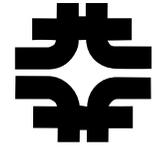


Project X and Collaboration with ILC

Steve Holmes

International Linear Collider Workshop 2008
University of Illinois at Chicago
November 16, 2008

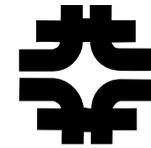
Outline



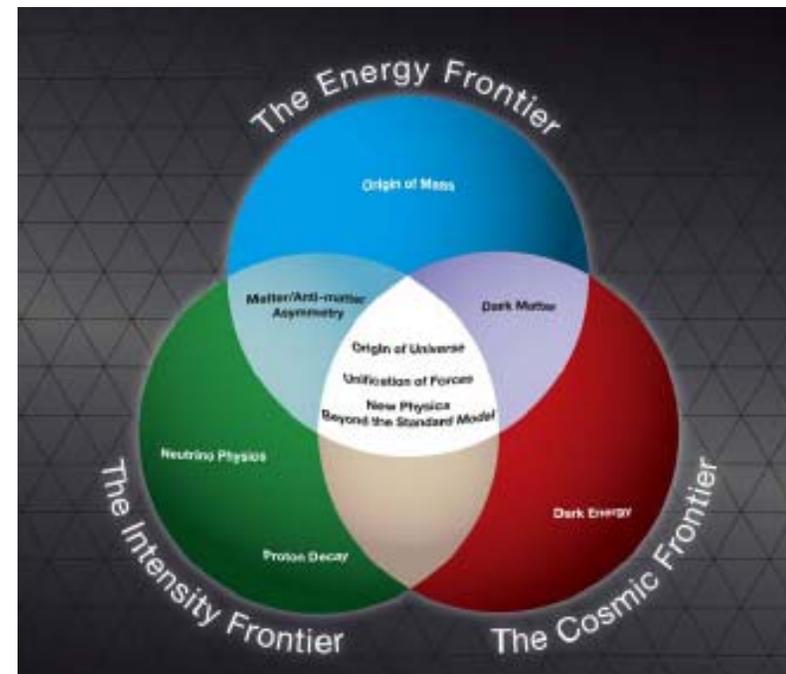
-
- Strategic Context
 - Project X Facility Overview
 - Project X Research, Design, and Development Plan
 - Relationship to ILC

Strategic Context

Fermilab Long Range Plan



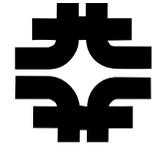
- Fermilab is the sole remaining U.S. laboratory providing facilities in support of accelerator-based Elementary Particle Physics.
- The Fermilab long-term strategy is fully aligned with the HEPAP/P5 plan:
 - Energy and intensity frontiers share strong reliance on accelerators



www.science.doe.gov/hep/files/pdfs/P5_Report%2006022008.pdf

Strategic Context

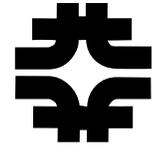
P5 Recommendations



- Energy Frontier
 - “The panel recommends for the near future a broad accelerator and detector R&D program for lepton colliders that includes continued R&D on ILC ... in support of the international effort.”
 - “The panel also recommends R&D for alternative accelerator technologies, to permit an informed choice when the lepton collider energy is established.”
- Intensity Frontier
 - “The panel recommends an R&D program in the immediate future to design a multi-megawatt proton source at Fermilab and a neutrino beamline to DUSEL...”

Strategic Context

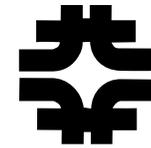
Evolution of the Accelerator Complex



- Energy Frontier
 - Tevatron → ILC or Muon Collider as options for the Fermilab site
- Intensity Frontier
 - NuMI → NOvA → very long baseline/ $\mu 2e$ → multi-MW Proton Source
 - Initial stages supported by ANU (NOvA): 700 kW
- Fermilab view: Most effective implementation of a multi-MW proton facility would be based on a superconducting 8 GeV linac
 - Alignment with ILC technology development
 - Flexibility for the future
 - aka “Project X”

Project X Initial Configuration

Mission Need



- The P5 report identified the mission need based on:
 - **A neutrino beam for long baseline neutrino oscillation experiments.**

A new 2 megawatt proton source with proton energies between 50 and 120 GeV would produce intense neutrino beams, directed toward a large detector located in a distant underground laboratory.
 - **Kaon and muon based precision experiments exploiting 8 GeV protons from Fermilab's Recycler, running simultaneously with the neutrino program.**

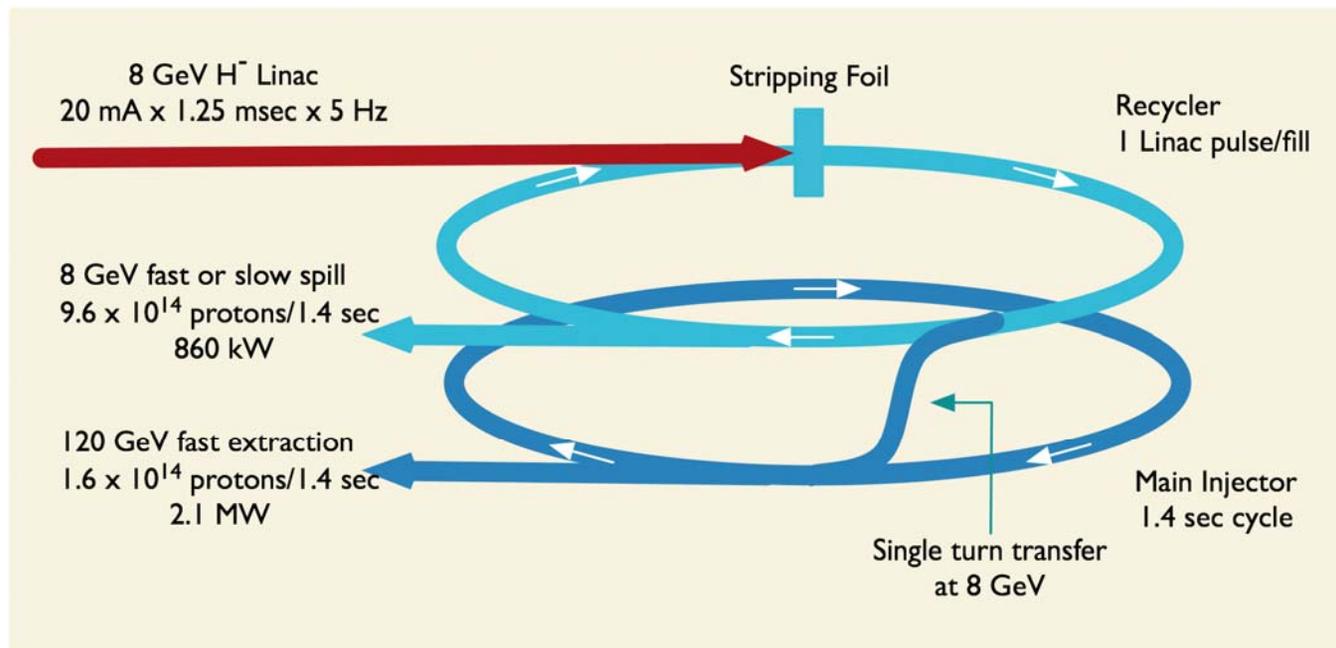
These could include a world leading muon-to-electron conversion experiment and world leading rare kaon decay experiments.
 - **A path toward a muon source for a possible future neutrino factory and, potentially, a muon collider at the Energy Frontier.**

This path requires that the new 8 GeV proton source have significant upgrade potential.

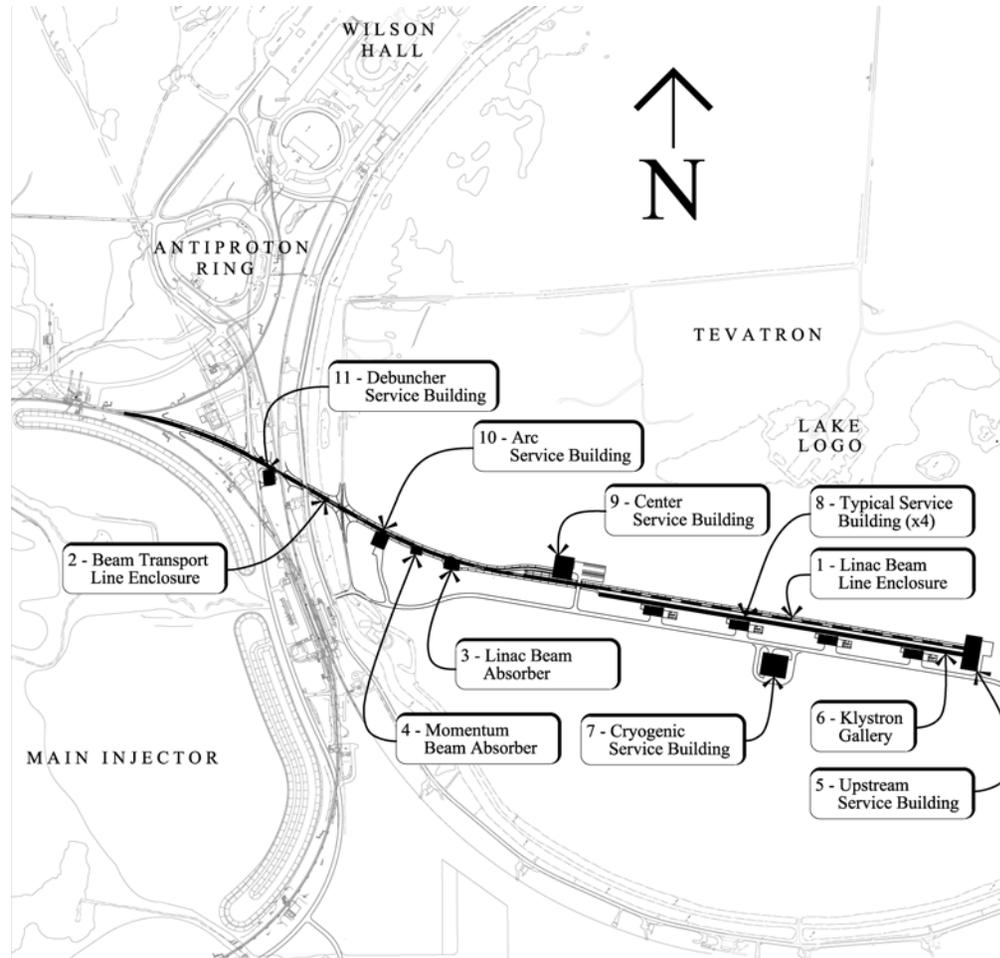
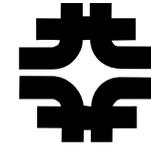
Project X Initial Configuration



- Project X Design Criteria
 - 2 MW of beam power over the range 60 – 120 GeV;
 - Simultaneous with at least 600 kW of beam power at 8 GeV;
 - Compatibility with future upgrades to 2-4 MW at 8 GeV

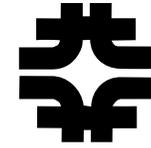


Project X Initial Configuration Provisional Siting



Project X Facility Overview

High Level Performance Goals



Linac

Particle Type	H ⁻	
Beam Kinetic Energy	8.0	GeV
Particles per pulse	1.6×10^{14}	
Linac pulse rate	5	Hz
Beam Power	280-1000	kW

Recycler

Particle Type	protons	
Beam Kinetic Energy	8.0	GeV
Cycle time	1.4	sec
Particles per cycle to MI	1.6×10^{14}	
Particles per cycle to 8 GeV program	1.6×10^{14}	
Beam Power to 8 GeV program	140-860	kW

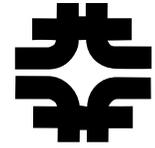
Initially:

- 2 linac beam pulses/1.4 seconds
- Remaining (5) pulses available for
 - Maintain 2 MW down to 60 GeV
 - Future upgrades
 - Diagnostics

Main Injector

Beam Kinetic Energy (maximum)	120	GeV
Cycle time	1.4	sec
Particles per cycle	1.7×10^{14}	
Beam Power at 120 GeV	2100	kW

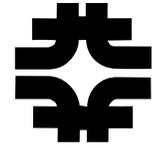
Project X RD&D Plan



-
- The primary goal of the Research, Design, and Development (RD&D) program is to support Critical Decision 2 in 2012, leading to a 2013 construction start.
 - Design and technical component development;
 - Fully developed baseline scope, cost estimate, and schedule;
 - Formation of a multi-institutional collaboration capable of executing both the RD&D plan and the follow-on construction project.
 - Secondary goals:
 - Coordination of Project X and ILC scrf programs to provide maximal benefit to each;
 - Retain alignment of Project X and the Neutrino Factory and Muon Collider programs to assure that Project X could serve as a stepping stone to either facility.

Project X RD&D Plan

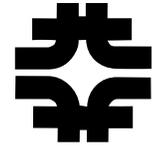
Near-term Strategy



- Develop an Initial Configuration Document
 - Meeting the design criteria and program goals
 - ICD subject to configuration control
 - ⇒ Complete Rev. 1.0: available at <http://projectx.fnal.gov/>
- Revise/update the current RD&D Plan
 - Based on the ICD
 - Review existing plan to emphasize reduction of risk
 - ⇒ In process, expect to have draft available for November Collaboration Meeting
- Create a preliminary cost estimate
 - Based on the ICD
 - ⇒ In process

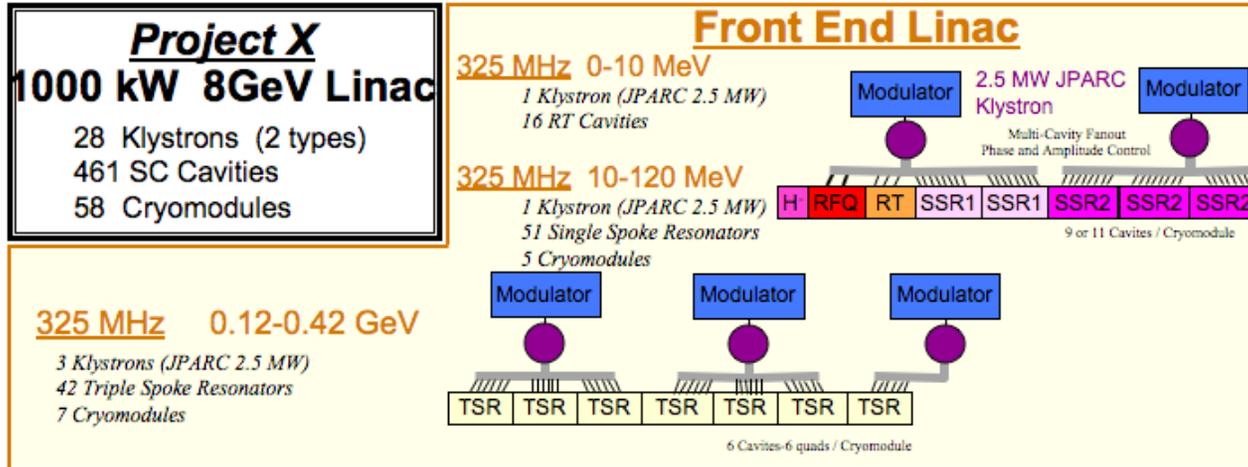
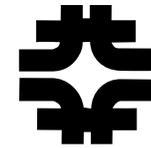
Project X RD&D Plan

Near-term Strategy



- Establish a multi-institutional collaboration for the RD&D phase
 - Fermilab holds overall responsibility as host laboratory;
 - Achieve maximal alignment with institutional expertise and experience;
 - Recognize it would be natural for responsibilities to carry over into the construction phase.
 - Retain “collaborating institution” relationship with the ILC/GDE through the R&D phase
 - ⇒ Collaboration Meeting scheduled November 21-22, 2008 at Fermilab
 - CD-0 in FY2009
 - Coordinated with very long baseline (DUSEL) and mu2e
 - Based on:
 - ICD
 - Preliminary cost estimate
 - P5 mission definition
-

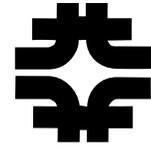
Relationship to ILC: Linac Technology



1300 MHz 0.42-1.3 GeV
4 Klystrons (ILC 10 MW MBK)
64 Squeezed Cavities ($\beta=0.81$)
8 Cryomodules

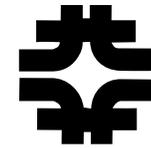
1300 MHz 1.3-8.0 GeV
19 Klystrons (ILC 10 MW MBK)
304 ILC-identical Cavities
38 ILC-like Cryomodules

Relationship to ILC: ILC/SRF/PX Joint Development Strategy



- 38 ILC-like (plus 8 $\beta=0.8$ ILC similar) cryomodules are required for Project X. In detail they will not be identical to ILC:
 - Gradient: 25 MV/m
 - Beam current: 20 mA \times 1.25 msec \times 5 Hz
 - Focusing: Quadrupole element required in each CM
 - Consistent with upgrade path
 - 1.25 \rightarrow 2.5 msec pulse length
 - 5 \rightarrow 10 Hz pulse rate
- } 4 MW at 8 GeV
- Development Plan aligned with ILC/GDE
 - Integrated srf effort at Fermilab, responsible for ILC and Project X
 - Development strategy based on ILC “plug compatibility”
 - Retain ILC cavity spacing and primary interface dimensions
 - CAF and ILCTA_NML are constructed via the SRF program:
 - 1 CM/month assembly capability;
 - Beam testing of a complete rf unit (ILC S2)

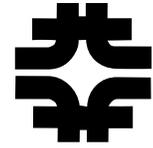
Relationship to ILC: ILC/SRF/PX Joint Development Strategy



- Development Plan: Cryomodule Assembly
 - CM1: TESLA Type III
 - Based on DESY supplied cavities (complete)
 - CM2: TESLA Type III
 - Based on U.S. supplied cavities
 - CM3: Type IV.1
 - U.S. cavities
 - Project X preliminary
 - CM4: Type IV.2
 - Project X prototype



Relationship to ILC: ILC/SRF/PX Joint Development Strategy



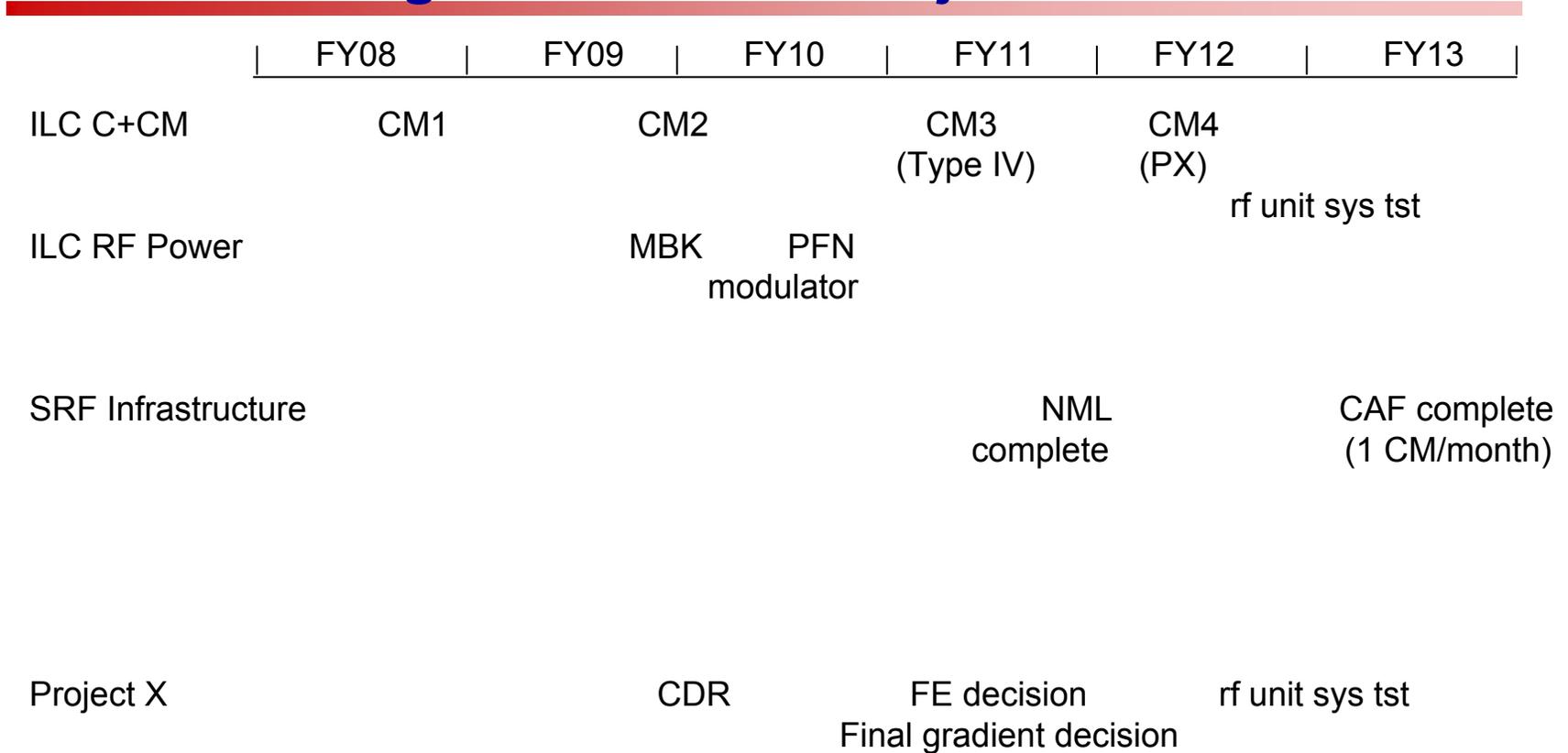
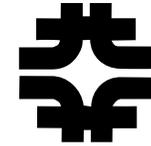
- Industrialization

- Production of 46 1.3 GHz CMs over a 2-3 year period is consistent with CAF capabilities in ~2013; however, the production rate remains well below that required by ILC.

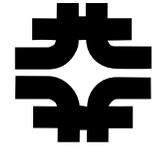
- ⇒ This activity could represent the initial phase of an industrialization buildup for ILC (in the U.S.).

Project X RD&D Plan

Integrated ILC/SRF/Project X Plan



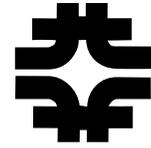
Relationship to ILC: ILC/PX Joint Development Strategy



- Other opportunities:
 - E-cloud studies and simulations, including participation in CESR TA
 - RF power generation, distribution, controls, and diagnostics share many features in common.
 - Conventional facilities designs provide opportunities for common solutions.
 - ILCTA_NML rf unit test will fulfill many of the requirements of S2, and will be available for studies with both PX and ILC beam current parameters.
 - Construction and operational experience with Project X will be invaluable in planning/executing ILC (if PX were to precede ILC, ditto for XFEL)
- ⇒ Essentially all these efforts are using shared (people) resources.

Project X RD&D Plan

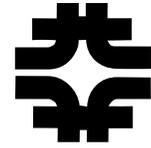
Collaboration Plan



- The intention is to organize and execute the RD&D Program via a multi-institutional collaboration.
 - Goal is to assign collaborators complete sub-projects ⇒ responsibility for design, engineering, cost estimating, and potentially construction if/when Project X proceeds.
 - Project X R&D Collaboration to be established via a Collaboration Memorandum of Understanding (MOU) outlining basic goals of the collaboration, and the means of organizing and executing the work.
 - It is anticipated that the Project X RD&D Program will be undertaken as a “national project with international participation”. Expectation is that the same structure of MOUs described above would establish the participation of international laboratories.

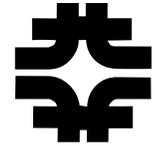
Project X RD&D Plan

Collaboration Plan



- A draft MOU covering the period through CD-2 is currently circulating for comment among the following potential U.S. collaborators:
 - ANL
 - BNL
 - Cornell
 - LBNL
 - ORNL/SNS
 - MSU
 - TJNAF
 - SLAC
 - ILC/GDE
 - Hope to finalize/sign at the initial Project X Collaboration Meeting scheduled for November 21-22, 2008 at Fermilab
-

Summary



- Project X is central to Fermilab's strategy for future development of the accelerator complex:
 - Energy Frontier: Aligned with ILC technology development; preserves Fermilab as a potential site for ILC or a Muon Collider
 - Intensity Frontier: Ultimate goal is 2 MW beam to very long ν baseline and >1 MW to $\mu 2e$ and other rare processes experiments
- An initial configuration has been established meeting requirements as specified in the P5 report
 - >2 MW at 60-120 GeV, simultaneous with >600 kW at 8 GeV
- Project X RD&D plan developed (through CD-2)
 - ⇒ Integrates efforts on Project X, ILC, and SRF
- Collaboration being formed
- More information at: <http://projectx.fnal.gov/>