Project X Overview

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UK-US Workshop
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Outline

- Fermilab Strategic Plan
- Project X Reference Design
- R&D Plan
- Status and Timeline

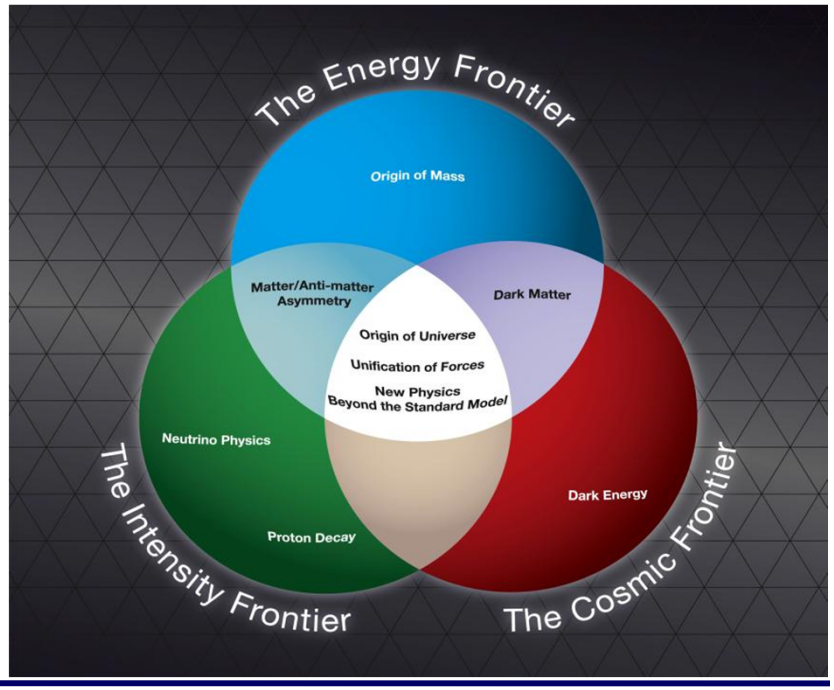
http://projectx.fnal.gov

Fermilab Long Range Plan

Fermilab is the sole remaining U.S. laboratory providing facilities in support of accelerator-based Elementary Particle Physics. Fermilab is fully aligned with the strategy for U.S. EPP developed by HEPAP/P5.

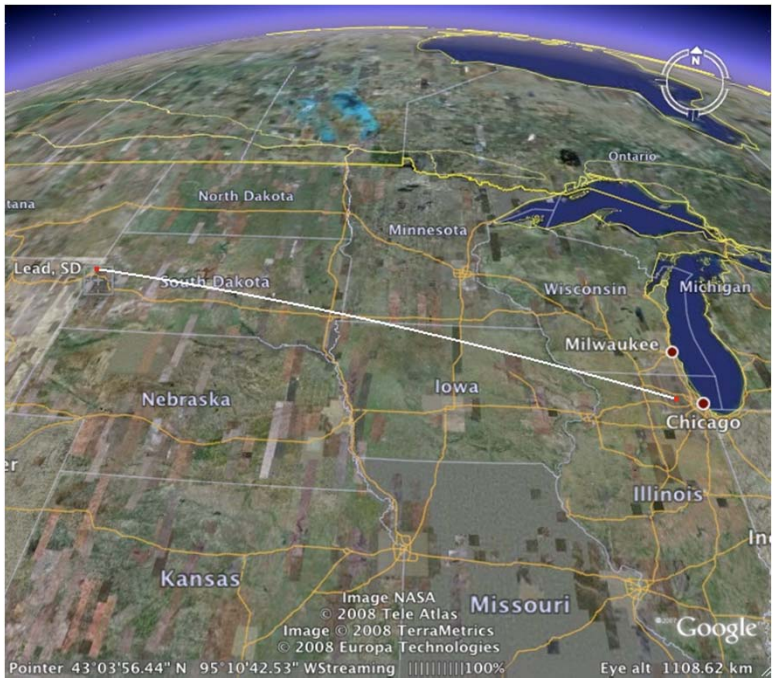
⇒***The Fermilab strategy is to mount a world-leading program at the intensity frontier, while using this program as a bridge to an energy frontier facility beyond LHC in the longer term.***

Project X is the key element of this strategy



Mission

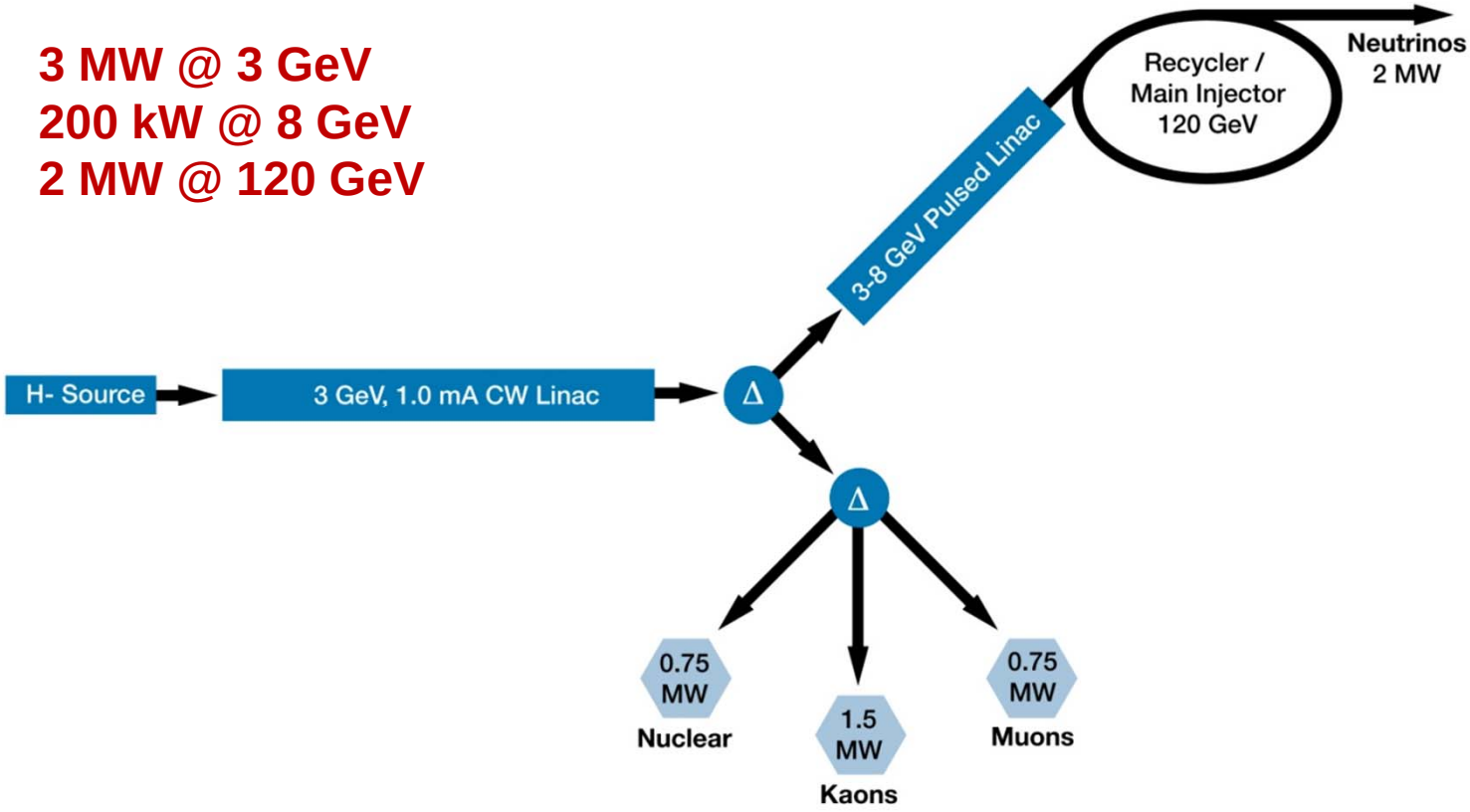
- A neutrino beam for long baseline neutrino oscillation experiments
  - 2 MW proton source at 60-120 GeV
- Low energy, MW-class proton beams for kaon, muon, and neutrino based precision experiments
  - Operations simultaneous with the long baseline neutrino program
- A path toward a muon source for possible future Neutrino Factory and/or a Muon Collider
  - ~4 MW at ~5-15 GeV; low duty factor



- Possible missions beyond EPP
  - Standard Model Tests with nuclei and energy applications

Reference Design

3 MW @ 3 GeV
200 kW @ 8 GeV
2 MW @ 120 GeV



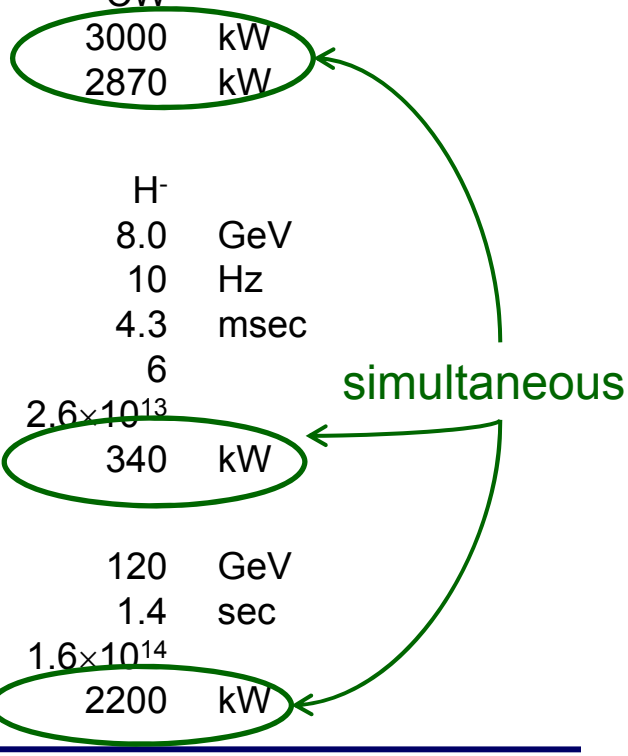
Reference Design Capabilities

- 3 GeV CW superconducting H- linac with 1 mA average beam current.
  - Flexible provision for variable beam structures to multiple users
    - CW at time scales >1 μsec, 20% DF at <1 μsec
  - Supports rare processes programs at 3 GeV
  - Provision for 1 GeV extraction for nuclear energy program
- 3-8 GeV pulsed linac capable of delivering 300 kW at 8 GeV
  - Supports the neutrino program
  - Establishes a path toward a muon based facility
- Upgrades to the Recycler and Main Injector to provide ≥ 2 MW to the neutrino production target at 60-120 GeV.

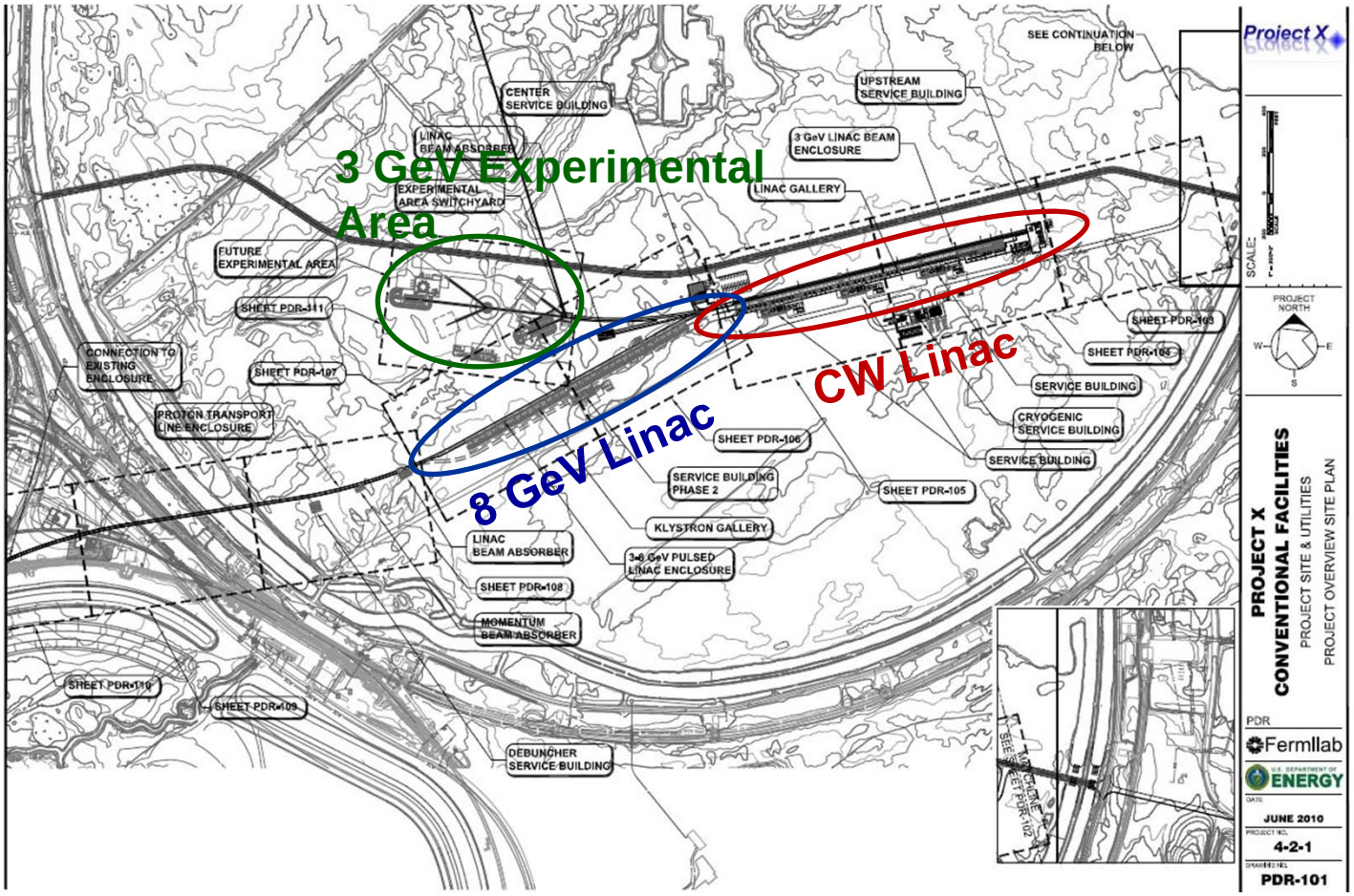
⇒ ***Utilization of a CW linac creates a facility that is unique in the world, with performance that cannot be matched in a synchrotron-based facility.***

Performance Goals

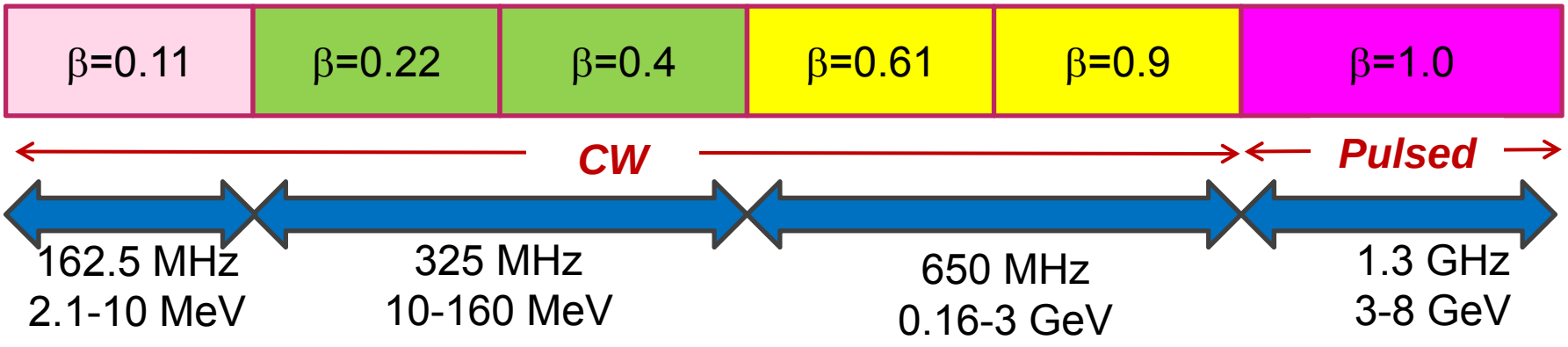
Linac		
Particle Type	H^-	
Beam Kinetic Energy	3.0	GeV
Average Beam Current	1	mA
Linac pulse rate	CW	
Beam Power	3000	kW
Beam Power to 3 GeV program	2870	kW
Pulsed Linac		
Particle Type	H^-	
Beam Kinetic Energy	8.0	GeV
Pulse rate	10	Hz
Pulse Width	4.3	msec
Cycles to MI	6	
Particles per cycle to MI	2.6×10^{13}	
Beam Power to 8 GeV	340	kW
Main Injector/Recycler		
Beam Kinetic Energy (maximum)	120	GeV
Cycle time	1.4	sec
Particles per cycle	1.6×10^{14}	
Beam Power at 120 GeV	2200	kW



Siting


3 GeV Experimental Area
CW Linac
8 GeV Linac
CENTER SERVICE BUILDING
UPSTREAM SERVICE BUILDING
SEE CONTINUATION BELOW
LINAC BEAM ABSORBER
EXPERIMENTAL AREA SWITCHYARD
3 GeV LINAC BEAM ENCLOSURE
LINAC GALLERY
FUTURE EXPERIMENTAL AREA
SHEET PDR-111
SHEET PDR-107
CONNECTION TO EXISTING ENCLOSURE
PROTON TRANSPORT LINE ENCLOSURE
SHEET PDR-103
SHEET PDR-104
SERVICE BUILDING
CRYOGENIC SERVICE BUILDING
SERVICE BUILDING
SHEET PDR-106
SERVICE BUILDING PHASE 2
SHEET PDR-105
KLYSTRON GALLERY
LINAC BEAM ABSORBER
3-8 GeV PULSED LINAC ENCLOSURE
SHEET PDR-108
MOMENTUM BEAM ABSORBER
SHEET PDR-110
SHEET PDR-109
DEBUNCHER SERVICE BUILDING
SEE SHEET PDR-102
Project X
SCALE:
PROJECT NORTH
PROJECT X
CONVENTIONAL FACILITIES
PROJECT SITE & UTILITIES
PROJECT OVERVIEW SITE PLAN
PDR
Fermilab
ENERGY
JUNE 2010
4-2-1
PDR-101

SRF Linac Technology Map



Section	Freq	Energy (MeV)	Cav/mag/CM	Type
HWR (β_G=0.1)	162.5	2.1-10	9/6/1	HWR, solenoid
SSR1 (β_G=0.22)	325	10-42	16/18/ 2	SSR, solenoid
SSR2 (β_G=0.47)	325	42-160	36/20/4	SSR, solenoid
LB 650 (β_G=0.61)	650	160-460	42 /14/7	5-cell elliptical, doublet
HB 650 (β_G=0.9)	650	460-3000	152/19/19	5-cell elliptical, doublet
ILC 1.3 (β_G=1.0)	1300	3000-8000	224 /28 /28	9-cell elliptical, quad

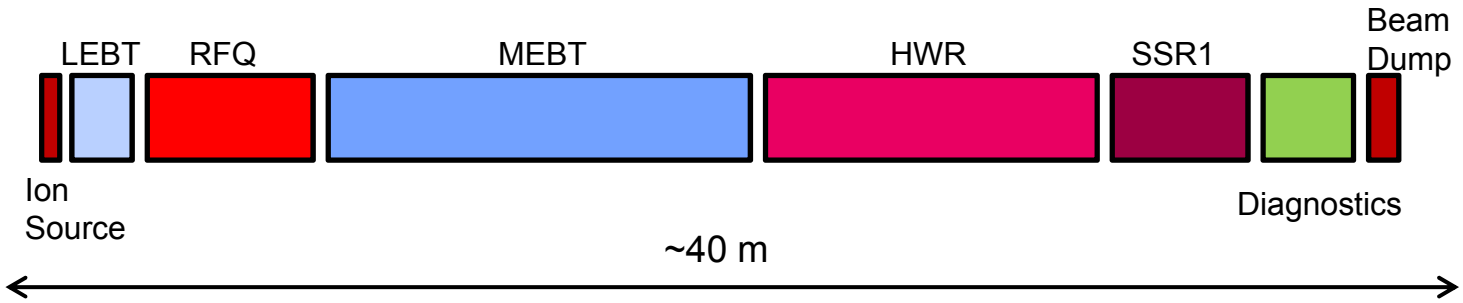
R&D Program

- Goal is to mitigate risk: technical, cost, and schedule
- Primary elements of the R&D program:
  - Development of front end including wide-band chopper
  - Development of an H- injection system
  - Superconducting rf development
    - Cavities, cryomodules, rf sources – CW to long-pulse
    - Development of partners and vendors
  - High Power targetry
  - Integrated facility design
    - Physics performance requirements
    - reliability analysis
  - Upgrade paths: MC and Muons@PX Task Forces
  - Test Facilities
- Goal is to complete R&D phase by 2016

Test Facilities

- New Muon Lab (NML) facility under construction for ILC RF unit test
  - Three CM's driven from a single rf source
  - 9 mA x 1 msec beam pulse
  - Large extension and supporting infrastructure under construction
    - Refrigerator to support full duty factor operations
    - Horizontal test stands for all frequencies
    - Building extension for additional CM's and beam diagnostic area
- The Meson Detector Building (MDB) Test Facility ultimately comprises:
  - 2.5 – 3 MeV beam (p, H-): 1% duty factor, 3 msec pulse
    - Chopper tests
    - H^- beam instrumentation development
  - Shielded enclosures and RF power systems for testing individual, dressed 1.3 GHz, 650 MHz, and 325 MHz superconducting RF cavities

Project X Injector Experiment (PXIE)



- Proposing integrated systems testing of components within the first ~15-30 MeV of Project X.
  - Validate concept for the Project X front end, thereby mitigating the primary technical risk within the Reference Design
  - Operate components, both individually and collectively, at full design parameters
- Integrated systems test goals:
  - 1 mA average current with 80% chopping of beam delivered from RFQ
  - Efficient acceleration with minimal emittance dilution through ~15-30 MeV

⇒Goal: Beam in fall 2016

Possible Timeline

- We are currently being well supported for R&D on Project X and associated srf development
- We believe Project X could be constructed over
  - 5 year period if paced by technical requirements;
  - More like 6-8 year period if paced by budgetary realities
- We are working toward completing the R&D phase by 2016
- Planning Timeline (not agreed to by DOE)

CD-0, Approve Mission Need	FY 2012
CD-1, Approve Alternative Selection and Cost Range	FY 2013
CD-2, Approve Performance Baseline	FY 2014
CD-3, Approve Start of Construction	FY 2016
CD-4, Approve Project Completion	FY 2021

Collaboration

- Multi-institutional collaboration to execute the RD&D Program.
  - Organized as a “national project with international participation”
    - Fermilab as lead laboratory
    - International participation established via bi-lateral MOUs.
- Collaboration MOUs for the RD&D phase outline basic goals, and the means of organizing and executing the work. Signatories:

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

- Draft Collaboration Governance Plan discussed at Collaboration Council April meeting
- Contacts with: ESS (MOU), CERN/SPL, China/ADS, UK, Korea

Summary

- Project X is central to Fermilab's strategy for development of the accelerator complex over the coming decade
  - World leading programs in neutrinos and rare processes
  - Aligned with ILC and Muon Accelerators technology development;
  - Potential applications beyond elementary particle physics
- The design concept has evolved over the last year, providing significantly enhanced physics capabilities
  - 2 MW to the neutrino program over 60-120 GeV
  - 3 MW to the rare processes program
  - Flexible provision for variable beam formats to multiple users
- CW linac is unique for this application, and offers capabilities that would be hard/impossible to duplicate in a synchrotron
- R&D program underway with very significant investment in srf infrastructure and development
- Project X could be constructed over the period ~2016 – 2020
  - Will be constructed as a national project with international participation