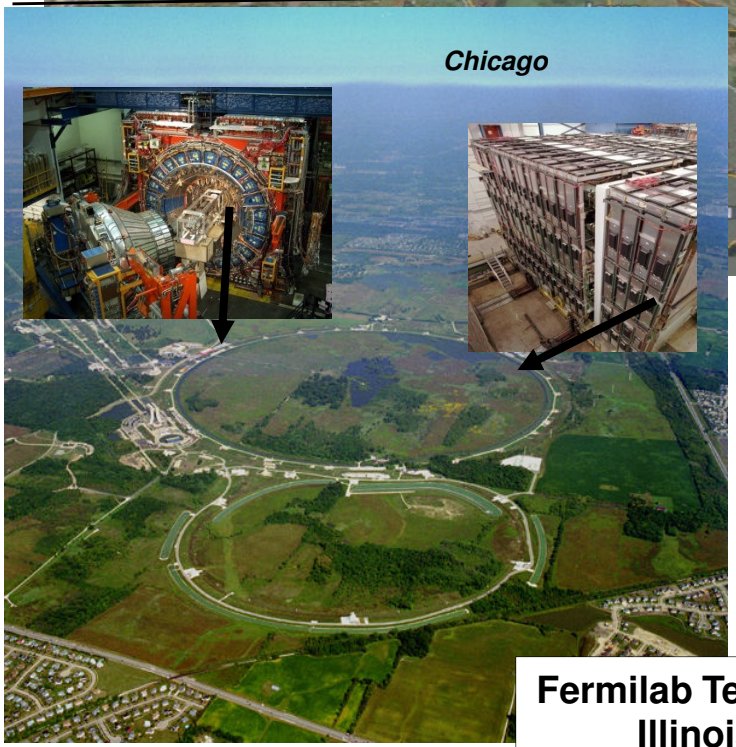




Large Hadron Collider Geneva

Neutrino Program

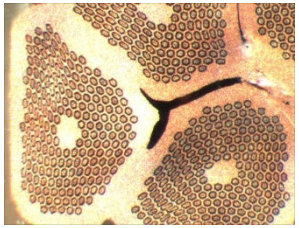


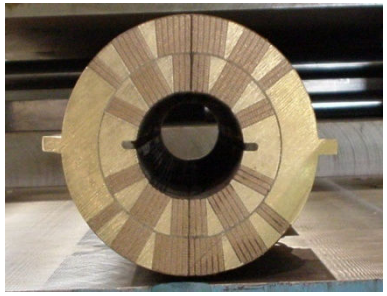


Fermilab Tevatron Illinois

Advanced Technology

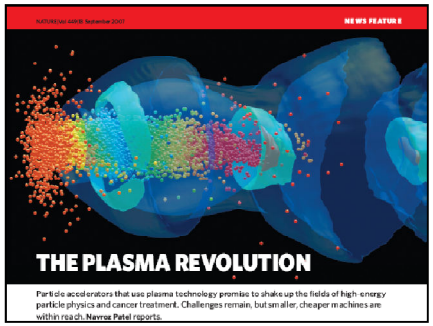
Superconducting Cable & High Field Magnets

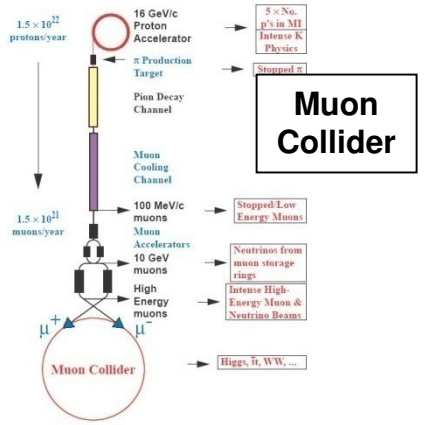




Superconducting Cavity Technology

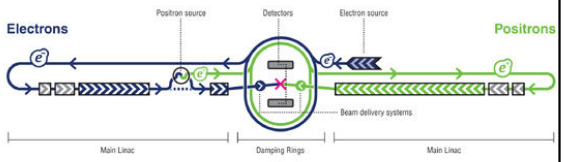
Accelerators





Muon Collider

International Linear Collider



Accelerator Science