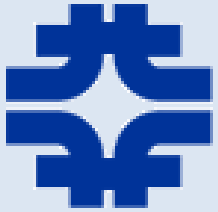


Status of Project X

Keith Gollwitzer
Accelerator Division
Fermilab

MAP Winter Meeting - March 1, 2011

Outline

- Project X Goals
- Evolution
  - Initial Configuration
- Documentation
  - Functional Requirements
- Upgrade to Proton Driver
- Site
- Bureaucracy
  - CD Process
  - Staging
- R&D and Collaboration

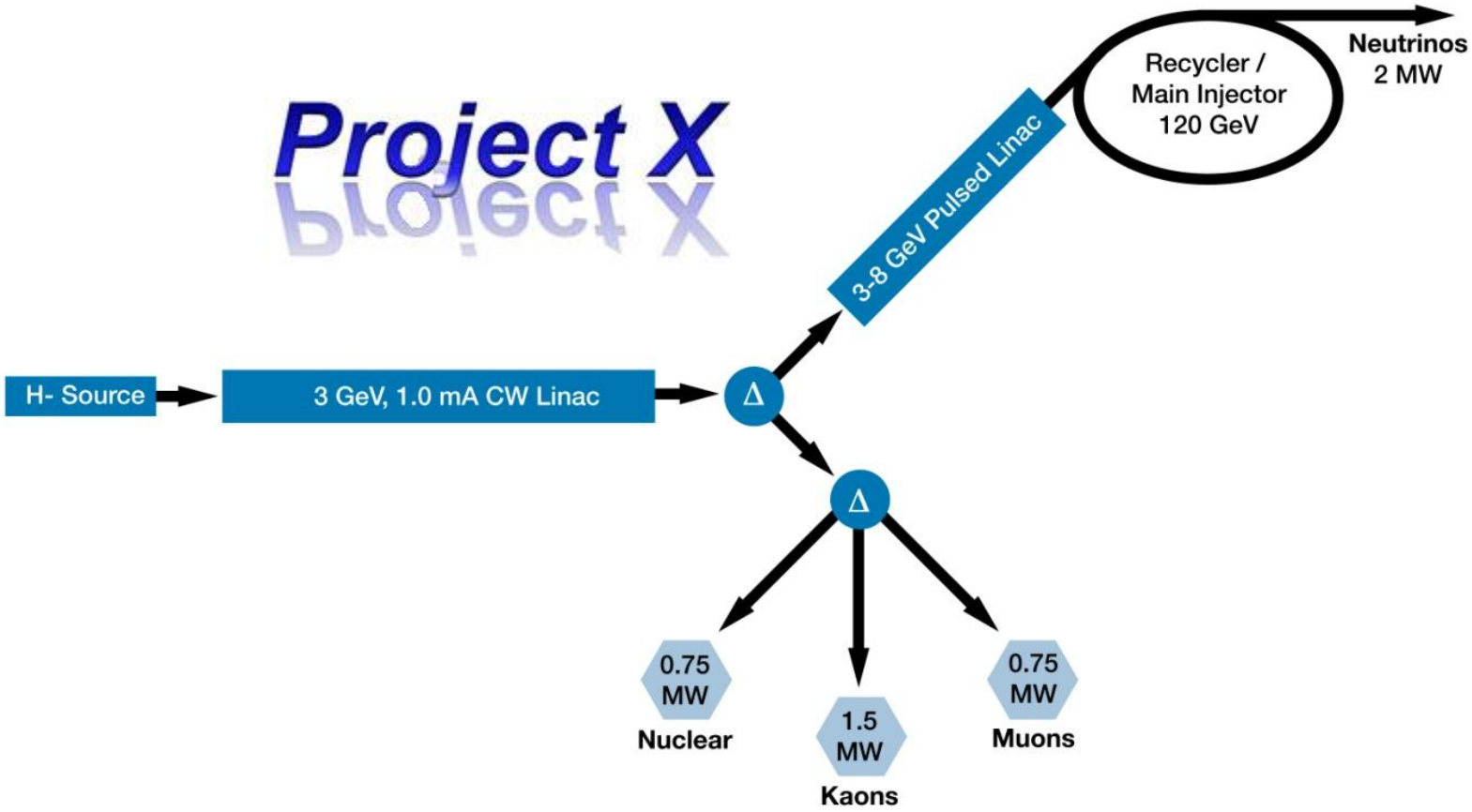
Project X Goals

- Mainly based upon P5 report
  - A neutrino beam for long baseline neutrino oscillation experiments
  - Kaon-and muon-based precision experiments
  - A path toward a muon source for a possible neutrino factory and potentially a muon collider
- Recognized can also serve nuclear physics community
  - Test bed for accelerator and target studies related to:
    - Accelerator Driver Subcritical reactors
    - Accelerator Transmutation of Waste

Project X Evolution

- Initial design (8 GeV pulsed linac)
  - Did not support kaon/muon precision measurement program
- Second design
  - CW 3 GeV 1 mA H^- linac
    - Above kaon production threshold
    - Produces low energy pions for low energy muon experiments
    - Allows nuclear physics experiments
    - Low energy chopping allow supporting different experiment needs
    - Splitter/switchyard to simultaneously support the experiments
  - 3-8 GeV pulsed linac (accumulation in Recycler)
    - Satisfies long baseline neutrino 2 MW program
    - Additional 8 GeV beam power available for other experiments

Project X Layout



Project X Documentation

- Functional Requirement Specification
  - Outlines the parameters needed/desired
- Reference Design Report
  - Initial design to achieve the Functional Requirements
  - Initial cost range is based upon this report

3 GeV Linac Requirements

Requirement	Description	Value
L1	Delivered Beam Energy, maximum	3 GeV (kinetic)
L2	Delivered Beam Power at 3 GeV	3 MW
L3	Average Beam Current (averaged over >1 μsec)	1 mA
L4	Maximum Beam Current (sustained for <1 μsec)	5 mA
L5	The 3 GeV linac must be capable of delivering correctly formatted beam to a pulsed linac, for acceleration to 8 GeV	
L6	Charge delivered to pulsed linac	26 mA-msec in < 0.75 sec
L7	Maximum Bunch Intensity	1.9×10^{8}
L8	Minimum Bunch Spacing	6.2 nsec (1/162.5 MHz)
L9	Bunch Length	<50 psec (full-width half max)
L10	Bunch Pattern	Programmable
L11	RF Duty Factor	100% (CW)
L12	RF Frequency	162.5 MHz and harmonics thereof
L13	3 GeV Beam Split	Three-way

Main Injector/Recycler Requirements

Requirement	Description	Value
M1	Delivered Beam Energy, maximum	120 GeV
M2	Delivered Beam Energy, minimum	60 GeV
M3	Minimum Injection Energy	6 GeV
M4	Beam Power (60-120 GeV)	> 2 MW
M5	Beam Particles	Protons
M6	Beam Intensity	1.6×10^{14} protons per pulse
M7	Beam Pulse Length	~10 μsec
M8	Bunches per Pulse	~550
M9	Bunch Spacing	18.8 nsec (1/53.1 MHz)
M10	Bunch Length	<2 nsec (fullwidth half max)
M11	Pulse Repetition Rate (120 GeV)	1.2 sec
M12	Pulse Repetition Rate (60 GeV)	0.75 sec
M13	Max Momentum Spread at extraction	2×10^{-3}

3-8 GeV Pulsed Linac Requirements

Requirement	Description	Value
P1	Maximum beam Energy	8 GeV
P2	The 3-8 GeV pulsed linac must be capable of delivering correctly formatted beam for injection into the Recycler (or Main Injector).	
P3	Charge to fill Main Injector/cycle	26 mA-msec in <0.75 sec
P4	Maximum beam power delivered to 8 GeV	300 kW
P5	Duty Factor (initial)	< 4%

Beam Power

- Initial Pulsed Linac to deliver ~300KW
  - Duty factor of < 4%
- We want to be able to have 4MW at 8GeV
  - 1 mA average current in CW Linac would mean a duty factor of 50% for Pulsed Linac
  - Pulsed Linac duty factor of 4% would mean an average current of 12.5mA for CW Linac
    - Or upgrade both Linacs

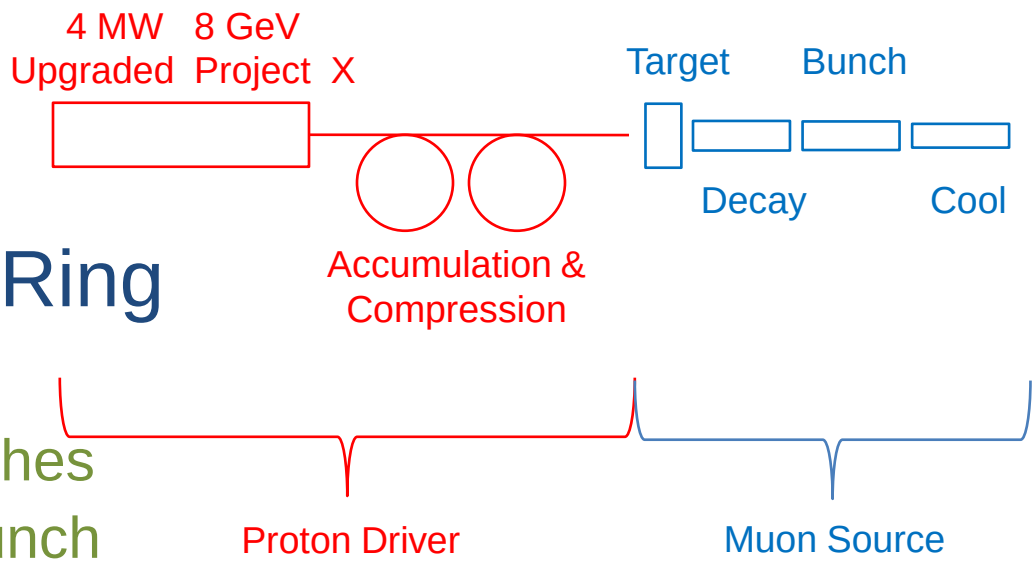
Upgradability Requirements

Requirement	Description
U1	Provisions should be made to support an upgrade of the CW linac to support an average current of 5 mA.
U2	Provisions should be made to support an upgrade of the Main Injector to support a delivered beam power of ~4 MW at 120 GeV.
U3	Provisions should be made to deliver CW proton beams as low as 1 GeV.
U4	Provision should be made to support an upgrade to the CW linac such that it can accelerate Protons.
U5	Provisions should be made to support an upgrade of the pulsed linac to a duty factor of 10%.
U6	Provisions should be made to support an upgrade of the CW linac to 3.1 ns bunch spacing.

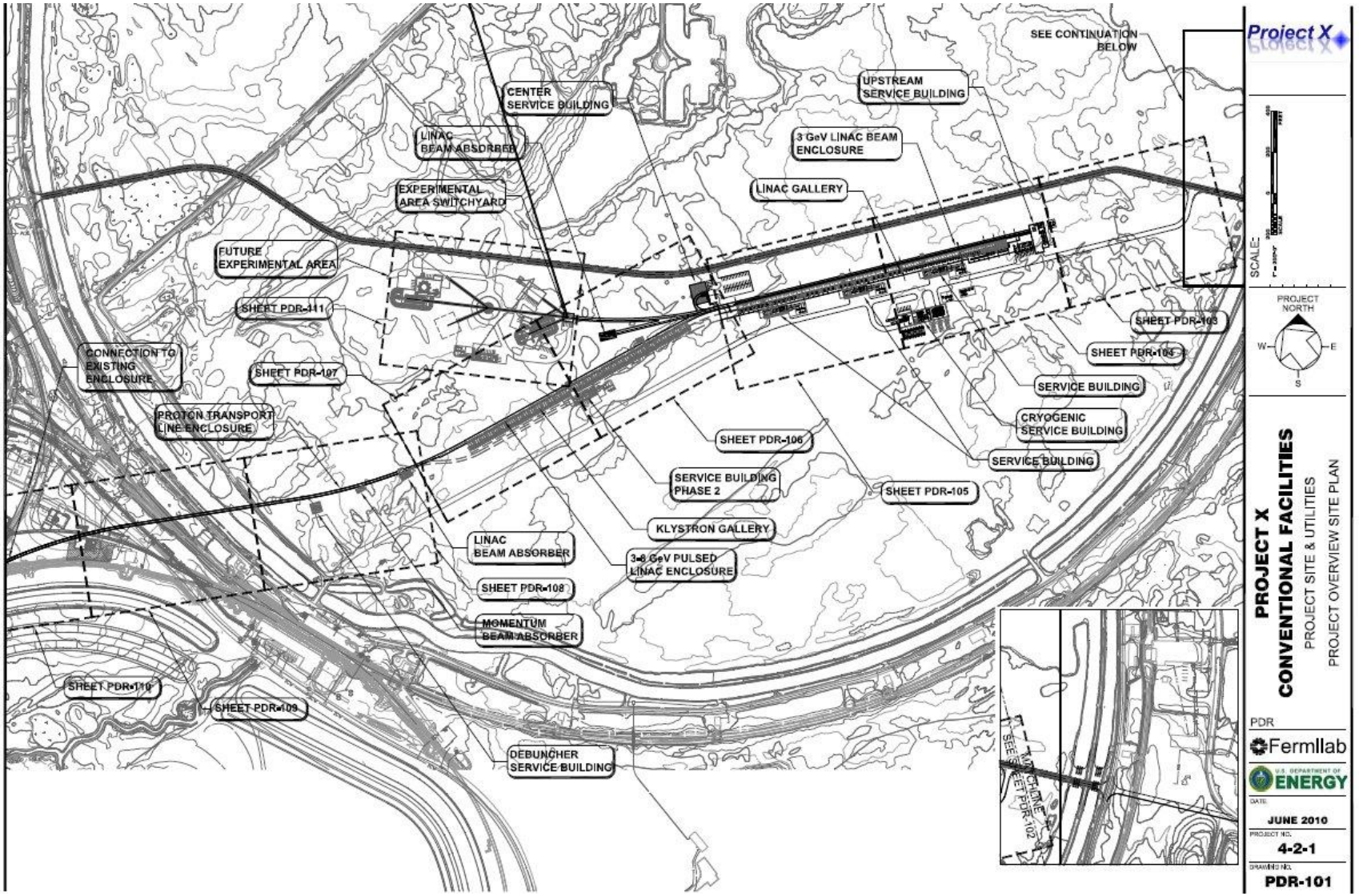
If requirements U1 and U5 are achieved, then will have 4MW at 8GeV

Project X to Proton Driver

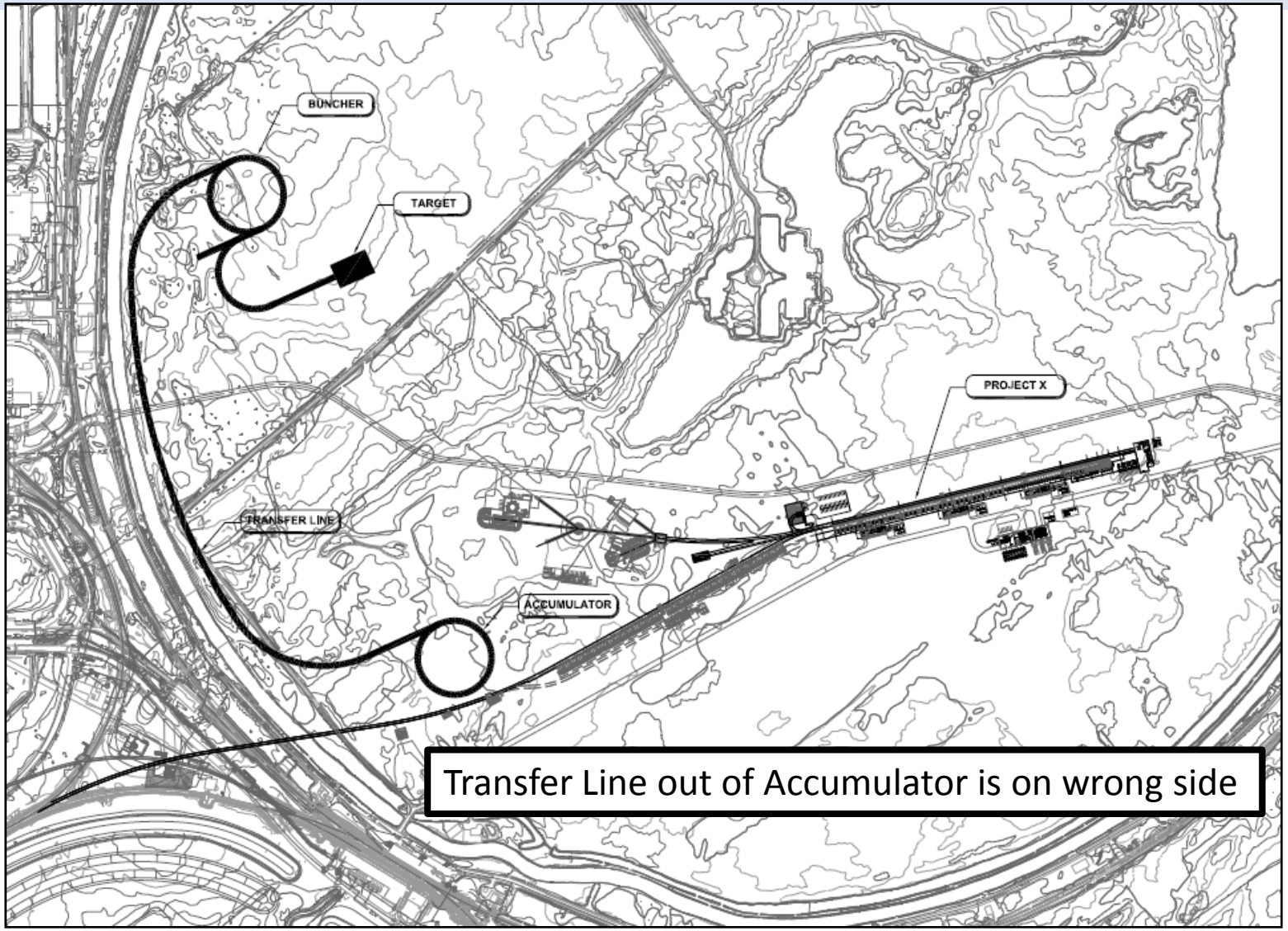
- Proton Accumulation Ring
  - Considerations
    - Space charge
    - H^- stripping
- Bunch Compressor Ring
  - Considerations
    - Forming 1-3 ns bunches
    - NF: keeping short bunch length for many turns before 2nd and 3rd bunch extractions
    - MC: one bunch or delivery of several bunches at once to target



Project X Site



Proton Driver Site



Transfer Line out of Accumulator is on wrong side

CD Process

- Will go through the DOE Critical Decision (CD) process for large projects (>$750M)
  - CD-0: Mission Need
  - CD-1: Alternative Selection and Cost Range
  - CD-2: Performance Baseline
  - CD-3: Start of Construction
  - CD-4: Start of Operations/Project Completion

    - Timeline with CD-0 in Mar11 is to have Project X operational in 2020

Project X & DOE

- Fermilab has provided accelerator documentation to DOE required for CD-0
  - New DOE order 4.13.3b going into effect
    - Allows for staging
      - Fermilab providing more documentation
        - » Phasing/staging
        - » Experimental area/detector(s) are being added
          - Rare Kaon experiment is being added
    - Independent Cost Review prior to CD-0
      - DOE is figuring out what they want for this

R&D Program

- The primary elements of the R&D program include:
  - Development of a wide-band chopper
    - Capable of removing bunches in arbitrary patterns at a 162.5 MHz bunch rate
  - Development of an H- injection system
    - Require between 4.4 – 26 msec injection period, depending on pulsed linac operating scenario
  - Superconducting rf development
    - Includes six different cavity types at three different frequencies
    - Includes development of qualified industrial partners

Collaboration

- 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.
  - Collaboration MOUs for the RD&D phase outlines basic goals, and the means of organizing and executing the work. Signatories:

ANL	ORNL/SNS	BARC/Mumbai
BNL	MSU	IUAC/Delhi
Cornell	TJNAF	RRCAT/Indore
Fermilab	SLAC	VECC/Kolkata
LBNL	ILC/ART	

Summary

- Project X continues to move forward
- Fermilab is working with DOE to move along the CD process
- DOE is working to provide a “funding profile” for Project X
- Project X collaboration is moving forward with R&D

Extras

Neutrino Factory

Muon Collider