

# **Project X: Introduction, Strategy, and Collaboration Meeting Goals**

Steve Holmes  
Project X Collaboration Meeting  
September 11, 2009



- 
- 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>

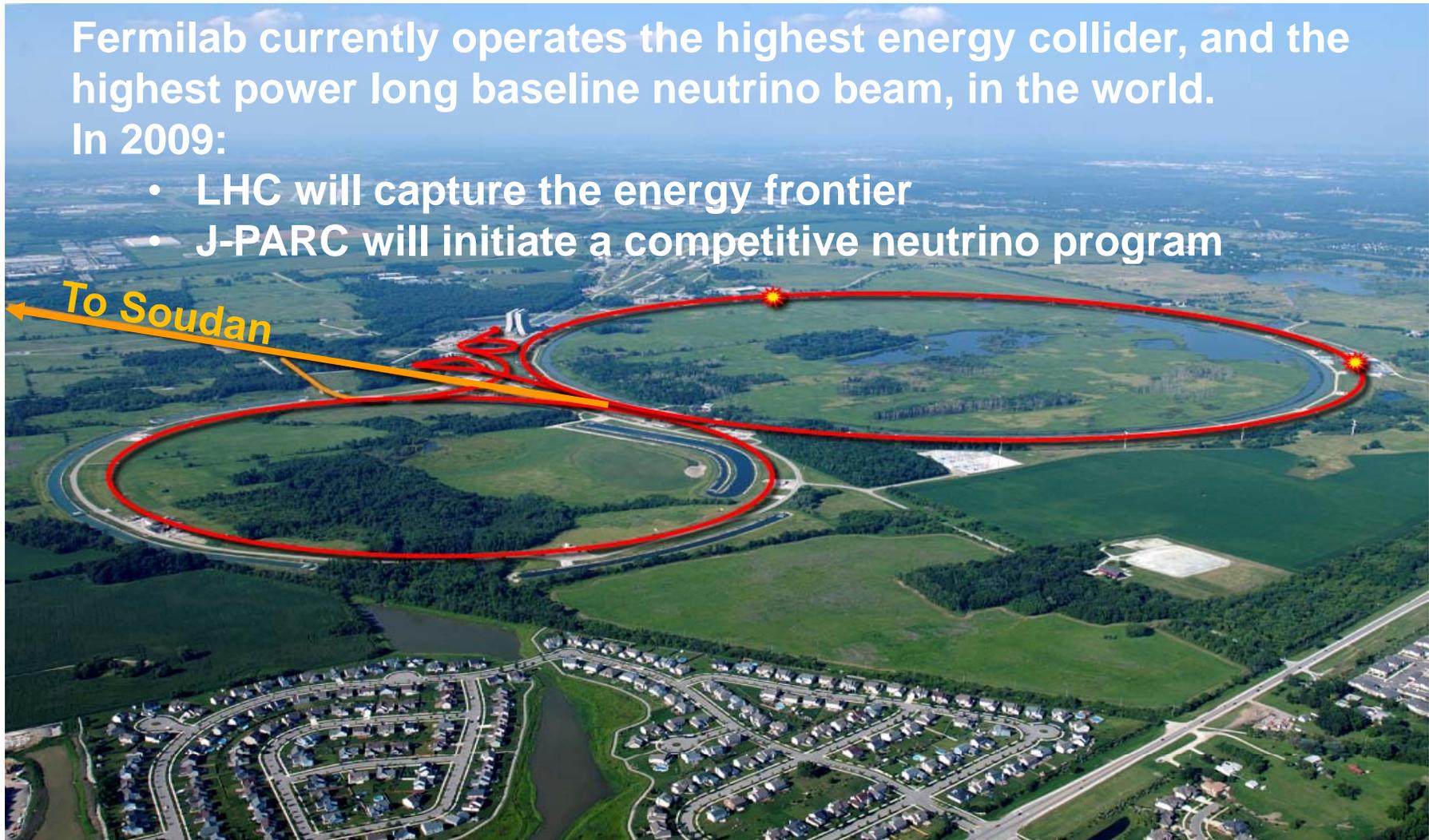
<http://projectx-docdb.fnal.gov>

# 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:

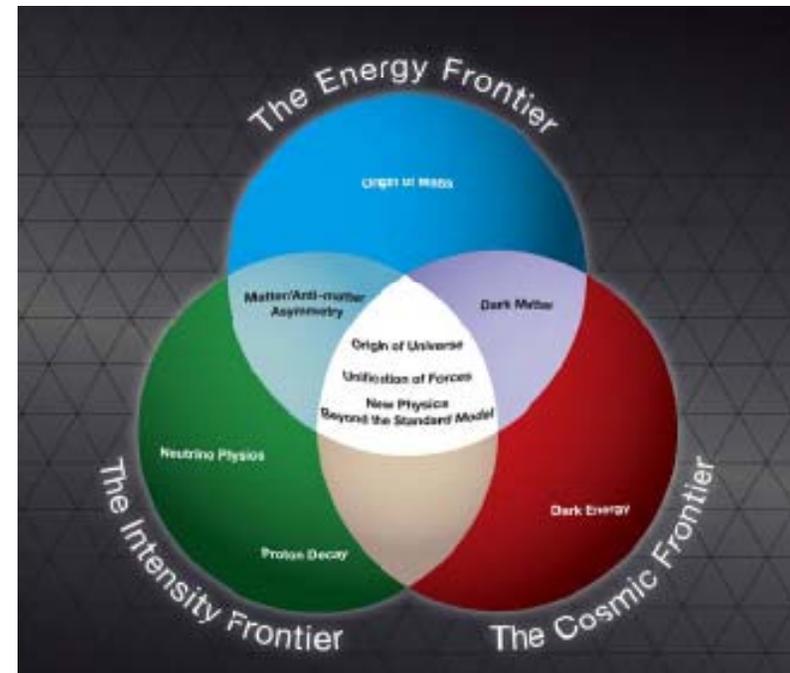
- LHC will capture the energy frontier
- J-PARC will initiate a competitive neutrino program



# 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%206022008.pdf](http://www.science.doe.gov/hep/files/pdfs/P5_Report%206022008.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:

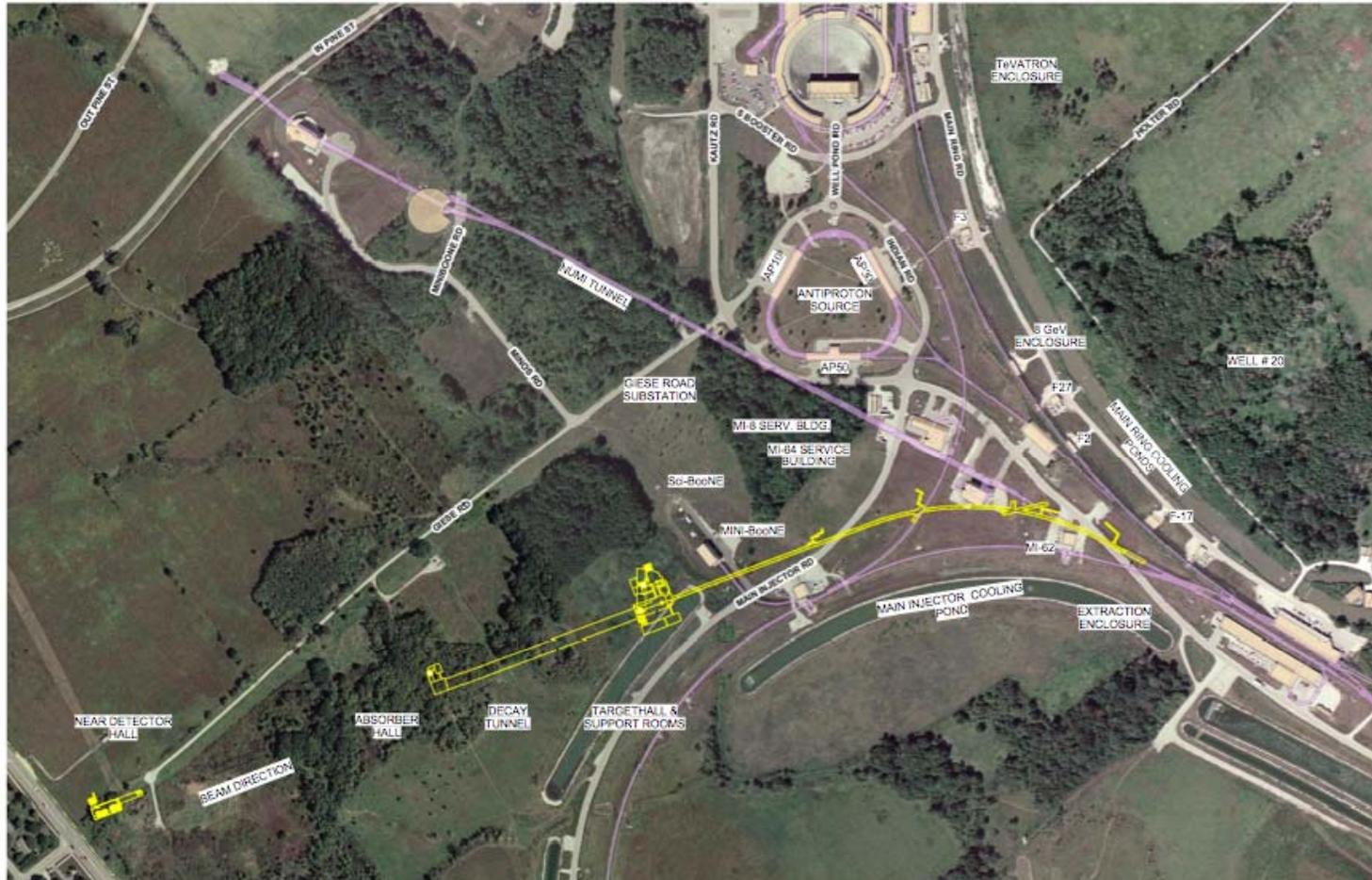
Tevatron → ILC or Muon Collider

    - Technology alignment
    - Project X development retains ILC and MC as options for the Fermilab site
  - Intensity Frontier:

NuMI → NOvA → LBNE/mu2e → multi-MW Proton Source → NuFact

    - Continuously evolving world leading program in neutrino physics and other beyond the standard model phenomena

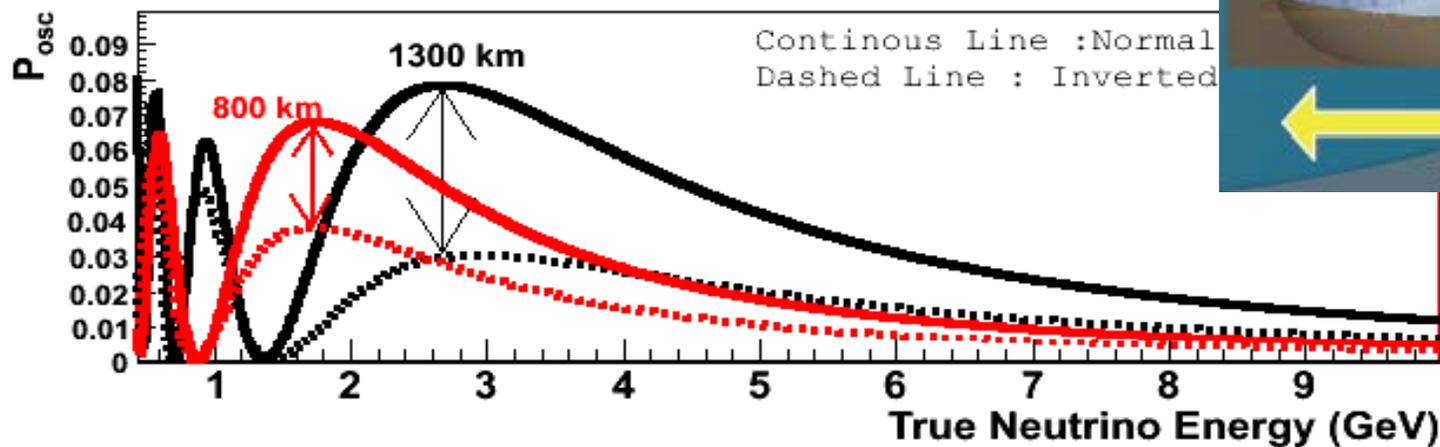
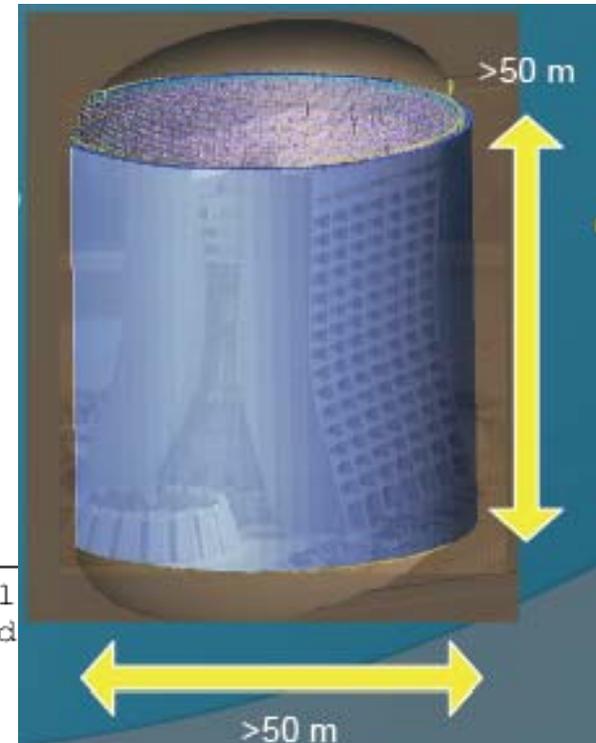
# Evolution of the Accelerator Complex: LBNE



# Physics Opportunities: Long Baseline $\nu$ 's (LBNE)



- A long baseline, a massive detector, and high beam power are required to access CPV at low  $\sin^2 2\theta_{13}$ :
  - 2<sup>nd</sup> 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



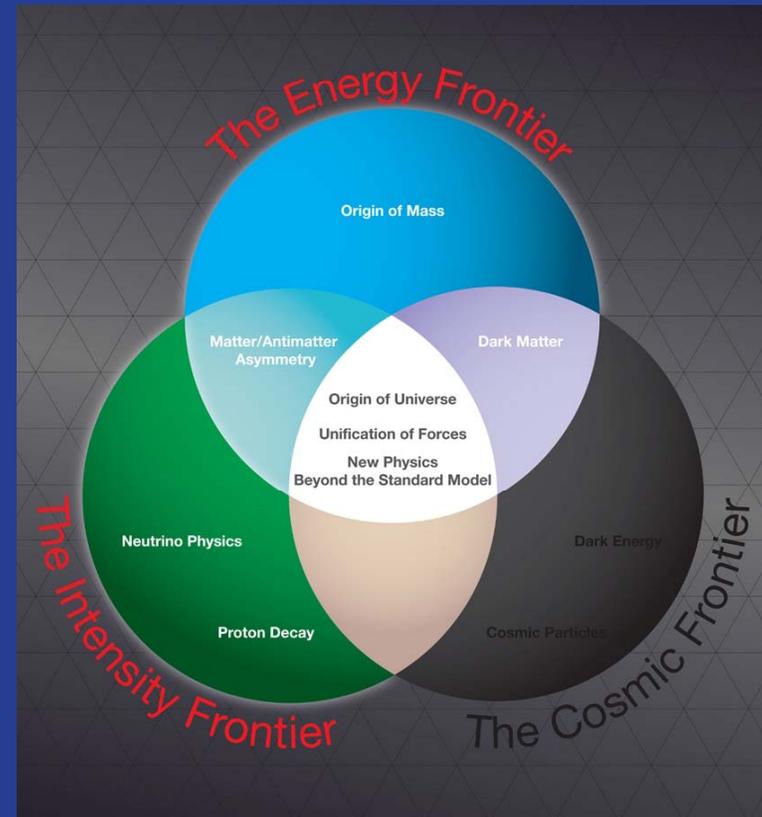


- Project X is moving through the DOE system in coordination with the Long Baseline Neutrino Experiment (LBNE) and the muon to electron conversion experiment (Mu2e)
  - LBNE and Mu2e will both establish mission need (CD-0) on the basis of modest upgrades to the existing complex.
    - Both have been 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





- 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

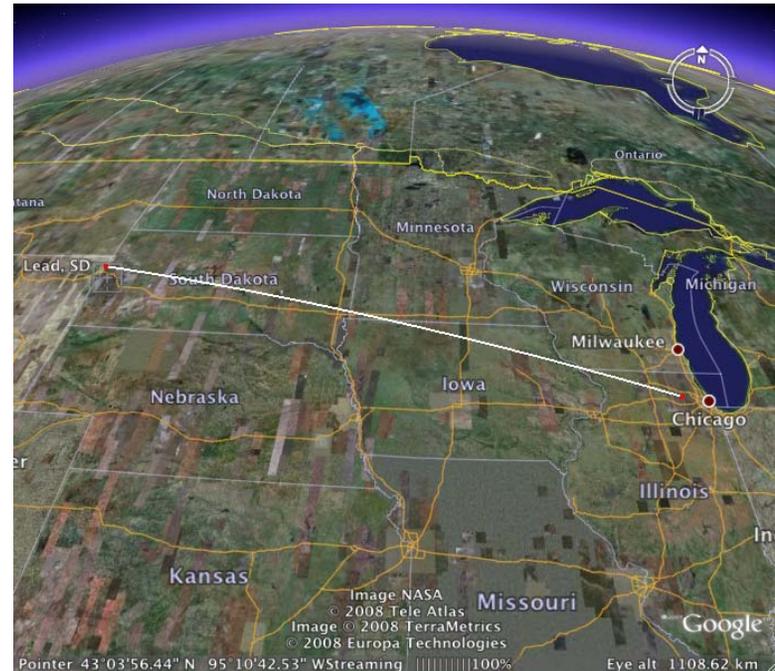


- \$42M received from ARRA funds for superconducting rf infrastructure at Fermilab and development of U.S. vendors.
  - Project X Collaboration MOU signed by all potential U.S. participants; Serves as the overall governing document for the collaboration
    - A number of secondary MOU's have now been 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 authorization 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

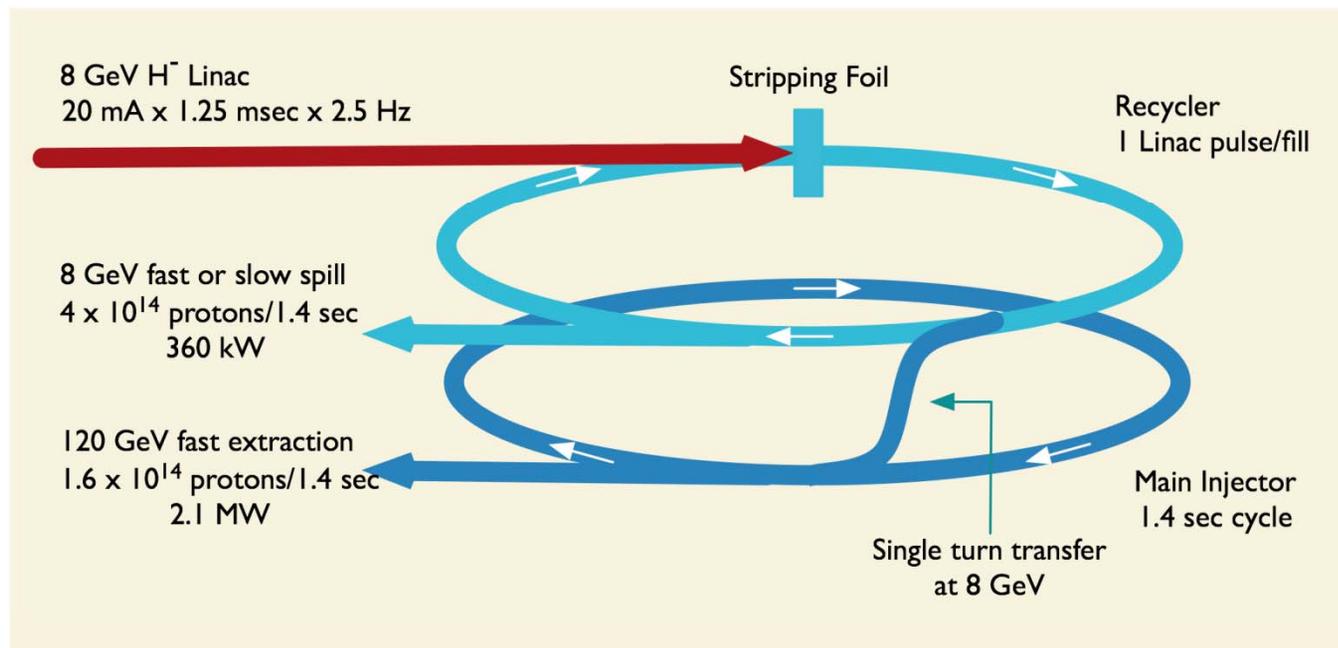


- The P5 report defines mission need for a multi-MW proton source based on :
  - A neutrino beam for long baseline neutrino oscillation experiments
    - 2 MW proton source at 60 - 120 GeV
  - High intensity, low energy protons for kaon and muon based precision experiments
    - Operations simultaneous 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.





- 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 <sup>-</sup>	
Beam Kinetic Energy	8.0	GeV
Particles per pulse	$1.6 \times 10^{14}$	
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	$1.6 \times 10^{14}$	
Particles per cycle to 8 GeV program	$1.6 \times 10^{14}$	
Beam Power available for 8 GeV program	220-360	kW

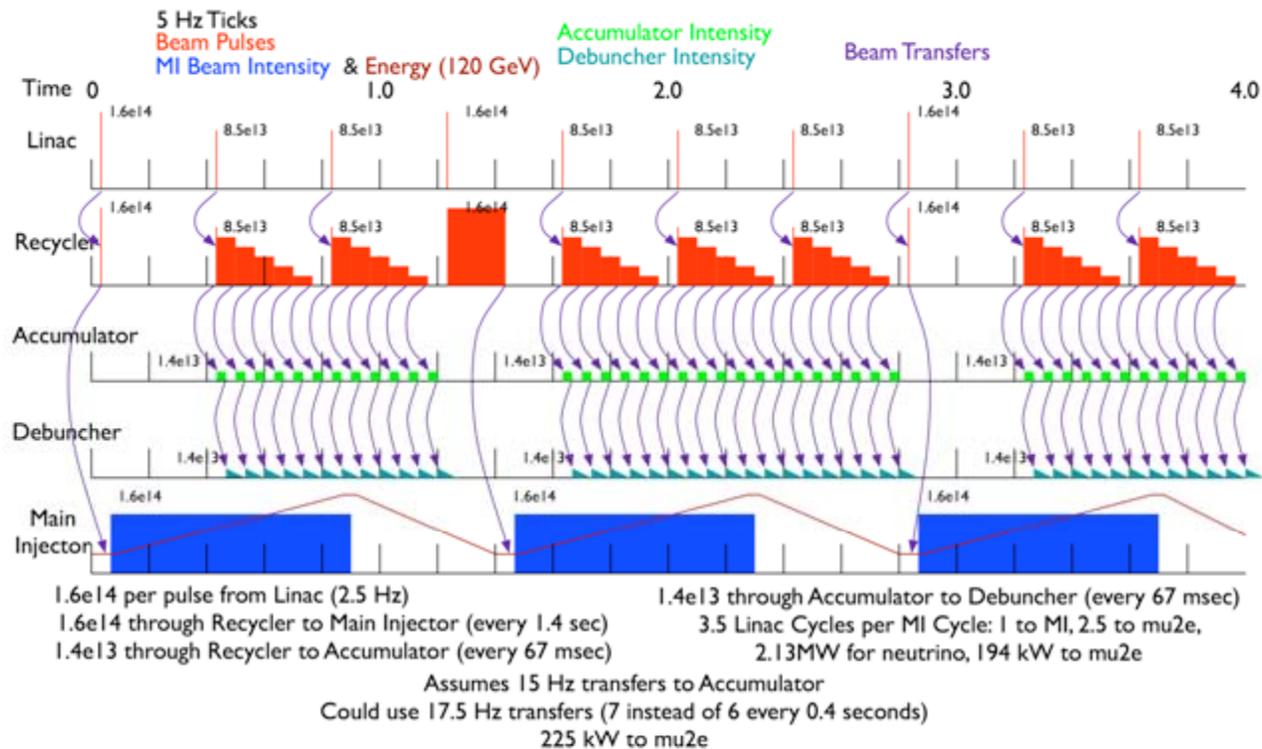
## Main Injector

Beam Kinetic Energy (maximum)	60-120	GeV
Cycle time	0.8-1.4	sec
Particles per cycle	$1.6 \times 10^{14}$	
Beam Power at 60-120 GeV	>2000	kW

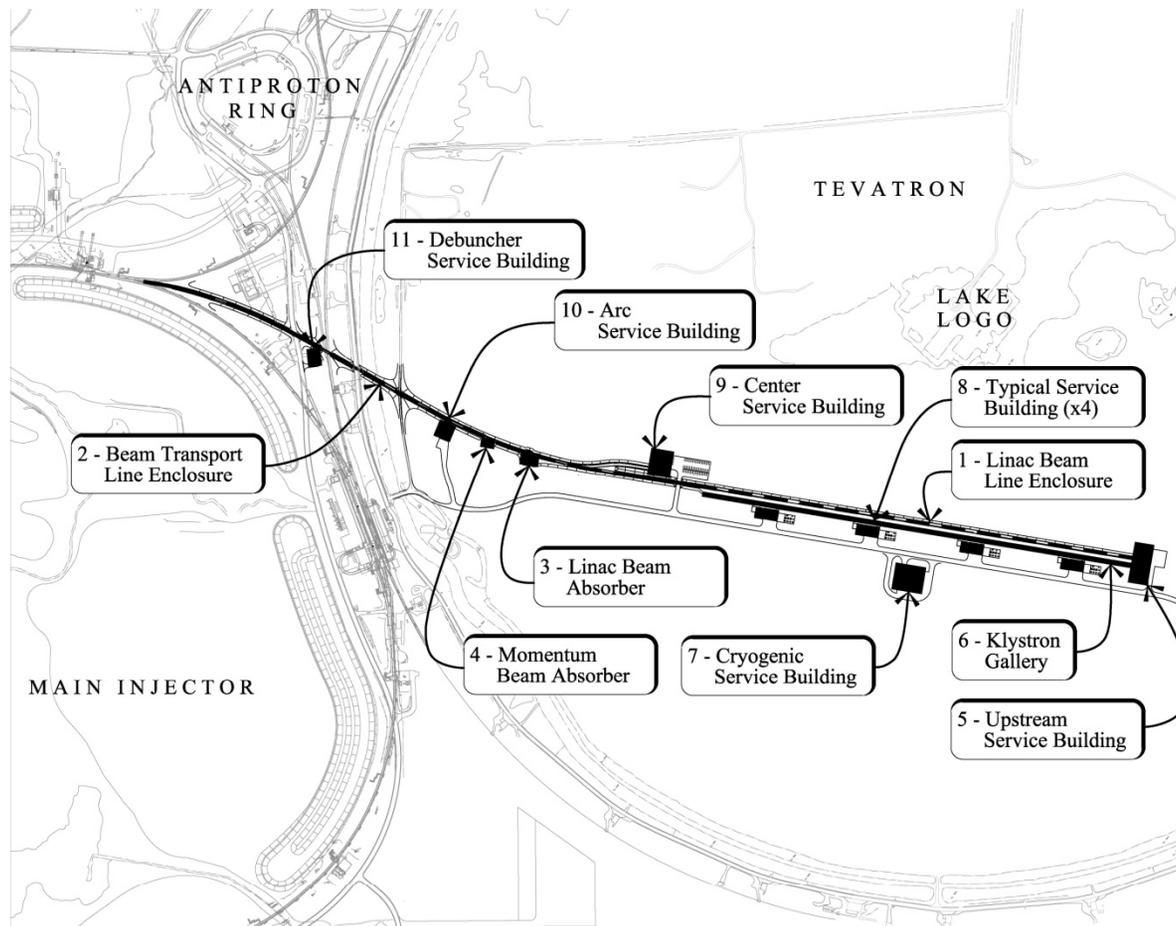
# Initial Configuration-1 Operating Scenarios



- 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

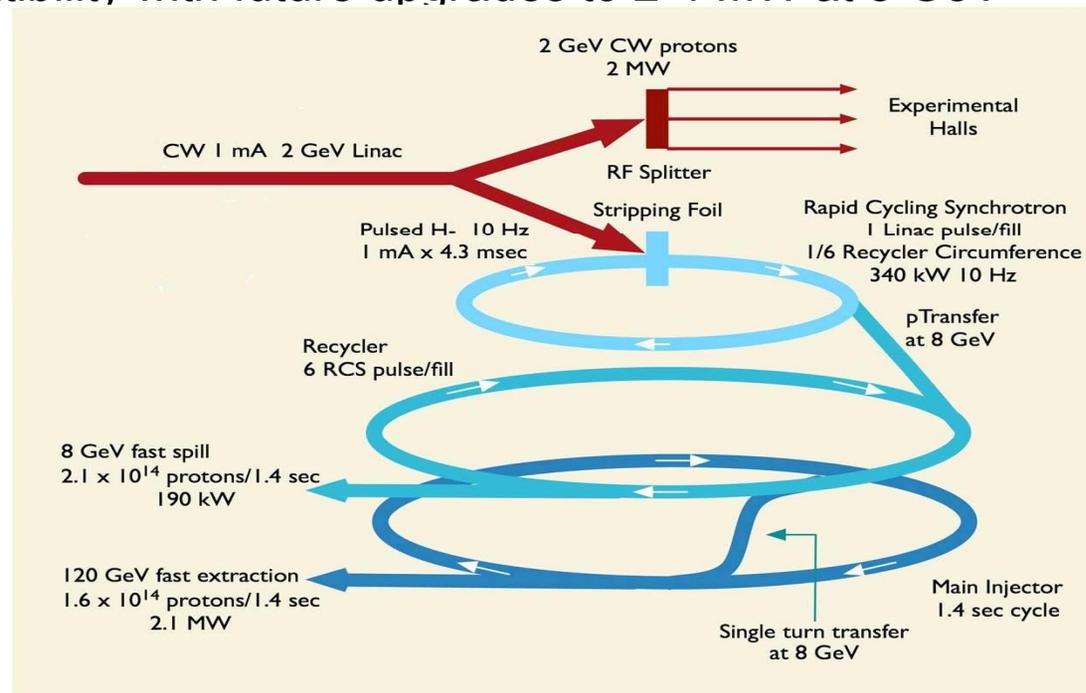
⇒ **We are able to generate substantially more beam power in ICD-1 than we can effectively utilize.**

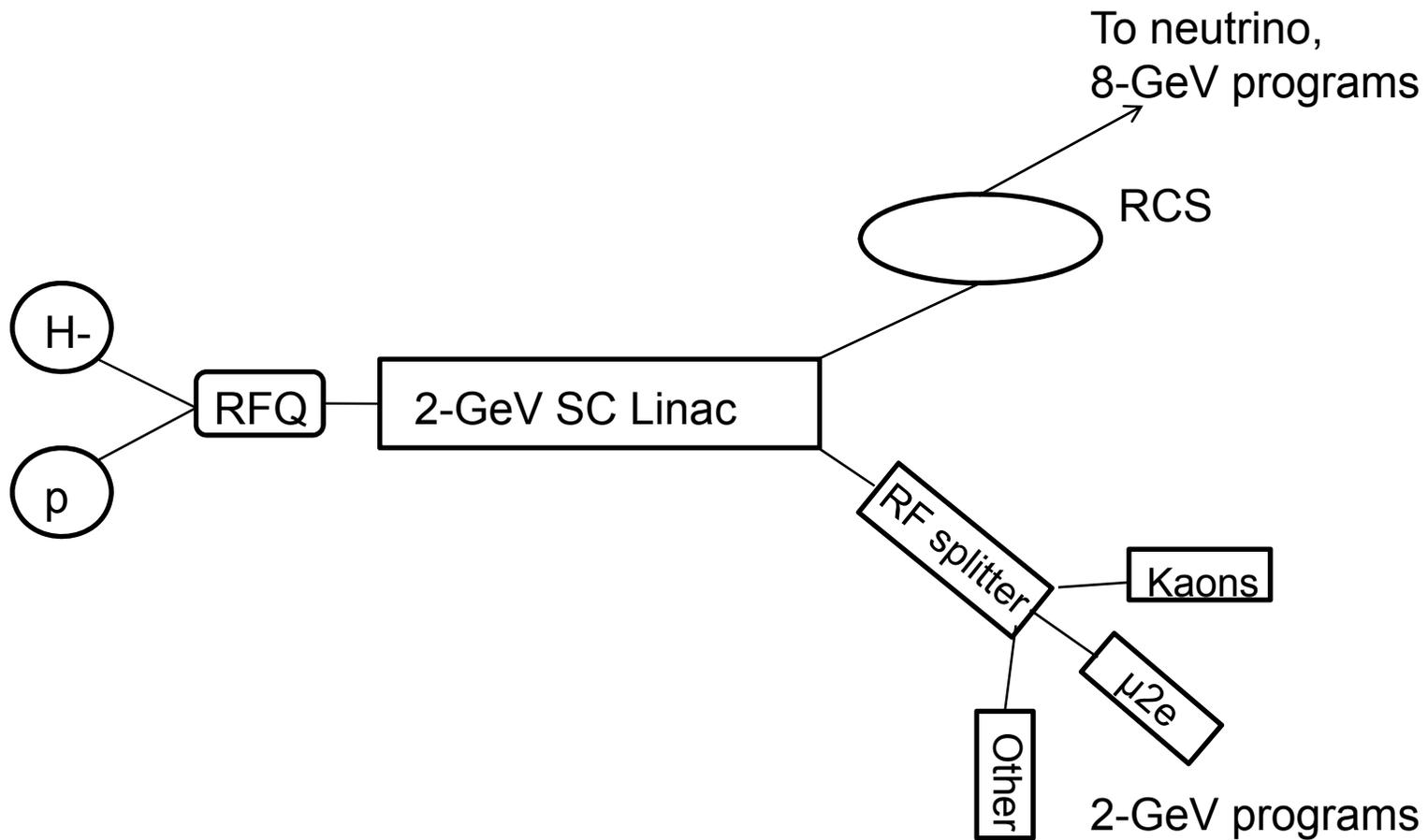


- Consideration of alternative designs is required by the DOE Project Management Order.
- A primary consideration is the low energy program
  - The Recycler as utilized in the ICD-1 has limitations in providing a flexible source of useful beam to the low energy flavor program
- Primary alternative we 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



- 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

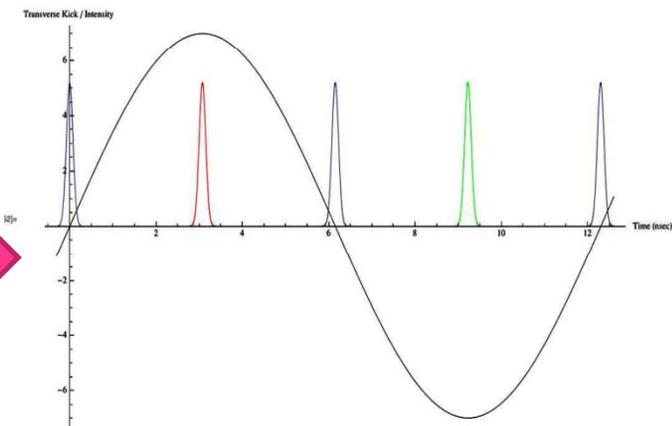
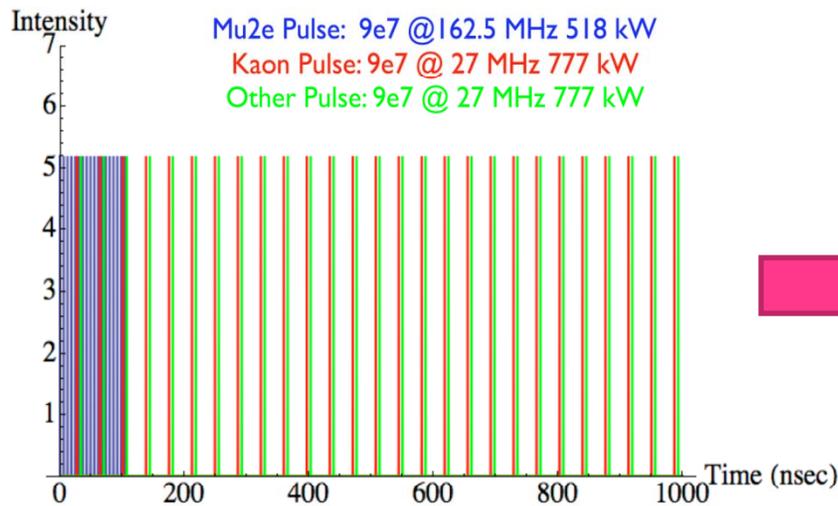




# Initial Configuration-2 Operating Scenario



- 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
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# 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



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- **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**
    - CD-0
    - Initiate work on Conceptual Design Report
    - Request PED funds for FY2012
    - Develop NEPA strategy
    - Initiate permitting documentation
    - Draft of all CD-1 documentation
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- FY2011
    - CD-1
  - FY2013
    - CD-2/3a
  - FY2014
    - CD-3: Initiate Construction
  - ~FY2014~2018
    - Construct



- 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.
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# Collaboration Meeting: Goals



- Collaboration Council Meeting
  - Discussion of working arrangements under the MOU
  - Review of current institutional responsibilities
  - Discussion of FY2010 plan
  - Discussion of criteria and process for identifying a CDR configuration and getting to CD-0
  - 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



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- 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):

	<u>M&amp;S</u>	<u>SWF</u>	<u>Labs</u>	<u>Total</u>
Available	\$2500	\$3350	\$1600	\$7450
Requested	\$3210	\$5540	\$2170	\$10920



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- 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



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- 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-1, 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
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# Working Group Room Assignments (session 1)



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

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