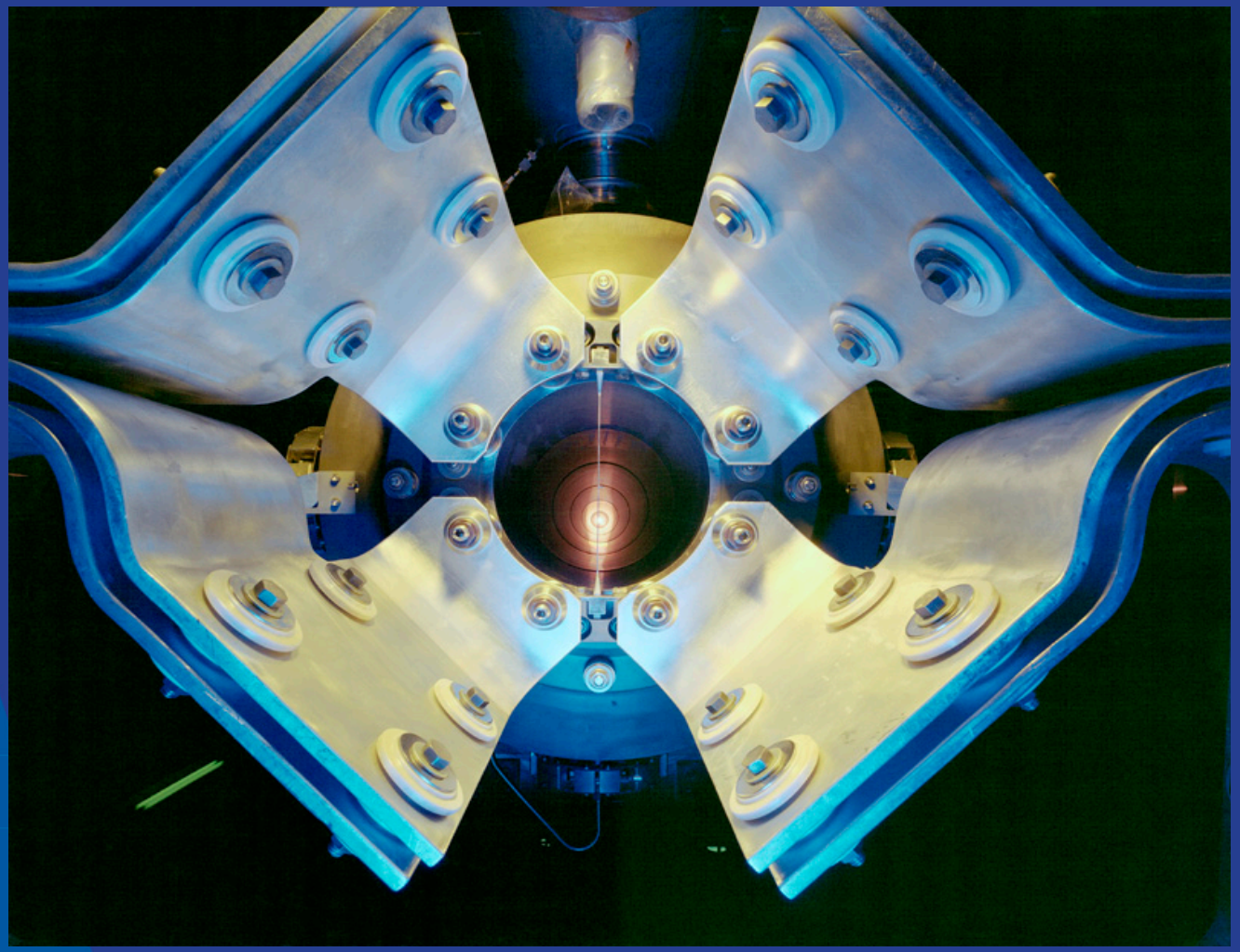
Fermilab: The State of the Lab

Pier Oddone, February 27th, 2012



U.S. DEPARTMENT OF ENERGY

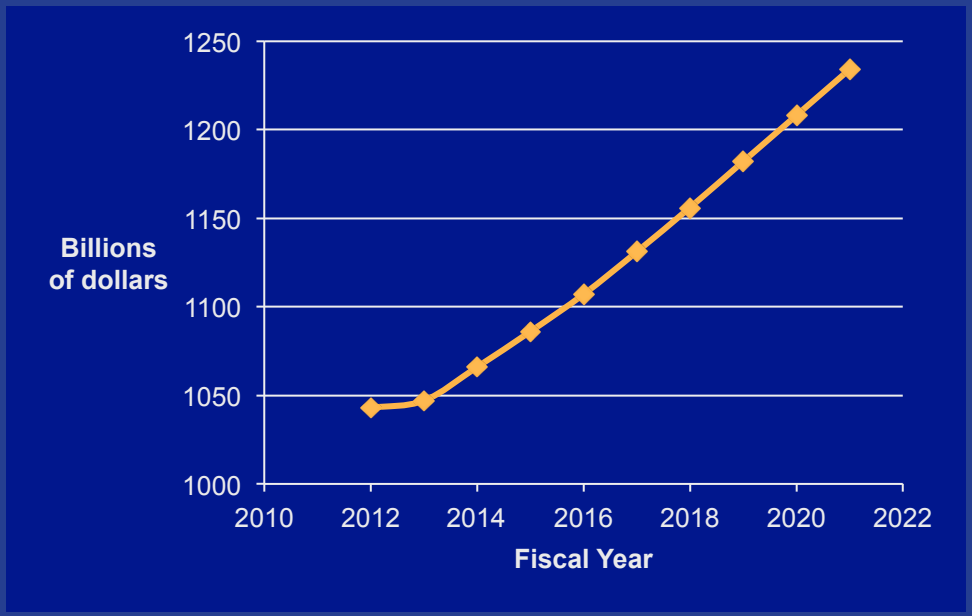
Fermilab

The President's Budget

- On February 13th the President submitted his budget request to Congress for FY2013 (the PBR)
- It is a highly constrained budget: both the President's budget and whatever budget Congress ultimately agrees to must fit the spending caps established by the Budget Control Act of 2011 (BCA2011)
- The BCA2011 sets caps for the years 2012 through 2021 for all discretionary spending. These caps are essentially flat from 2012 through 2021 with a small allowance for inflation

Budget Control Act

Fiscal Year	Budget Authority in $B
2012	1043
2013	1047
2014	1066
2015	1086
2016	1107
2017	1131
2018	1156
2019	1182
2020	1208
2021	1234



These numbers apply to both domestic and military expenditures (except for wars – they have a separate cap!). With these caps, the budget increases for the President's priorities must come at the expense of other areas of the budget.

DOE in the PBR

- The DOE fared quite well since it is at the leading edge of the Administration priorities in the development of green energy and advanced manufacturing. Among the proposed increases for programs at DOE:

DOE Office	% change from FY12 → FY13	FY13 PBR request in $B	Drivers
Science	2.4%	4,992	End-use inspired research, new materials, bioenergy
EERE (Energy Effciency…)	25.3%	2,267	Advanced manufacturing; Biomass/ biorefinery; Buildings and vehicles technology
Nuclear Energy	0.7%	770	
ARPA-E	27.3%	420	New and advanced energy technologies
DOE Defense Activities	5.5%	17,743	Non-proliferation; clean-up; weapons activities

Office of Science in the PBR

- Very strong priority given to programs that are coupled to green energy and advanced manufacturing: BER, BES and ASCR. Resources increase significantly in these areas, continuing the trend of the last decade toward end-use inspired basic research and applied research

- As a result, the budget creates crisis in the other program areas (FES, HEP, NP). These areas need some growth to accommodate planned facilities. We need investment at Fermilab for the long range projects that will take a decade to build

Office of Science in the PBR

	FY 2012 Enacted	FY 2013 Request	Request vs. FY 2012
Science	**4,873,634**	**4,992,052***	**118,418 (2.4%)**
Advanced Scientific Computing Research	440,868	455,593	14,725 (3.3%)
Basic Energy Sciences	1,688,093	1,799,592	111,499 (6.6%)
Biological and Environmental Research	609,557	625,347	15,790 (2.6%)
Fusion Energy Sciences	400,996	398,324	-2,672 (0.7%)
High-energy Physics	790,860	776,521	-14,339 (1.8%)
Nuclear Physics	547,387	526,938	-20,449 (3.7%)
Workforce Development for Teachers and Scientists	18,500	14,500	-4,000 (21.6%)
Science Laboratories Infrastructure	111,800	117,790	5,990 (5.4%)

Office of Science in the PBR

- FUSION: the ITER project ramps up from $105M in FY12 to $150M in FY13 within an overall declining budget for fusion. As a consequence the domestic program is cut by 15%, a sharp reduction in domestic facilities and research. Since ITER has to more than double in future years, there will be future pressures on fusion and/or the rest of the program of Office of Science

- NUCLEAR PHYSICS: suffers the sharpest overall reduction (3.7%) at a time that FRIB is started and required increasing budgets. Flat or declining budgets in the future do not allow to build FRIB and maintain operations at RHIC and JLAB

High Energy Physics under the PBR

- HEP: suffers a 1.8% cut. However the major cuts affect Fermilab much more deeply:
  - The Long Baseline Neutrino Experiment was cut from the number proposed by OHEP by $25M to a keep-alive level of $10M, less than half of what we have in FY12
  - The ILC was zeroed in FY13. We are receiving nearly $10M of these R&D funds in FY12 and had planned to ramp down by some 35% but not by 100%
  - The profile for Mu2e experiment was slowed from the expected profile by $5M
- The bottom line is that the budget of the laboratory drops from $395M to $365M after significant help by OHEP. Our bottom line in FY11 was $407M

Next steps

- Presently budgets are set year-by-year and every year the priorities remain the same: green energy, climate change, industrial innovation and advanced manufacturing. If the situation is not stabilized at some level for the more fundamental science programs, these programs will shrink far below our competitors in Europe and Asia
- We are trying to elevate the debate to the highest levels of the Administration and to make sure that there is a well understood plan for the more fundamental aspects of research such as ours
- Congress will take up the debate next

Next steps in the budget process

- We expect that both House and Senate Appropriation Committees will mark (modify) the bills. The committees will work with the established caps in the BCA2011.
- There is a strong possibility that the appropriation bills will not be finished before the election, in which case we would be in a continuing resolution (CR) until well after the election
- A complicating factor this year is the automatic sequestering that, in principle, kicks in January of FY13 due to the failure of the Congressional Joint Committee on Deficit Reduction to reach agreement. These cuts would be across all discretionary spending and would be automatic

Next steps in the budget process

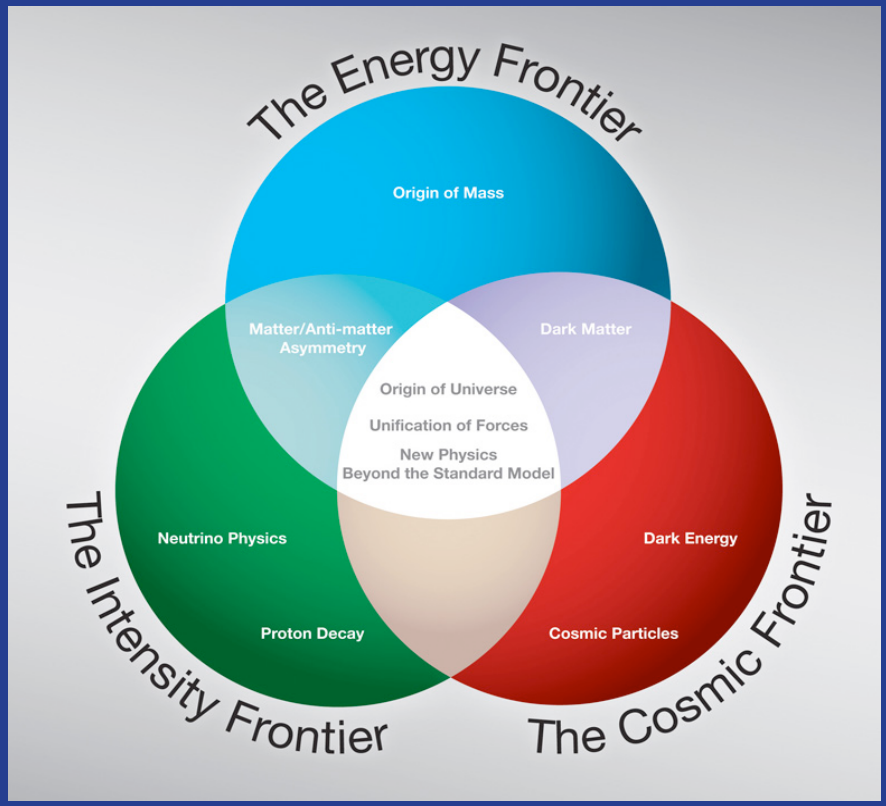
- We have ongoing discussions with OHEP and the Office of Science on our future program and on how we handle the proposed cuts.
- We are keeping Congress informed of the consequences of the proposed cuts, especially regarding the future of particle physics. The US and Fermilab have been leaders in this field. To maintain that role, we need continuity and some new investments.
- If a cap is rigorously applied to Office of Science there will be severe consequences for all new facilities, especially since the caps extend for a decade and they are considered to be real limits

An age of uncertainty….

- We have to live with uncertainty for the next year. At best, Congress could attenuate the cuts significantly. At worst, sequestration in FY2013 could make them even worse
- Every $10M cut translates into roughly 50 jobs lost. We will not announce any moves regarding workforce restructuring until we have understood the best path forward. It will take at least a couple of months. In the meantime we will do various exercises to prepare
- Most importantly we need to continue to produce excellent science, operate our facilities safely, keep our projects on track, continue to deliver value for the funding we receive and continue to make the case for fundamental research

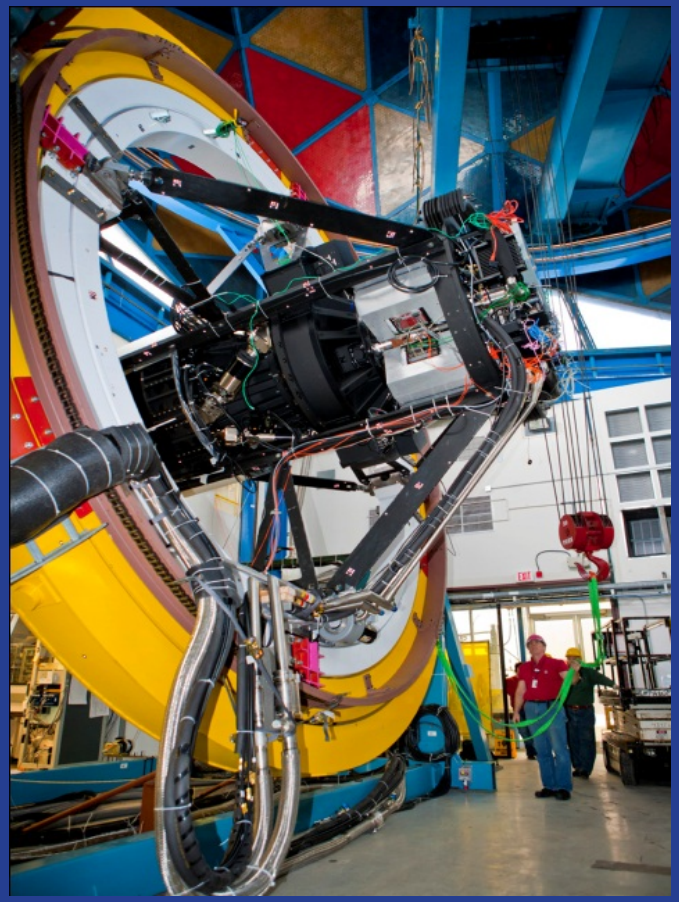
On the positive side…..

- We have a strong near term program
- We have a supportive Office of High Energy Physics and Office of Science
- We have many supporters in Congress
- And we are not done fighting



Fermilab at the cosmic frontier

- Principal goals are the study of dark energy and the study of dark matter
- Dark energy:
  - DES being installed in the Blanco (4m) telescope, Cerro Tololo, Chile; supported by DOE and NSF
  - This will be the leading experiment in understanding dark energy through the end of the decade



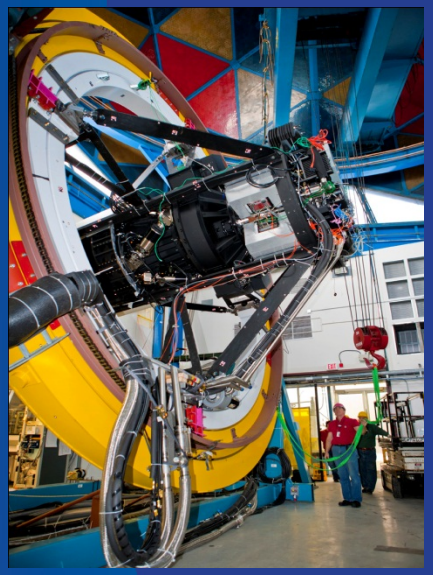
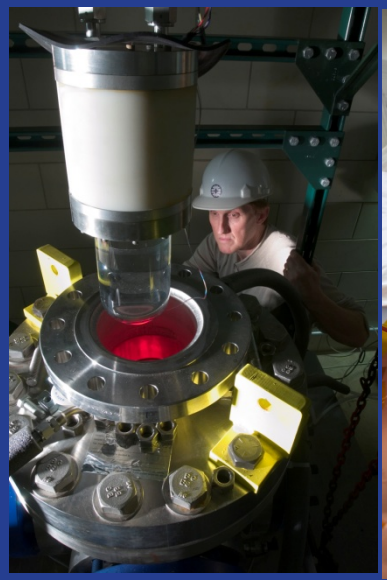
The cosmic frontier: dark matter

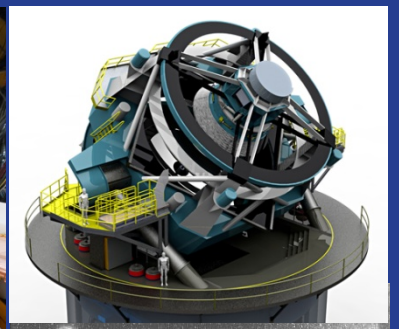
- Direct detection: trying to achieve "zero background", i.e. discriminating against electromagnetic backgrounds, alpha particles and shielding against neutrons.
  - CDMS (Ge bolometers) G1: 10kg (Soudan) → G2: 100kg (SNOLAB) → 1500 kg ??
  - COUPP (bubble chamber) G1: 60 kg (SNOLAB) → G2: 500kg (SNOLAB) → G3: 2000kg ??
  - Dark Side (depleted liquid Argon) G1: 50kg(Grand Sasso) → G2: 500kg (Grand Sasso) → 10,000kg ??

Other projects….

- Completion of Pierre Auger in three years: origin and composition of the highest energy particles
- Fermilab Holometer: fundamental physics (matter, energy, space and time), far beyond the TeV scale. It will probe Planck-scale non-commutative quantum geometry
- Future experiments may probe new interactions of axion-like particles using the same technology

Cosmic Frontier at Fermilab

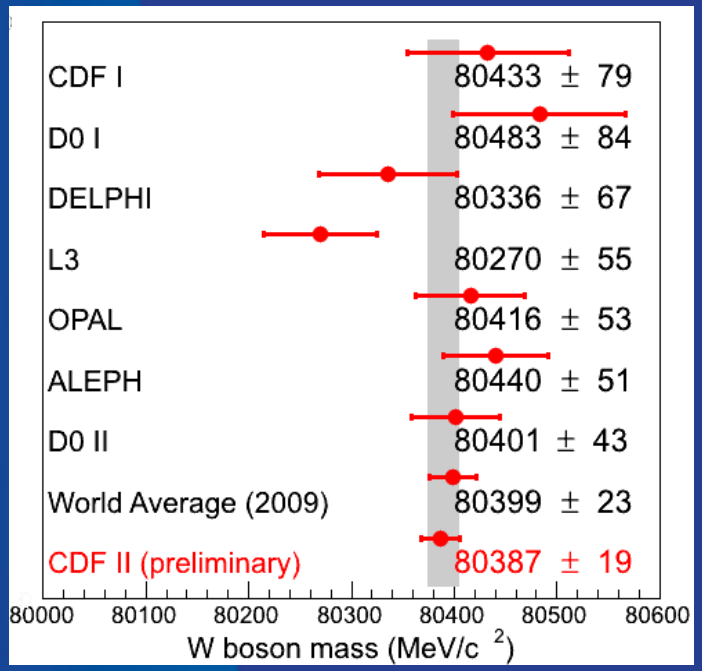


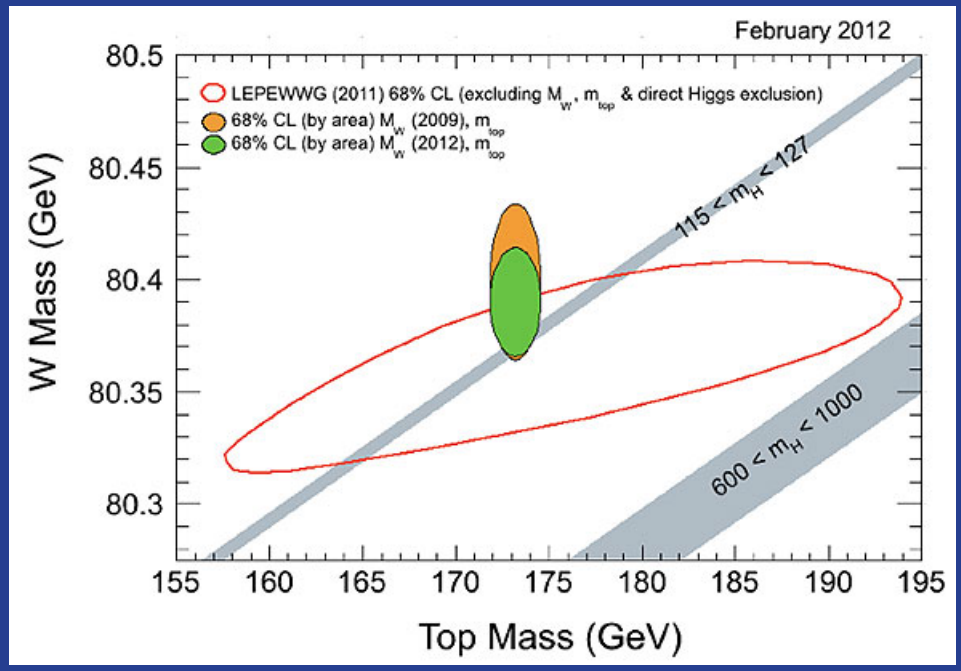

DDM: ~10 kg DE: SDSS P. Auger	DDM: ~100 kg DE: DES P. Auger Fermi Holometer	DDM: 1+ ton DE: LSST DE: BigBOSS??	DDM: 1+ ton DE: LSST DE: WFIRST??

Now → Long-term future

Fermilab at the energy frontier

- Continued analysis of Tevatron data

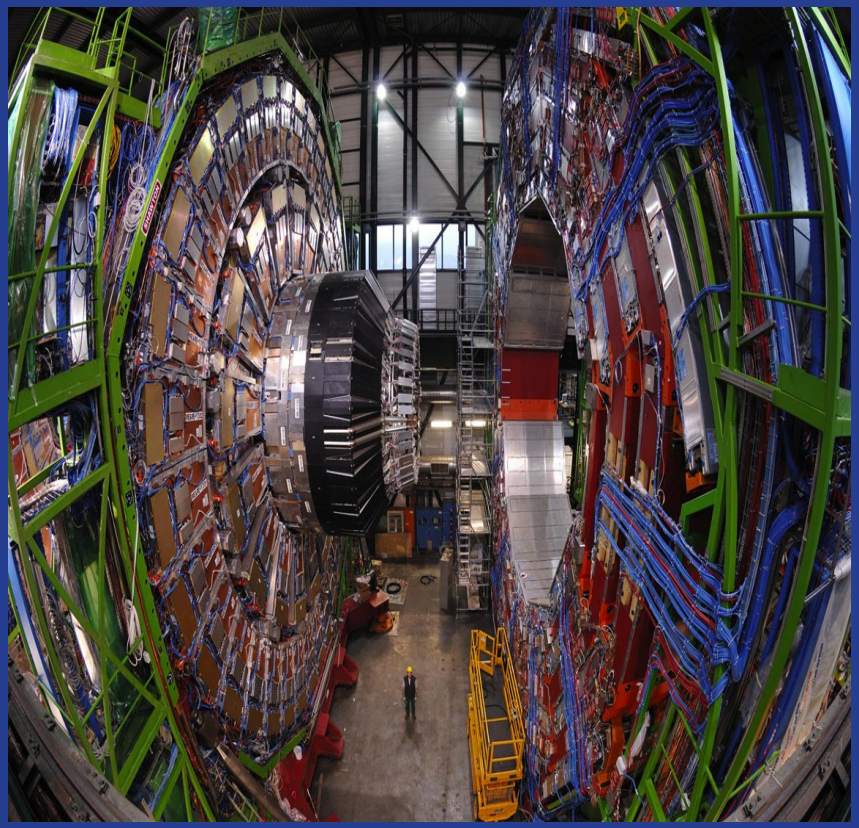




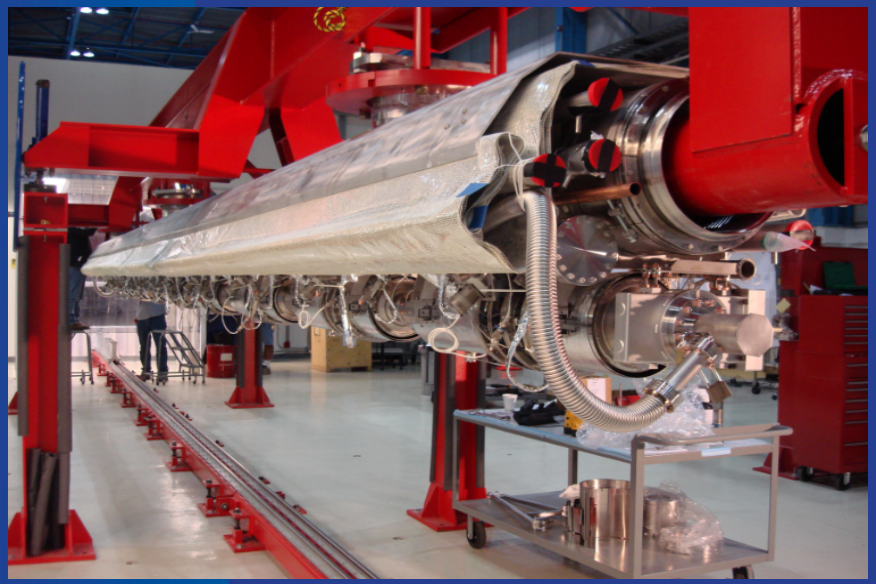
- The principal activity for the foreseeable future is exploitation of the LHC with CMS; small effort on ATLAS (FTK)

Next steps at the energy frontier

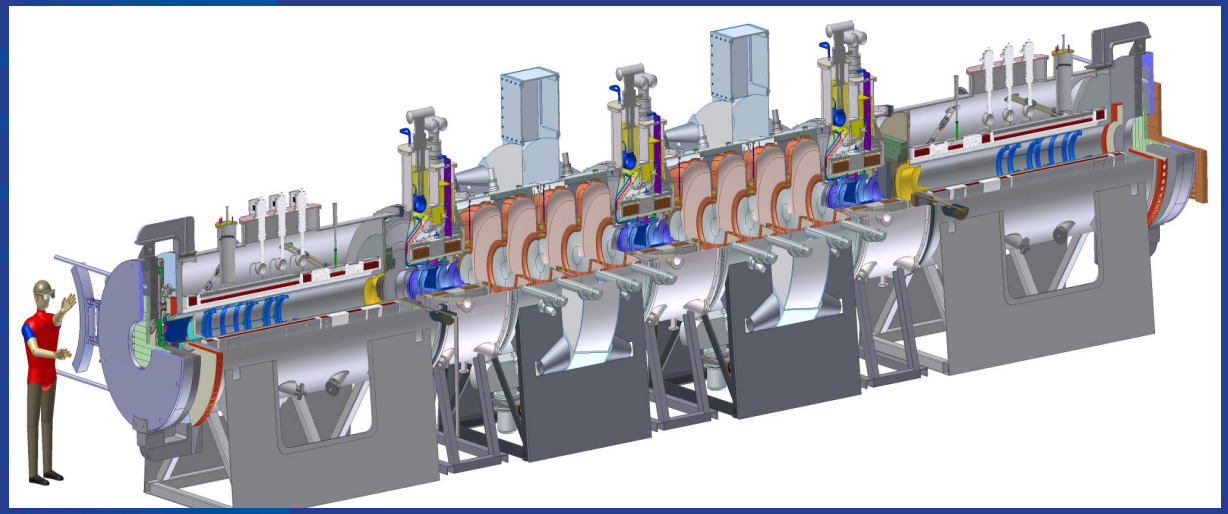
- The next steps will be to contribute to the High Luminosity LHC with both detector and accelerator upgrades.
- The biggest unknown is what follows the LHC?: ILC? CLIC? Muon Collider? Energy doubler ?



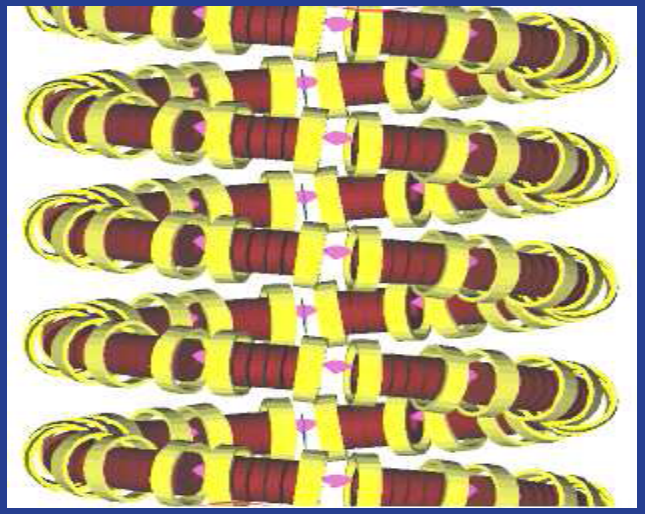
ILC R&D → General SRF Program



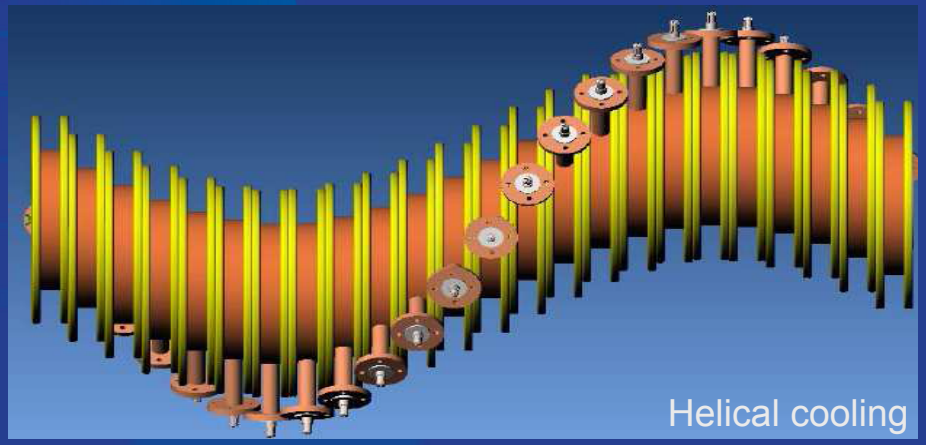
Muon Accelerator Program (MAP)



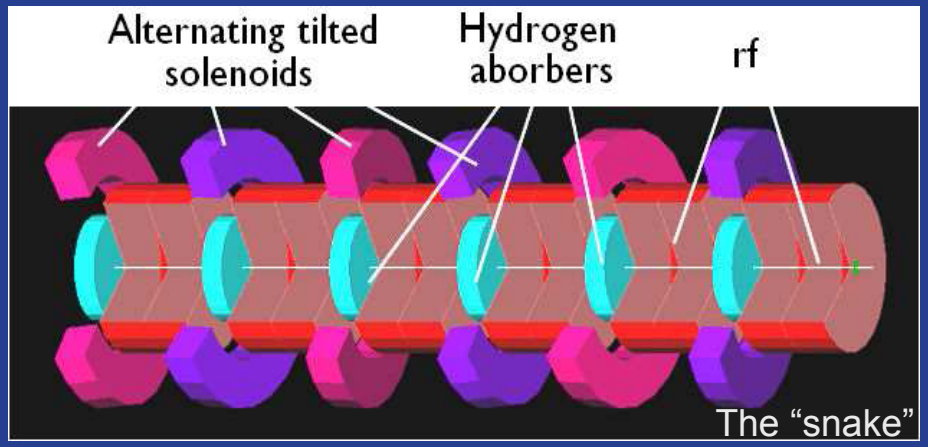
MICE



"Guggenheim"



Helical cooling

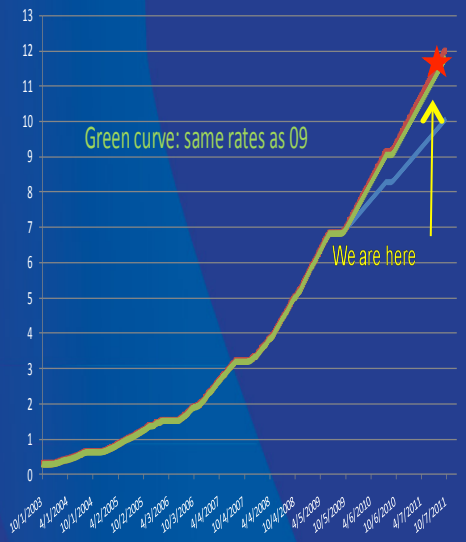


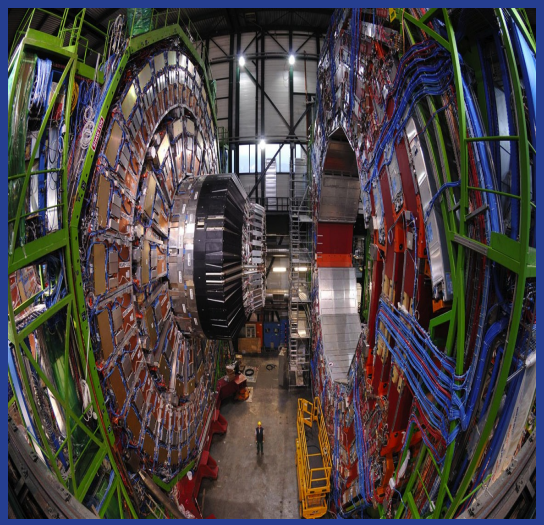
The "snake"

The US at the energy frontier

Tevatron LHC	LHC	LHC Upgrades ILC??	LHC HE-LHC ILC, CLIC or Muon Collider

Now → Long-term future



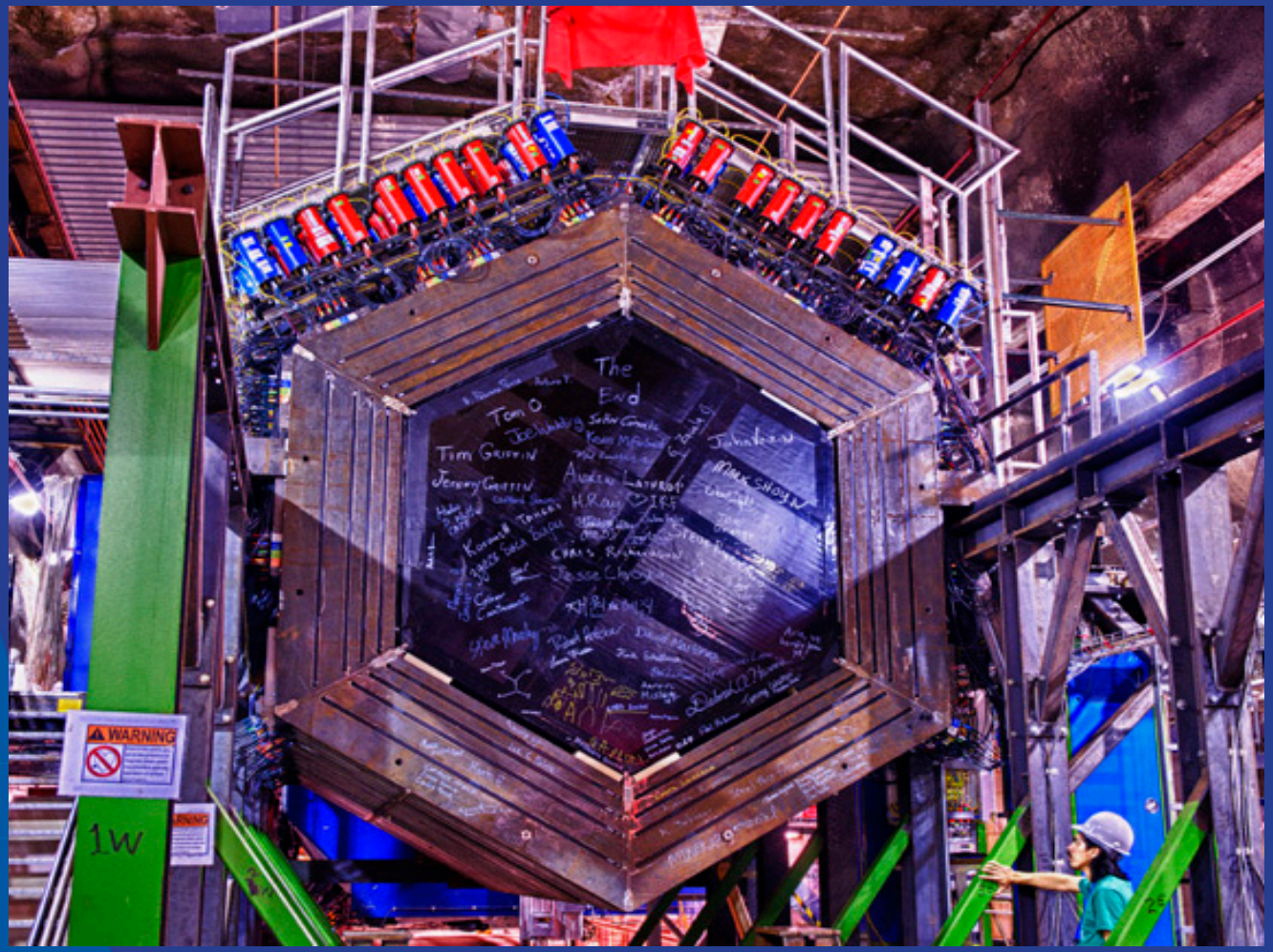


Fermilab facilities → intensity frontier

- Neutrinos: we have a very strong program on neutrinos – the least understood particle in our picture of nature. We have the most intense beams at low energies (Booster) and high energies (Main Injector)

- Rare processes: provide a window into energies that are much beyond the energies that are accessible directly by the LHC. Important hunting ground for new physics beyond the Standard Model

MINERvA

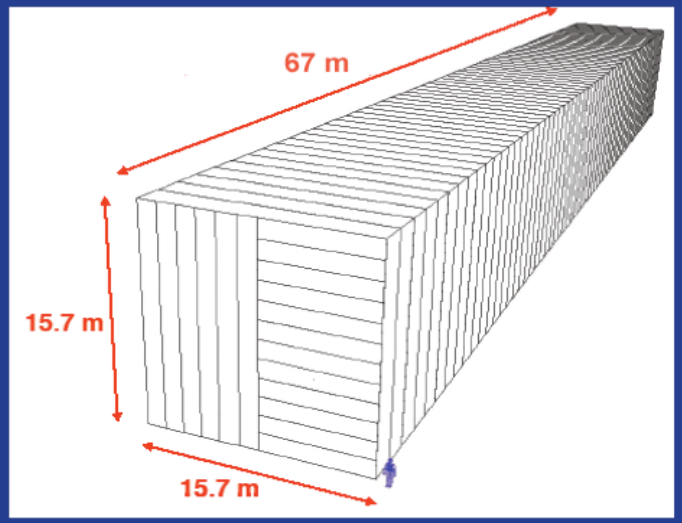


MINOS + (FY13-14)

The MINOS detector will continue to run along with NOvA. It will explore the higher flux and higher energy neutrinos available during the NOvA era.

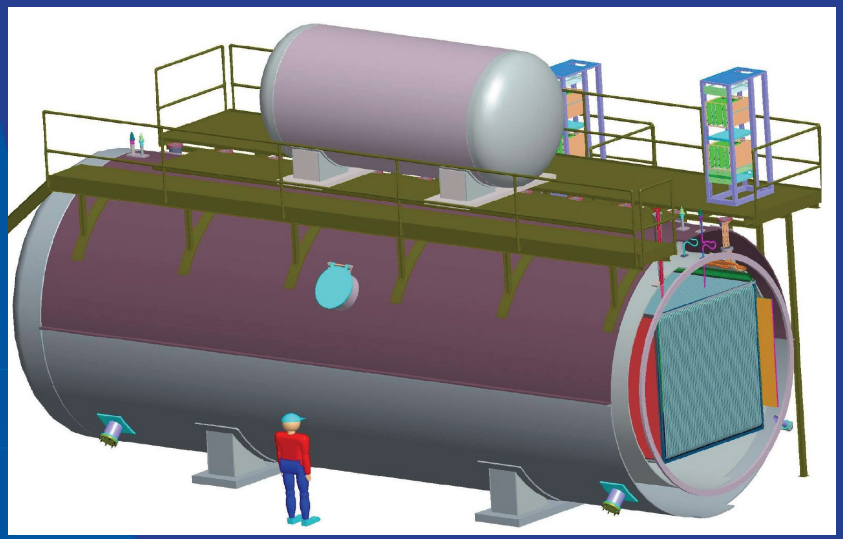
NOvA: electron appearance

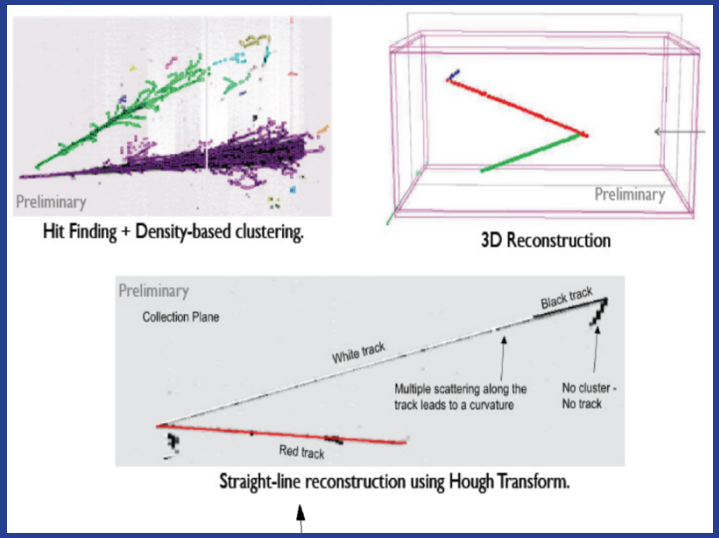
- NOvA detector going well
- Planned shutdown for accelerator improvements starts May 1st – it will give us the most intense neutrino beam in the world for several years



MicroBooNE

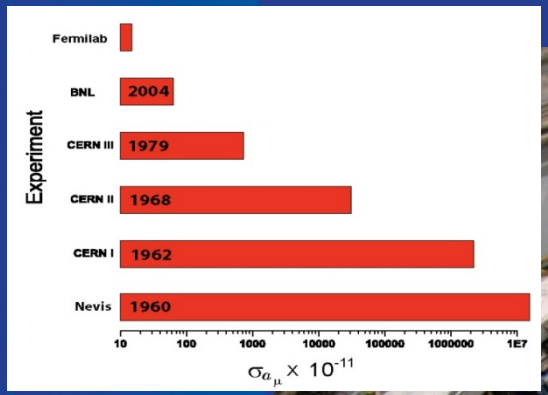
- Follow excess in MicroBooNE data. Critical to determine is it electrons or photons?
- Use Liquid Argon TPC: physics + further development of the technology. Ground breaking of LAr test building

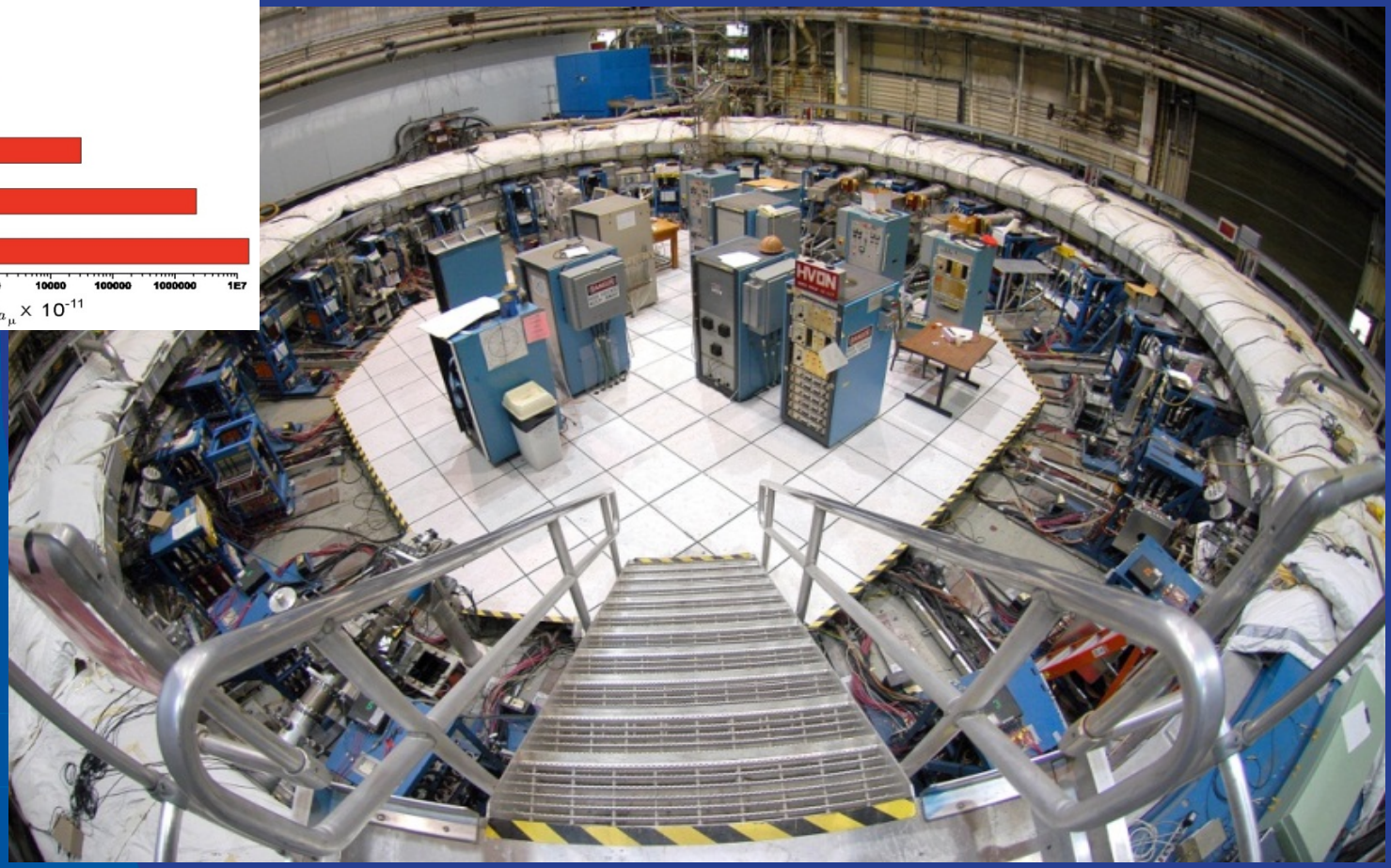




SeaQuest

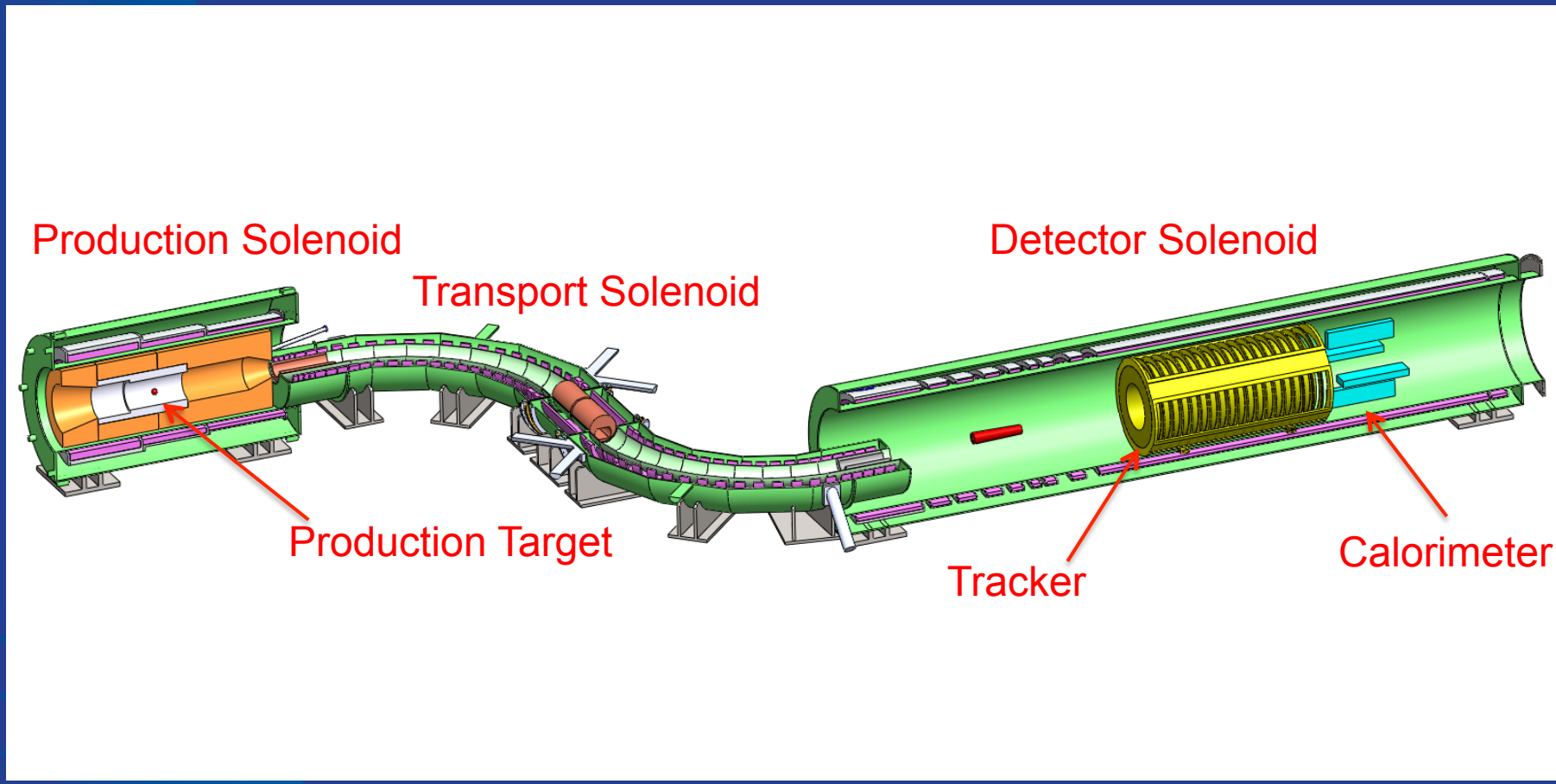
A new (g-2) to uncertainty $0.14*10^{-11}$





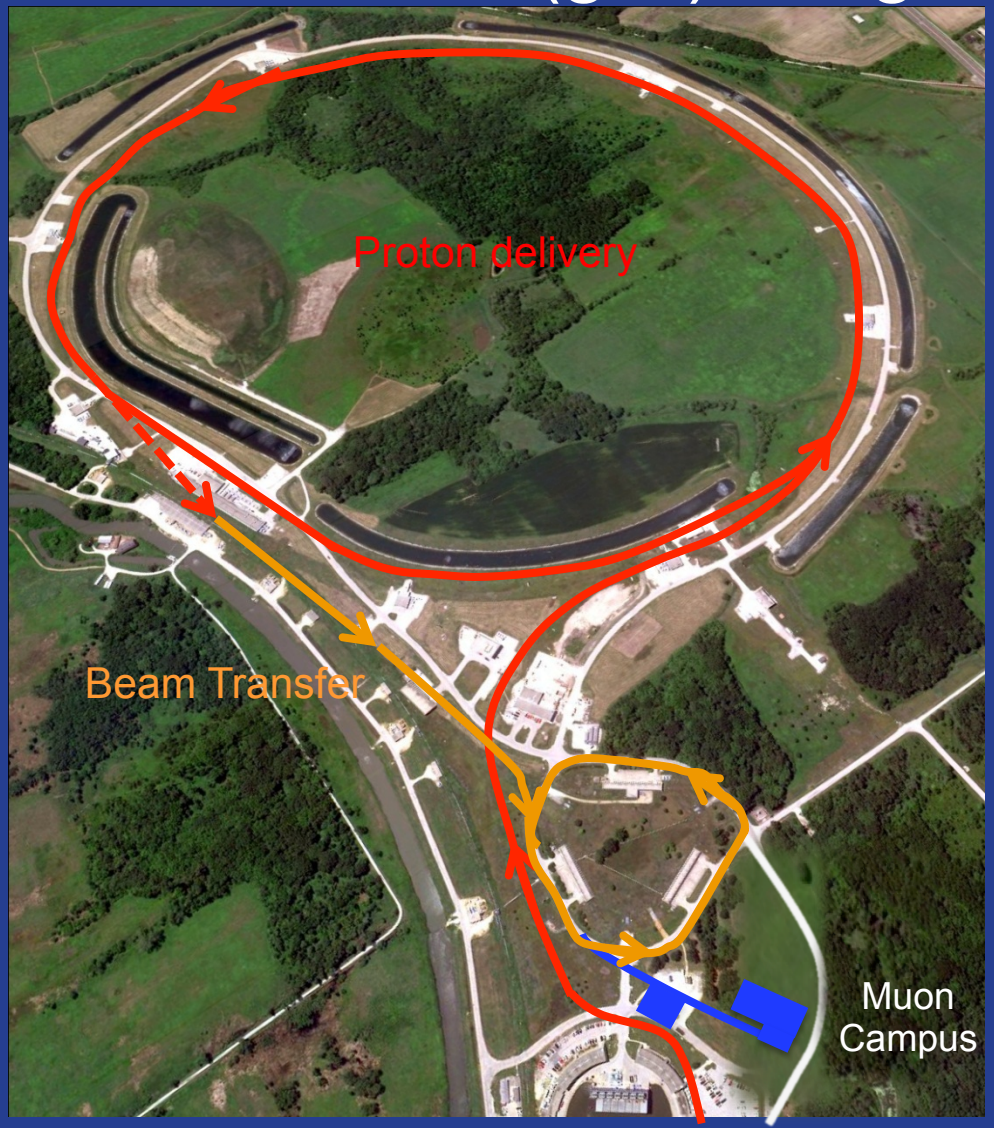
Will allow much better sensitivity to new physics than previous experiments. It is a gate all new theories must pass through

Muon to electron conversion: Mu2e



Conversion of a muon into an electron in the field of a nucleus: negligible rate in the SM and measurable in almost any extension of the SM

Mu2e and Muon (g-2) Programs



Muon Campus

- Mu2e and Muon (g-2) will use common beam line enclosure and infrastructure

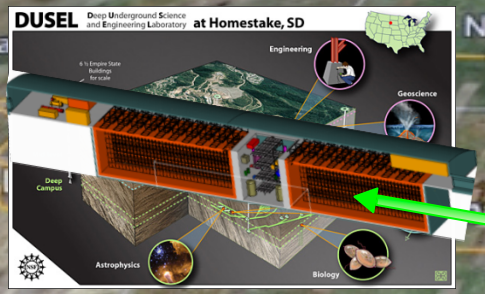
Support for programs above and the need for support for the long term

- The programs described up to this point are on track and provide a great program for the remainder of the decade
- It is important, however, to define the long term goals for our future major facilities
- Beyond great physics contributions, future facilities are important because we are a global field and work across borders. International partners will help us build domestic facilities that have ambitious goals
- Absence of domestic facilities may require US users of facilities abroad to pay operational costs since there is no reciprocal contribution of US facilities

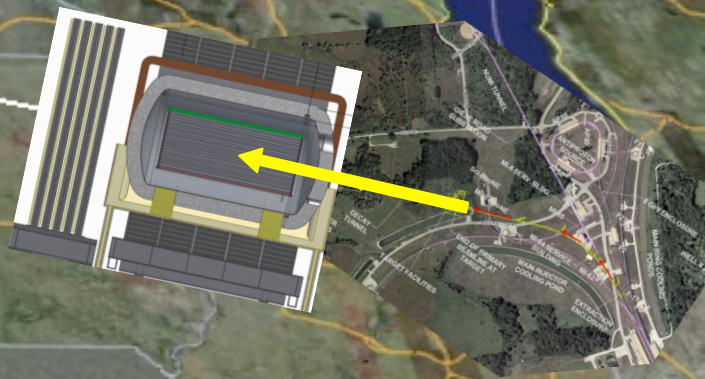
Major future facilities

- LBNE (750 kW): the long-baseline neutrino experiment
  - Neutrino mass spectrum (mass hierarchy)
  - Matter-antimatter symmetry
  - Neutrino/antineutrino differences
  - Anomalous interactions
- Project X: a broad program with megawatts of continuous beam, ideal to lead at the intensity frontier
  - Neutrino, long/short base-lines, more than 2 MW to LBNE
  - Kaons where the Standard Model backgrounds are minimal and we are sensitive to many models
  - Rare muon decay with sensitivity to masses 10000 TeV
  - Symmetry violations through electric dipole moments in nuclei
  - Applications to transmutation, spallation targets, ADS

Long Baseline Neutrino Experiment



New Neutrino Beam at Fermilab…
Precision Near Detector



Directed towards a distant detector

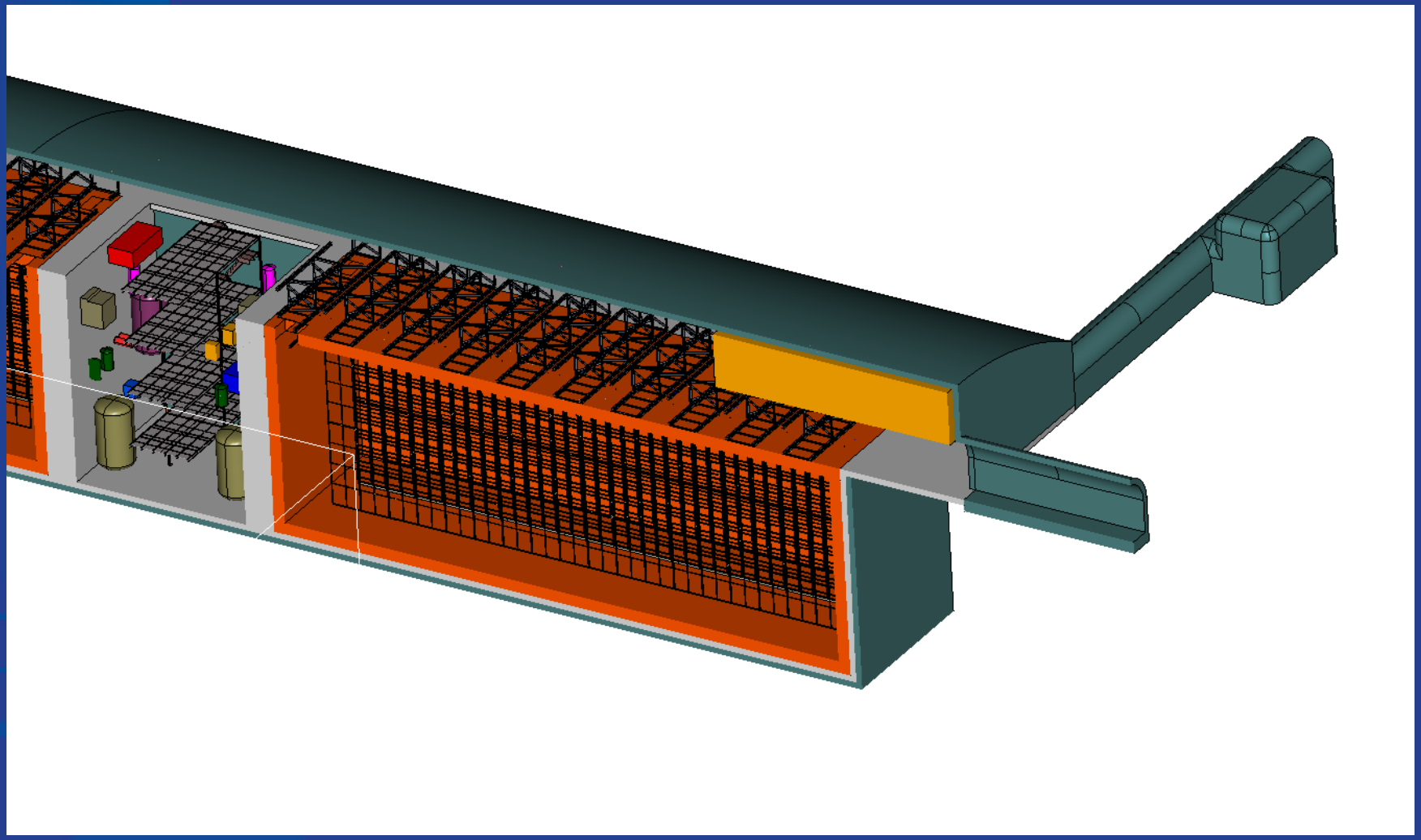
33 kton Liquid Argon Far Detector

Collaboration: 331 members
61 institutions (6 US labs) and 5 countries (India, Italy, Japan, UK, US)
Continue to grow!

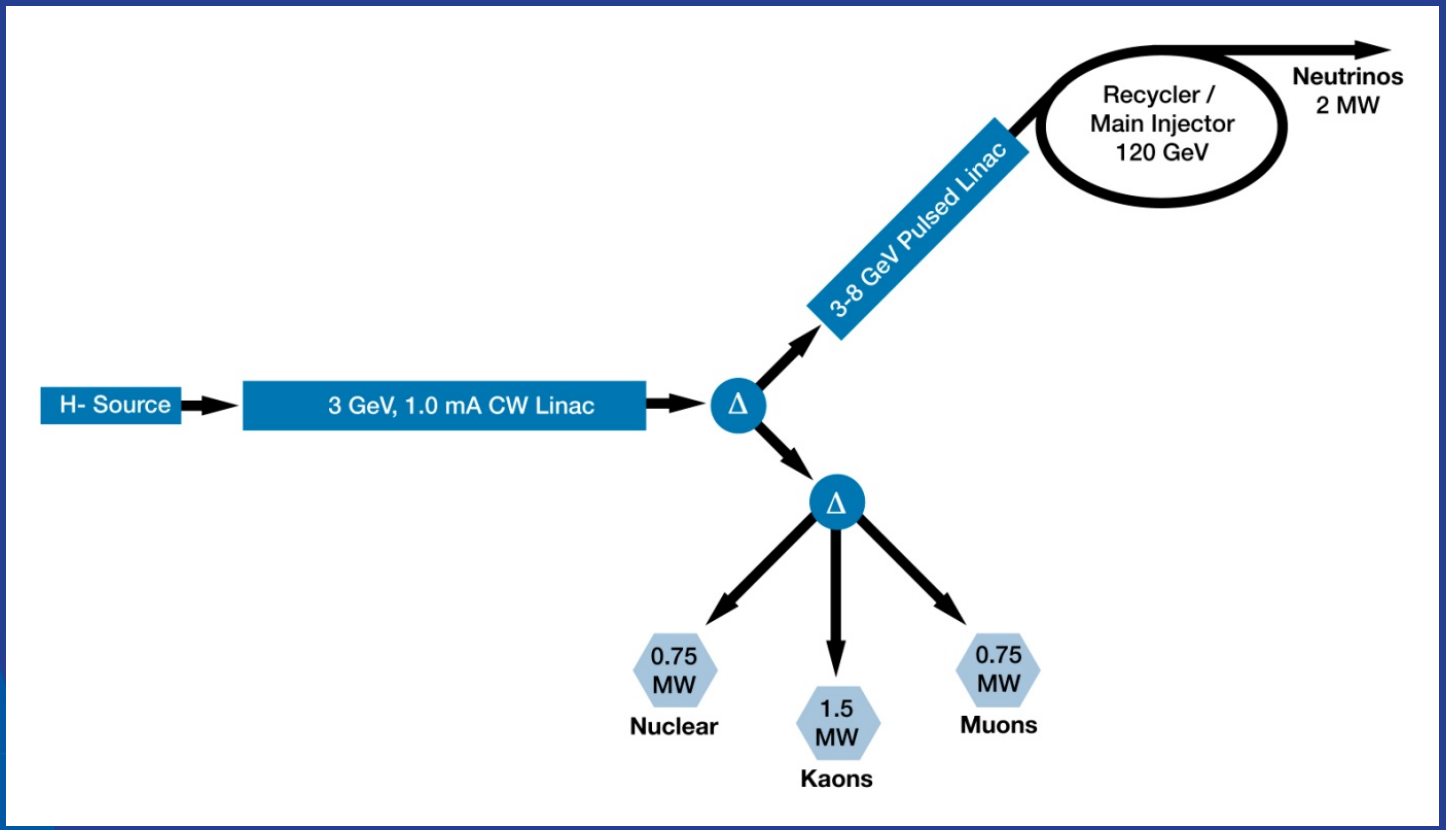
The physics is extraordinary

- Sheds light on fundamental aspects of the laws of nature
- Neutrinos: do they explain why matter dominates? Do they show new symmetries? Do they tell us something about the unification of forces? We can answer these questions through measuring crucial mixing angles, the mass-ordering and most importantly CP violation
- Proton decay: its discovery would have a profound significance for unification ideas. The unification of forces implies the proton will decay
- Supernova neutrinos: allows the only direct experimental view of the complex dynamics of supernova core collapse

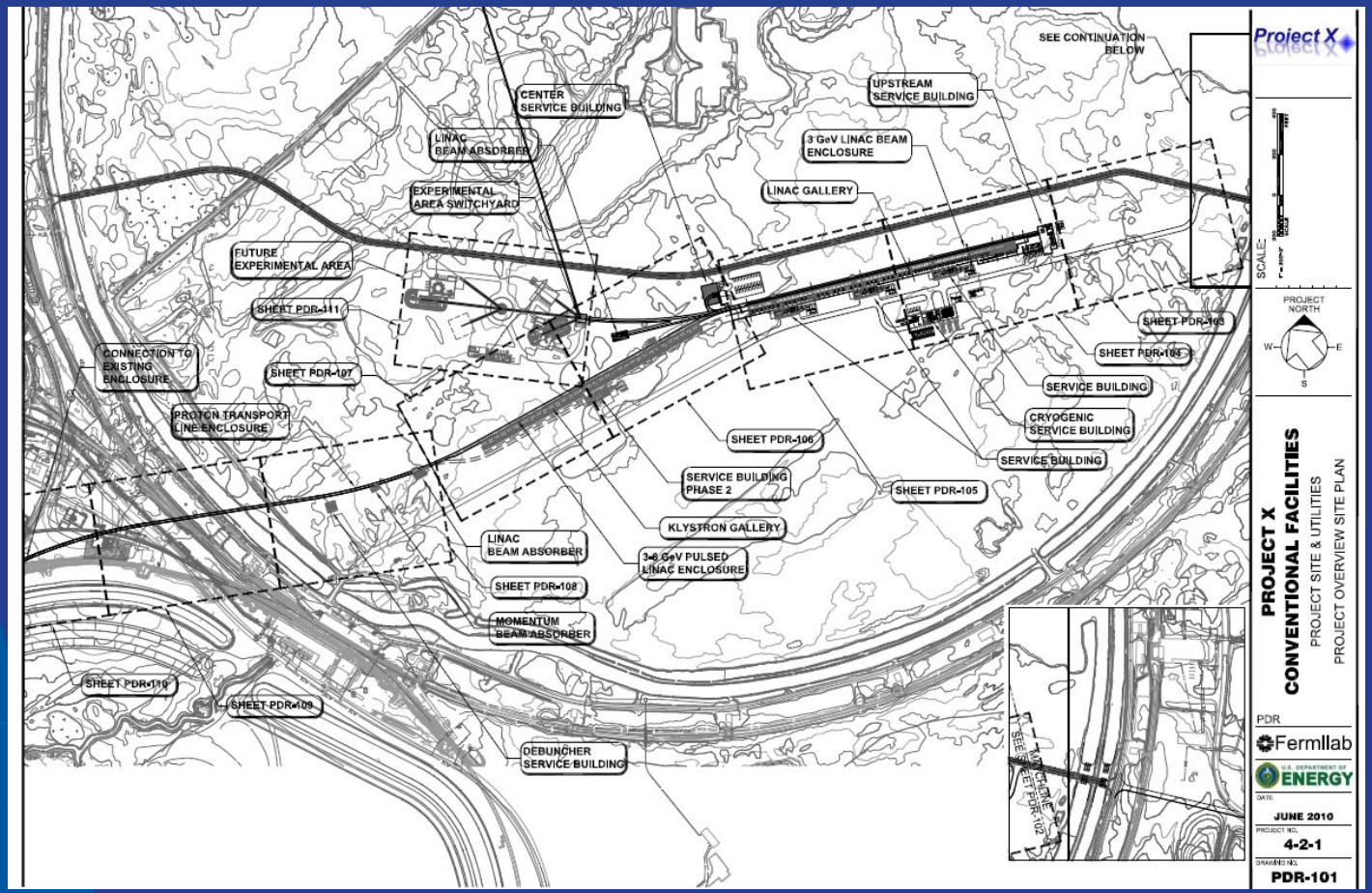
Underground LAr TPC



Project X Reference Design



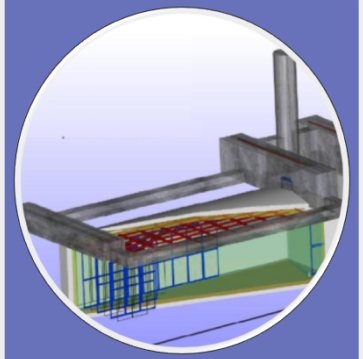
Project X Siting



Project X

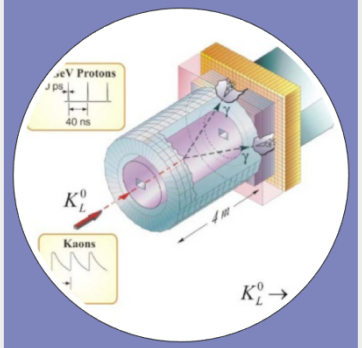
- Unique facility with 3 MW, continuous wave (CW) linac. Multiplies low energy flux of protons at Fermilab by 100 with flexible timing patterns, ideal for rare decays
- Solves “proton economics”. Experiments run simultaneously at 3 GeV, 8 Gev and 60-120 GeV at high power
- Delivers 2+ MW to LBNE
- To be developed consistently to serve as front end of neutrino factory or muon collider

Project X: new experiments



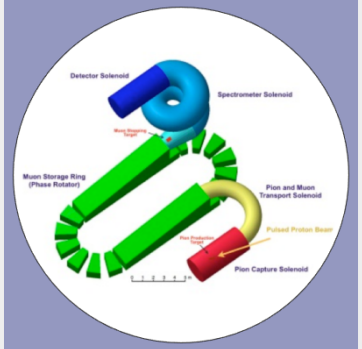
Neutrinos

- Matter-antimatter asymmetry
- Neutrino mass spectrum
- Neutrino-antineutrino differences
- Anomalous interactions
- Proton decay
- SuperNova bursts



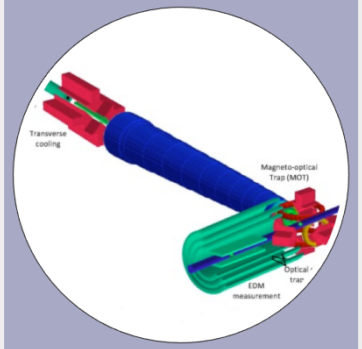
Kaons

- Physics beyond the Standard Model
- Elucidation of LHC discoveries
- Two to three orders of magnitude increase in sensitivity



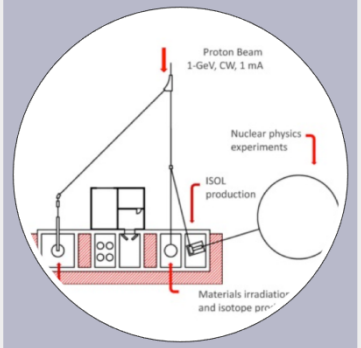
Muons

- Oscillation in charged leptons
- Physics beyond the Standard Model
- Elucidation of LHC physics
- Sensitive to energy/mass scales three orders of magnitude beyond LHC



Nuclei

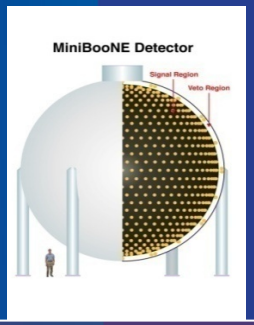
- New generation of symmetry-test experiments
- Electric Dipole Moments
- Three or more orders of magnitude increase in Francium, Radium, Actinium isotopes

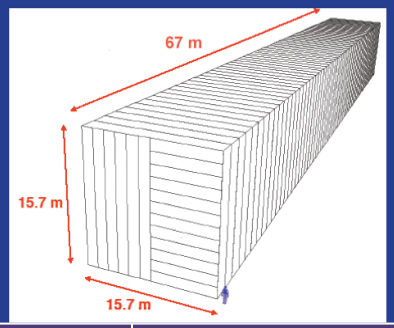


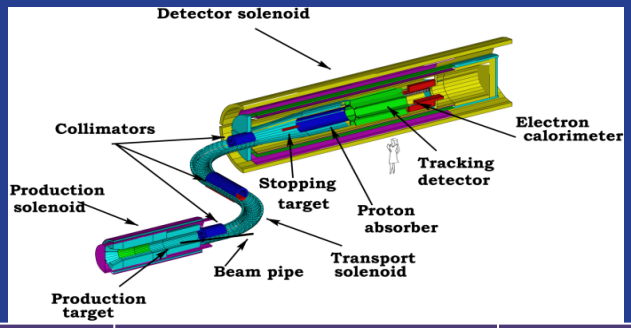
Energy Applications

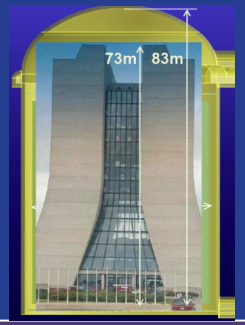
- Transmutation experiments with nuclear waste
- Spallation target configurations
- Materials test under high irradiation
- Neutron fluxes under various configurations relevant to ADS

Fermilab and the intensity frontier



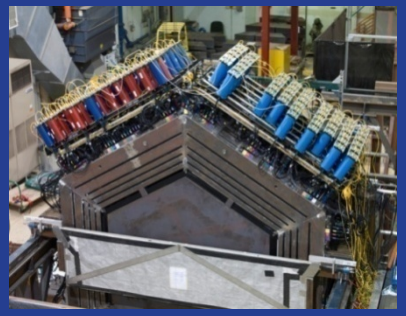


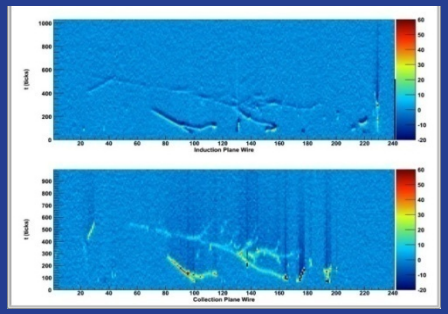


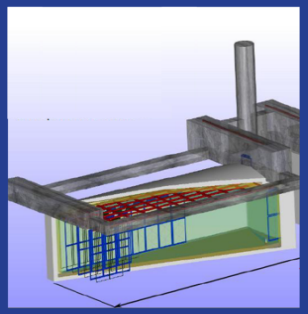


MINOS MiniBooNE MINERvA SeaQuest	NOvA MicroBooNE g-2 MINERvA MINOS+ SeaQuest	NOvA g-2 LBNE Mu2e ORKA?	Project X+LBNE μ, K, nuclear, … ν Factory ??

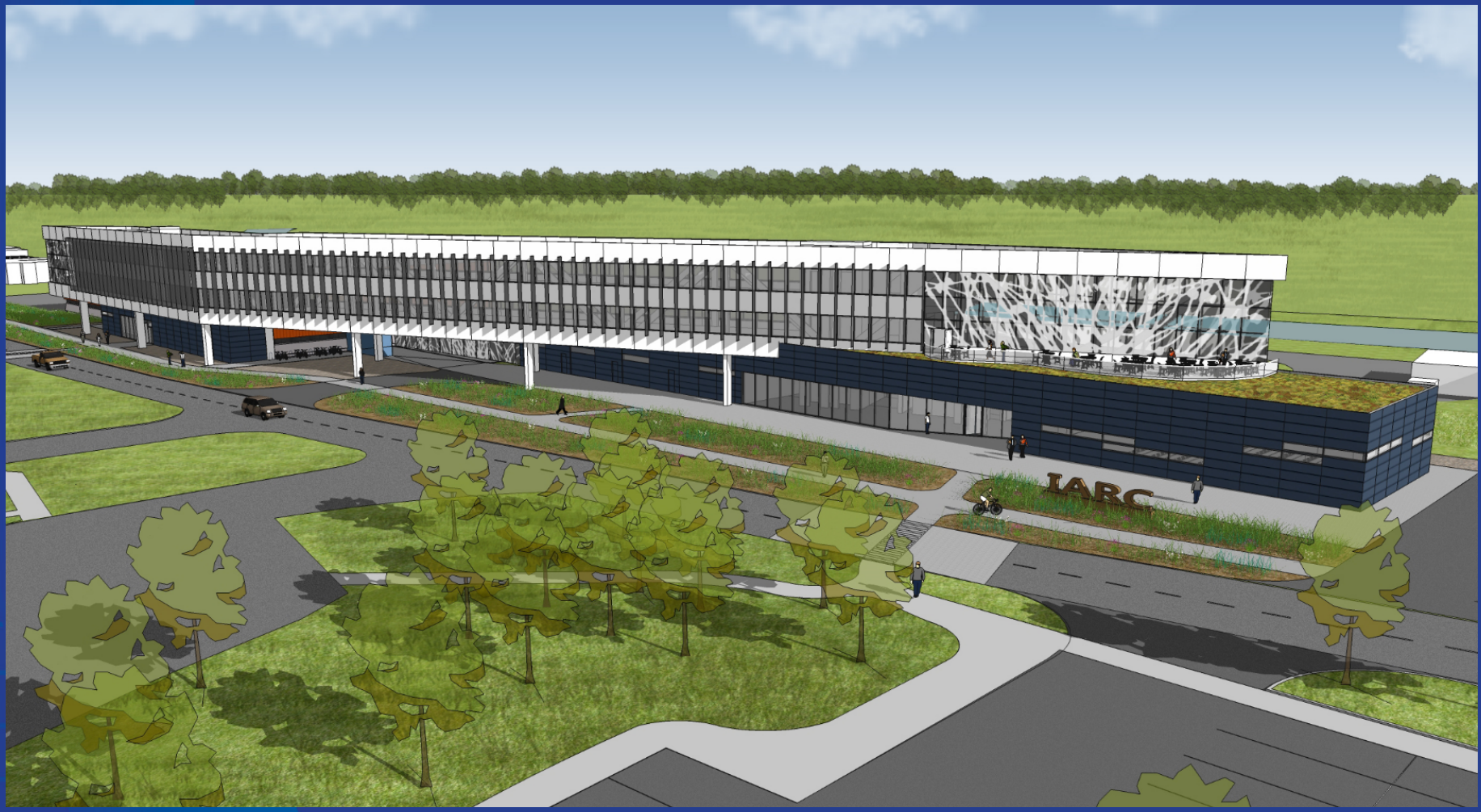
Now → Long-term future







Illinois Accelerator Research Center (IARC)



Impacts on Society

U.S. DEPARTMENT OF ENERGY

Fermilab

Illinois Accelerator Research Center

- An opportunity to work with university and industrial partners on advanced accelerators for multiple applications: discovery science, medicine, national security, industrial processes, diagnostics, waste remediation
- A mandate to put substance behind the claim that HEP is the developer/steward of accelerator technology within the Office of Science
- Opportunity to become national center in education of accelerator physicists and engineers

Some concluding remarks

- A very strong, world leading program in three frontiers. Local facilities for neutrinos and rare processes;
- That will come under tremendous stress with the proposed budget for FY2013
- Significant reduction of the base and of staff → large fixed costs implies indirect costs are likely to go up
- Very difficult planning: large uncertainties remain. We have a lot of work to do at all levels of the government
- Nonetheless we have some support for LBNE and considerable support in technology development for our future accelerators. We will continue to work on defining the long range program