Project X: Introduction, Strategy, and Collaboration Meeting Goals

Steve Holmes
Project X Collaboration Meeting
September 11, 2009

Outline

- Strategic Context and Goals
- Update on Activities of the Last Year
- Project X Goals and Initial Configuration(s)
- FY2010 Plan
- Meeting Goals, Agenda, and Organization

Our websites:

http://projectx.fnal.gov

http://projectx-docdb.fnal.gov

Strategic Context: Fermilab and the World Program

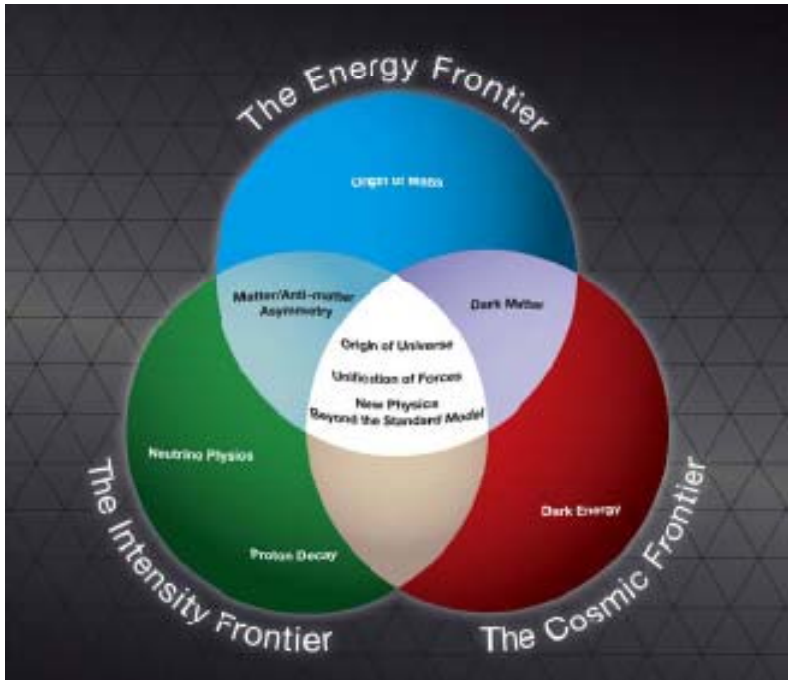
Fermilab currently operates the highest energy collider, and the highest power long baseline neutrino beam, in the world.

In 2009:

- LHC will capture the energy frontier
- J-PARC will initiate a competitive neutrino program

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 to provide world-leading accelerator facilities supporting forefront research at the Energy and Intensity Frontiers
  - Consistent with the HEPAP/P5 plan for U.S. EPP



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

Evolution of the Accelerator Complex

- A multi-MW Proton Source, Project X, is the linchpin of Fermilab's strategy for future development of the accelerator complex.
- Project X is designed to provide flexibility in evolving the Fermilab program in response to research results anticipated circa 2012.
  - Energy Frontier:

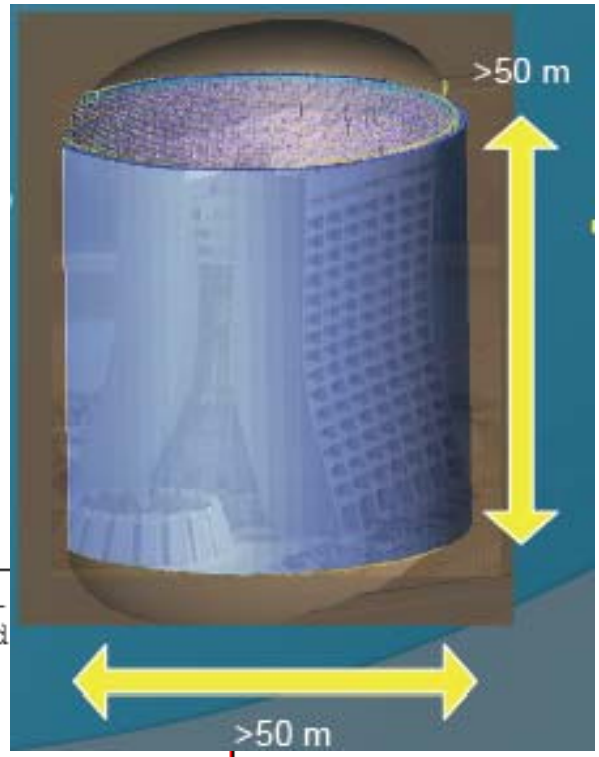
    Tevatron → ILC or Muon Collider
    - Technology alignment
    - Project X development retains ILC and MC as options for the Fermilab site
  - Intensity Frontier:

    NuMI→ NOνA→ LBNE/mu2e→ multi-MW Proton Source → NuFact
    - Continuously evolving world leading program in neutrino physics and other beyond the standard model phenomena

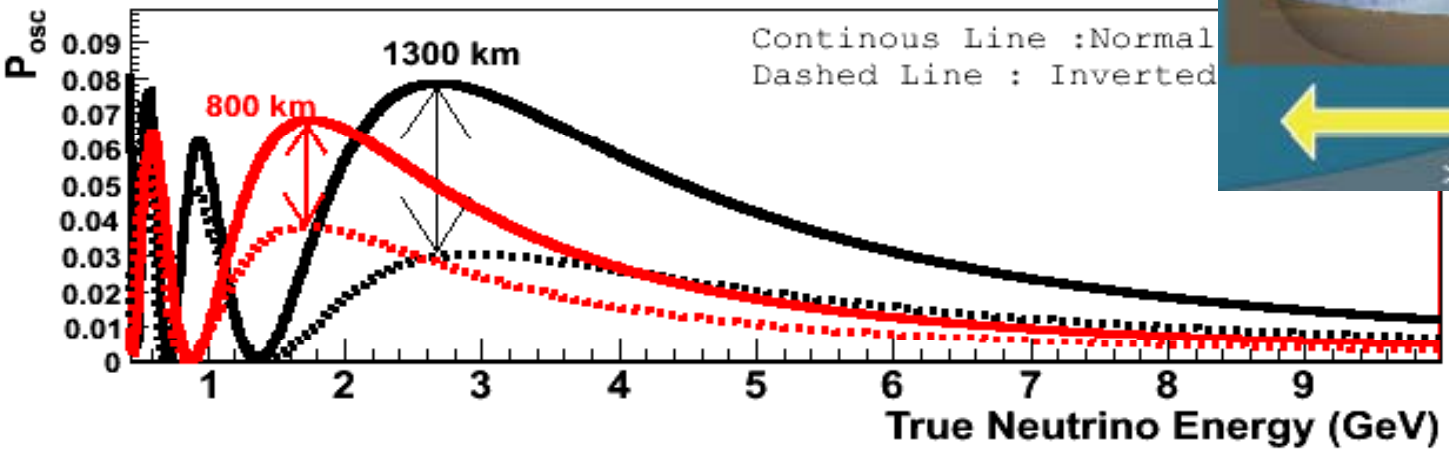
Evolution of the Accelerator Complex: LBNE

Physics Opportunities: Long Baseline ν's (LBNE)

- A long baseline, a massive detector, and high beam power are required to access CPV at low $\sin^2 2\theta_{13}$:
  - 2nd oscillation maximum visible at 1300 km
  - More straightforward separation of CPV and matter effects
  - Longer baseline enhances matter effects



$\nu_\mu \rightarrow \nu_e$ probability



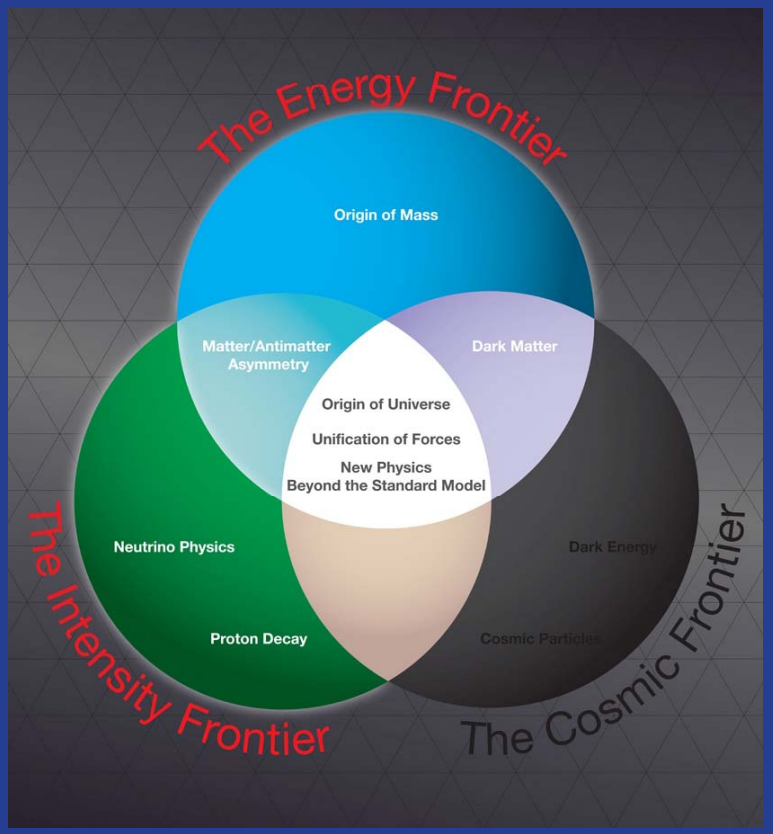
Near Term Strategy

- Project X is moving through the DOE system in coordination with the Long Baseline Neutrino Experiment (LBNE) and the muon to electron coversion experiment (Mu2e)
  - LBNE and Mu2e will both establish mission need (CD-0) on the basis of modest upgrades to the existing complex.
    - Both have been told to expect CD-0 “shortly”, and to be prepared for CD-1 at the end of FY2010.
  - The Project X mission will be to provide significant extension of the reach of these two initiatives, while simultaneously creating a broader range of intensity frontier opportunities (Bob Tschirhart presentation)
- Several briefings for the Office of Science on strategy, including to Bill Brinkman by Pier Oddone on August 13

⇒ CD-0 for LBNE & Mu2e are pre-requisites to CD-0 for Project X

Outline

- Why the intensity frontier answers fundamental questions
- Why Project X is the key
- And how Project X can lead us back to the energy frontier



Update on FY09 Activities

- Initial Configuration Document (ICD-1 V1.1) and updated RD&D plan (V2.2) released in March 2009
  - Available at http://projectx.fnal.gov
- Initial cost estimate based on ICD-1 released and subject to Director's Review in March 2009.
  - The review utilized Collaboration members as reviewers, and included DOE observers. ICD-1 is currently under (soft) configuration control.
  - TPC = $1.5B.
- Work initiated on developing an alternative design concept based on a 2 GeV CW linac, followed by a 2-8 GeV rapid cycling synchrotron.
  - Initial Configuration Document (ICD-2) in preliminary draft
  - Associated cost estimate under development.
    - Primary motivation for ICD-2 is to provide a more flexible base for the low energy rare processes program supported by Project X

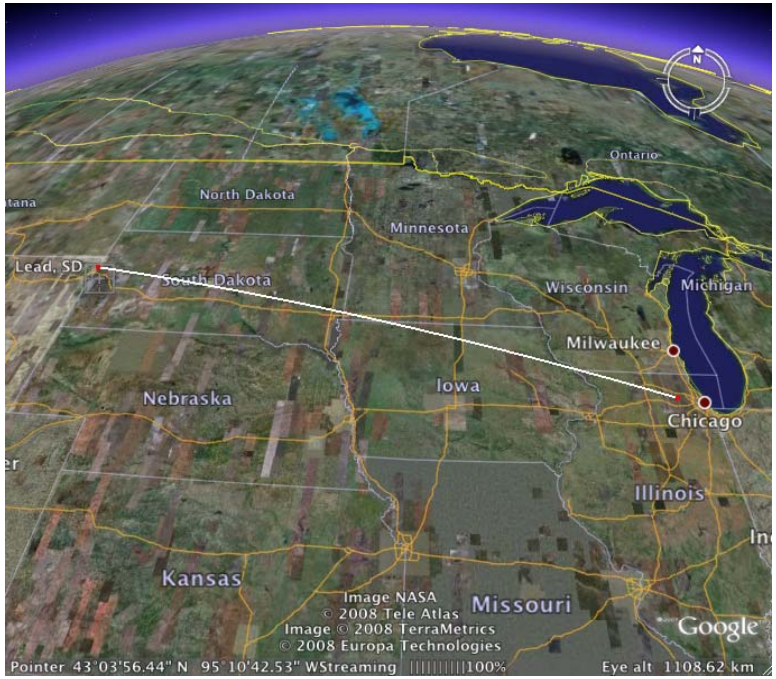
Update on Activities

- $42M received from ARRA funds for superconducting rf infrastructure at Fermilab and development of U.S. vendors.
- Project X Collaboration MOU signed by all potential U.S. participants; Serves as the overall governing document for the collaboration
  - A number of secondary MOU's have now been established within the collaboration, covering specific scopes of work.
- CD-0 is now currently expected in FY2010 (following LBNE)
  - Based on: ICDs, preliminary cost estimates, P5 mission definition
- Anticipated funding for Project X R&D in FY10 will total $9.2M

⇒ **The September 2009 Collaboration Meeting will provide an opportunity to discuss ICD-2 and to develop/finalize the plan for FY2010.**

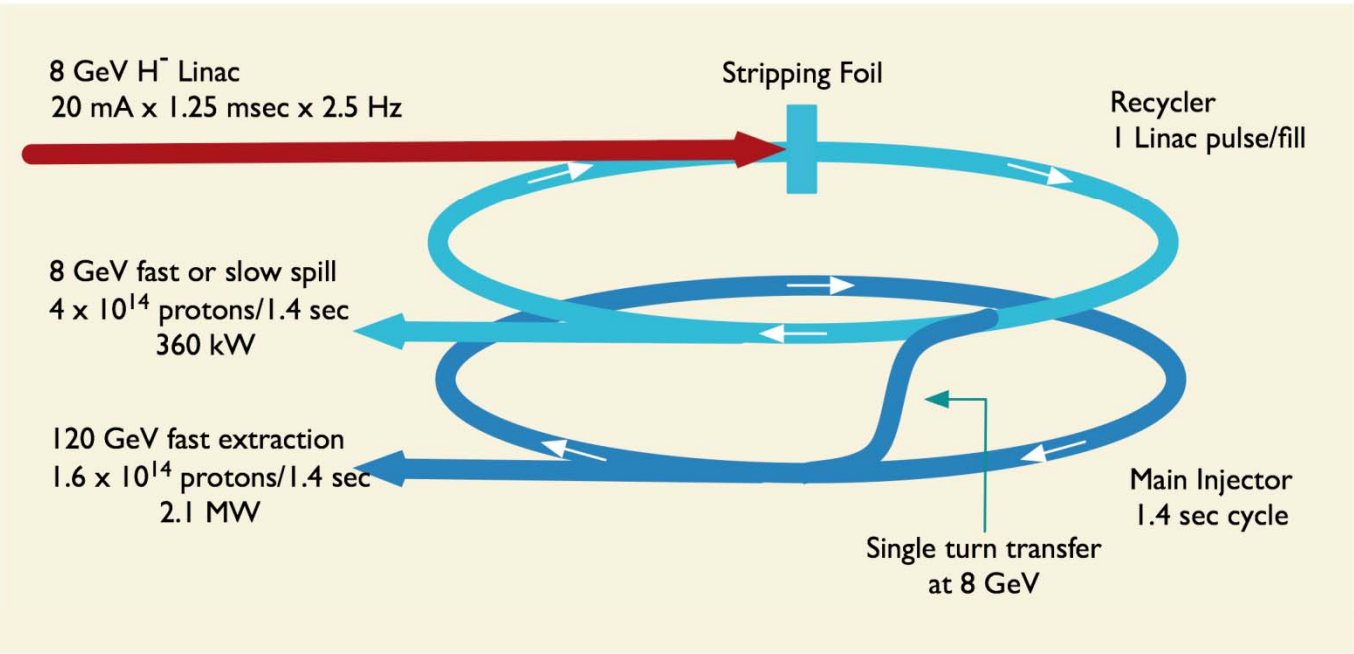
Goals and Strategy: Mission Need

- The P5 report defines mission need for a multi-MW proton source based on :
  - A neutrino beam for long baseline neutrino oscillation experiments
    - 2 MW proton source at 60 - 120 GeV
  - High intensity, low energy protons for kaon and muon based precision experiments
    - Operations simultaneous with the neutrino program.
  - A path toward a muon source for a possible future neutrino factory and/or a muon collider at the Energy Frontier.
    - Requires upgrade potential to 2-4 MW at ~8 GeV.



Initial Configuration-1

- Project X Design Criteria
  - 2 MW of beam power over the range 60 – 120 GeV;
  - Simultaneous with at least 150 kW of beam power at 8 GeV;
  - Compatibility with future upgrades to 2-4 MW at 8 GeV

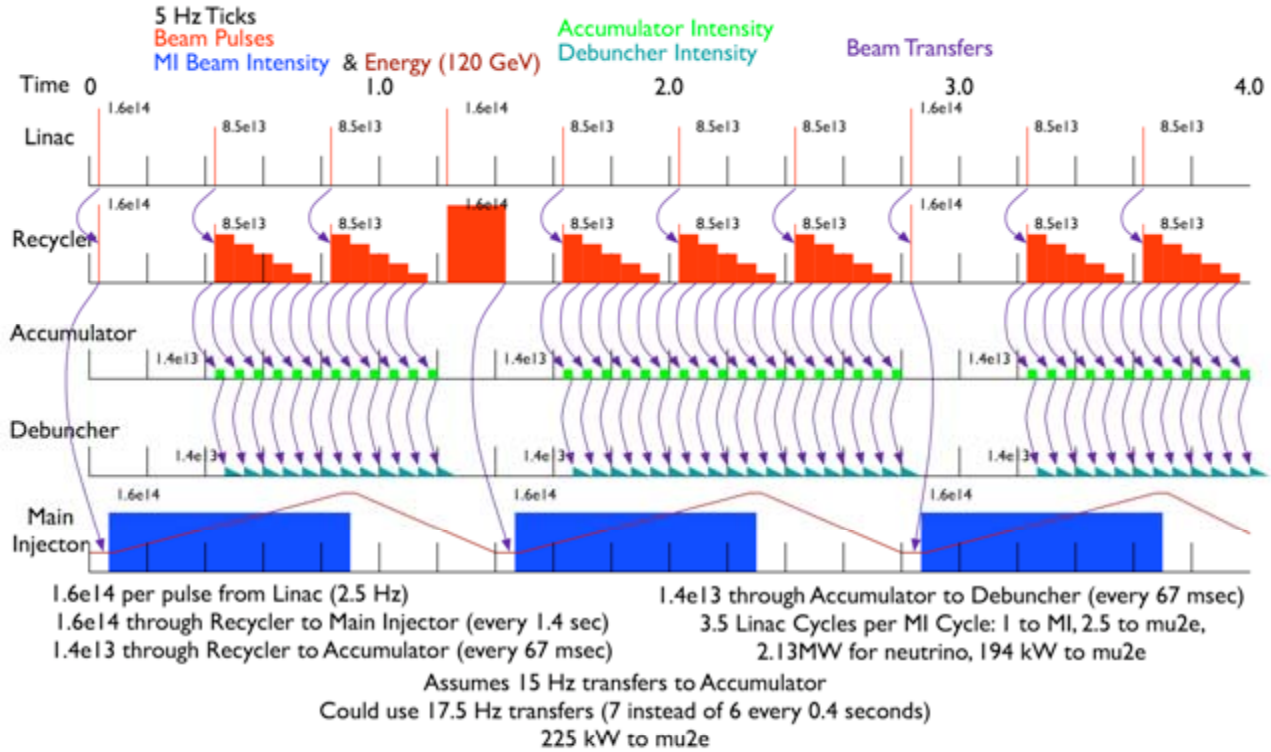


Initial Configuration-1 Performance Goals

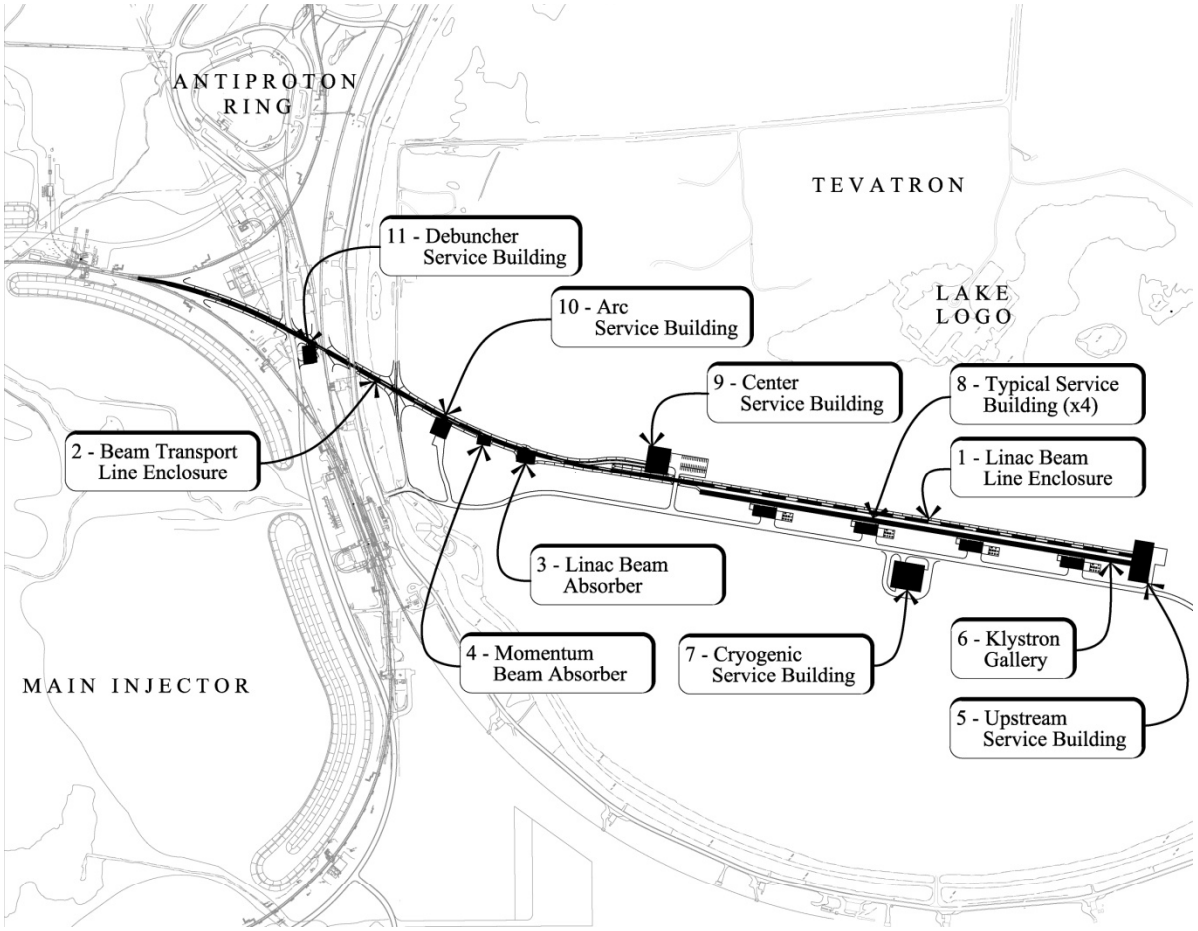
Linac		
Particle Type	H^-	
Beam Kinetic Energy	8.0	GeV
Particles per pulse	1.6×10^{14}	
Linac pulse rate	2.5	Hz
Beam Power	500	kW
Recycler		
Particle Type	protons	
Beam Kinetic Energy	8.0	GeV
Cycle time	1.4	sec
Particles per cycle to MI	1.6×10^{14}	
Particles per cycle to 8 GeV program	1.6×10^{14}	
Beam Power available for 8 GeV program	220-360	kW
Main Injector		
Beam Kinetic Energy (maximum)	60-120	GeV
Cycle time	0.8-1.4	sec
Particles per cycle	1.6×10^{14}	
Beam Power at 60-120 GeV	>2000	kW

Initial Configuration-1 Operating Scenarios

- Operating scenarios for 120 GeV (2.1 MW)
  - 194 kW at 8 GeV to mu2e experiment in parallel



Initial Configuration-1 Provisional Siting



Initial Configuration-1 Operational Challenges

- We know that ICD-1 does not provide an ideal platform for mounting a low energy flavor program.
  - "Golden Book" requirements:

	Train Frequency (MHz)	Pulse Width (nanoseconds)	Inter-Pulse Extinction
Kaon experiments	20-30	0.1-0.2	10^{-3}
Muon conversion experiment	0.5-1.0	50	10^{-9*}
Muon g-2 experiment	30-100	50	---

  - The Recycler is ill-suited to providing high intensity slow spilled beam
    - In ICD-1 the Recycler delivers 15 Hz packets to the Debuncher for slow spill to mu2e.
      - The Debuncher appears limited to <150 kW in this mode
  - ICD-1 does not yet have a solution for the kaon requirements

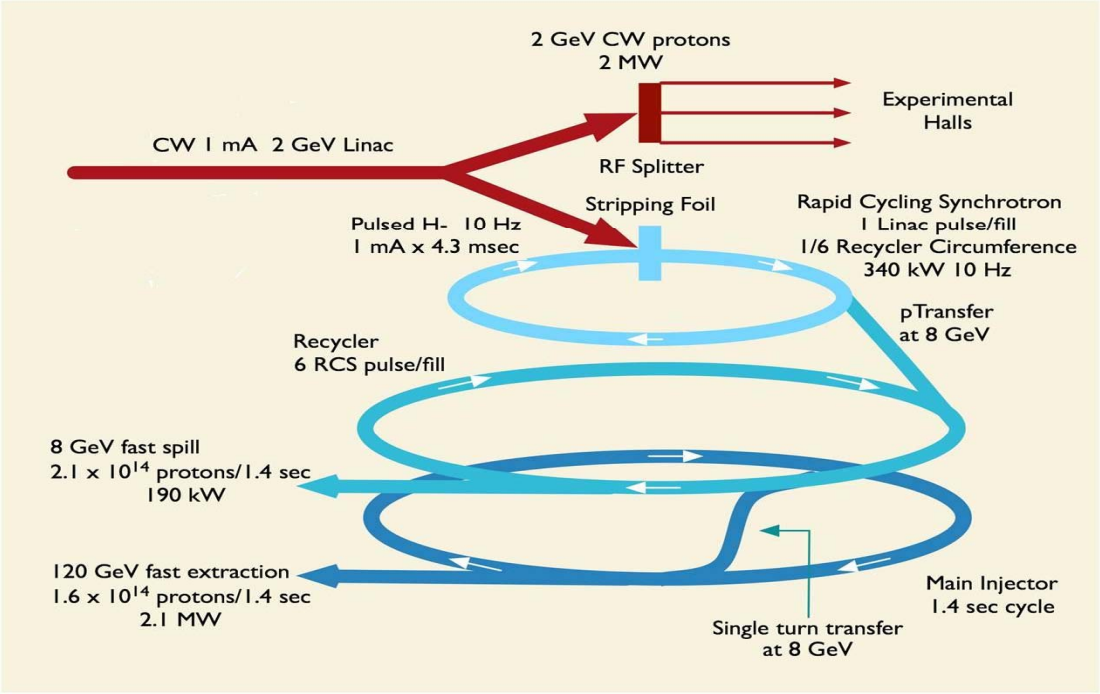
⇒**We are able to generate substantially more beam power in ICD-1 than we can effectively utilize.**

Initial Configuration-2

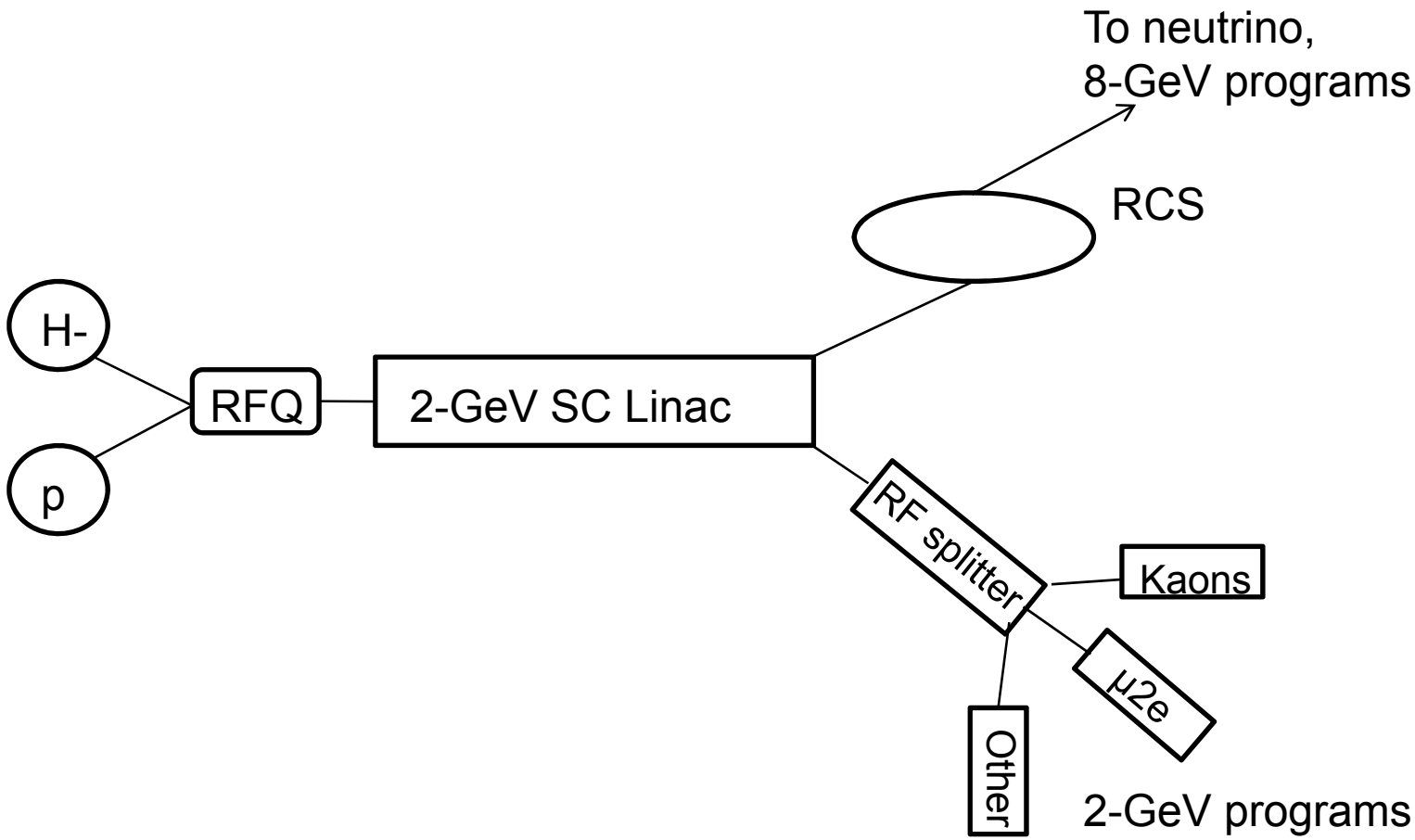
- Consideration of alternative designs is required by the DOE Project Management Order.
- A primary consideration is the low energy program
  - The Recycler as utilized in the ICD-1 has limitations in providing a flexible source of useful beam to the low energy flavor program
- Primary alternative we are looking at:
  - Linac operated in CW (1 mA) mode up to 2 GeV
  - Rapid cycling synchrotron for acceleration from 2 GeV to 8 GeV
  - ⇒ "Mix and match" opportunities for the evaluation phase
  - Upgrade to NF/MC power capabilities requires more thinking
- Initial Configuration Document-2 (ICD-2) under development
  - Document, and associated cost estimate, to be prepared utilizing same team, methodology, and design criteria as ICD-1
  - Anticipate release late summer

Initial Configuration - 2

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

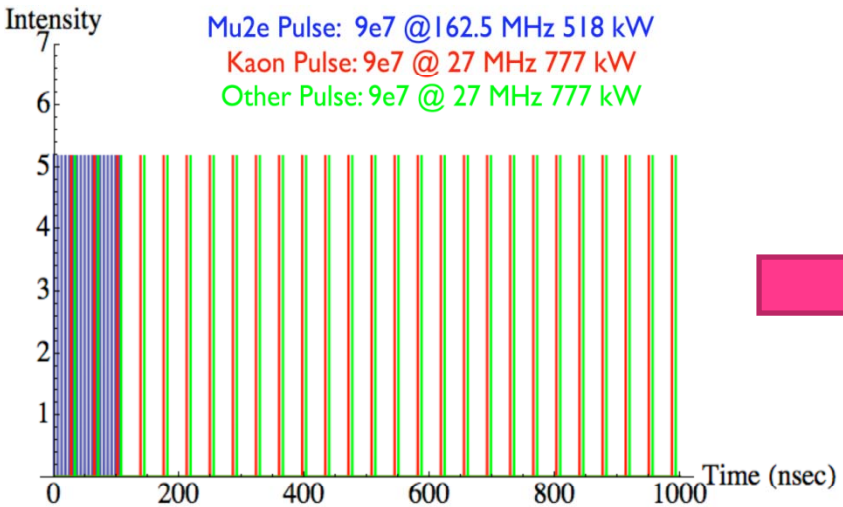


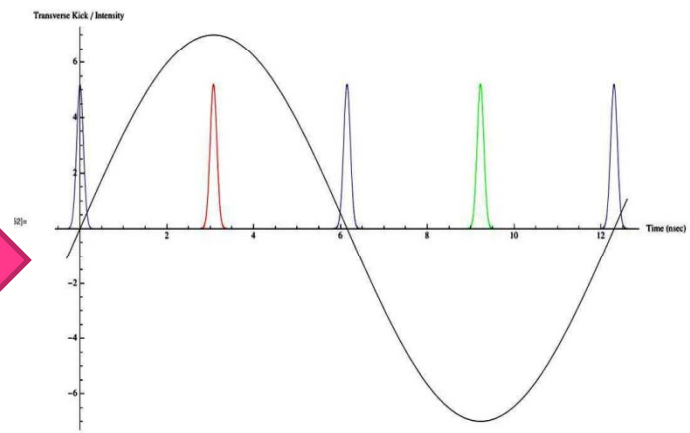
Initial Configuration-2



Initial Configuration-2 Operating Scenario

- H- ion source capable of up to 10 mA DC
- Variable bunch formats:
  - Bunch-by-bunch chopping example (ion source at 4.7 mA), chopping and rf splitting for 3 experiments





Transverse kick at rf splitter
(81 MHz, similar to crab cavity)

Near Term Strategy
FY10 Plan

- September 11-12, 2009: Collaboration Meeting
  - Input on ICD-2
  - Work plan for FY10
- October 1, 2009: Release ICD-2 Rev. 1.0
- October 19-21, 2009: Workshop on Applications of High Intensity Proton Accelerators (Fermilab)
  - Feeds into DOE Symposium/Workshop the following week
- November 1, 2009: Complete initial cost estimate for ICD-2
- November 9-10, 2009: Workshop on Physics with a High Intensity Proton Source (Fermilab)
  - Emphasis on rare processes/flavor program

Near Term Strategy
FY10 Plan

- November 10-12, 2009: Muon Collider Physics Workshop (Fermilab)
  - Physics and detector requirements
- November 12-14, 2009: Fermilab Physics Advisory Committee Meeting
- November 16-18, 2009: Fermilab Accelerator Advisory Committee Meeting
  - ICD-2 concept and revised R&D plan
- January, 2010: Potential Director's Review of ICD Cost Range

Near Term Strategy
FY10 Plan

- January, 2010: Identify ICD-1 or ICD-2 as preferred option to move forward. Evaluation metrics:
  - Cost
  - Performance
  - Technical risk
  - Upgradability/flexibility
  - Interactions with other programs

  ⇒ Weighting associated with metrics is to be determined(!)

- January, 2010: Initiate conceptual development of the preferred configuration

Working Timeline

- FY2009
  - Complete Initial Configuration Documents (ICD-1 and ICD- 2) and preliminary cost estimates
  - Develop Upgrade Concepts for 2-4 MW at 8 GeV
  - Form RD&D Collaboration
  - Establish Project Management team
  - Revise RD&D plan and initiate work
- FY2010
  - Establish preferred configuration
  - CD-0
  - Request PED funds for FY2012
  - Develop NEPA strategy

Working Timeline

- FY2011
  - Initiate work on Conceptual Design Report
  - Initiate permitting documentation
  - Draft of all CD-1 documentation
- FY2012
  - CD-1
- FY2013
  - CD-2/3a
- FY2015
  - CD-3: Initiate Construction
- ~FY2015~2019
  - Construct

Collaboration Plan

- A multi-institutional collaboration has been established to execute the Project X RD&D Program.
  - Organized as a "national project with international participation".
    - Fermilab as lead laboratory
    - International participation via in-kind contributions, established through bi-lateral MOUs. (First MOU with India in place)
  - Collaboration MOU for the RD&D phase outlines basic goals, and the means of organizing and executing the work. Signatories:

ANL	ORNL/SNS
BNL	MSU
Cornell	TJNAF
Fermilab	SLAC
LBNL	ILC/ART

  - Collaborators to assume responsibility for components and sub-system design, development, cost estimating, and potentially construction.

Collaboration Meeting: Goals

- Discuss Project X configurations
  - Review of ICD-1
  - Introduction to ICD-2
  - Comments from collaboration
- Establish RD&D Plan for FY10
  - Discuss required modifications to the current RD&D plan to accommodate ICD-2
  - Discuss/establish work plan for FY10
    - Goals, milestones, assignments
    - Presentation of planned FY10 budget
  - Discussions with potential international and university collaborators on possible interests and modes of participation.
  - Understand the integration with the ILC and SRF infrastructure programs.

Collaboration Meeting: Goals

- Collaboration Council Meeting
  - Discussion of working arrangements under the MOU
  - Review of current institutional responsibilities
  - Discussion of criteria and process for identifying a CDR configuration
  - Discuss potential interactions with international and university collaborators
    - Associates status?
  - Desired meeting frequency

Collaboration Meeting:
Agenda

- Friday, September 11
  - Opening plenary session 08:30-10:30
    - Project X Introduction and Strategy Steve H.
    - Project X ICD-1 and ICD-2 Overview Sergei N.
    - Project X Physics Opportunities Bob T.
  - Coffee Break (1 West) 10:30-11:00
  - Working Groups session one 11:00-12:30
  - Lunch (self-serve) 12:30-13:30
  - Working Groups session two 13:30-15:30
  - Collaboration Council meeting 13:30-14:30
  - Coffee Break (WH2, W&C) 15:30-16:00
  - Working Groups session three 16:00-17:30
  - Adjourn 17:30

Collaboration Meeting:
Agenda

- Saturday, September 12
  - Working Group Reports 08:30-10:00
    - Linac Design
    - RCS Design
    - Cavities and Cryomodules
    - RF Sources
  - Coffee Break 10:00-10:30
  - Working Group Reports 10:30-12:00
    - Cryogenics
    - Instrumentation and Controls
    - Main Injector/Recycler
    - Beam Transfer Line/Injection
  - Adjourn 12:00

Collaboration Meeting:
Working Groups

- Charge to the working groups:
  - Discussion/potential modifications to ICD-1 and ICD-2;
  - Discuss potential modifications to the existing RD&D plan for ICD-2;
  - Establish goals and work plan for FY2010 (elements and sequencing);
    - Includes foreseen MOUs
    - Provisional distribution of responsibility and funding
  - Identify any issues related to the above that need resolution

- Provisional FY2010 budget distribution ($K, direct costs only):

	M&S	SWF	Labs	Total
Available	$2500	$3350	$1600	$7450
Requested	$3210	$5540	$2170	$10920

Collaboration Meeting:
Working Groups

• RF Systems	J. Reid/R. Pasquinelli/B. Chase/L. Harwood, A. Nassiri
• Cavities & CMs	M. Champion/B. Rimmer
• Main Injector/Recycler	I. Kourbanis/U. Wienands
• Instrumentation/Controls	M. Wendt/J. Patrick/W. Blokland
• Cryogenics	A. Klebaner/D. Arenius
• Transfer Line/Injection	D. Johnson/D. Raparia
• Linac Design/Integration	S. Nagaitsev/N. Solyak/P. Ostroumov/C. Adophsen
• RCS Design	V. Lebedev/M. Plum

Project X

Summary

- Project X is central to Fermilab's strategy for future development of the accelerator complex:
  - Energy Frontier: Aligned with ILC technology development; Fermilab as potential site for ILC or a Muon Collider
  - Intensity Frontier: World leading program in neutrinos and rare processes; Fermilab as potential Neutrino Factory site
- Initial configuration, and preliminary cost estimate, established
  - >2 MW at 60-120 GeV, simultaneous with >150 kW at 8 GeV
  - Upgradable to 2-4 MW at 8 GeV
  - Initial configuration-2 under development
- Project X could be constructed over the period ~2014 - 2018
- Collaboration Meeting Goals:
  - Look at ICD-2
  - Formulate the plan for next year

Working Group Room Assignments (session 1)

RF Systems	1-West
Cavities & CMs	1-West
Main Injector/Recycler	Comitium (WH2-SE)
Instrumentation/Controls	Fishtank (WH13-N)
Cryogenics	MW-9 (follow Arkadiy)
Transfer Line/Injection	Huddle (X-Gallery)
Linac Design/Integration	1-West
RCS Design	Huddle (X-Gallery)