Project X Accelerator Facility
Summary

Description: Project X is a high intensity proton facility that will support a world-leading program of Intensity Frontier physics over the next several decades at Fermilab. Project X is completely unique in its ability to deliver, simultaneously, up to 6 MW of site-wide beam power to multiple experiments, at multiple energies, and with flexible beam formats. A complete concept for Project X has been developed and is documented in the Project X Reference Design Report (Project X RDR). The Reference Design is based on a continuous wave (CW) superconducting 3 GeV linac providing up to 1 and 3 MW of beam power at 1 and 3 GeV respectively. A pulsed linac provides acceleration of roughly 4% of the beam delivered from the CW linac to the 8 GeV injection energy of the existing Recycler/Main Injector complex. Upgrades to the Recycler and Main Injector support a factor of three increase, over current capabilities, in proton beam power at 60 to 120 GeV. Project X is an integral part of the U.S. Intensity Frontier Roadmap as described in the P5 report of May 2008 (P5 Report) and within the Fermilab Strategic Plan of November 2011 (Fermilab Plan for Discovery).

Science: The science mission of Project X has been developed through the P5 and Fermilab Strategic Planning processes. The primary mission elements include:

Neutrino Experiments: A high-power source of protons with energies between 1 and 120 GeV will produce intense neutrino beams illuminating near detectors on the Fermilab site and massive detectors at distant underground laboratories.

Goal: At least 2 MW of proton beam power at any energy between 60 to 120 GeV; several hundred kW of proton beam power at 8 GeV.

Kaon, Muon, Nuclei, and Nucleon Precision Experiments: World leading experiments pursuing ultra-rare muon and kaon decays , atomic, proton and neutron electron dipole moments (edms), ultra-rare kaon decays, and precision measurement of neutron properties including pursuit of neutron-antineutron oscillations.

Goal: MW-class proton beams supporting multiple experiments at 1 and 3 GeV, with flexible capability for providing distinct beam formats to concurrent users. Simultaneous operation with the neutrino program is required.

Platform for Evolution to a Neutrino Factory and Muon Collider: Platform for future development of a Neutrino Factory or Muon Collider, providing long-term opportunities for continuation of world leading Intensity and Energy Frontier capabilities.

Goal: Provide a straightforward upgrade path for a 4 MW, low duty factor, source of protons at energies between 5 to 15 GeV.

Material Science and Nuclear Energy Applications: Accelerator, spallation target, and transmutation technology demonstrations as critical input into the design of future energy systems, including next generation fission reactors, nuclear waste transmutation systems and future thorium fuel-cycle power systems. Possible applications of muon spin rotation techniques (muSR) as sensitive probes of the magnetic structure of materials.

Goal: Provide MW-class proton beams at 1 GeV, coupled with novel targets required to support a range of materials science and energy applications.

Collaboration: The Project X R&D Program is being undertaken by a collaboration of twelve national laboratories and universities, and four Indian laboratories (Project X Collaboration). R&D assignments of the collaborating institutions are made on the basis of unique skills and competencies, with the assumption that these assignments will continue into the construction phase. A very significant in-kind contribution to Project X is currently under discussion between the U.S. Department of Energy and the Indian Department of Atomic Energy.

Staging: Budgetary constraints have led to development of a staged approach to Project X, based on application of the following principles:

- Each stage must present compelling physics opportunities;
- Each stage should be constructible for significantly less than $1B;
- Each stage should utilize existing elements of the Fermilab complex to the extent possible;
- Each stage should be constructible with minor interruptions to the ongoing program;
- At the completion of the final stage the full Reference Design should be realized.

A three stage implementation of the Reference Design consistent with the above principles has been developed (Project X Performance by Stage), with significant scientific potential associated with all mission elements at each stage. In particular, Stage 1 physics opportunities are described in Physics Opportunities with Stage 1 of Project X

Science Classification and Readiness: The physics potential, in particular the first three mission elements, are absolutely central to the U.S. particle physics program. The capabilities of Project X reach far beyond other facilities in the planning stages elsewhere in the world. In particular, Project X is completely unique in its ability to deliver, simultaneously, up to 6 MW of site-wide beam power to multiple experiments, at multiple energies, and with flexible beam formats.

A comprehensive R&D program is underway, aimed at mitigating the primary technical and cost risk associated with Project X. The existing Reference Design is supported by comprehensive electromagnetic and beam dynamics modeling and simulations, and provides the context for the R&D program. The primary supporting technologies required to construct Project X exist today. Fermilab, with national and international collaborators, has an extensive development program in superconducting radio frequency acceleration. This program has produced both spoke resonator and elliptical accelerating structures that meet the requirements of Project X. The Project X Front End breaks new ground technically and is the focus of an intensive development and systems testing program. Proof-of-concept components exist.

Project X is pre- CD-0. However, a preliminary, bottoms-up, cost estimate exist and the state of development is sufficient to support an expeditious move to construction (CD-3), in parallel with ongoing development, over the next three-four years. Project X is ready to construct.