Project X/ILC/SRF Integrated Plan

Steve Holmes
Fermilab

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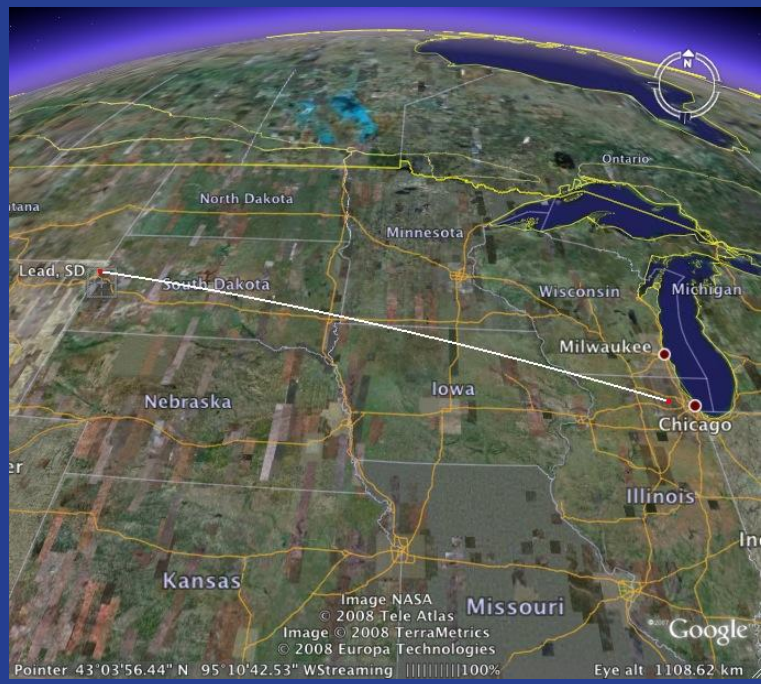
Fermilab

Outline

- Project X Current Status
- PX/ILC/SRF Integrated Plan
- Integrated Funding Profile

Project X Mission Objectives (unchanged)

- 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
  - >1 MW operations simultaneous with the neutrino program
- A path toward a muon source for a possible future Neutrino Factory and/or a Muon Collider
  - Requires upgrade potential to 4 MW at ~5-15 GeV



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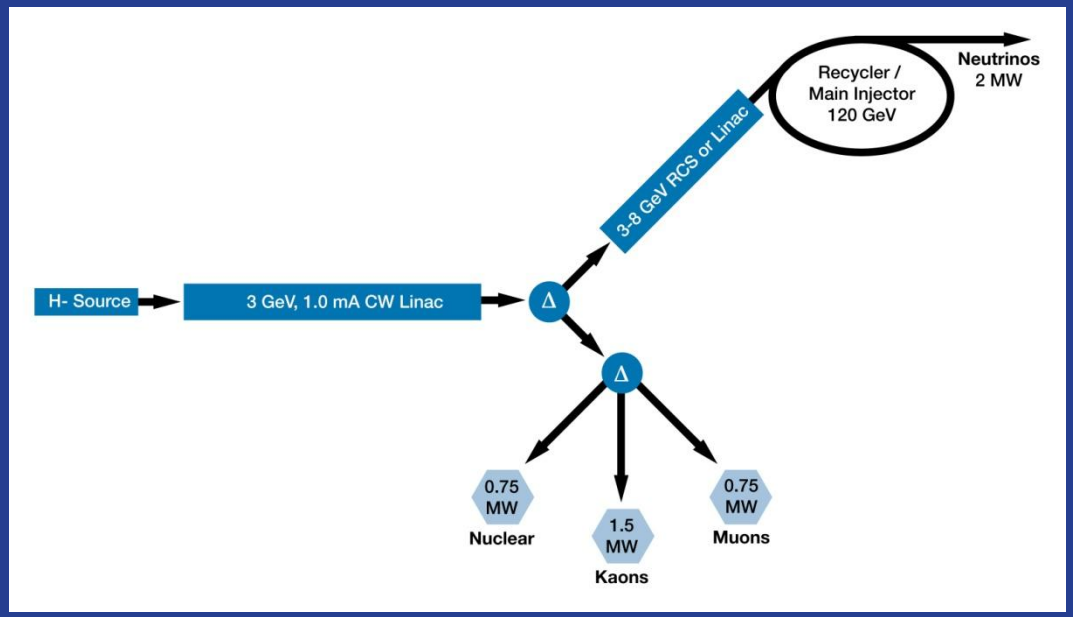
Initial Configuration – 1: Issues

- The originally established configuration featured strong alignment with ILC: 8 GeV superconducting pulsed linac
- IC-1 does a great job of meeting the long baseline neutrino mission, but…
- It does not provide a strong platform for mounting a low energy rare processes program
  - Recycler is ill-suited to providing high intensity slow spilled beam
  - Debuncher appears limited to <150 kW in this mode

  ⇒ We believe there is a fundamental limit on the amount of beam power that can be delivered via a resonant extraction system
  - Difficulties supporting multiple users with differing spill structure requirements

⇒ **These considerations have led to the development of IC-2**

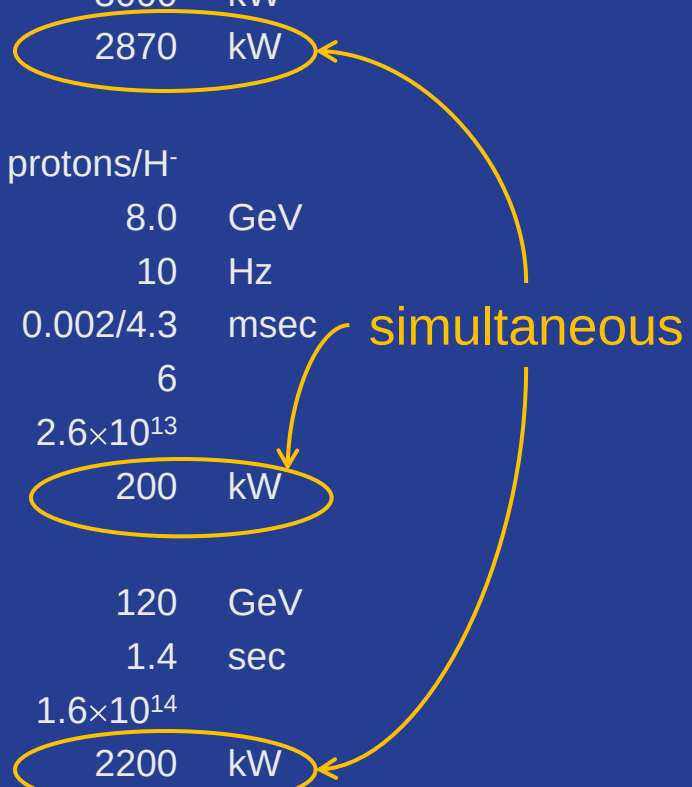
Initial Configuration-2



- 3 GeV CW linac provides greatly enhanced rare process program
  - 3 MW; flexible provision for beam requirements supporting multiple users
- Options for 3-8 GeV acceleration: RCS or pulsed linac
  - Linac would be 1300 MHz with 4-25 msec pulse length
- Initial Configuration Document-2 in preparation for summer release

Initial Configuration-2: Performance Goals

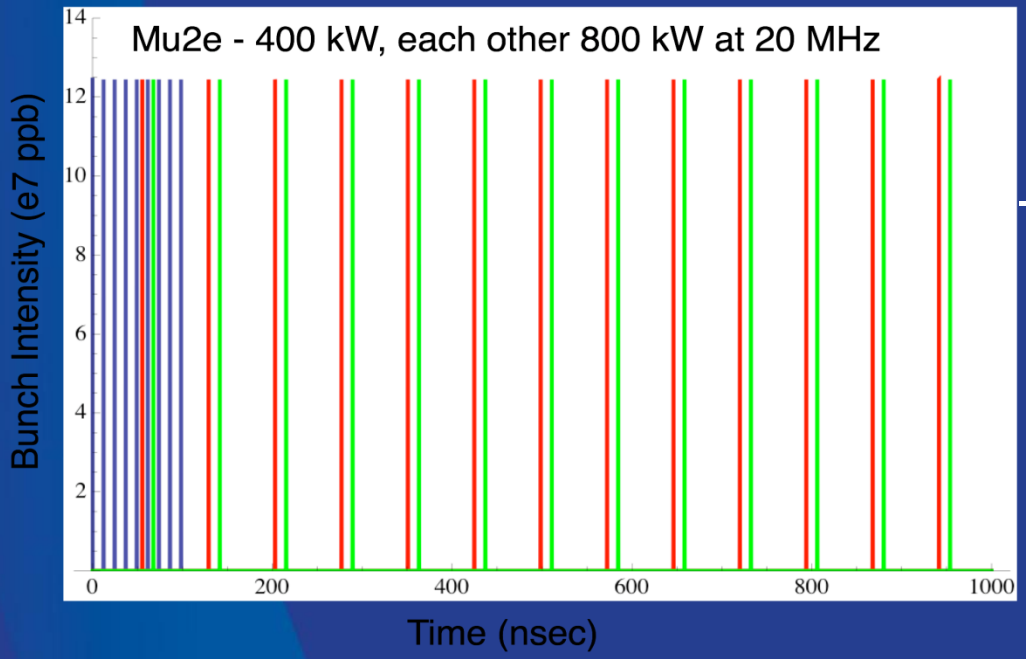
Linac		
Particle Type	H^-	
Beam Kinetic Energy	3.0	GeV
Average Beam Current	1	mA
Linac pulse rate	CW	
Beam Power	3000	kW
Beam Power to 3 GeV program	2870	kW
RCS/Pulsed Linac		
Particle Type	protons/H^-	
Beam Kinetic Energy	8.0	GeV
Pulse rate	10	Hz
Pulse Width	0.002/4.3	msec
Cycles to MI	6	
Particles per cycle to Recycler	2.6×10^{13}	
Beam Power to 8 GeV program	200	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

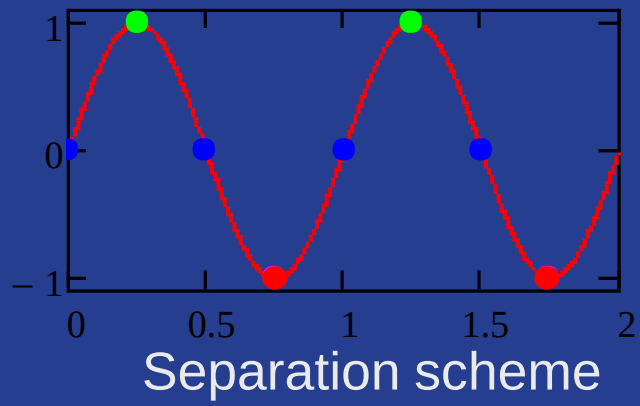


Initial Configuration-2: Operating Scenario

1 μsec period at 3 GeV

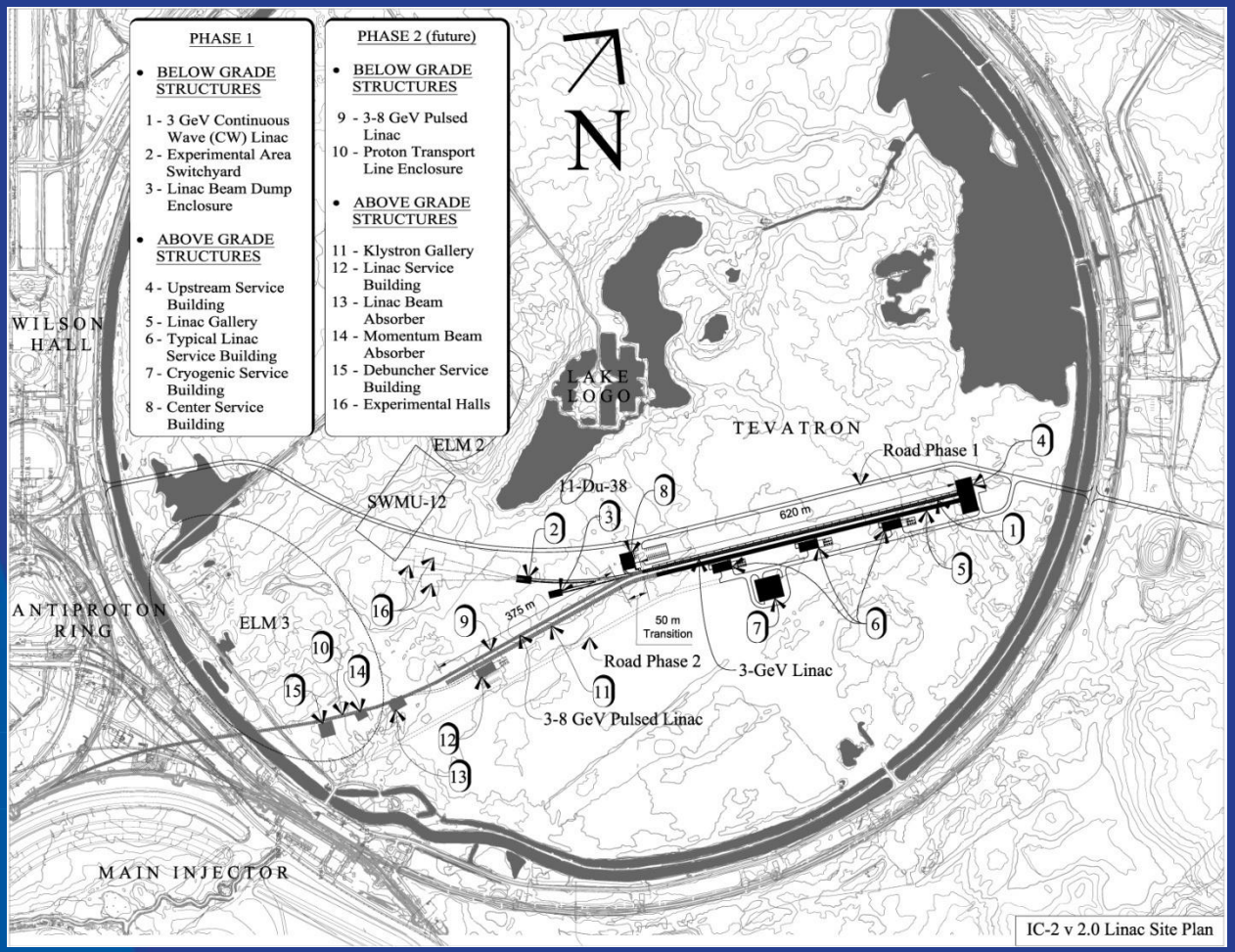
mu2e pulse (9e7) 162.5 MHz, 100 nsec	600 kW
Kaon pulse (9e7) 27 MHz	1200 kW
Nuclear pulse (9e7) 27 MHz	1200 kW



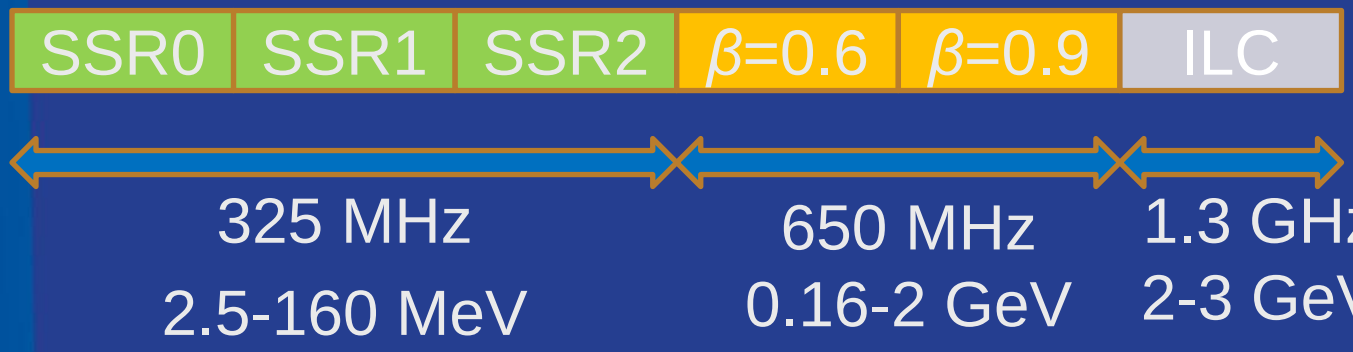


Separation scheme

Initial Configuration-2: Provisional Siting



Initial Configuration-2: Technology Map



Section	Freq	Energy (MeV)	Cav/mag/CM	Type
SSR0 (β_G=0.11)	325	2.5-10	26 /26/1	SSR, solenoid
SSR1 (β_G=0.22)	325	10-32	18 /18/ 2	SSR, solenoid
SSR2 (β_G=0.4)	325	32-160	44 /24/ 4	SSR, solenoid
LB 650 (β_G=0.61)	650	160-520	42 /21/ 7	5-cell elliptical, doublet
HB 650 (β_G=0.9)	650	520-2000	96 /12/12	5-cell elliptical, doublet
ILC 1.3 (β_G=1.0)	1300	2000-3000	64 / 8/ 8	9-cell elliptical, quad

Project X: Collaboration Status

- Multi-institutional collaboration established to execute the Project X RD&D Program.
  - Fermilab as lead laboratory
  - International participation via in-kind contributions, established through bi-lateral MOUs.
- MOU 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/Kolkota
LBNL	ILC/ART	

- Collaborator R&D responsibilities largely defined
- Other interested parties: CERN, IHEP, Korea, ESS
- Collaboration meeting 9/8-9

Project X/ILC/SRF Integrated Plan

Goals

- Provide integrated management of all superconducting rf development activities at Fermilab
- Provide coherent development of facilities and utilization of resources to meet the needs of the ILC, Project X, and ultimately Muon Accelerator Programs
- Align HINS activities directly with Project X needs
- Meet all commitments to the ILC program between now and FY2012

Project X/ILC/SRF Integrated Plan

Strategy

- Bring all srf activities under the purview of the ILC/SRF Program Director
  - ILC and Project X management define requirements
- Redefine the High Intensity Neutrino Source (HINS) program to directly support the needs of Project X
- Establish the General Accelerator R&D category as the primary funding source for srf cavity development outside of ILC applications.

Project X/ILC/SRF Integrated Plan

Strategy (cont.)

- Establish a set of srf R&D deliverables that are distinguishable from infrastructure
- Redefine the scope of the following programs consistent with the above strategy:
  - SRF Infrastructure
  - Project X R&D
  - General Accelerator Development
  - HINS
  - ILC
  - SRF Operations

Project X/ILC/SRF Integrated Plan

Plan

- Discontinue the (HINS) program as a stand-alone R&D program
  - Rescope the beam facility to support chopper and instrumentation development for Project X. Fund via Project X R&D
  - Retain low beta cavity development within General Accelerator Development
  - Eliminate HINS as a budget line item

Project X/ILC/SRF Integrated Plan

Plan (cont.)

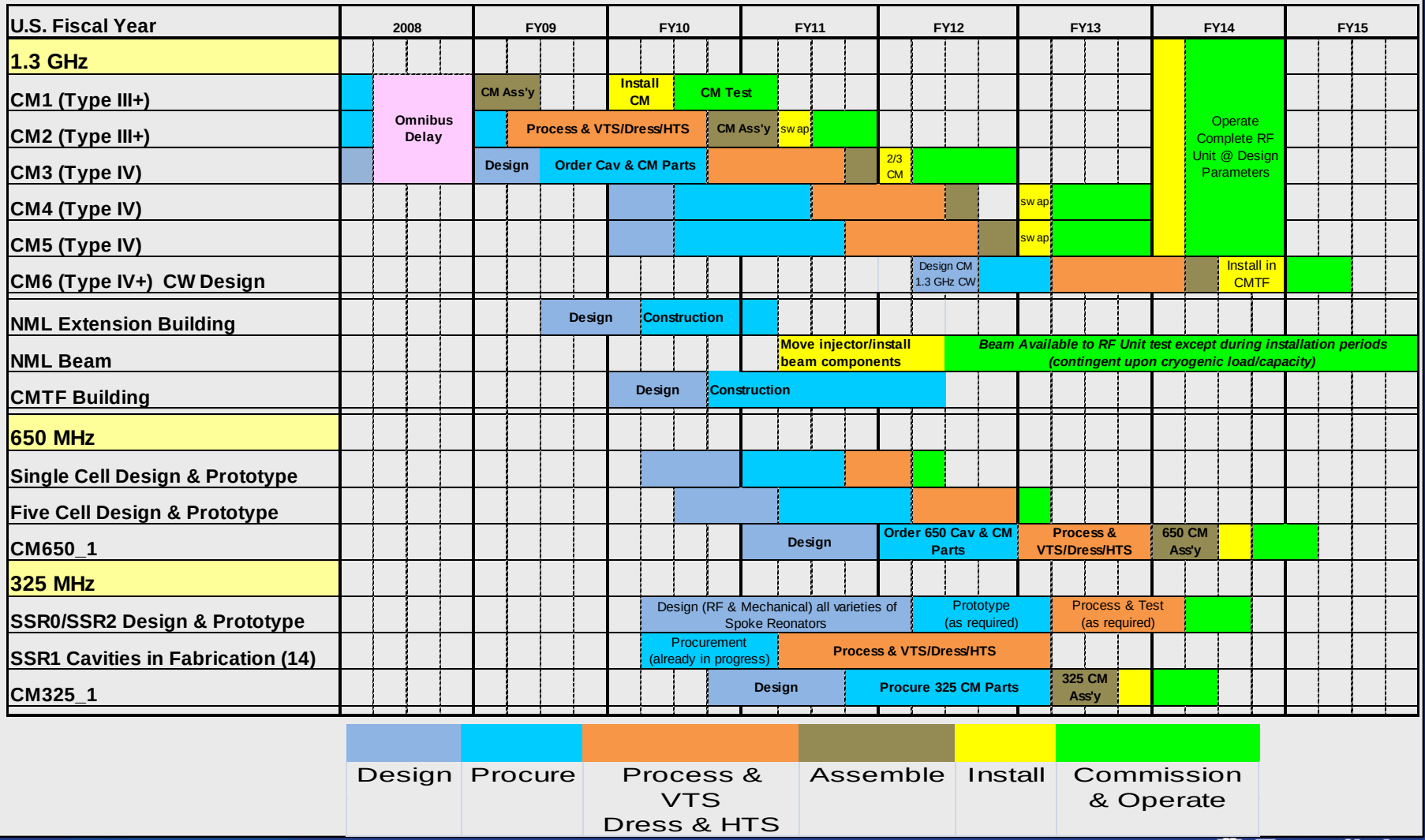
- Establish clear deliverables for the srf program over the period FY2010-15:
  - Six 1300 MHz cryomodules, culminating in a CW Project X prototype. High power rf test.
  - One 650 MHz cryomodule for Project X. High power rf test.
  - One 325 MHz cryomodule for Project X. High power rf test.
  - Complete Project X test facility at Meson Lab
  - ILC rf unit test, with beam, at NML based on three (ultimately six) 1300 MHz ILC cryomodules

Project X/ILC/SRF Integrated Plan

Plan (cont.)

- Establish a new SRF Operations line to support maintenance and operations of SRF facilities once infrastructure is complete and being utilized for ILC and Project X development.
- Implement the plan starting in FY2011

Integrated SRF Plan: Project X and ILC



Project X/ILC/SRF Integrated Plan

Funding Plan

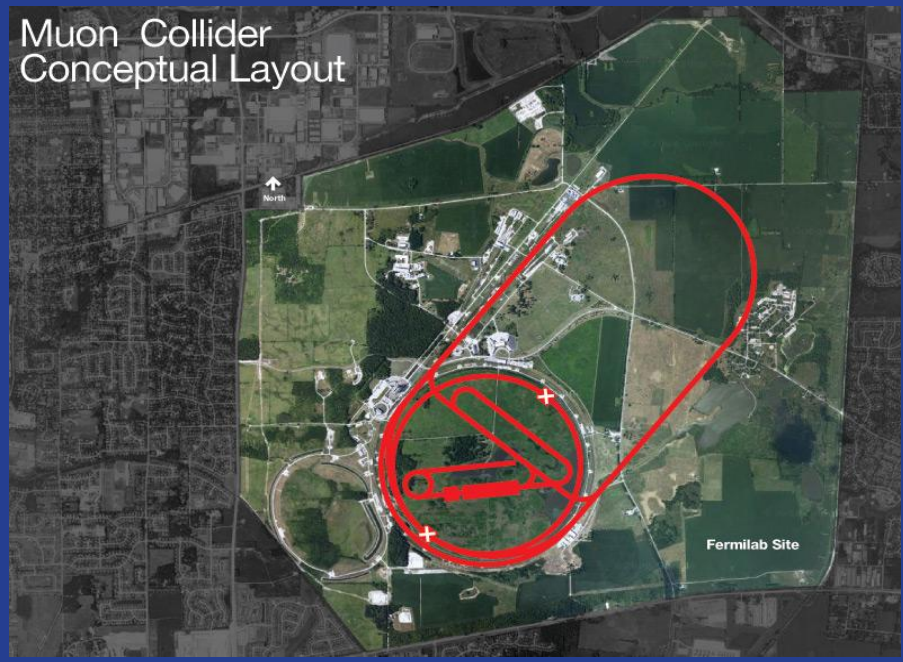
- The funding plan is consistent with that presented at the DOE budget briefing as Scenario B (COL on FY2010).
  - Supports primary deliverables of ILC and Project X, including preparations for a Project X construction start in FY2015.
- Project X assumed critical decision dates
  - CD-0: January, 2011
  - CD-1: July, 2012
  - CD-2: August, 2013
  - CD-3: September, 2014

Project X/ILC/SRF Integrated Funding Plan

Core Technologies R&D		FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16
KA1502011	General Accelerator Development ops	15,150	16,782	22,324	28,874	31,039	28,137	20,708
	SRF Development Activities	*7,557*	*11,731*	*16,713*	*23,151*	*25,201*	*22,182*	*14,635*
Total Core Technologies		**15,150**	**16,782**	**22,324**	**28,874**	**31,039**	**28,137**	**20,708**
KA1102034	R&D - Project X	11,003	15,566	19,692	19,128	19,035	0	0
39KA	Project X Construction	0	0	0	0	0	39,173	60,955
Total Project X		**11,003**	**15,566**	**19,692**	**19,128**	**19,035**	**39,173**	**60,955**
KA1502012	Superconducting RF	20,500	16,866	5,900	0	0	0	0
KA1502012	Superconducting RF - MIE	0	3,200	0	0	0	0	0
Total SRF Infrastructure		**20,500**	**20,066**	**5,900**	**0**	**0**	**0**	**0**
KA1502021	Lab ILC Accel R&D	11,321	10,650	10,650	5,325	5,485	5,677	0
Total ILC R&D (wo/GDE)		**11,321**	**10,650**	**10,650**	**5,325**	**5,485**	**5,677**	**0**
Total		**57,974**	**63,064**	**58,566**	**53,327**	**55,558**	**72,986**	**81,664**
KA 11 XX XX	Superconducting RF - operations	0	0	11,000	11,220	11,444	11,673	11,907

PX/NF/MC Evolution

- Project X shares many features with the proton driver required for a Neutrino Factory or Muon Collider
  - NF and MC require ~4 MW @ 10± 5 GeV
  - Primary issues are related to beam "format"
    - NF wants proton beam on target consolidated in a few bunches; Muon Collider requires single bunch
  - Project X linac is not capable of delivering this format



⇒ It is inevitable that a new ring(s) will be required to produce the correct beam format for targeting.

- MAP Collaboration formed, DOE Review in August

Strategy/Timeline

- Next six months: Complete all preliminary design, configuration, and cost range information for IC-2
  - ICD-2v2.0
  - Cost estimate
  - Updated RD&D Plan with resource loaded schedule
- Continue conceptual development on outstanding technical questions
  - Baseline concept for the chopper
  - Concepts for marrying a 3-8 GeV pulsed linac to CW front end
  - Injection into RCS or Recycler
- Pursue R&D aimed at the CW linac
  - Emphasis of srf development at all relevant frequencies
  - Engage external collaborators and identify roles
- Department of Energy has advised that the earliest possible construction start is FY2015
  - Requires CD-0 in FY2011
- We believe that we could construct Project X over a five year time period, assuming a commensurate funding profile

  ⇒ **Project X could be up and running ~2020**

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 at 60-120 GeV, simultaneous with 3 MW at 3 GeV
  - Flexibility for supporting multiple experiments
  - CW linac is unique for this application, and offers capabilities that would be hard/impossible to duplicate in a synchrotron
- Project X and ILC (and HINS) srf activities are now integrated
- The accelerator concept is sufficient to support CD-0
- Details in Breakout Session (Nagaitsev & Kephart)