Project X Briefing to DOE

Fermilab Strategy

Pier Oddone, November 17, 2010

U.S. DEPARTMENT OF ENERGY

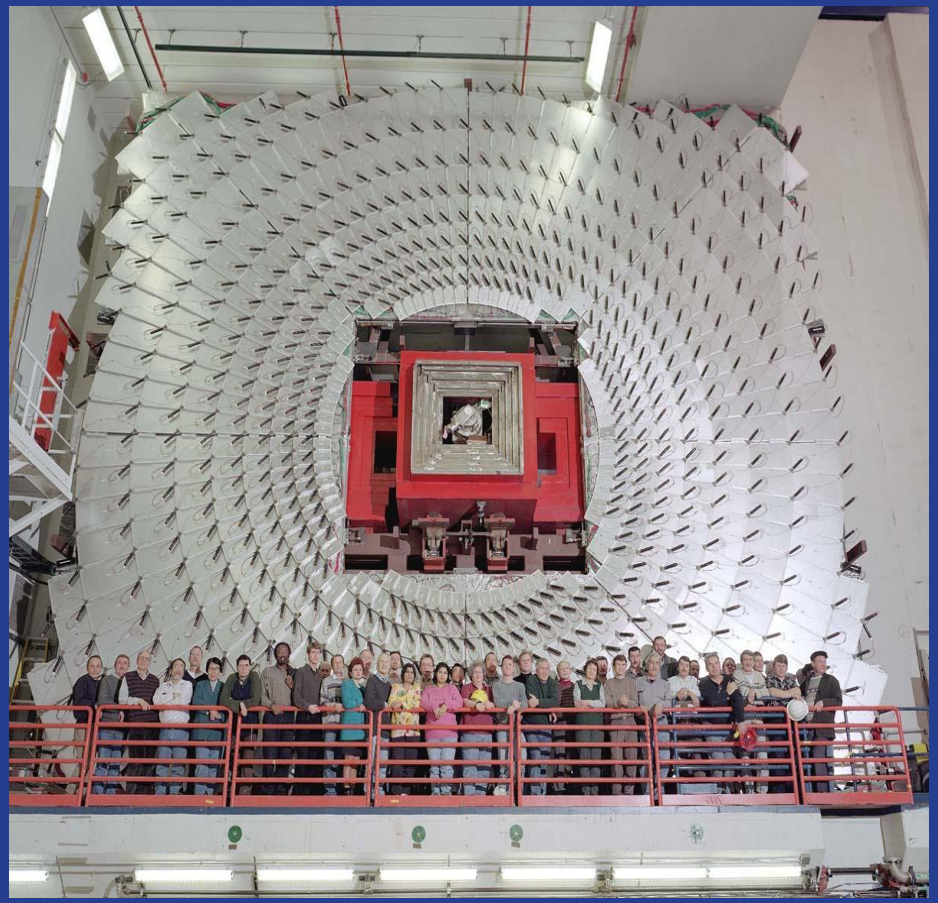
Fermilab

Outline

- Overall mission
- Strategy: gaps and overview of roles
  - At the energy frontier
  - At the intensity frontier
  - At the cosmic frontier
- Project X is central to the strategy
  - Project X a unique facility in the world
  - Project X and future evolution
- National and international collaboration

Mission: the national particle physics lab

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

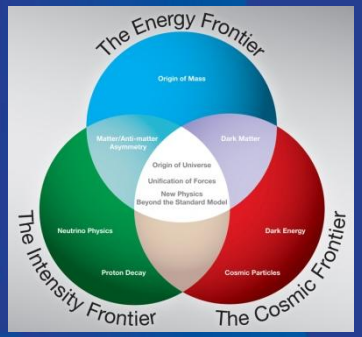


Program drivers: science

- The sense of mystery has never been greater. With increased knowledge our ignorance has become more acute:
  - 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 our imagination and that of the public and the press
- As the national laboratory for particle physics, we work to place the US in a leadership position in the world



Most elements are in place: exciting opportunities and national strategic plan following P5 at each of the three frontiers of particle physics: energy, intensity and cosmic frontiers

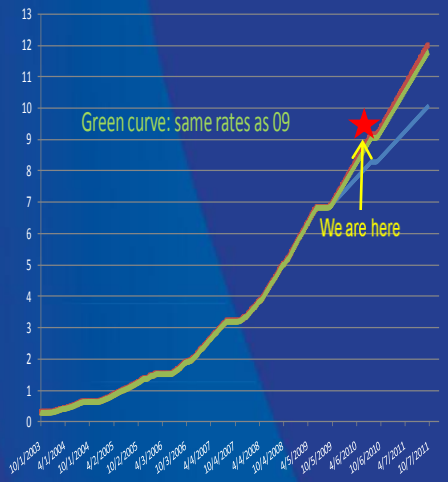
- Historically many applications in society through development of accelerator, detector and computational technology

Gaps and roles: energy frontier

- Next two decades: dominated by LHC. Upgrades to machine and detectors
- Biggest gap: what follows the LHC? Depends on results and at what energy results occur
- Fermilab strategy: physics exploitation and upgrades of LHC. R&D on future machines: ILC if at "low" energy; muon collider if at high energy; new high field magnets for extension of LHC or future proton colliders at ultra-LHC energies

Roles: energy frontier

Now	2013	2016	2019	2022
Tevatron LHC	LHC	LHC Upgrades ILC??	LHC ILC, CLIC or Muon Collider	



Gaps and roles: cosmic frontier

- The principal connection to particle physics: the nature of dark matter and dark energy
- Gap in the direct search for dark matter: get to "zero—background" technology. Gap in understanding dark energy is establishment of time evolution of the acceleration: new major telescopes (ground and space)
- Fermilab strategy: establish scalable "zero-background" technology for dark matter. Participate in future ground and space telescopes (the principal agencies are NSF and NASA, not DOE)

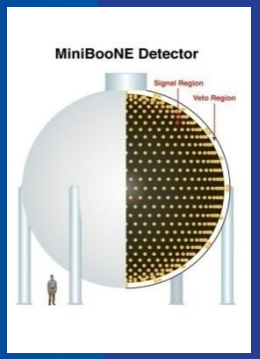
Roles: cosmic frontier

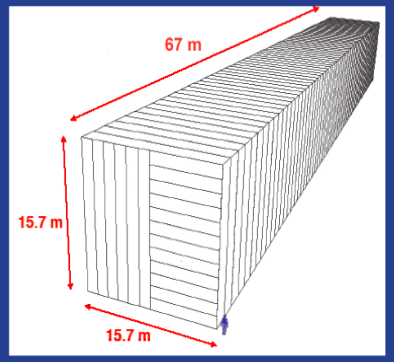
Now	2013	2016	2019	2022
DM: ~10 kg DE: SDSS P. Auger	DM: ~100 kg DE: DES P. Auger Holometer?	DM: ~1 ton DE: LSST WFIRST?? BigBOSS??	DE: LSST WFIRST??	

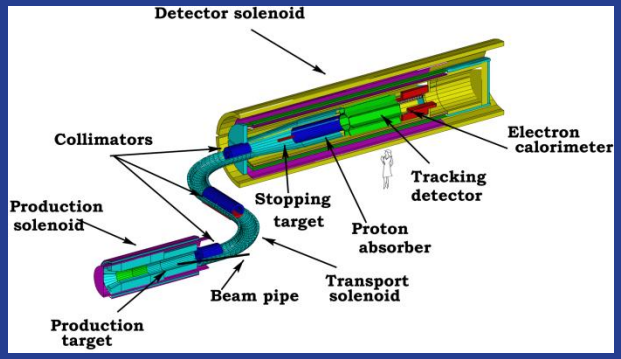
Gaps and roles: intensity frontier

- Two principal approaches: 1) proton super-beams to study neutrinos and rare decays and 2) quark factories: in e^+e^- and LHCb
- Principal gap is the understanding of neutrinos and the observation of rare decays coupled to new physics processes
- Fermilab strategy: develop the most powerful set of facilities in the world for the study of neutrinos and rare processes, way beyond the present state of the art. Complementary to LHC. DOE is a unique player in this arena.

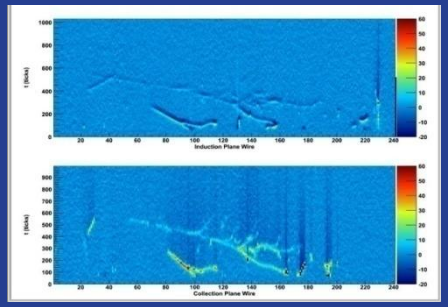
Roles: intensity frontier

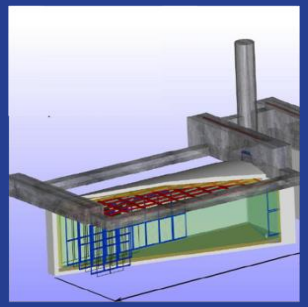






Now	2013	2016	2019	2022
MINOS MiniBooNE MINERvA SeaQuest	NOvA MicroBooNE g-2? SeaQuest	LBNE Mu2e	Project X+LBNE μ, K, nuclear, … ν Factory ??	





Project X is central to the strategy

- Unique facility for rare decays: a continuous wave (CW), very high power, superconducting 3 GeV linac. Unique in the world
- CW linac greatly enhances the capability for rare decays of kaons, muons
- CW linac is the ideal machine for other uses: Standard Model tests with nuclei (ISOL targets), possible energy and transmutation applications, cold neutrons

Project X is central to the strategy

- Coupled to an 8 GeV pulsed LINAC and to the Recycler and Main Injector, gives the most intense beams of neutrinos at high energy (LBNE) and low energy (for the successors to Mini and MicroBooNE)
- Makes use of modern accelerators at Fermilab (Recycler and Main Injector) and its scope would be difficult to reproduce elsewhere without this established base
- Eliminates proton economics as the major limitation: all experiments run simultaneously

Project X is central to the strategy

- Project X benefits from the word-wide ILC R&D: SCRF and photo-e cloud. SCRF R&D positions the US to play a leading role in ILC.
- Capabilities and infrastructure developed for Project X will be useful for other domestic non HEP projects.
- Project X with upgrades can be the front end of a neutrino factory or a muon collider, opening paths for development of the intensity frontier and a road back to the energy frontier

Comparative situation

- Europe: now fully occupied at the energy frontier: LHC upgrades and future energy frontier machines (ILC, CLIC). To get into neutrinos competitively would need to do the same as in present US plans, with the addition of a modern high energy synchrotron. Not excluded but very unlikely

- Japan: Is the nearest competitor, however there are crucial long term advantages to Project X

Comparative advantages

- Higher CW power at low energies: push rare decays one to two orders of magnitude further
- Proton economics: run multiple rare decay experiments and neutrinos simultaneously. At JPARC the 50 GeV synchrotron is used for neutrinos and rare decays – requiring sharing
- Long base-line experiment to DUSEL detectors with baselines not possible in Japan
- Far more flexible set of facilities and plenty of land for expansion

Present collaborative efforts

- International Collaborations for our programs

27 countries

16 countries

23 countries

- Collaboration among DOE laboratories
  - Project X, ILC/SRF, Muon collider, neutrino factory, LHC Accelerator, many particle experiments, …

Project X collaborations

- Most important to attract major international collaborators
- Possible in-kind contributions to Project X of about 30%, with full participation in physics experiments
  - India: well on its way
  - China: upcoming two workshops with IHEP
  - Korea: interest on technology collaboration
  - Europe: important next stage will come out of the European Strategy (2012). In the meantime explore bi-lateral agreements

Conclusions

- Without Project X we risk other regions making strong moves towards the intensity frontier, decreasing interest in the US program. Without it we are headed to the use of accelerator facilities abroad for all our experiments.

- With Project X the US program can be a major player in particle physics in the world for decades to come