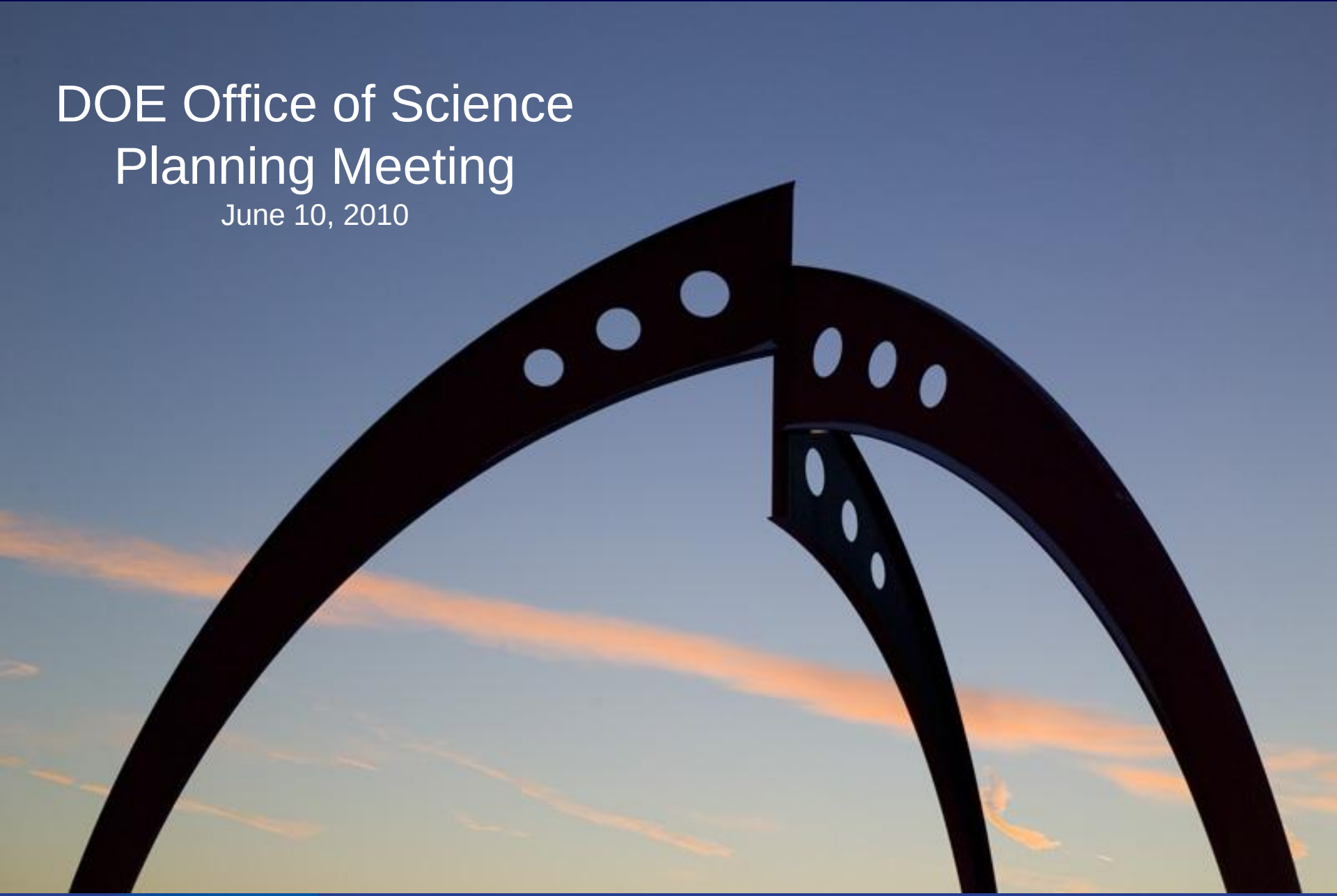
DOE Office of Science Planning Meeting

June 10, 2010



U.S. DEPARTMENT OF ENERGY

Fermilab

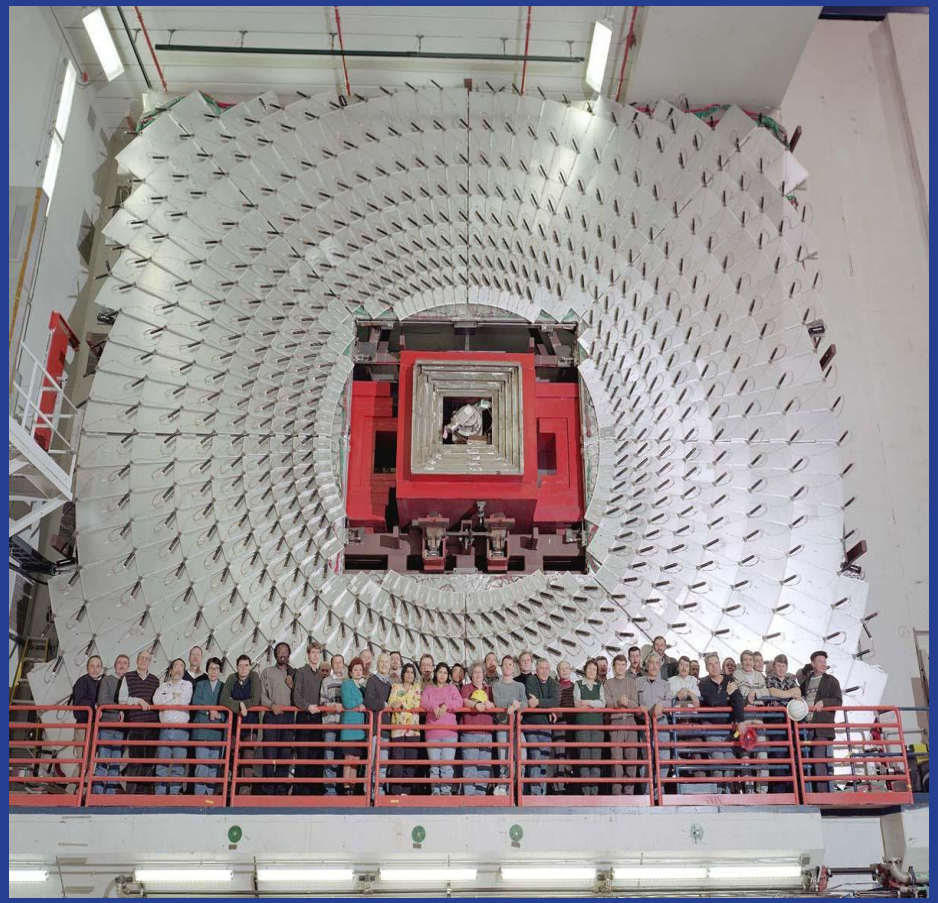
Fermilab characteristics (FY2009)

- 1912 employees; $ 374.7 M
- 2300 users and visiting scientists
- 6800 acres, park-like site
- Tevatron: most productive collider probably through 2011

- Highest intensity neutrino beams (low and high energy)
- A world class astrophysics , particle theory and computation programs
- Advanced detector and accelerator technology

Mission: the national particle physics lab

- Enable the US community to tackle the most fundamental physics questions of our era
- Interdependence: integrate the universities and other laboratories fully into national and international programs

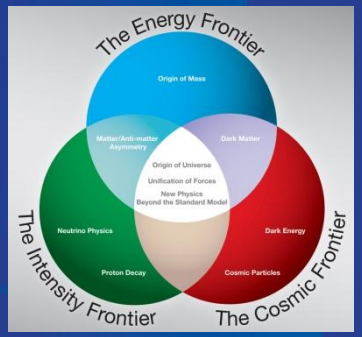


Program drivers: science

- The sense of mystery has never been more acute and evident
  - Where does mass come from?
  - Are there extra dimensions of space?
  - Why only three families of quarks and lepton?
  - Why is matter dominant?
  - What are the neutrino masses and what do they say?
  - Where are the heavy neutrino partners?
  - Does nature use supersymmetry?
  - Do the forces unify?
  - What is dark matter?
  - What is dark energy?

Program drivers: science

- These questions fire the imagination of the public and the press
- As the national laboratory for particle physics, we place the US in a leadership position in the world



Most elements are in place: exciting opportunities and national strategic plan at each of the three frontiers of particle physics: energy, intensity and cosmic frontiers

- Historically many applications in society through development of accelerator, detector and computational technology

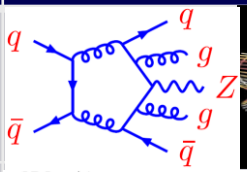
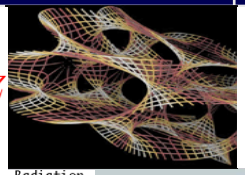
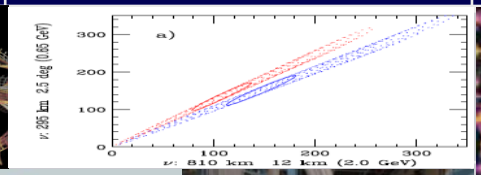
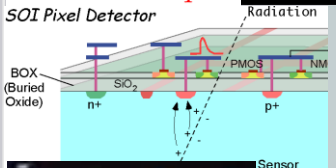
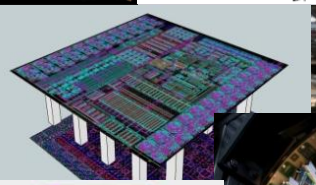
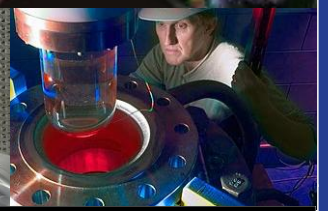
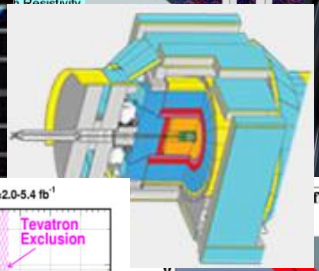
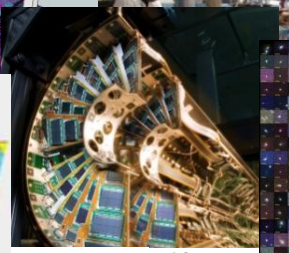
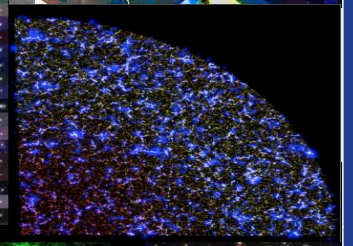
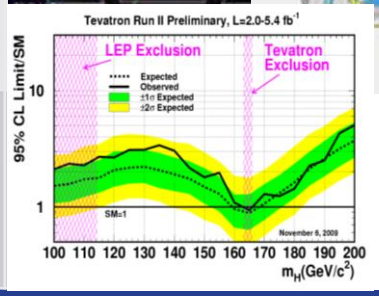
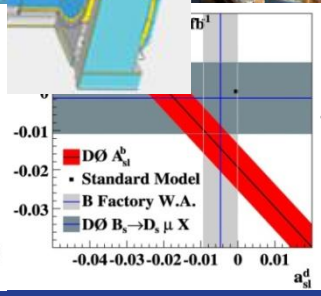
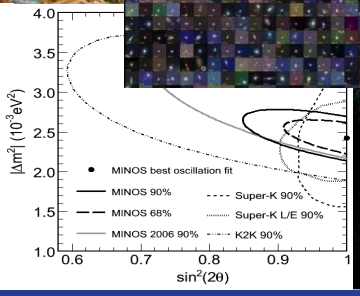
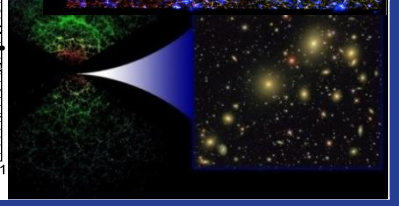
Laboratory Total Budget

	Energy Frontier	Intensity Frontier	Cosmic Frontier
Particle Physics	11%	6%	4%
Accelerator Science	13%	6%	0%
Large Scale User Facilities	33%	25%	2%

World class skills → core capabilities

Skill	Particle Physics	Accelerator Science	Large Scale User Facilities
Theory	✔	✔	✔
Accelerator Technologies		✔	✔
Advanced Instrumentation	✔	✔	✔
Simulation	✔	✔	✔
Data Analysis & Distributed Computing	✔	✔	✔
Systems Integration & Operations			✔
Project Management			✔

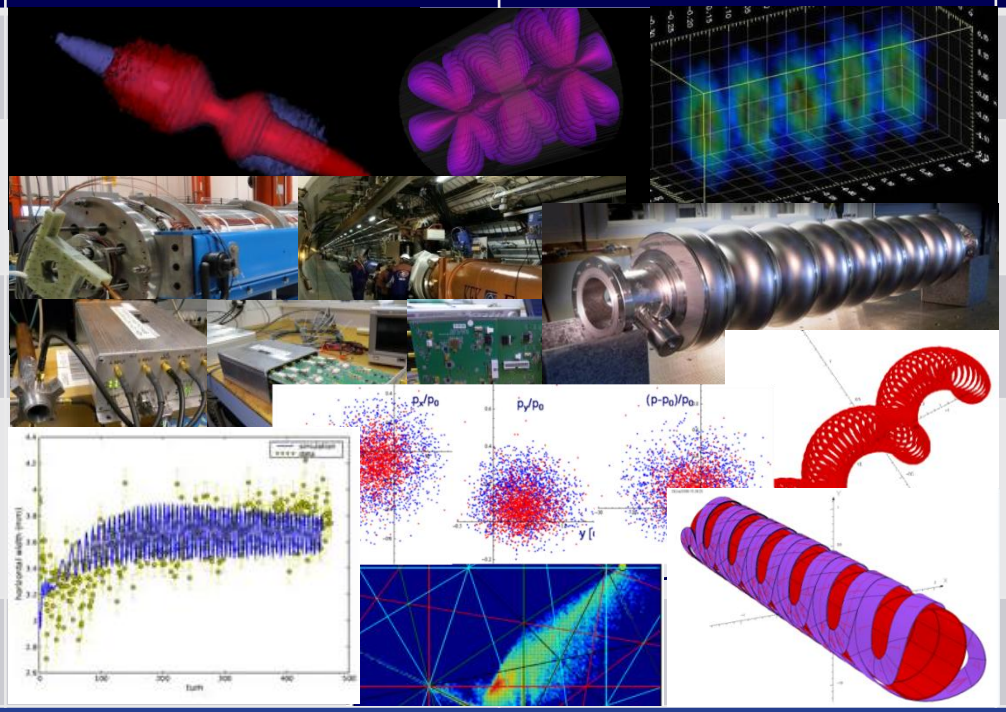
World class skills → Particle Physics

Particle Physics: Skill	Energy Frontier	Intensity Frontier	Cosmic Frontier
Theory	 		
Advanced Instrumentation	    		
Simulation	    		
Data Analysis & Distributed Computing	   		

World class skills → Particle Physics

Particle Physics: Skill	Energy Frontier	Intensity Frontier	Cosmic Frontier
Theory	QCD, Beyond Standard Model, Monte Carlo Generator	Matter dominated universe, rare processes, Neutrino Mixing	Phenomenology and analysis of cosmic frontier experiments
Advanced Instrumentation	Silicon Vertex detectors, 3D ASIC Design	Liquid Argon TPC	Cryogenic detector Bubble chambers CCD packaging Laser Cavities
Simulation	Simulation for lepton and hadron colliders, GEANT4 detector simulation, Lattice QCD	Neutrino simulation (a various kinds of detectors) Muon simulation	Large scale cosmological simulation
Data Analysis & Distributed Computing	Analysis of large Tevatron and LHC datasets, World-wide collaboration	Understanding low energy nuclear interactions and flux, World-wide collaboration	Management of data intensive cosmic surveys (SDSS, DES, JDEM, …)

World class skills → Accelerator Science

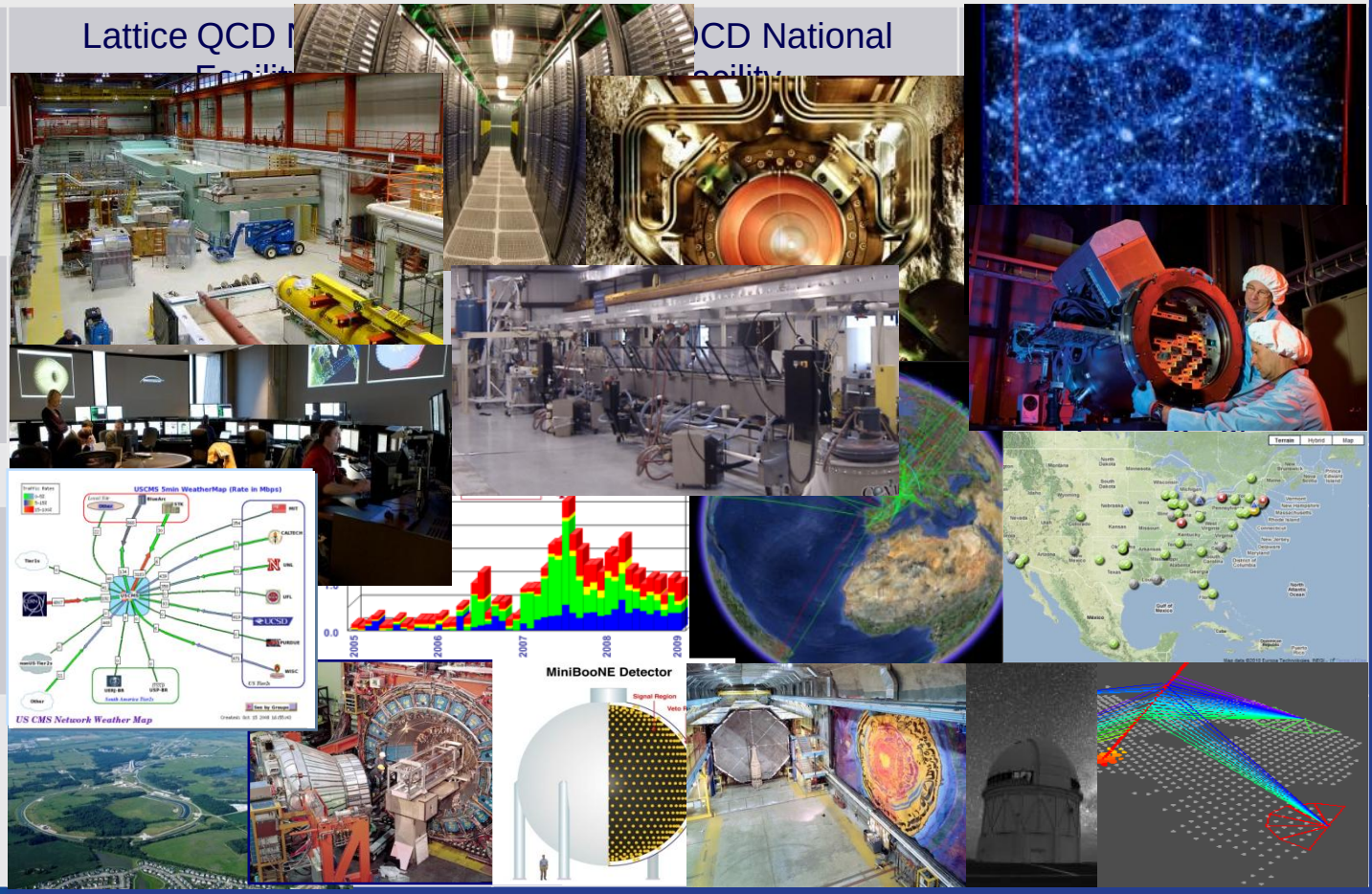
Accelerator Science: Skill	Energy Frontier	Intensity Frontier	Cosmic Frontier
Theory			
Accelerator Technologies			
Advanced Instrumentation			
Simulation			
Data Analysis & Distributed Computing			

World class skills → Accelerator Science

Accelerator Science: Skill	Energy Frontier	Intensity Frontier	Cosmic Frontier
Theory	Collider beam dynamics (beam-beam, IBS, etc)	Instabilities, loss mitigation (energy deposition)	
Accelerator Technologies	SC Magnets (Nb_3Sn, HTS), SC RF (β=1), RF power	SC RF (β<1), Particle Sources, RF power	
Advanced Instrumentation	Beam diagnostics and feedback	Beam diagnostics and feedback	
Simulation	Integrated accelerator simulations (Synergia, Muon Collider), Energy Deposition (MARS)	Integrated accelerator simulations (Synergia, Muon Collider) Energy Deposition (MARS)	
Data Analysis & Distributed Computing	Shot Data Analysis		

World class skills → Large Scale User Facilities

Large Scale User Facilities: Skill	Energy Frontier	Intensity Frontier	Cosmic Frontier
Theory	Lattice QCD N…	…CD National …	
Accelerator Technologies			
Advanced Instrumentation			
Simulation			
Data Analysis & Distributed Computing			
Systems Integration, Operations, Project Management			



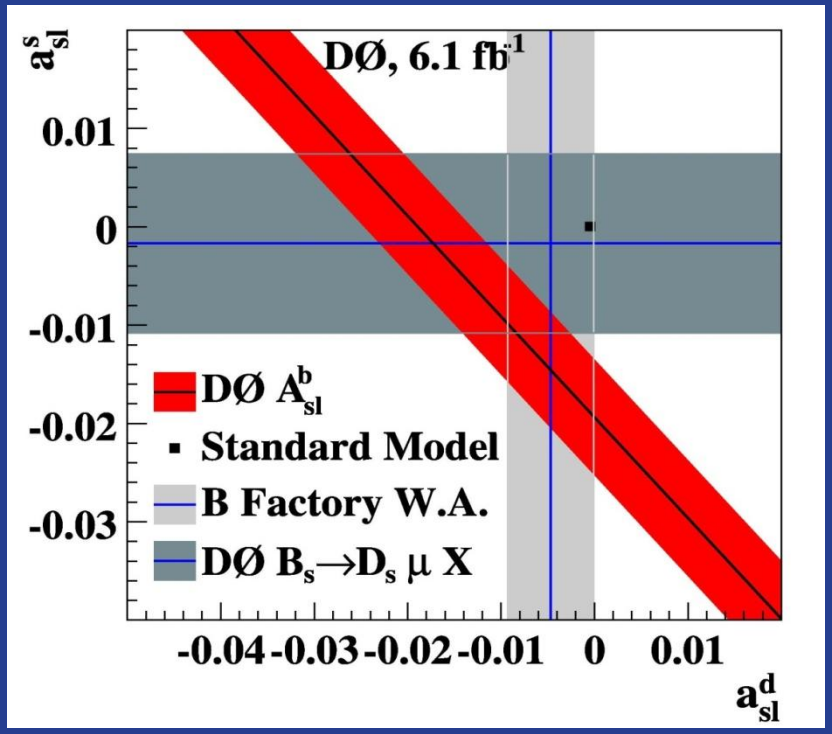
World class skills → Large Scale User Facilities

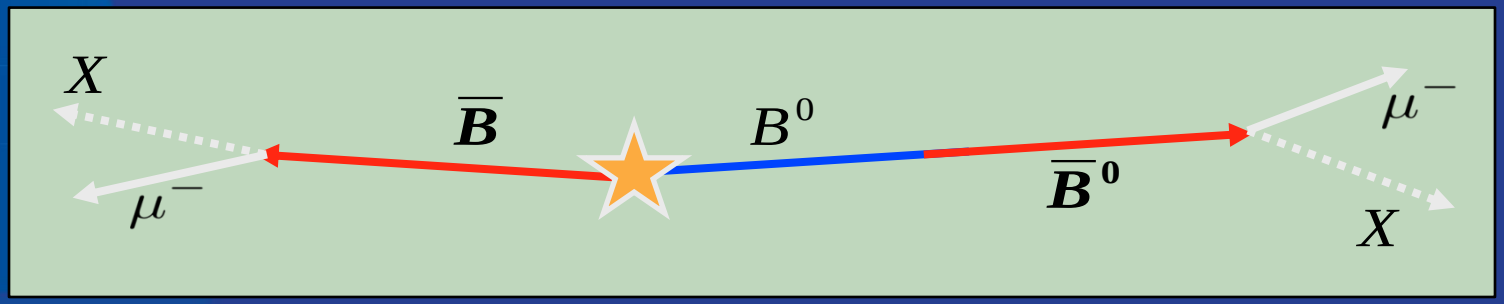
Large Scale User Facilities: Skill	Energy Frontier	Intensity Frontier	Cosmic Frontier
Theory	Lattice QCD National Facility	Lattice QCD National Facility	Cosmological Computing
Accelerator Technologies	NML Accel Test Facility, MuCOOL Test Area, Muon Collider, ILC	NML Accel Test Facility, NuMI, LBNE, Mu2e, Project X, Neutrino Factory	
Advanced Instrumentation	Silicon Detector Facility Center	LAr R&D Facility, Extruded Scintillator Facility	LAr R&D Facility, Silicon Detector Facility Center (DES CCD packaging)
Simulation			
Data Analysis & Distributed Computing	LHC Physics Center, Open Science Grid, CMS Tier-1 Center, Advanced Network, Massive Data Storage	Open Science Grid	Survey Data Archive
Systems Integration, Operations, Project Management	Tevatron Complex, CDF/DZero detectors, LHC Remote Oper. Center, Testbeam	NuMI & BNB (ν beams), Neutrino detectors, Soudan Underground Lab, Testbeam / small expt.s	Testbeam, Soudan Underground Lab., Silicon Detector Facility Center, Pierre Auger

Energy Frontier: achievements

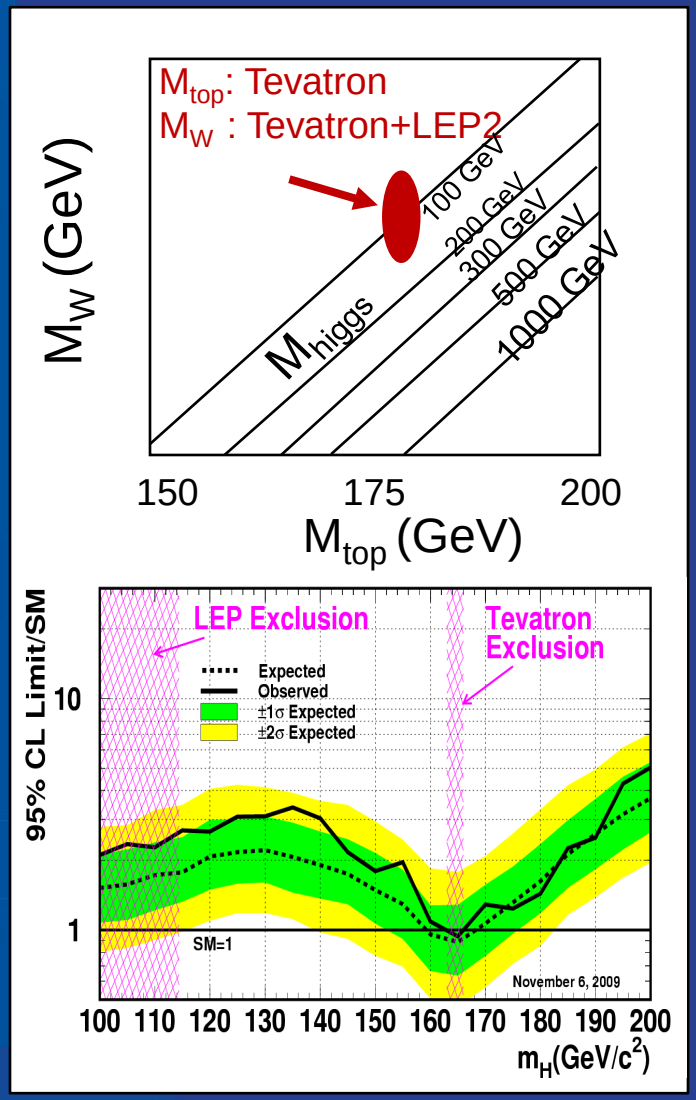
Tevatron graduates 60 PhDs per year and produces about a 100 results per year; an example is the recent matter-antimatter asymmetry in DZERO

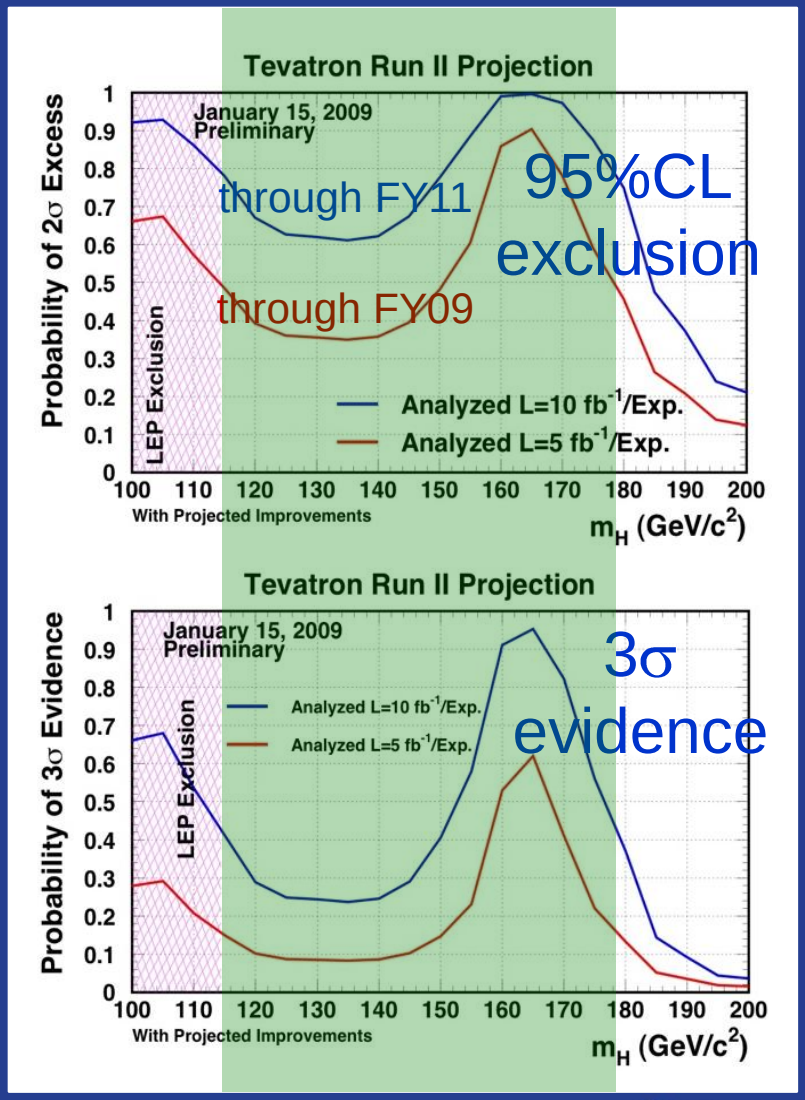
$$A_{sl}^{b} \equiv \frac{N_b^{++} - N_b^{--}}{N_b^{++} + N_b^{--}}$$





Is there more juice in the Tevatron?

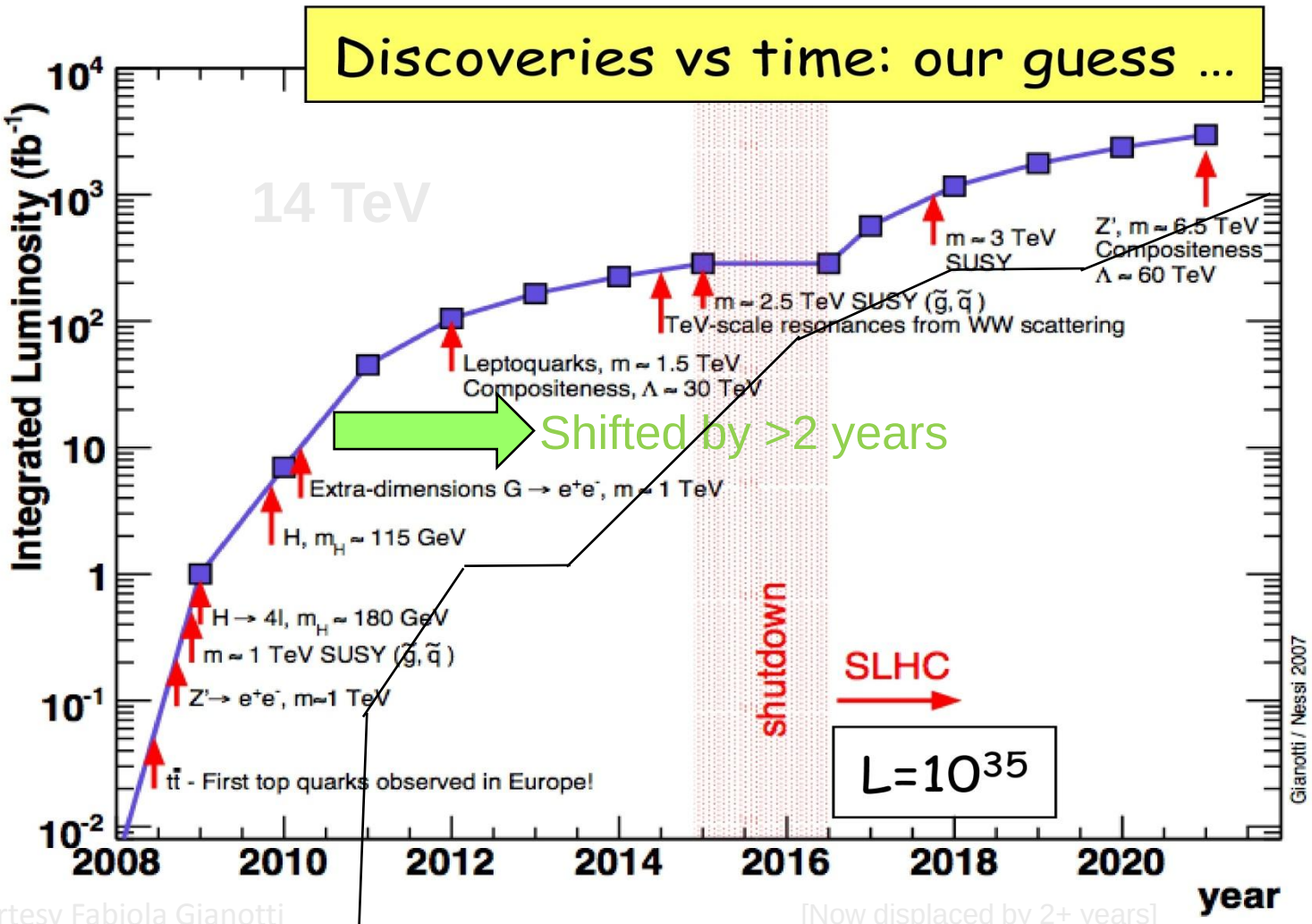




Energy frontier will move to the LHC

Fermilab is the lead US lab on the accelerator and the only US lab in CMS supporting over 50 universities

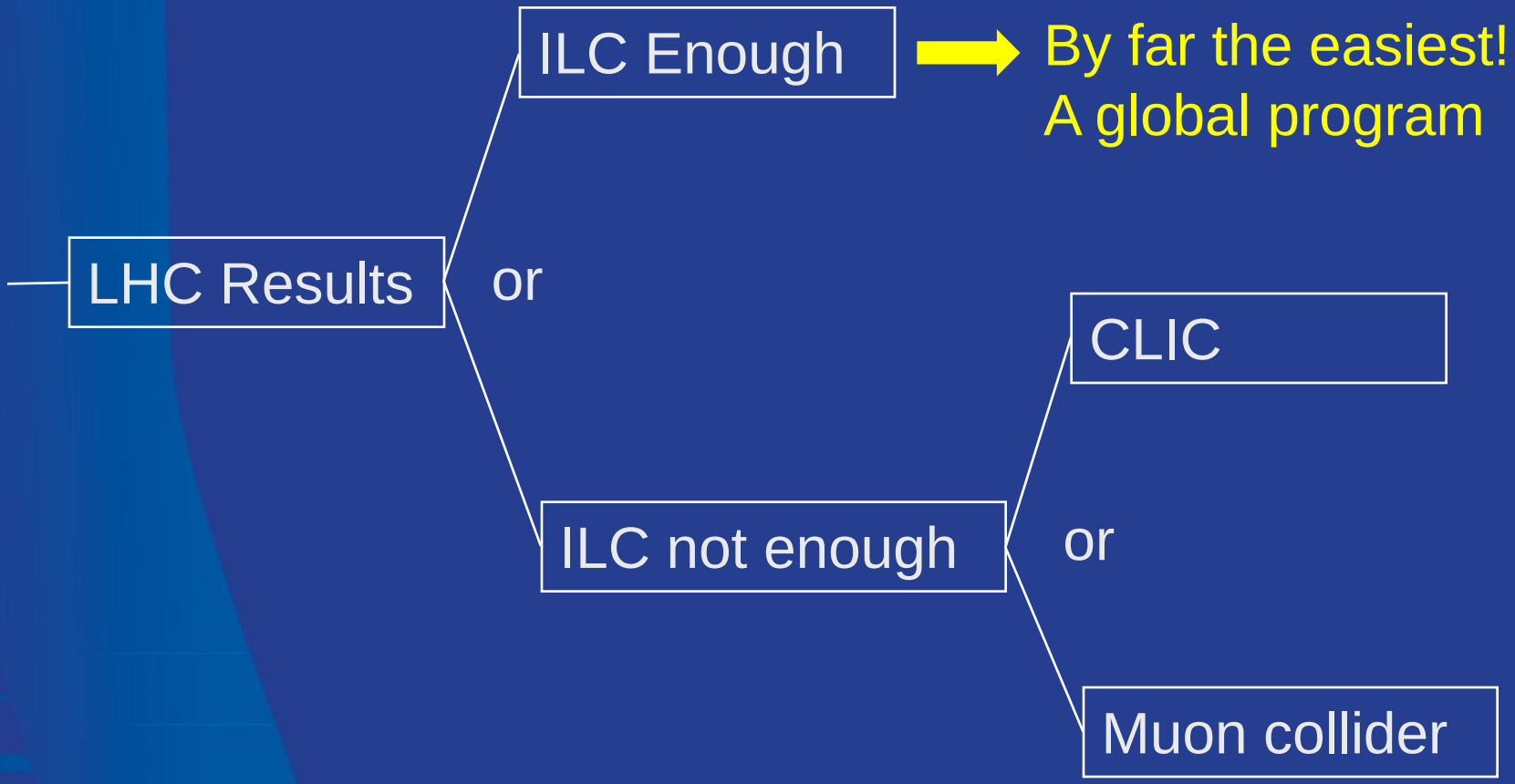
LHC physics reach (3 years ago)



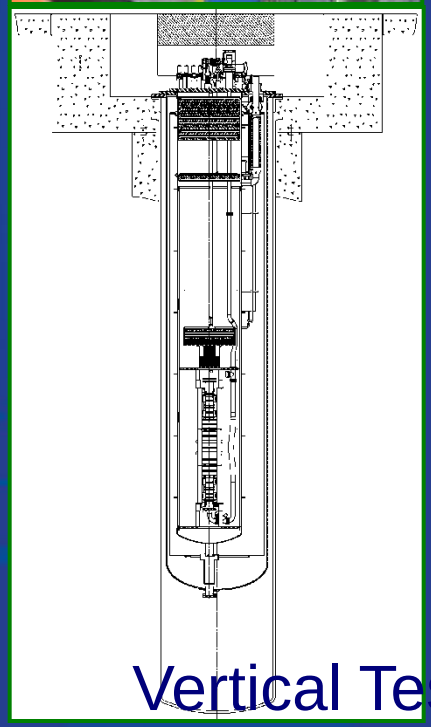
Courtesy Fabiola Gianotti

[Now displaced by 2+ years]

Biggest decision of the decade !



ILC/Project X/XFEL technology



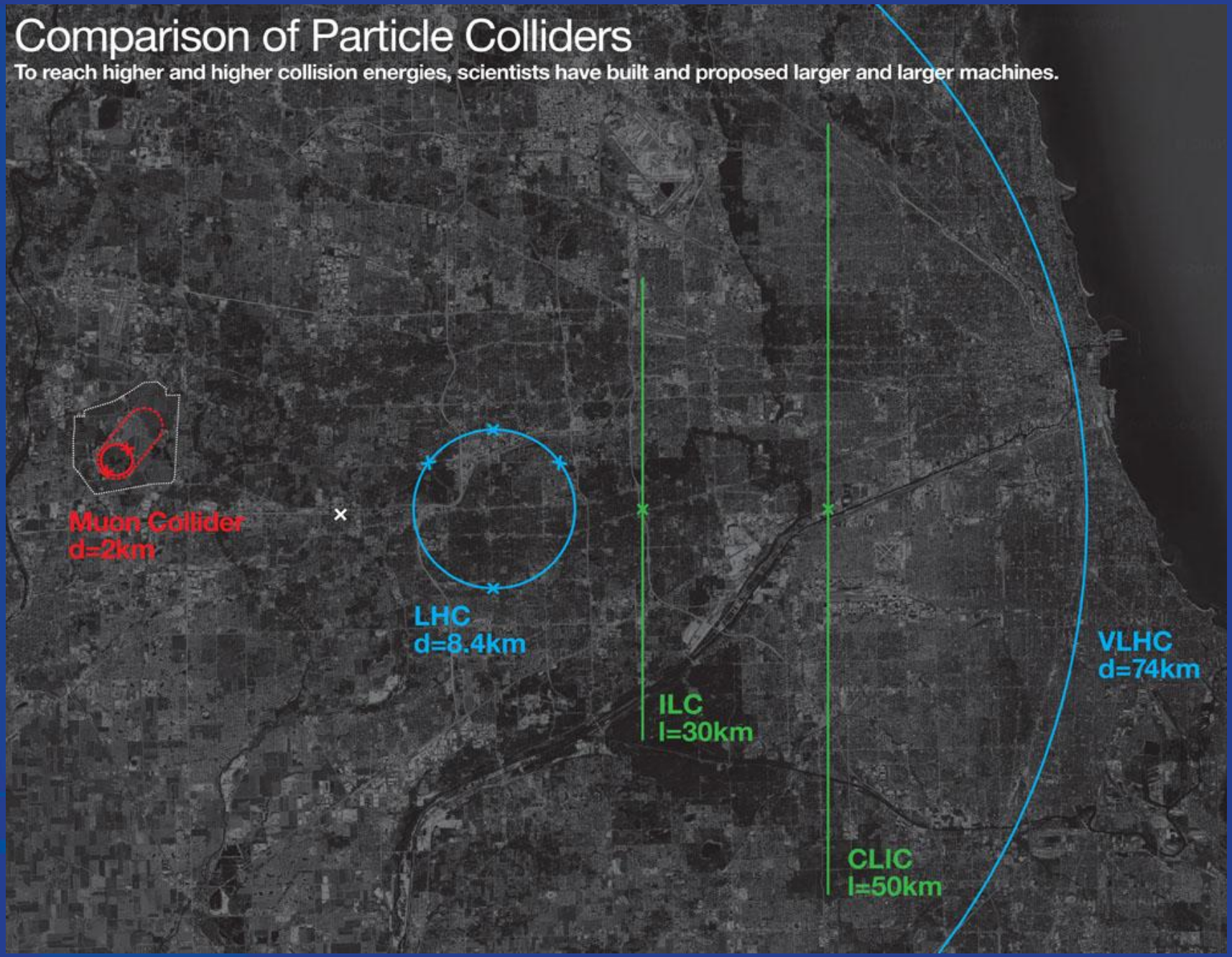
Vertical Test Stand

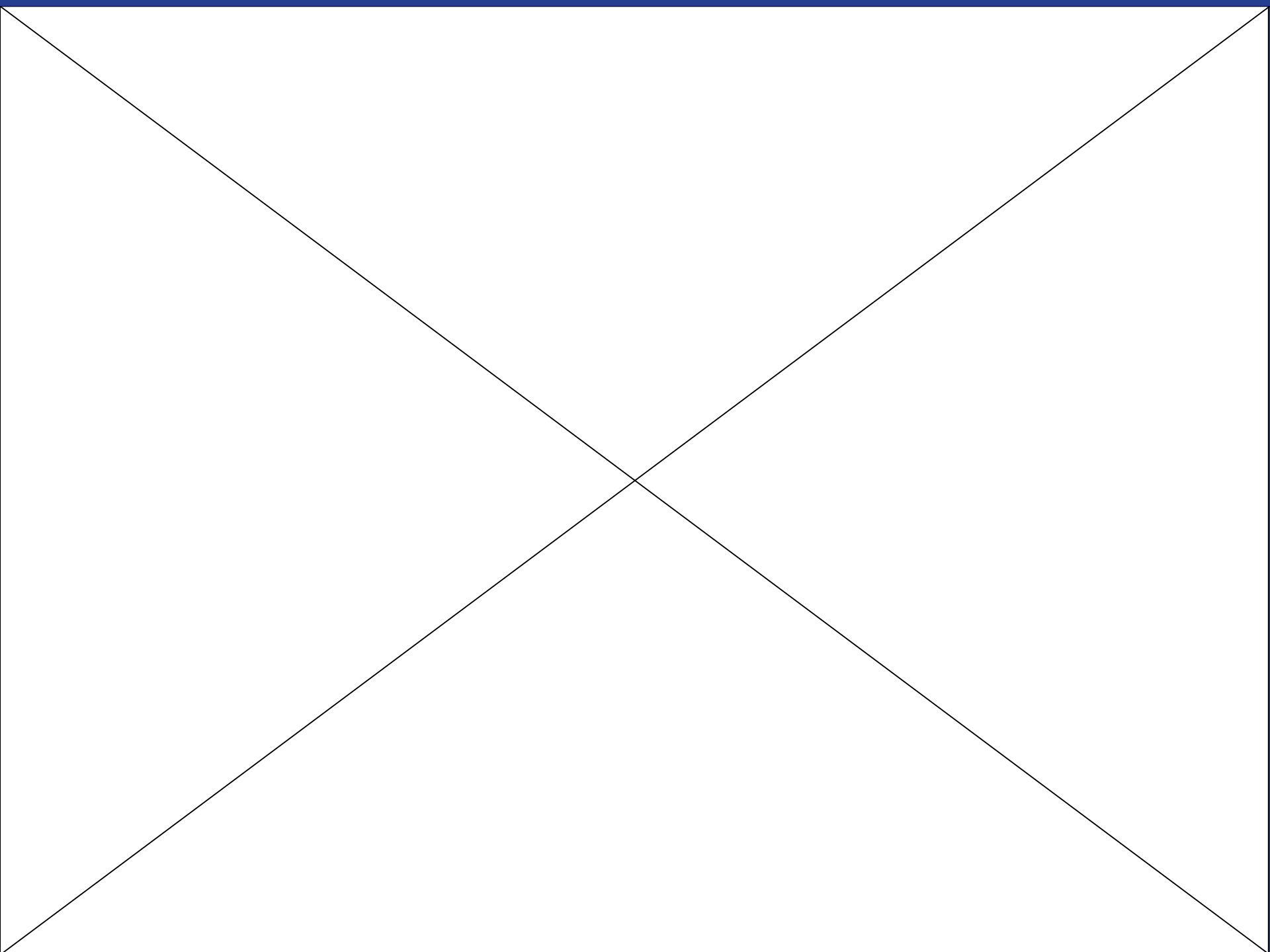
Horizontal Test Stand

1st cryomodule

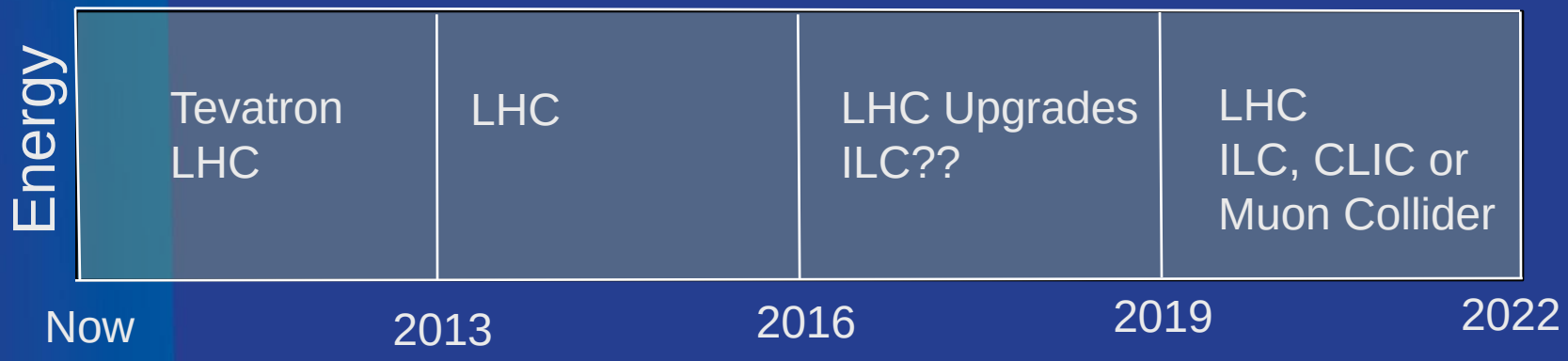
Muon Collider approach

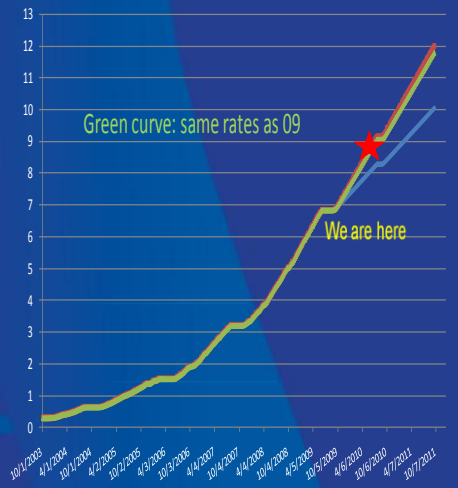
- Collider based on a secondary beam: we have experience basing colliders on antiprotons. For muons we must do it in 20 msec.
- The biggest advantages are: narrow energy spread (no beamstrahlung) and small physical footprint (no synchrotron radiation
- DOE OHEP has asked Fermilab to organized the national R&D program

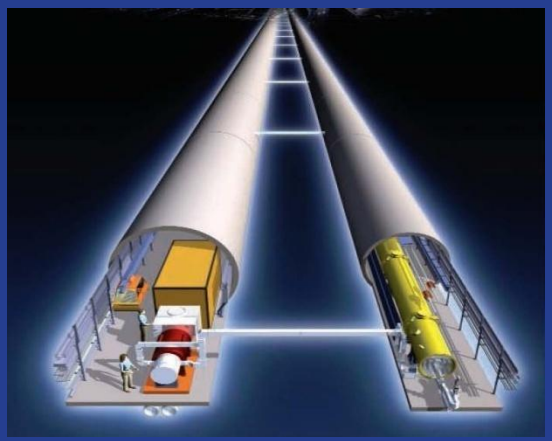

Comparison of Particle Colliders
To reach higher and higher collision energies, scientists have built and proposed larger and larger machines.
Muon Collider
d=2km
LHC
d=8.4km
ILC
l=30km
CLIC
l=50km
VLHC
d=74km



Energy frontier summary

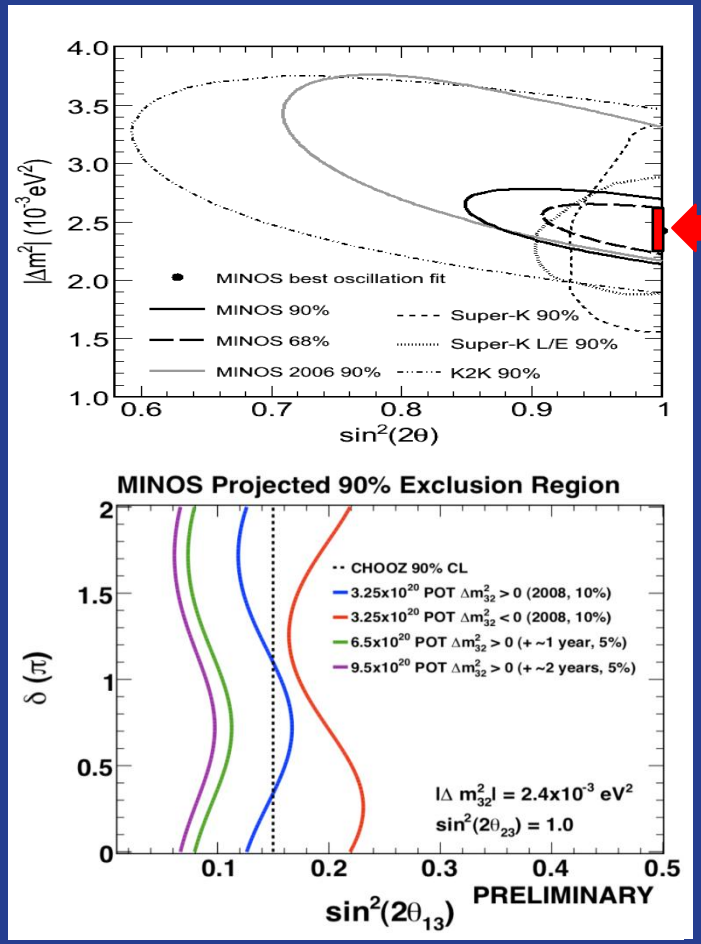






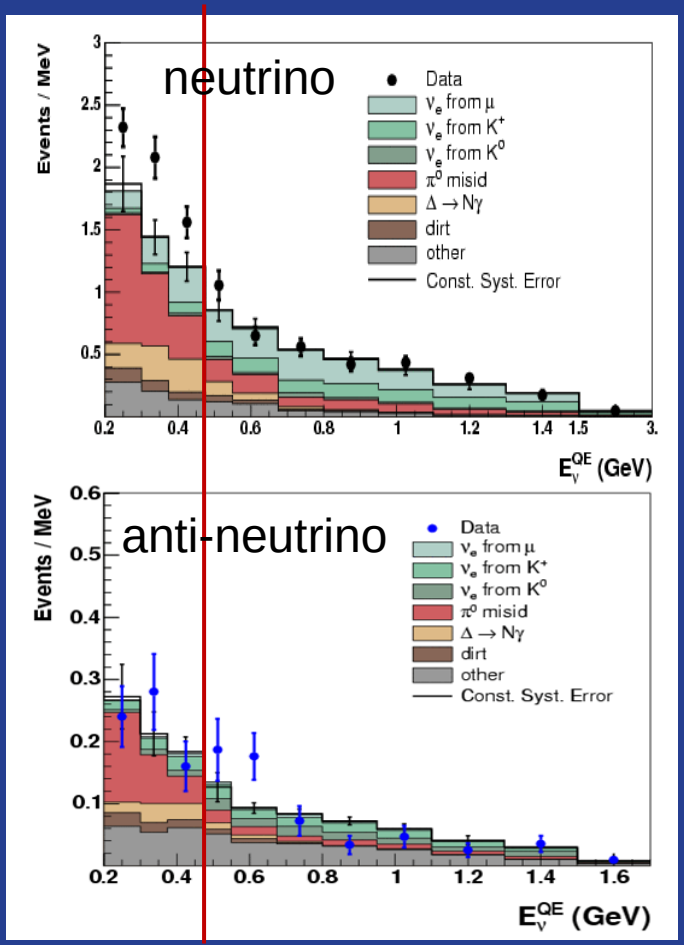
Intensity frontier: achievements

- MINOS:
  - Neutrino runs
    - best Δm^2_{23}
    - $\sin^2(2\theta_{13})$ limit
  - Anti-neutrino runs
    - CPT test
    - "blind analysis" results next week



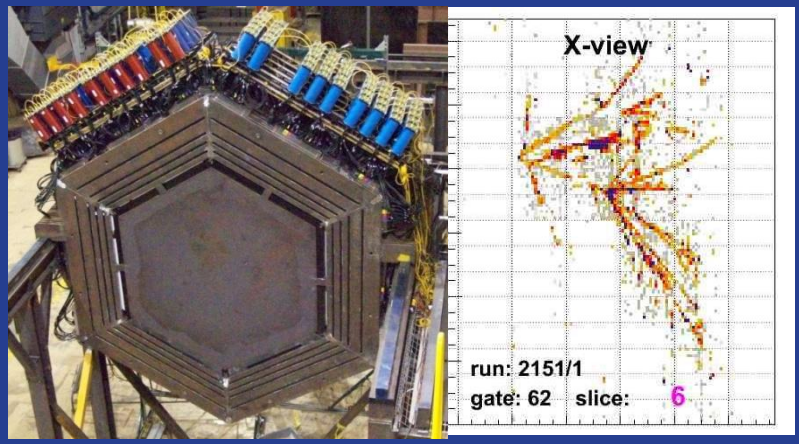
Intensity frontier: achievements (cont.)

- MiniBooNE
  - Neutrino runs
    - Anomalous
  - Antineutrino runs
    - New results next week (oscillation and low energy)

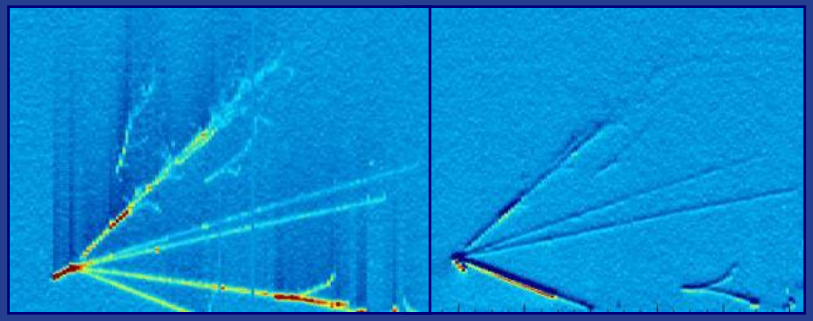


Intensity frontier: achievements (cont.)

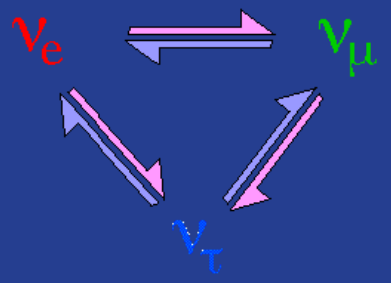
- MINERvA
  - CD-4 June 2010
  - ν interactions with various targets



- ArgoNeut
  - 0.3 ton LAr TPC
  - New ν detector technology



Intensity is key for neutrinos

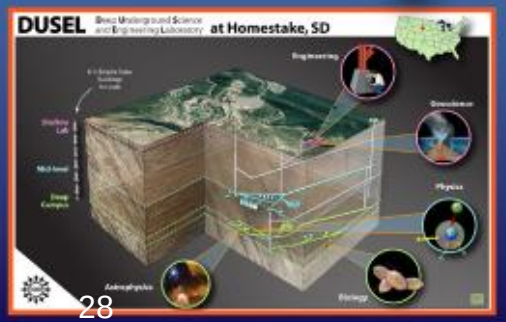


- Recent Discoveries
  - produced much excitement.
- Behave so different from other particles
- Possibly key to understand the matter-dominate Universe
- Unification
- Cosmic Connection
- This route like the energy path depends of what we find in the current generation of experiments

“Ultimate Goal”

multi MW beam
larger detector (a few 100 kton)
long distance (> 1,200 km)

2 MW (60-120 GeV)
1300 km



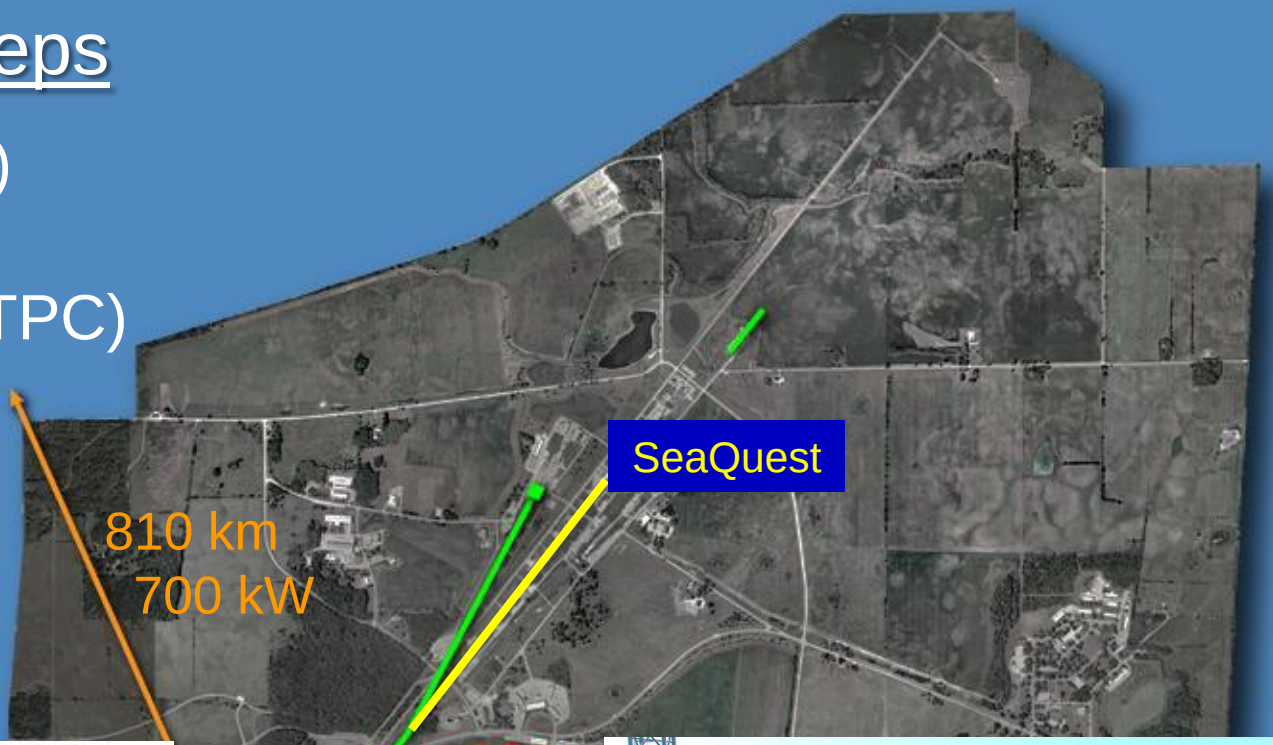
Project X provides:
neutrinos
muons
kaons
nuclei
“simultaneously”

DUSEL Deep Underground Science and Engineering Laboratory at Homestake, SD

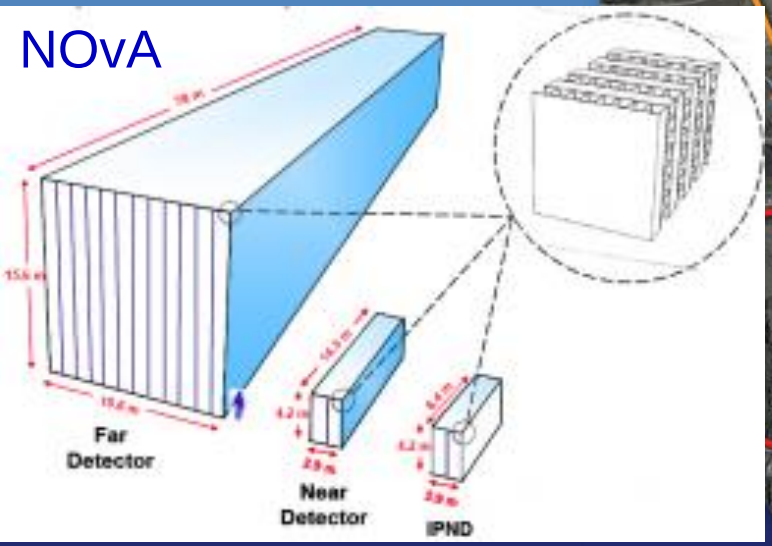
Ray Davis's Experiment

Intermediate Steps

NOvA (off-axis)
MINERvA
MicroBooNE (LAr TPC)



NOvA



NOvA Construction (ARRA)

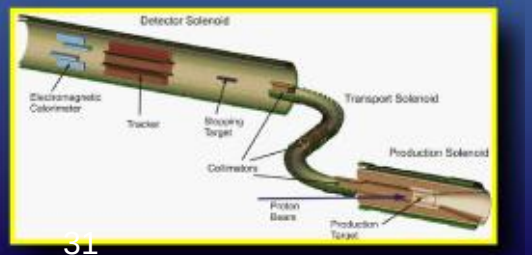
Intermediate Steps

Neutrinos:

LBNE (ν, proton decay, …)
(CD-0 approval)

Muons:

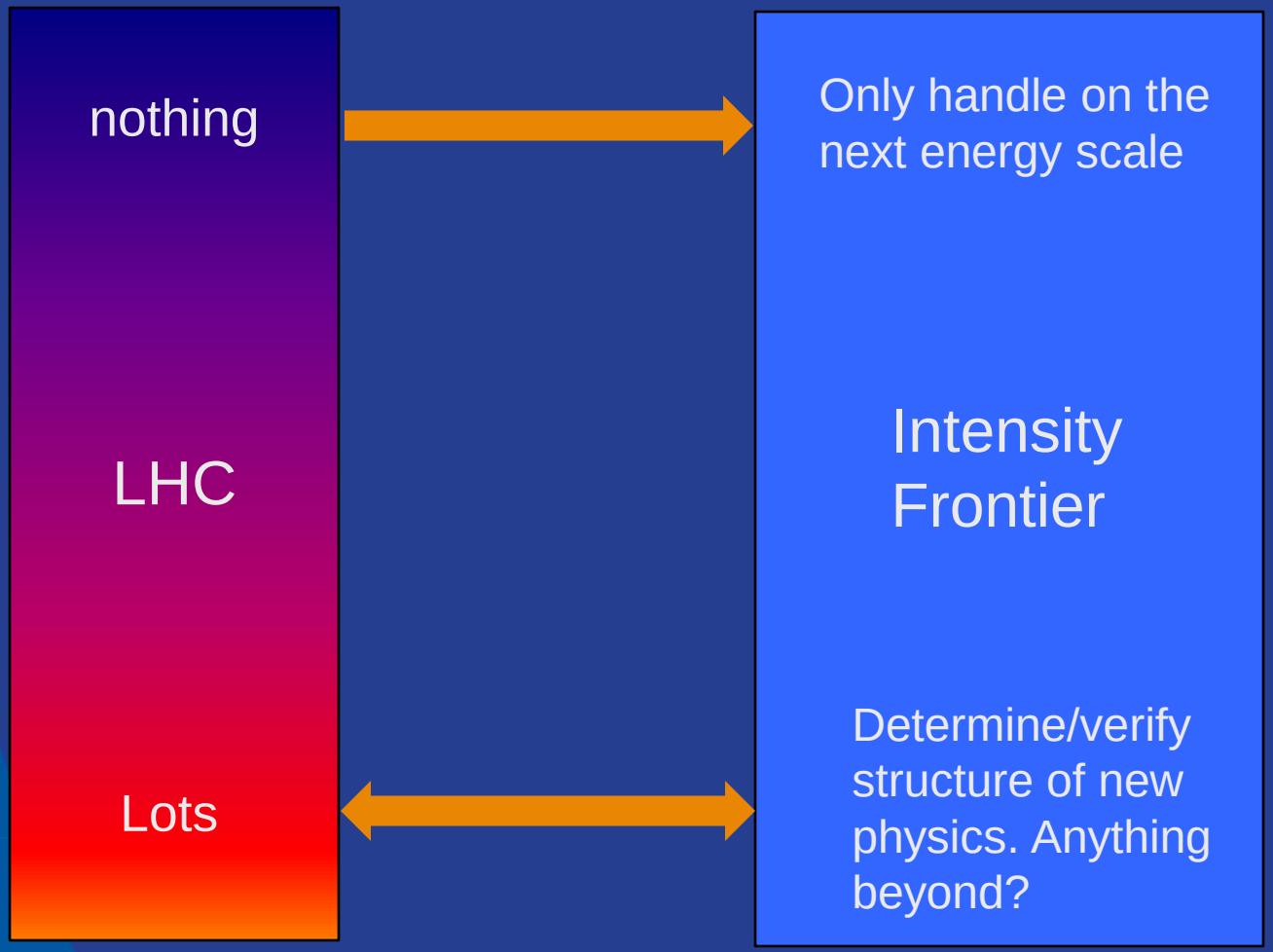
Mu2e (CD-0 approval)
μ g-2/EDM(DOE review in Aug)



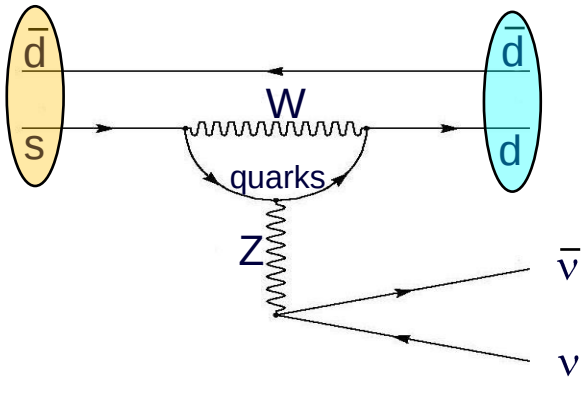
700 kW
1300 km

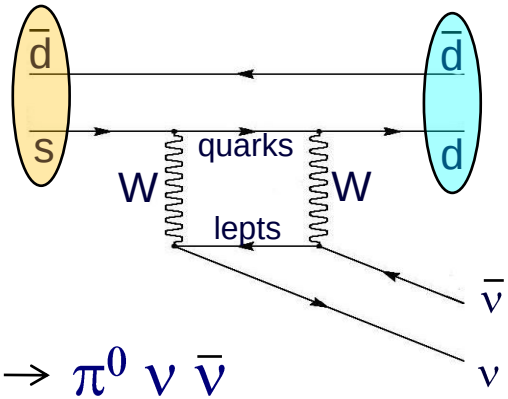
Kaons:
$K^+ \rightarrow \pi^+\nu\nu$
(proposed, but …)

Interplay: LHC ⟺ Intensity Frontier

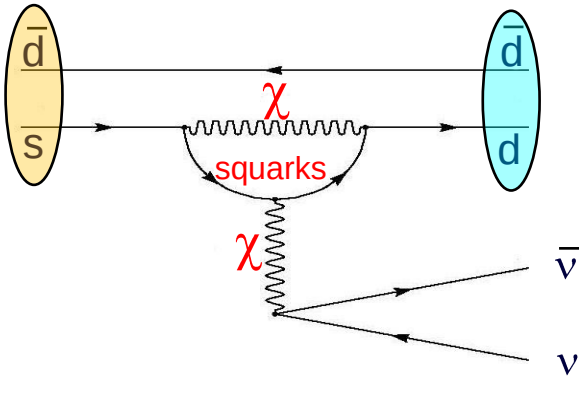


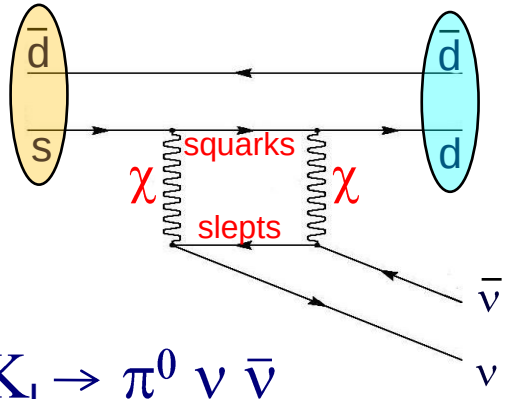
Large effects in kaon decay rates





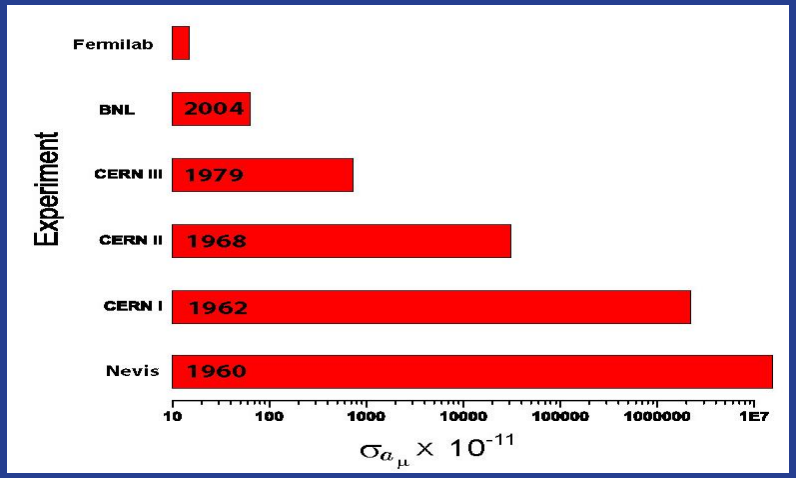
SM: $K_L \rightarrow \pi^0 \nu \bar{\nu}$

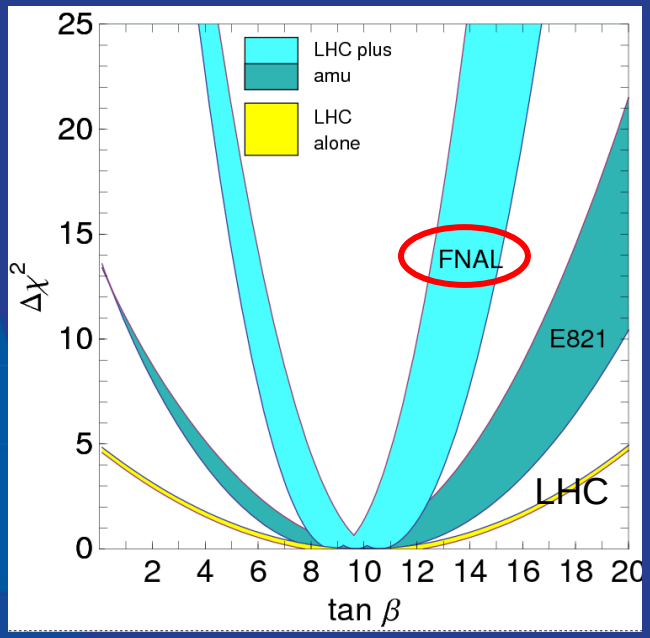


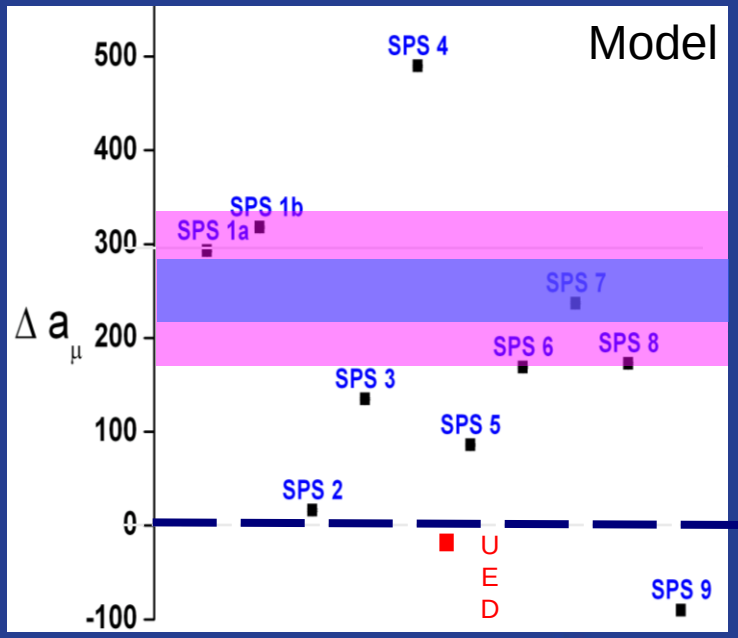


BSM: $K_L \rightarrow \pi^0 \nu \bar{\nu}$

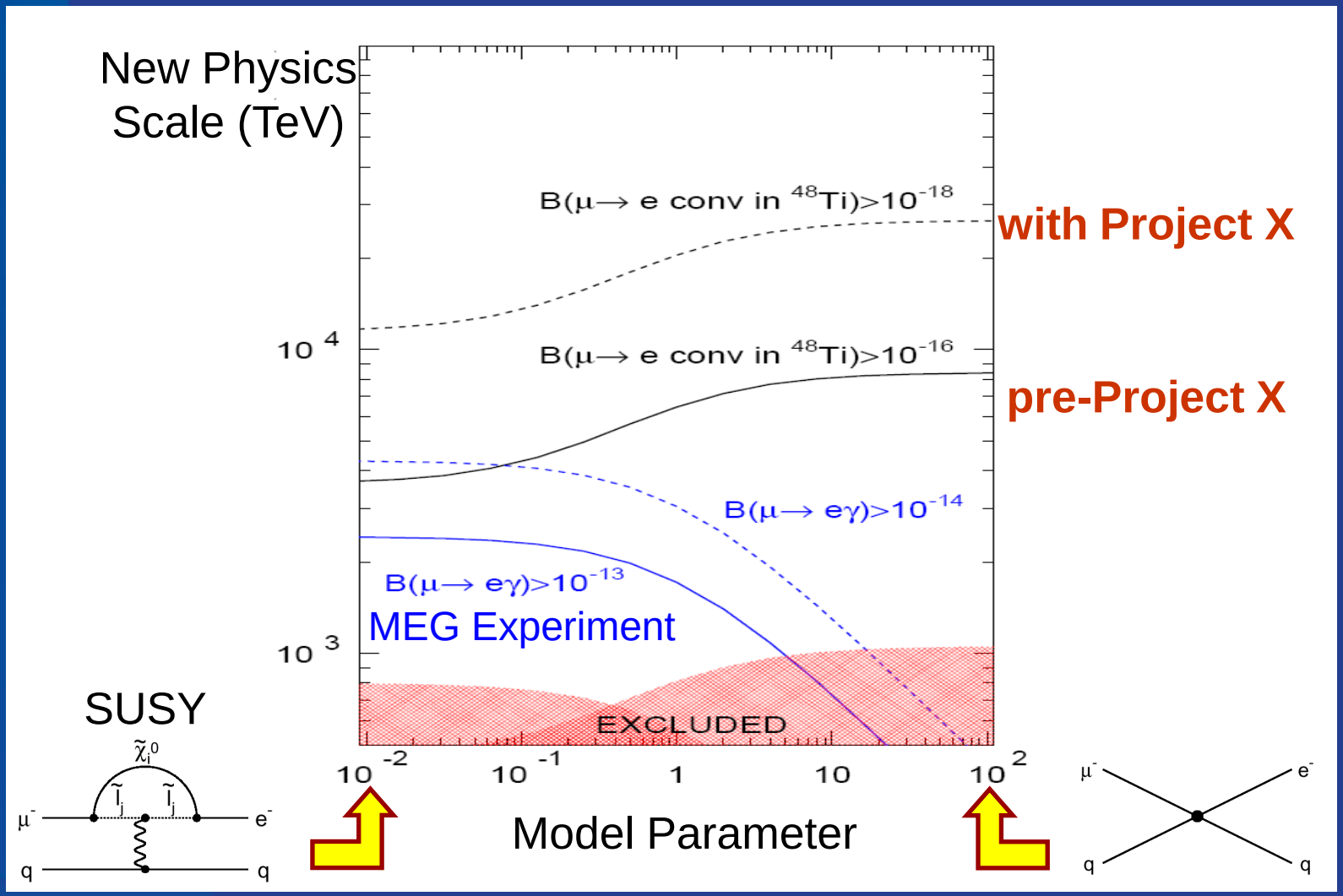
A new (g-2) to uncertainty $0.14*10^{-11}$



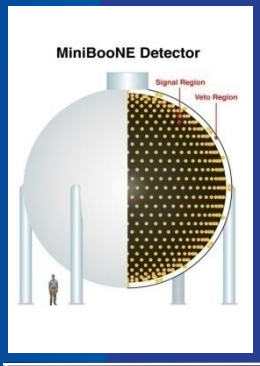


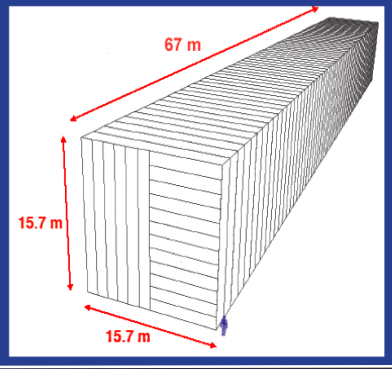


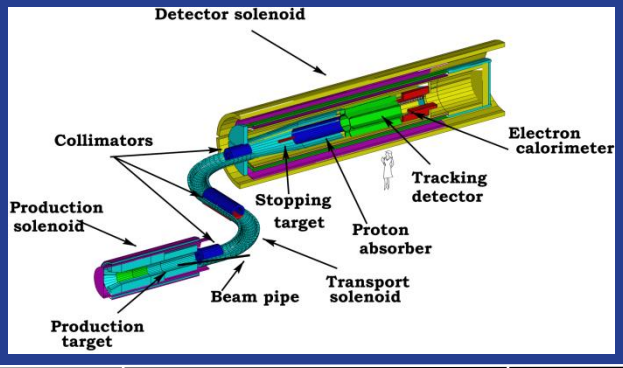
Mu2e can probe 10^3 – 10^4 TeV

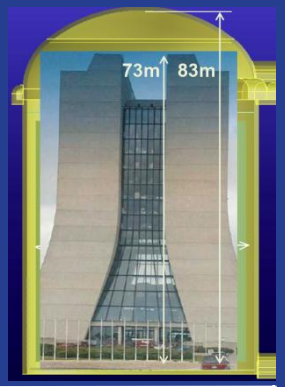


Summary: intensity frontier strategy



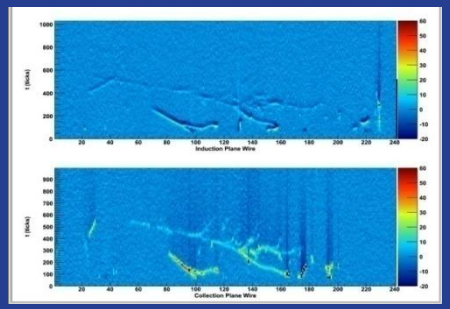


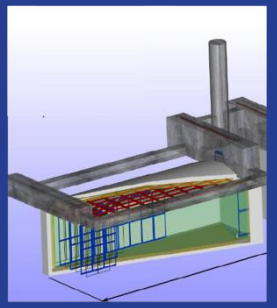




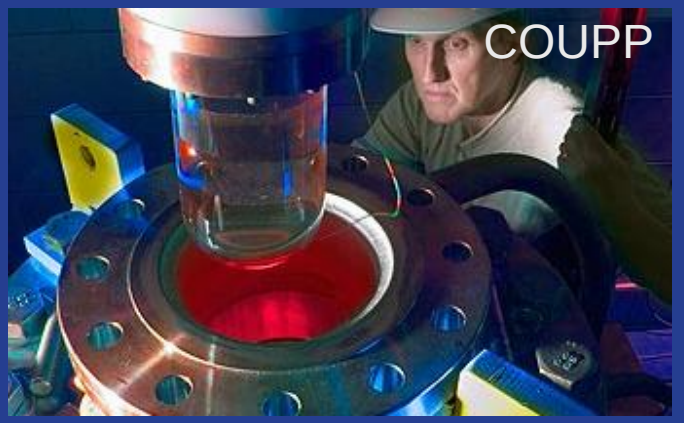
Intensity

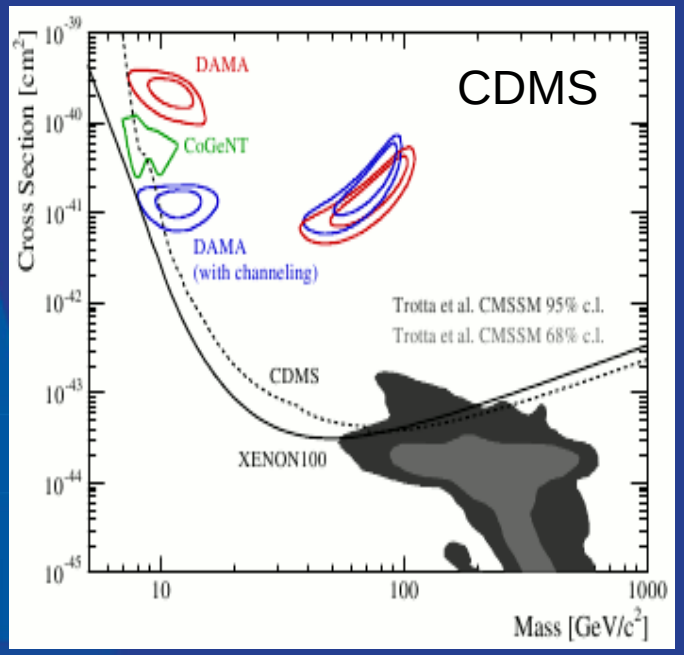
Now	2013	2016	2019	2022
MINOS MiniBooNE MINERvA SeqQuest	NOvA MicroBooNE g-2? SeaQuest	LBNE Mu2e	Project X+LBNE μ, K, nuclear, … ν Factory ??	

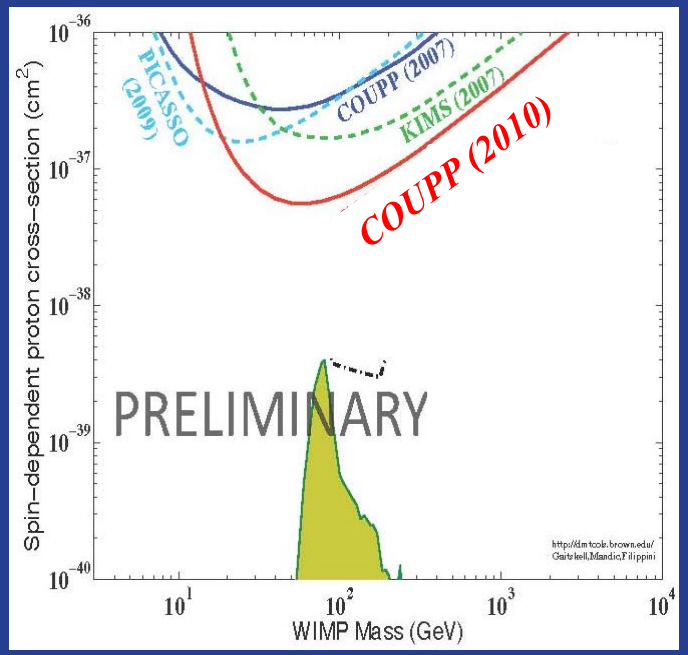




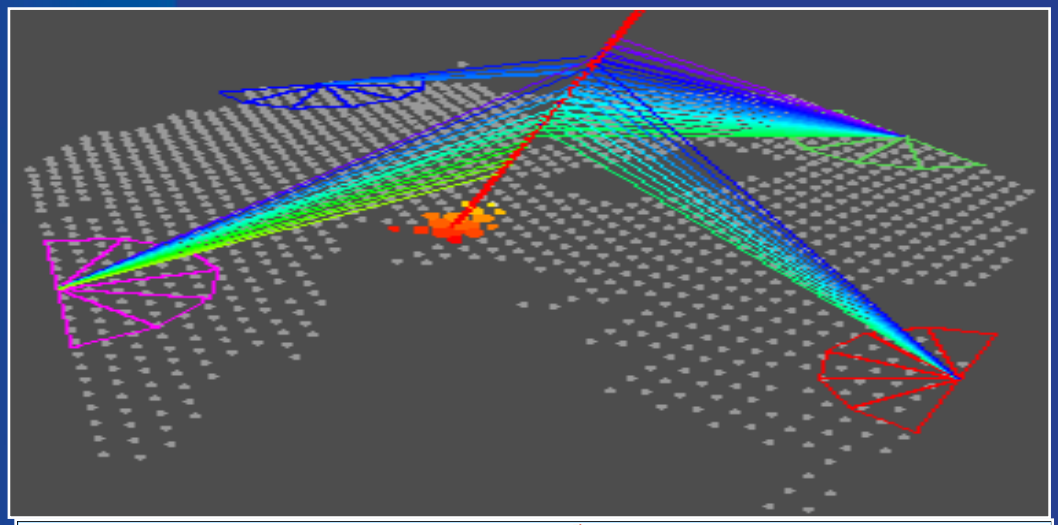
Cosmic Frontier: achievements

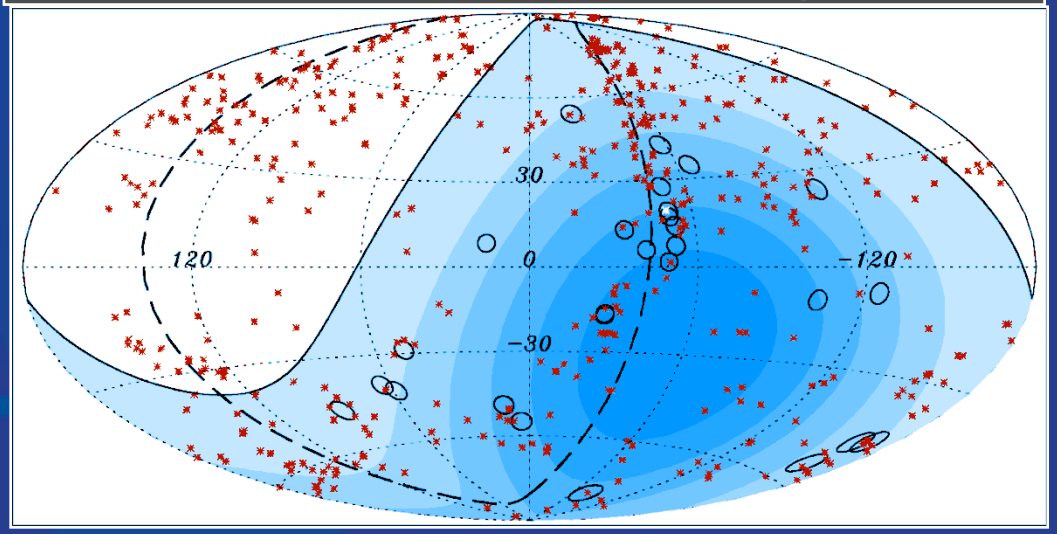






Present results: UHE Cosmic Rays





Auger Observatory studies ultra-high energy cosmic rays.

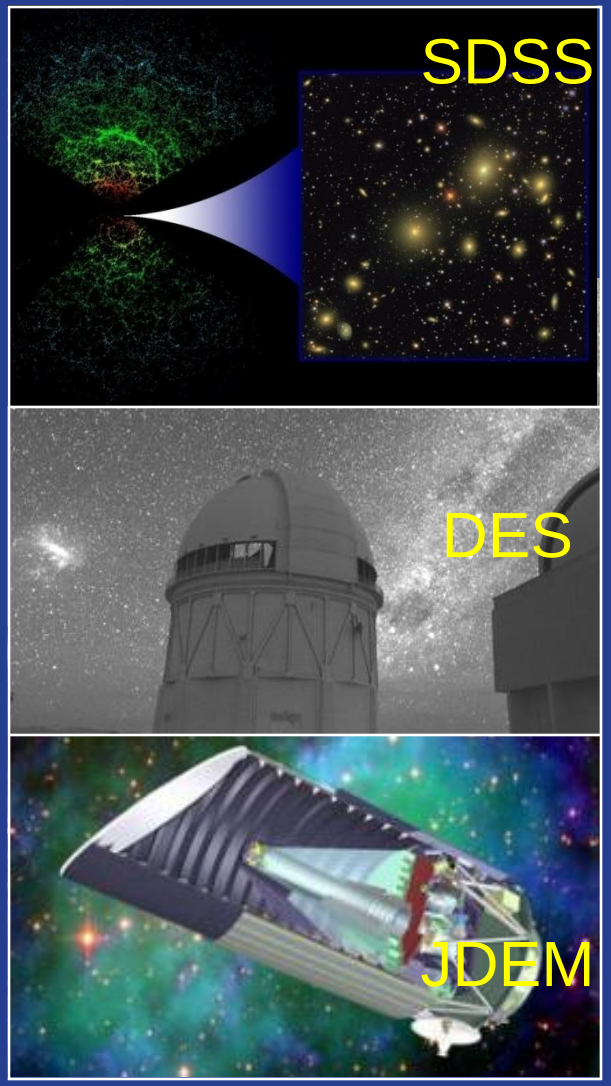
o – Cosmic rays with E > 57,000,000 TeV

Correlation

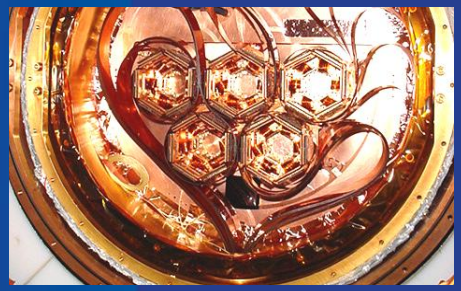
x – Active Galactic Nuclei

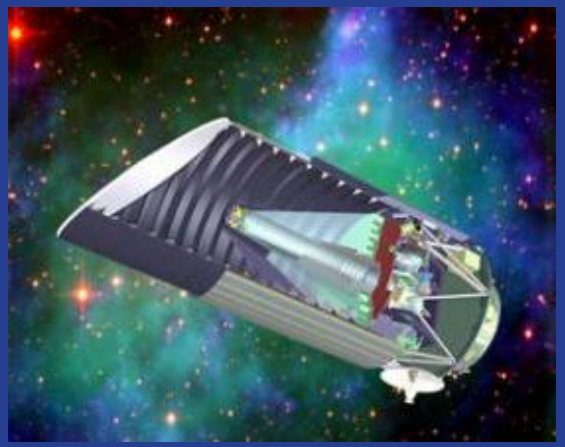
Dark Energy

1. SDSS (Sloan Digital Sky Survey)
   - Ranks as highest impact facility in astronomy for the 4rd year in a row.
   - Baryon acoustic oscillations
2. DES (Dark Energy Survey)
   - 4 meter telescope in Chile
   - DES Camera under construction
   - Operation: 2011 – 2016
3. JDEM (Joint Dark Energy Mission)
   - Space telescope
   - Fermilab: Science Operation Center



Summary: cosmic frontier strategy





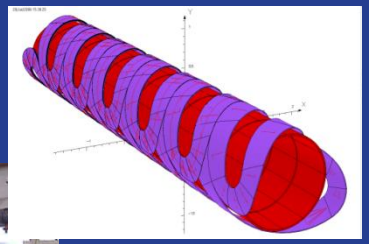
Cosmic				
	DM: ~10 kg DE: SDSS P. Auger	DM: ~100 kg DE: DES P. Auger North?	DM: ~1 ton DE: JDEM, .. Holometer?	DE: JDEM, …
	Now	2013	2016	2019 2022

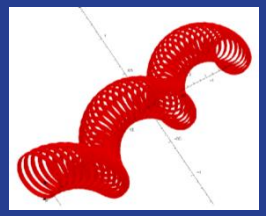
Risks

- Energy Frontier
  - Physics
  - Timeliness in which physics will come
  - Cost and feasibility of lepton colliders
- Intensity Frontier
  - Maintaining the momentum
  - International participation
- Cosmic Frontier
  - Uncertainty on space-based telescope

Work for Others

- Work for Others
  - Currently small < 0.5%





  - Future: open to opportunities aligned with core capabilities and assets

Collaborative Efforts

- International Collab.s for our programs

16 countries

23 countries

- Collaboration among DOE laboratories
  - Project X, ILC/SRF, Muon collider, neutrino factory, LHC Accelerator, many particle experiments, …
- Work for other DOE laboratories
- Argonne-UChicago-Fermilab Collaboration

Education (K-12, undergrads, public)

http://www.fnal.gov/pub/education/k-12_programs.html

- NSF, DOE, Fermilab Friends, Fee-based cost recovery
- CY2009: 45,390 teachers, students, general public
  - Regular teacher workshop: 98
  - Summer interns: 55
  - Summer teachers: 22
  - Students field trip: 8,693
  - Science adventure classes: 1,655
  - Visitors to science center: 3,011
  - Tours: 3,357 students;127 teachers;7,760 public
  - Classroom presentation: 14,689
  - Science Chicago Fest: 6,000
  - …..

Fermilab Mission Readiness

- Major Initiatives, related facilities / infrastructure
  - Over five years, capable of performing the mission
  - Power / cooling demands for computing remain an issue.
- Mission readiness depends on
  - SLI Utility Upgrade Project: CD-0 at $34.9M TPC
  - $32.1M in ARRA GPP in support of science programs.
- FY11-FY15 GPP
  - $19.5M total (based on overall lab budget levels)
  - Partially addresses needs of comp./det. infrastructure
- Great opportunity
  - $20M Illinois Accelerator Research Center (IARC) grant: aligned with mission, education, technology transfer

Fermilab Sustainability

- Energy consumption reduction
  - (excluding programs; 10% of total GHG) - 18.7% from the 2003 baseline; expecting to meet the 30% goal by 2015
- Water consumption reduction
  - 35.6% from the 2007 baseline; exceeds the 16% goal for 2015 – progress mostly from leak reduction pipe repairs
- Petroleum fuel reduction
  - 85% of fleet will be alternatively fueled vehicles by end of FY10; tracking to meet petroleum fuel reduction goal
- Green House Gas reduction
  - 90% of GHG - accelerator complex, detectors, computing
  - Significant reduction right after the Tevatron shuts down + increase from new projects.

Cost of Doing Business

Major Drivers ($M)

	FY05	FY06	FY07	FY08	FY09	FY10
Electric Power	$18.3	$21.3	$25.0	$27.9	$27.7	$24.0
IT / Cyber Security	$14.4	$13.7	$14.7	$16.5	$22.4	$23.9
Facilities Maintenance	$9.1	$9.4	$11.8	$12.6	$15.1	$13.9
Health Care Benefit	$22.0	$23.2	$21.5	$23.0	$23.9	$24.0
TOTAL	$63.8	$67.6	$73.0	$80.0	$89.1	$85.8

Increase in Major Drivers

- Electrical Power:
  - Competitive procurements through DOD Defense Energy Supply Center
  - Locked in FY10 at low rate due to economy
- IT/Cyber Security:
  - IT consolidation reclassification of some direct costs
  - ISO20000 certification initiative
- Facilities Maintenance:
  - Significant aging infrastructure (power/water)
  - SLI will be effective in reducing this line
  - Deal with Batavia on power lines saved $5M
- Employee Benefits/Health Care:
  - Aging workforce (increase)
  - Aggressive negotiation with insurance carriers (decrease)
  - Increase cost burden by employees and retirees

Top initiatives competing for overheads

- IT Engineering Process Initiative
- Consolidation and standardization (ISO20000)
- Integrated Quality Assurance Program
- Workforce planning
- Lab-wide work breakdown structure initiative
- ES&H initiatives
- Modernization of Information Systems and Business processes
- EVMS

Performance To Date

- Expect to meet all “Notable Outcomes”
- “Beyond Notable Outcomes”
  - Towards one laboratory system integration
    - Lab’s strategic plan, workforce planning, 10 year facility plan, master plan, lab-wide work breakdown structure, time and labor system, human resources database, project management software, engineering manual
  - Better working place
    - Focus groups (10% staff + users) and recommendations
    - Employee advisory group as a sounding board for proper implementation
  - Certified
    - EVMS, towards ISO20000

Appendix A: Performance to Date (Notable Outcomes)

Goal 1.0, 2.0, and 3.0

Obj	Notable Outcome	Status / Projection
1.1	CDF and D-Zero will improve the exclusion limits on the allowed mass of a standard model Higgs Boson, and continue to study the most pressing Standard Model issues accessible at the Tevatron	On track: in FY2010 so far • New Higgs limits • 80 new results
2.1	The Long Baseline Neutrino Experiment will make satisfactory progress toward CD-1 as determined by a peer review held in FY 2010	Significant progress made; Director's Review in July to evaluate CD-1 preparations
2.2	The NOvA Project continue to progress towards completion on time and with budget.	CD-3b in Oct 2009; DOE OECM rating from yellow to green in Nov. 2009; Expect to be complete complete on time and with budget
2.3	The Tevatron and NuMI will deliver at least as much data as in FY2009	• Tevatron – on track • NuMI – already achieved
3.2	The Laboratory will make progress in matching their staffing to the needs of the planned program.	On track: Lab-wide annual process "OHAP (Organization and Human Asset Plan)" as a tool

Goal 4.0

Obj	Notable Outcome	Status / Projection
4.1	Lab leadership will develop a strategic plan for the future scientific & technical activities of the Lab, which aligns with the Office of Science and Department goals, and a detailed strategy for executing the plan during the next 2-5 years.	The strategic plan documented, made publicly available; Implementing this plan together with DOE HEP; OHAP – staffing plan to support the strategic plan (Objective 3.2)
4.2	Lab. leadership will make significant progress in defining and implementing its contractor assurance system. It is expected that a collaborative and uniform approach to this issue among all contractors will be evident.	On track: Completed • Root Cause Analysis Training & Graded Approach • Suspect/Counterfeit Program • Lessons Learned Program • Corrective Action / Preventive Action Procedure • Management (Self) Assessment Procedure • Science As-Is Assessment
4.3	The contractor will fill all key leadership positions at the Lab in a timely manner.	Appointed: • AD for Computing, Science & Technology / CIO • AD for Accelerators In search: Head of OPMO

Goal 5.0

Obj	Notable Outcome	Status / Projection
5.1	Maintain ISO 14001 & OHSAS 18001 Registrations, as evidenced by successful completion of third-party surveillance audits conducted roughly every six months.	Surveillance audit in Oct. 09 Recertification audit in Jun. 10 Many new Initiatives
5.2	Meet planned FY2010 milestones contained in the Corrective Action Plan that is being developed in response to the Mar 2009 Accelerator Safety Review.	• 3 of 4 corrective actions completed on or ahead of schedule • The 4th's completion date is 2014.
5.3	In support of the Federal Electronics Challenge and the requirements of Executive Order 13423, reduce the environmental impact of using personal computers (including laptops), monitors and printers. During FY2010, establish formal policies & procedures on energy efficient computing. Procurements of computers for scientific programming will include energy efficiency in the evaluation criteria for the procurement. A baseline assessment of the Lab's EPEAT system performance will be conducted by the end of third quarter, FY 2010.	Oct. 2009 – Jan. 2010: 88% purchase EPEAT registered Feb. 2010 – April 2010: 98% purchase EPEAT registered For large procurements, scientific computing energy efficiency was included in RFP – an awarded point in the bid evaluation process

Goal 6.0

Obj	Notable Outcome	Status / Projection
6.1	Complete full implementation of the electronic Time and Labor System by the end of 3rd quarter, 2010.	Adopted Kronos timecard Go-live late June
6.1	Efficiently and effectively manages all activities in conjunction with the ARRA funding in accordance with all rules and requirements. No significant OIG or FNAL Internal Audit findings will serve as the measurement of success in meeting this notable target.	Milestones met; Costing rate accelerating; Procurement kept up. IG report, CH review → no issues identified
6.2	Demonstrates the effectiveness of its procurement systems as evidenced by achieving a comprehensive score of 90 out of 100 on the DOE approved Procurement Balanced Scorecard.	Achieved so far (94/100); Expect to be 94 or 95 by end FY2010
6.3	Upgrade its vehicle fleet maintenance software from the current FOCUS database to the Sunflower Maintenance module, thereby replacing an unsupported system with a more modern system that is integrated with other Property management(Sunflower) software. This will ensure the long term viability of the fleet management system	Achieved
6.4	Design/implement a Succession Plan and Executive Pay Grade Structure for senior management positions (Deputy Director, COO/Associate Director, CFO, and CIOO) by the end of 4th quarter, FY 2010.	Succession Plan expect to be done by June 2010. Pay Grade Structure implementation by July 2010
6.5	Completes scheduled FY2010 milestones and key activities identified in the DOE approved Quality Implementation Plan for an Integrated Quality Assurance program. Complete the start up of the Assessment Program and have it fully operational by the end of 3rd quarter, FY2010, in addition to implementing the Lessons Learned Program by 2nd quarter, FY2010	On track

Goal 7.0

Obj	Notable Outcome	Status / Projection
7.1	Update the FNAL Transformational Energy Action Management (TEAM) Executable Plan (EP) for FSO approval by the date specified in the DOE Guidance. FNAL will meet specific FY 2010 goals established in this EP.	EP updated and approved by the date requested All FY 2010 EP goals expected to be met
7.2	Develop a Mission Readiness Plan for FY2010 which includes participation in two peer reviews and the development of FNAL Mission Readiness policies and procedures. This plan will be implemented by the end of 3rd quarter, FY2010.	Developed drafts of Director's Policy on planning that includes mission readiness, and a draft process for the Annual Lab Plan including the Facility Mission Matrix 3 Peer Reviews: ANL (Nov. 2009), PPPL(Jul.2010),TJNAF (Sep.2010)
7.2	Complete final designs and start construction on ARRA General Plant Projects (GPP) Augmentation covered under Work Authorization Number KA/CH14/9/ARRA-1, consistent with established milestones in the approved Project Operating Plans.	Final designs were completed, and construction is underway on 6 ARRA GPP projects All milestones have been met

Goal 8.0

Obj	Notable Outcome	Status / Projection
8.1	A joint FNAL/FSO review of the Emergency Management Program will be performed no later than the end of third quarter, FY 2010. Corrective actions and lessons learned will be developed as appropriate.	Review complete Revisited Continuity of Operations Plan, call lists, etc. Fall 2009 with H1N1 Recent event with fatality in Wilson Hall clearly tested the emergency program. Lessons learned are in progress
8.2	In accordance with the FNAL Corrective Action Plan Addressing S&S Cyber Security Findings, dated May 2009, all computers will be monitored using centrally managed tools to inspect the configuration for compliance with Microsoft Windows Workstation Class Baseline Security Configuration by the end of July 2010.	Tremendous progress made All milestones expected to be met
8.2	All FNAL employees responsible for handling PII will receive training by the end of first quarter, FY 2010, and a review will be conducted of all applications in the ES&H area to clarify the need to maintain and handle PII. A new set of security plans will be written and approved in response to this review by June 2010.	PII training – Achieved Extensive survey of all ES&H systems were carried out

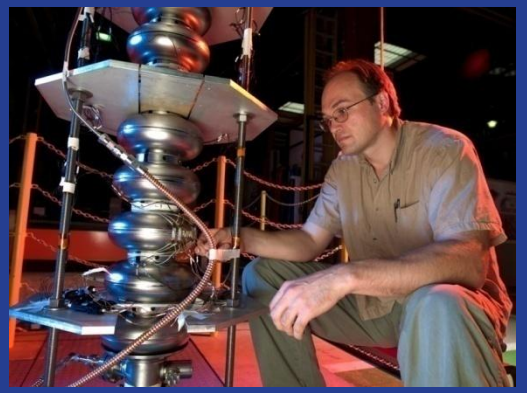
Appendix B: ARRA Activities

http://www.fnal.gov/recovery/

ARRA: NOvA

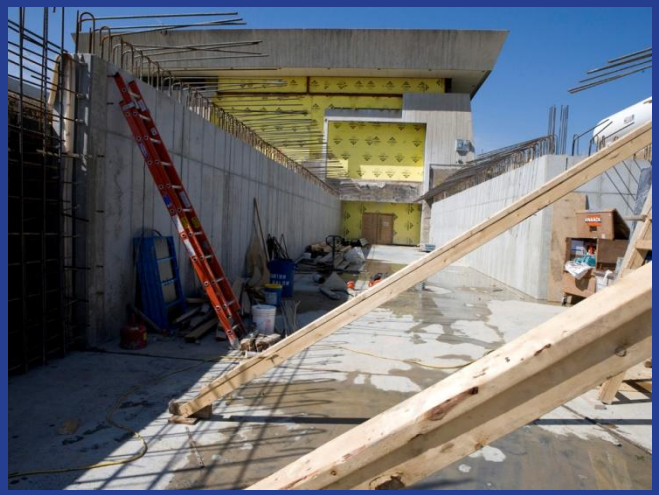
ARRA: SCRF

cavity fabricated
by joint venture of Roark and Niowave



Cryostats for SCRF Cavity Testing

ARRA: GPP (NML Extension)

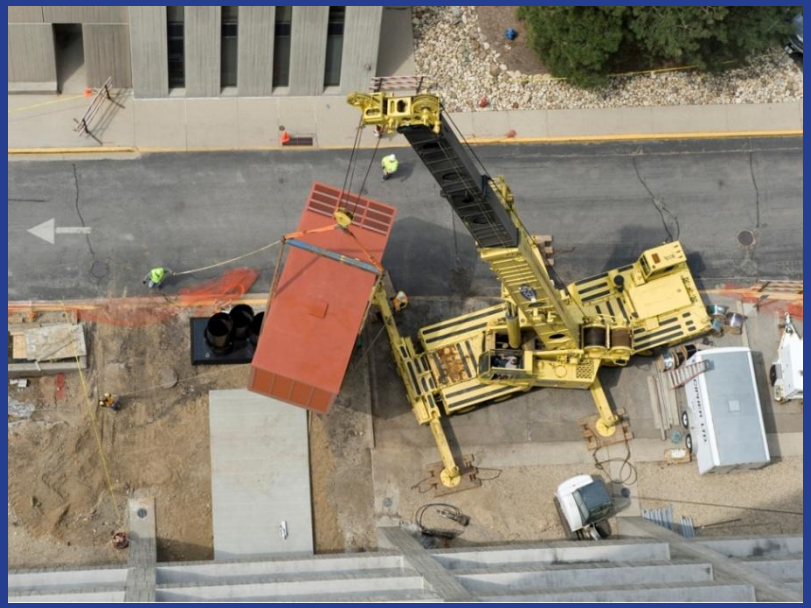


ARRA: GPP (IB-3)

ARRA: GPP (MI-8)

ARRA: GPP (Feynman Comp. Center)

ARRA: GPP(Wilson Hall Generator)



ARRA: LBNE (Seismic Testing &Drilling)