Project X
Accelerator R&D Plan

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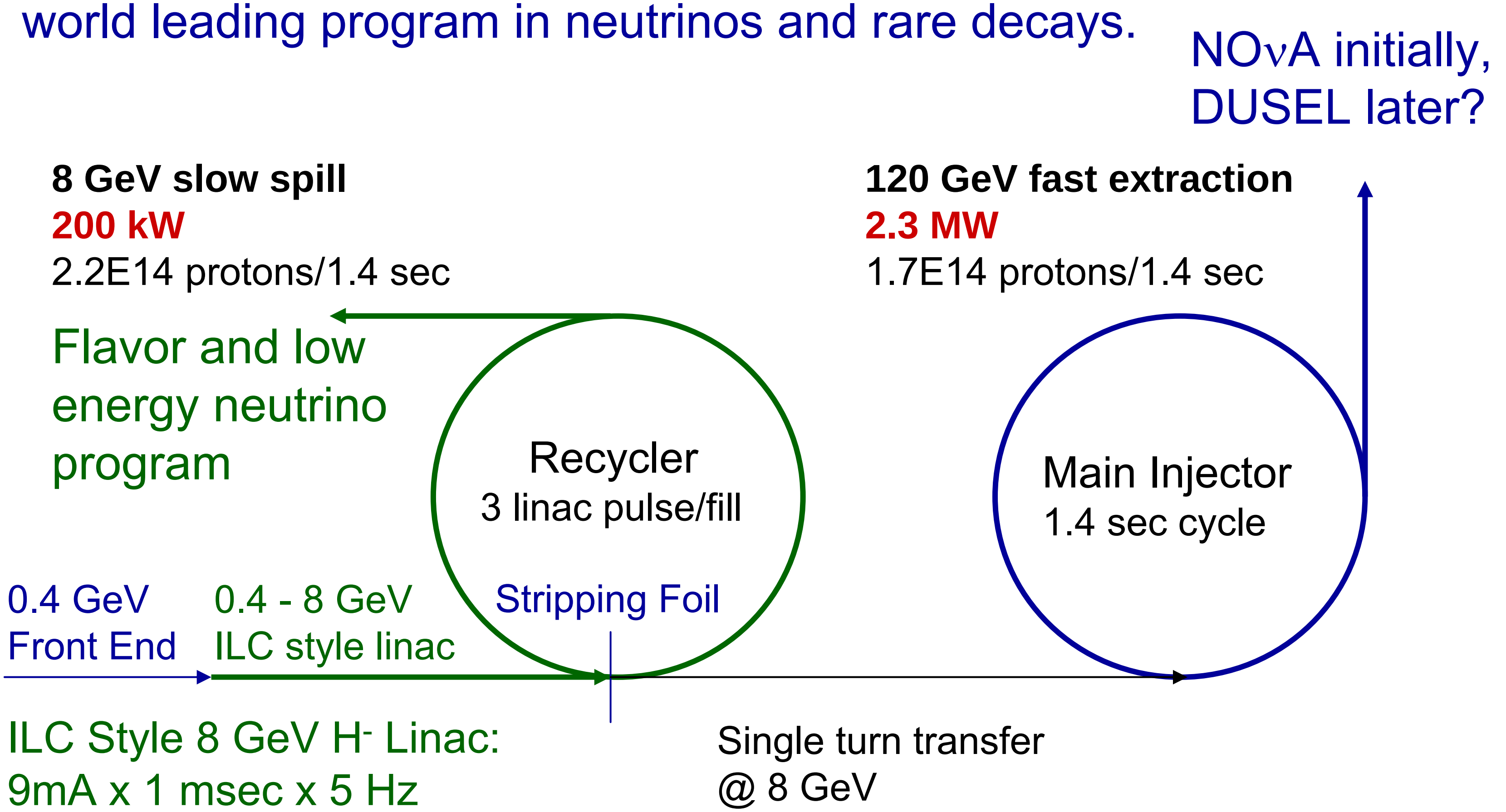
P5 Meeting
January 31, 2008

Outline

- Project X Facility Overview
- R&D Goals
- R&D Strategy
- Project X R&D Plan

Project X Facility Overview

Project X is a high intensity proton facility aimed at supporting a world leading program in neutrinos and rare decays.



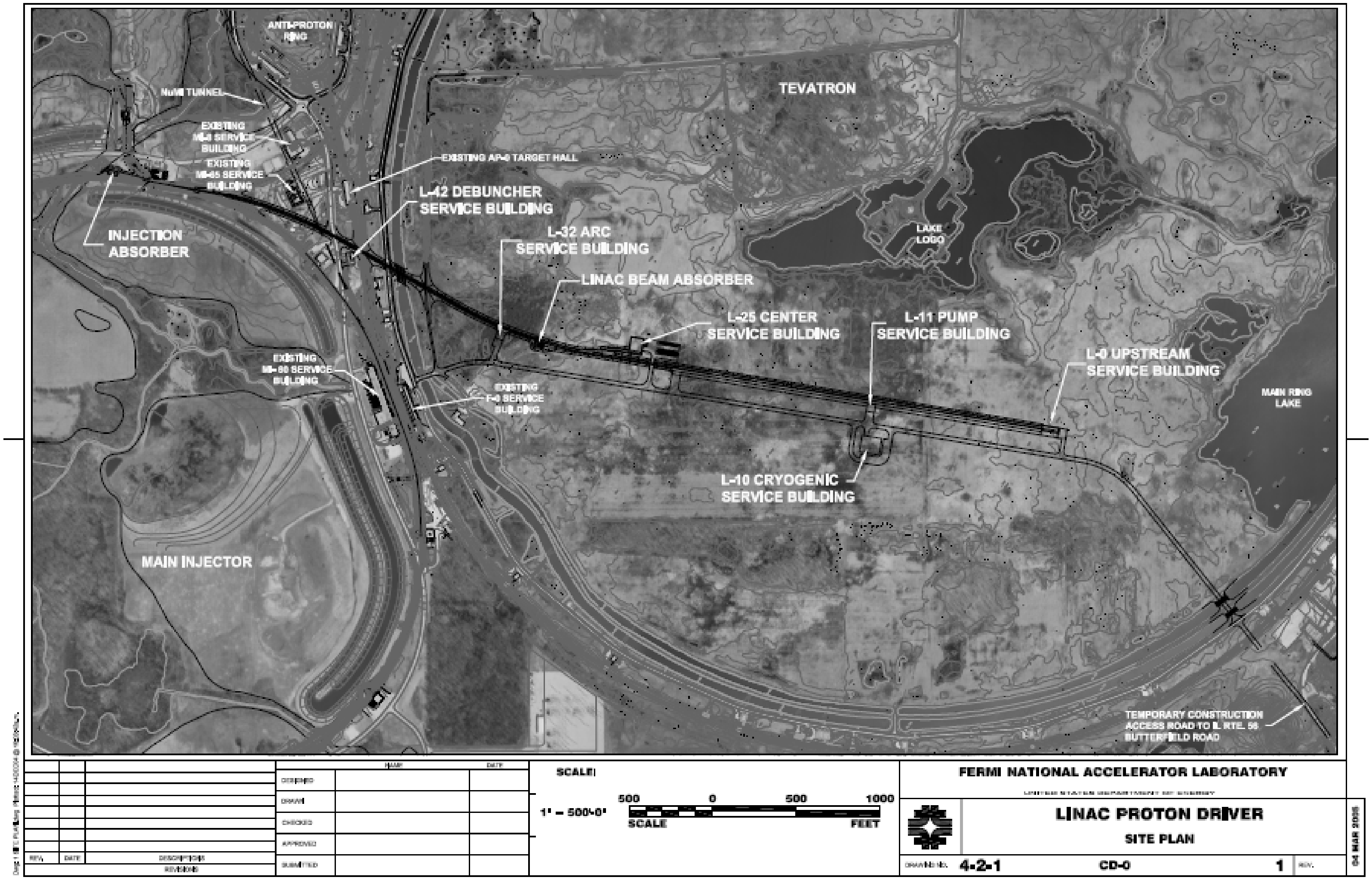
Project X Facility Overview
Scope

- The R&D program supports a facility scope that includes:
  - A new 8 GeV, superconducting, H^- linac;
  - A new beamline for transport of 8 GeV H^- from the linac to the Recycler Ring;
  - Modifications to the Recycler required for 8 GeV H^- injection, accumulation, and delivery of protons to the Main Injector;
  - Modifications to existing beamlines to support transfer of 8 GeV protons from the Reycler to the Main Injector;
  - Modifications to the Main Injector to support acceleration and extraction of high intensity proton beams over the range 60-120 GeV;
  - Modifications to the NuMI facility to support operations at 2 MW beam power;
  - Modifications to the Recycler to support a new extraction system that will allow delivery of 8 GeV protons in support of a dedicated flavor program.

Project X Overview
High Level Performance Goals

Linac		
Particle Type	H^-	
Beam Kinetic Energy	8.0	GeV
Particles per pulse	5.6×10^{13}	
Pulse rate	5	Hz
Beam Power	360	kW
Recycler		
Particle Type	protons	
Beam Kinetic Energy	8.0	GeV
Cycle time	1.4	sec
Particles per cycle to MI	1.7×10^{14}	
Particles per cycle to 8 GeV program	2.2×10^{14}	
Beam Power to 8 GeV program	206	kW
Main Injector		
Beam Kinetic Energy (maximum)	120	GeV
Cycle time	1.4	sec
Particles per cycle	1.7×10^{14}	
Beam Power at 120 GeV	2300	kW

Project X Overview
Provisional Siting



Project X R&D Goals
Program Goals

- The goal of the Project X R&D program is to provide support for a Critical Decision 1 (CD-1) in 2010, leading to a CD-2/3a in 2011.
  - Design and technical component development;
  - Fully developed baseline scope, cost estimate, and schedule for CD-2
  - Formation of a multi-institutional collaboration capable of executing both the R&D plan and the follow-on construction project.
- The primary technical goal is a complete facility design that meets the needs of the US research program, as established via CD-0.
  - 2 MW of beam power over the range 60 – 120 GeV,
  - simultaneous with at least 100 kW of beam power at 8 GeV.

Project X R&D Goals
Technical Goals

- Complete preliminary design and cost estimate for Project X:
  - technical and conventional construction elements,
  - systems integration, and
  - installation and commissioning plan.
- A supporting technology development program targeting key accelerator physics and engineering challenges
- Alignment with the ILC and SRF programs:
  - Development of shared technologies to the benefit of both efforts
    - Cavity/cryomodule design, rf sources, e-cloud, civil infrastructure
  - Project X linac designed to accommodate accelerating gradients in the range 23.6 – 31.5 MV/m (XFEL – ILC)
    - Final design gradient determined prior to CD-2.
- Preliminary identification of performance upgrade paths

Project X R&D Goals
Management/Organization Goals

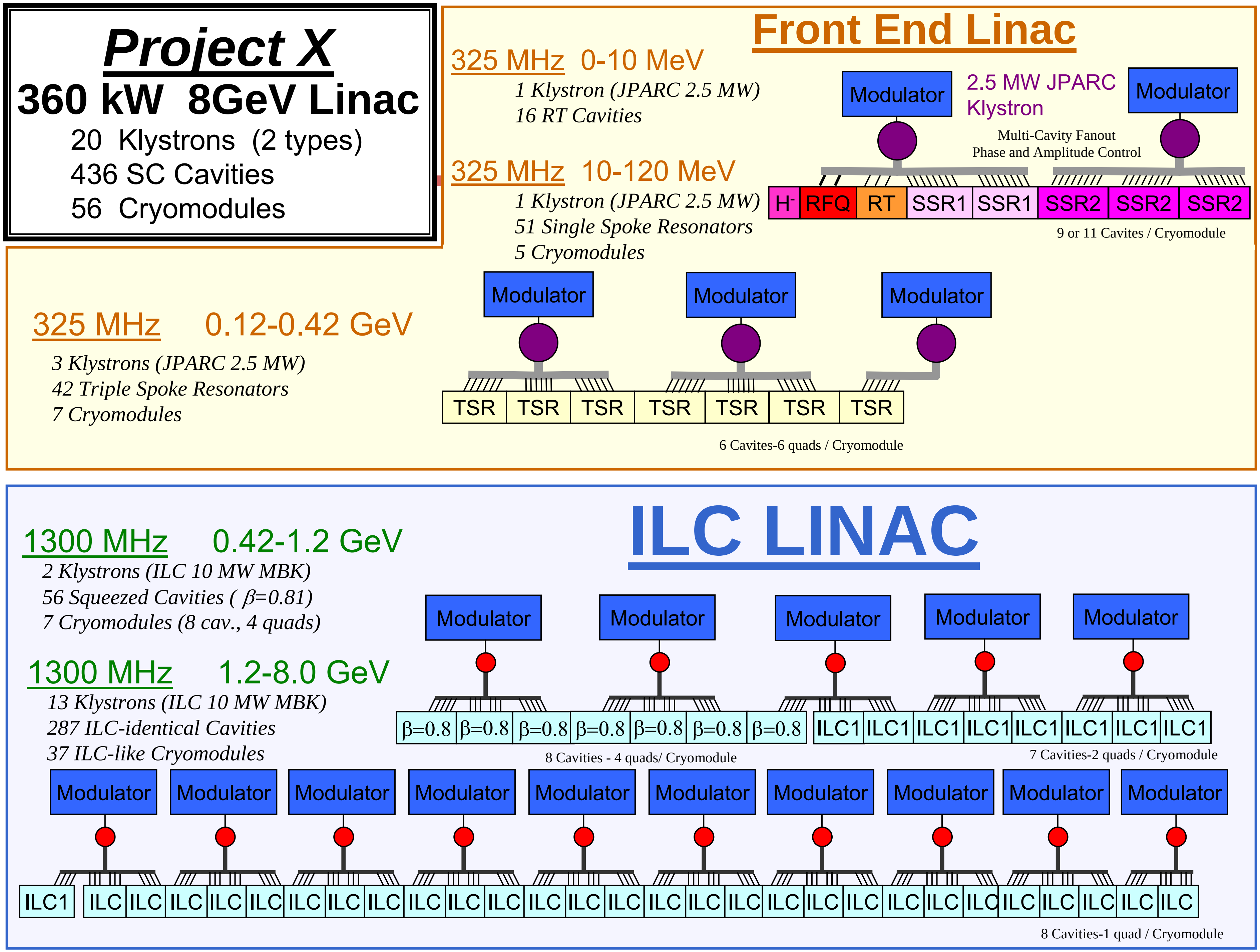
- Formation of a multi-institutional collaboration to carry out the Project X R&D program and to prepare a plan for construction.
- Development all project documentation and organizational structures required by DOE 413.3.
- Timeline:
  - 2008: CD-0
    - Form Project X R&D Collaboration
  - 2009:
    - Start project documentation (including CDR), and accompanying R&D program
  - 2010: CD-1
    - Finish CDR, form collaboration to undertake construction project
  - 2011: CD-2/3a
    - Establish project baseline (scope, cost, schedule)

Project X R&D Strategy
Preliminaries

- Proton Driver Design Studies over 2002-2004
  - Director's Review in March 2005
- Project X Preliminary Report - August 1, 2007
  - Delivered to Fermilab Directorate Long Range Steering committee
  - Reviewed by Fermilab Accelerator Advisory Committee
    - "We congratulate the Project X team on an innovative design…Project-X is especially suitable for Fermilab in the current scenario of a not well-defined schedule of ILC construction, because of synergies with ILC…The committee therefore very strongly supports the work that is planned for Project-X."

      http://projectx.fnal.gov/AACReview/ProjectXAacReport.pdf
- Project X Accelerator Physics and Technology Workshop - Nov. 12-13, 2007
  - 175 attendees from 28 different institutions.

    http://projectx.fnal.gov/Workshop/ProjectXWorkshopReport.pdf



Project X
360 kW 8GeV Linac
20 Klystrons (2 types)
436 SC Cavities
56 Cryomodules
Front End Linac
325 MHz 0-10 MeV
1 Klystron (JPARC 2.5 MW)
16 RT Cavities
325 MHz 10-120 MeV
1 Klystron (JPARC 2.5 MW)
51 Single Spoke Resonators
5 Cryomodules
Modulator
2.5 MW JPARC Klystron
Modulator
Multi-Cavity Fanout
Phase and Amplitude Control
H-
RFQ
RT
SSR1
SSR1
SSR2
SSR2
SSR2
9 or 11 Cavites / Cryomodule
325 MHz 0.12-0.42 GeV
3 Klystrons (JPARC 2.5 MW)
42 Triple Spoke Resonators
7 Cryomodules
Modulator
Modulator
Modulator
TSR
TSR
TSR
TSR
TSR
TSR
TSR
6 Cavites-6 quads / Cryomodule
ILC LINAC
1300 MHz 0.42-1.2 GeV
2 Klystrons (ILC 10 MW MBK)
56 Squeezed Cavities (β=0.81)
7 Cryomodules (8 cav., 4 quads)
1300 MHz 1.2-8.0 GeV
13 Klystrons (ILC 10 MW MBK)
287 ILC-identical Cavities
37 ILC-like Cryomodules
Modulator
β=0.8
ILC1
8 Cavities - 4 quads/ Cryomodule
7 Cavities-2 quads / Cryomodule
ILC1
ILC
8 Cavities-1 quad / Cryomodule

Project X R&D Strategy
Technical Elements Outline

- **Requirements** - develop major system requirements
  - Eight major systems
  - 17 base requirements
  - 68 derived requirements
- **Issues** - discuss issues arising from the requirements
- **Elements** - define the elements of an R&D plan that
  - Addresses the issues arising from the requirements
  - Are directed towards a completion of Conceptual Design Report
- **Resources and Schedule** - estimate:
  - The resources required to complete the R&D plan
  - The schedule required to complete the R&D plan

Note: The Project X R&D strategy assumes the existence of ILC, SRF, and HINS programs.

Project X R&D Strategy
Major Project X Components

- A front end linac operating at 325 MHz.
- An ILC-like linac operating at 1300MHz.
- An 8 GeV transfer line and H- Injection system.
- The Recycler operating as a stripping ring and a proton accumulator.
- The Main Injector acting as a rapid cycling accelerator.
- A slow extraction system from the Recycler.
- 120 GeV Neutrino beamline.
- Civil Construction and Utilities
- Controls

Project X R&D Strategy
Major System Requirements

Req. No.	Description	Req.	Unit	Reference Requirements			
1.0	**General**						
1.1	120 GeV Beam Power	2.3	MW				
1.2	8 GeV Beam Power	360	kW				
1.3	8 GeV Slow Spill Beam Power	200	kW				
1.4	8 GeV Slow Spill Duty Factor	55	%				
1.5	120 GeV Availability	75	%				
1.6	8 GeV Availability	80	%				

Req. No.	Description	Req.	Unit	Reference Requirements			
2.0	**325 MHz Linac**						
2.1	Average Beam Current	9	mA	1.2			
2.2	Pulse Length	1	mS	1.2			
2.3	Repetition rate	5	Hz	1.2			
2.4	325 MHz Availability	98	%	1.6			
2.5	Peak RF Current	14.4	mA	2.1	2.11	2.13	2.14
2.6	Final Energy	420	MeV	3.6			
2.7	Energy Variation (rms)	1	%	3.10			
2.8	Bunch Phase jitter (rms)	1	degree	3.11			
2.9	Linac Species	H-		4.1			
2.10	Transverse Emittance (95% normalized)	2.5	π-mm-mrad	5.7	5.8		
2.11	Macro Bunch Duty Factor	67	%	5.10	5.12		
2.12	Macro Bunch Frequency	53	MHz	5.12			
2.13	Micro Pulse Length	10.4	uS	5.13			
2.14	Micro Pulse Period	11.1	uS	5.13			

Project X R&D Strategy
Major System Requirements

Req. No.	Description	Req.	Unit	Reference Requirements			
3.0	**1300 MHz Linac**						
3.1	Average Gradient (ILC portion)	26	MV/meter				
3.2	Average Gradient (S-ILC portion)	23	MV/meter				
3.3	Average Beam Current	9	mA	1.2			
3.4	Pulse Length	1	mS	1.2			
3.5	Repetition rate	5	Hz	1.2			
3.6	1300 MHz Availability	88	%	1.6			
3.7	Initial Energy	420	MeV	2.6			
3.8	Length (approx.)	700	meters	3.1	3.13		
3.9	Peak RF Current	14.4	mA	3.3	3.15	3.17	3.18
3.10	Linac Species	H-		4.1			
3.11	Energy Variation (rms)	1	%	4.9			
3.12	Bunch Phase jitter (rms)	1	degree	4.9			
3.13	Final Energy	8	GeV	4.10			
3.14	Transverse Emittance (95% normalized)	2.5	π-mm-mrad	5.7	5.8		
3.15	Macro Bunch Duty Factor	67	%	5.10	5.12		
3.16	Macro Bunch Frequency	53	MHz	5.12			
3.17	Micro Pulse Length	10.4	uS	5.13			
3.18	Micro Pulse Period	11.1	uS	5.13			

Project X R&D Strategy

Major System Requirements

Req. No.	Description	Req.	Unit	Reference Requirements			
4.0	**8 GeV Transfer Line**						
4.1	Injection Stripping efficiency	98	%				
4.2	Length (approx.)	1000	meters				
4.3	Maximum average activation level	20	mrem/hr				
4.4	Availability	98	%	1.6			
4.5	Momentum Aperture	+/- 0.8	%	3.10			
4.6	Minimum Transverse Aperture	25	π-mm-mrad	3.13	4.3		
4.7	Maximum Dipole Field	0.05	T	4.1	4.3		
4.8	Transfer Efficiency	99.99	%	4.3			
4.9	Final Energy Variation	+/- 0.11	%	5.10			
4.10	Energy	8	GeV	5.1			

Req. No.	Description	Req.	Unit	Reference Requirements			
5.0	**Recycler**						
5.1	Energy	8	GeV				
5.2	Storage Efficiency	99.5	%				
5.3	Average Recycler Beam Current	0.6	A	1.2			
5.4	Availability	95	%	1.6			
5.5	Injection Rate	5	Hz	2.3			
5.6	Maximum Space Charge Tune Shift	0.05		5.2			
5.7	95% normalized transverse emittance	25	π-mm-mrad	5.6			
5.8	r.m.s. normalized transverse emittance	13	π-mm-mrad	5.6			
5.9	Bunching factor	2		5.6			
5.10	Longitudinal emittance per Bunch	0.5	eV-Sec	5.6	5.12		
5.11	Cycle Time	1.4	S	6.1			
5.12	RF Frequency	53	MHz	6.2			
5.13	Abort Gap Length	700	nS	6.3			
5.14	Peak Recycler Beam Current	2.4	A	6.5			

Project X R&D Strategy
Major System Requirements

Req. No.	Description	Req.	Unit	Reference Requirements		
6.0	**Main Injector**					
6.1	120 GeV cycle Time	1.4	S			
6.2	RF Frequency	53	MHz			
6.3	Abort Gap Length	700	nS			
6.4	Acceleration Efficiency	99	%			
6.5	Main Injector Beam Current	2.4	A	1.1		
6.6	Final Energy	120	GeV	1.1		
6.7	120 GeV Beam Power	2.3	MW	1.1		
6.8	Availability	87	%	1.5		
6.9	Injection Energy	8	GeV	5.1		
6.10	Longitudinal emittance per Bunch	0.5	eV-Sec	6.2	6.11	
6.11	Space Charge Tune Shift	0.05		6.4		
6.12	95% normalized transverse emittance	25	π-mm-mrad	6.11		
6.13	r.m.s. normalized transverse emittance	13	π-mm-mrad	6.11		
6.14	Bunching factor	2		6.11		
7.0	**8 GeV Slow Spill**					
7.1	8 GeV Slow Spill Beam Power	200	kW	1.3		
7.2	Peak Spill Rate	280	$x10^{12}$ pps	1.3	1.4	7.5
7.3	8 GeV Slow Spill Duty Factor	55	%	1.4		
7.4	8 GeV Availability	80	%	1.6		
7.5	Cycle Time	1.4	S	6.1		
7.6	Peak Recycler Beam Current for slow spill	0.8	A	7.2		
8.0	**120 GeV Targeting**					
8.1	120 GeV Beam Power	2.3	MW	1.1		
8.2	120 GeV Availability	95	%	1.5		
8.3	Cycle Time	1.4	S	6.1		

Project X R&D Strategy
325 MHz Linac Issues

- No special accelerator physics issues are posed by a 420 MeV linac with this beam intensity.
- Development via the High Intensity Neutrino Source (HINS) program
  - 60 MeV front end demonstration based on scrf
- Technology choices
  - room temperature vs. superconducting
  - Upgrade path
- Beam duty cycle and machine availability requirements push the envelope of any existing H- ion source
- Superconducting triple-spoke accelerating cavity is outside the scope of the HINS program
  - RF power distribution and control
  - Cryomodules
  - Beam diagnostics

Project X R&D Strategy
325 MHz Linac Technical Elements

- FY08
  - Basic accelerator physics design
  - HINS vs. alternative technology study
- FY09
  - Basic machine design and technology decisions completed
  - Begin
    - Ion source development,
    - Triple-spoke cavity electromagnetic and mechanical design,
    - Material procurement,
    - Low level RF development
- FY10
  - Ion source prototyping and testing
  - Triple-spoke prototype fabrication,
  - vector modulator and RF distribution system development
- FY11
  - Fabrication triple-spoke cavities
  - Ion source development,
  - RF power distribution system design development
  - Beam instrumentation
  - Complete design
  - Complete cost estimates.

Project X R&D Strategy
1300 MHz Linac Issues

- Project X 1.3 GHz linac is based on the ILC cryomodule design.
  - ~40 CMs required for Project X
    - Accommodate cavity gradients in the range 23.6 – 31.5 MeV
  - GDE is developing a standardized CM design as a high priority near-term item, with goal of testing a complete 31.5 MeV/m CM by 2012.
  - ART plan calls for the assembly and testing of several CMs by 2012
  - Fermilab is playing a leading role in CM design, fabrication, and testing
- Project X has same average current as ILC (9 mA$\times$1 msec$\times$5 Hz)
  - Bunch structure is different
  - Beam test addresses significant, but not all, ILC issues.
- Project X construction will require a production rate of ~one cryomodule/month, with a procurement leadtime of <1 year.
  - Supported by SRF infrastructure program
  - Engage industry in a manner that leads to a cost effective design

Project X R&D Strategy

1300 MHz Linac Technical Elements

- FY08
  - initiate conceptual linac design :
    - lattice
    - RF systems
  - begin design of the S-ILC cavities
- FY09
  - Continue with conceptual linac design
  - Begin to prototype S-ILC tuners, couplers, and cavities
  - Initiate RF system test with first ILC-like cryomodule in concert with the ILC
- FY10
  - Finish conceptual design of the linac
  - Test dressed prototype S-ILC cavities
  - Continue with RF system tests
  - Begin design of the machine protection system
- FY11
  - Finish all prototype tests
  - Complete RF system and machine protection system design
  - Complete cost estimates

Aimed at test of complete rf unit in 2012

Project X R&D Strategy
8 GeV Transfer Line Issues

- Control and mitigation of beam loss due to single particle loss mechanisms in the transport line.
- Uncontrolled losses in the injection region due to the injected and circulating beam interaction with the stripping foil.
- The stripping efficiency and lifetime of the injection foil, or
- The stripping efficiency of a laser stripping injection system.
- The collection of the stripped electrons and neutrals from the injection process.

Project X R&D Strategy
8 GeV Transfer Line Technical Elements

- FY08
  - Begin physics design
  - Begin component specification for the Transfer line and the Injection system
- FY09
  - Finish physics design and component specification.
  - Begin component design of the chicane magnets, painting magnets, foil support and changer, electron catcher, power supply design, vacuum system design
- FY10
  - Finish component design
  - Initiate controls and instrumentation design
  - Begin prototyping of the painting magnets, foil support and changer, electron catcher, and cryogenic beam pipe
- FY11
  - Finish prototyping
  - Begin and finish cost estimates.

Project X R&D Strategy
Ring Issues

- Recycler Ring
  - Space Charge tune shift
  - Electron cloud instabilities
  - Storage efficiency

- Main Injector
  - Space Charge tune-shift
  - Electron cloud instabilities
  - RF Power
  - Beam loading
  - Transition crossing

Project X R&D Strategy
Ring Technical Elements

- FY08
  - Begin design of a two harmonic RF system
  - Run simulations for e-cloud (EC)
  - Continue EC measurements in MI; begin in other rings (e.g. CESR, RHIC, CERN)
  - Investigate the possibility of coating the beam pipe
- FY09
  - Select RF Frequency and finalize RF design
  - Begin RF system prototype
  - Continue with EC simulations and measurements
  - Begin beam coating prototype
- FY10
  - Finish RF system prototype and begin testing
  - Continue with EC simulations and measurements
  - Coat two MI and Recycler dipoles in a service building and evaluate the results
- FY11
  - Finish high power RF system prototype and install in MI tunnel for beam tests
  - Finalize EC mitigation plan
  - Begin and finish cost estimates.

Project X R&D Strategy
8 GeV Slow Spill Issues

- Extraction system configuration: chromatic effects on the transverse phase space at the extraction Lambertson
- Lattice requirements
  - existing gradient magnet harmonics,
  - new powered harmonic elements,
  - modifications to the Recycler lattice.
- RF beam structure requirements
- Duty factor
- Speed of the extraction process
- Extraction point location
- Loss mitigation and shielding requirements

Project X R&D Strategy
8 GeV Slow Spill Technical Elements

- FY08
  - Begin 1/3 and ½ integer extraction studies
  - Develop bunch structure specifications
- FY09
  - Finish1/3 and ½ integer extraction studies
  - Decide on extraction strategy
  - Begin design of extraction devices
    - Lambertson,
    - Septum
    - Harmonic Elements
    - Recycler Lattice modifications
- FY09
  - Continue design of extraction devices
  - Begin necessary prototype construction (septum)
- FY10
  - Finalize physics design
  - Finish design of extraction devices
  - Test Prototypes (septum)
  - Begin and finish cost estimates

Project X R&D Strategy
Neutrino Beamline Issues

- Development of a proton target and magnetic horn system capable of handling 2.3 MW of beam power at 120 GeV
  - Project X will increase beam power by a factor of 5-6 beyond the original NuMI design.
  - Initial investigation suggest that the NuMI target hall could be upgraded to handle about 1-2 MW of beam power
    - NuMI beamline was conservatively designed,
    - Redundancy in the initial design.
- Reliability, maintainability, and uptime of the NuMI facility.
  - Limits on the decay pipe window
  - Residual radiation, airborne emissions, and ground water protection
  - Handling of radioactive components

Project X R&D Strategy
Neutrino Beamline Technical Elements

- FY08
  - Target design begins.
  - Study of decay pipe window begins.
- FY09
  - Target design continues.
  - Magnetic horn design begins.
  - Module upgrades design begins.
  - Study of decay pipe window continues.
  - Study of decay pipe system.
  - Remote handling study begins.
- FY10
  - Target design concludes.
  - Magnetic horn design continues
  - Module upgrades designs conclude.
- FY10 (cont.)
  - Target chase cooling design begins.
  - Study of decay pipe window continues.
  - Hadron absorber design begins.
  - Remote handling study continues.
  - Radiological study begins.
  - Infrastructure design.
- FY11
  - Magnetic horn design concludes.
  - Target chase cooling design concludes.
  - Study of decay pipe window concludes.
  - Hadron absorber design concludes.
  - Remote handling study concludes.
  - Radiological study concludes.

Project X R&D Strategy
Civil Construction Issues

- Existing design concept for Proton Driver facilities meets many Project X requirements
- Wetland mitigation options
- Re-use of existing utility capabilities?
- Re-use of existing cryo facilities?
- Large injection abort
  - Significant civil construction required
- Project X has significant utility infrastructure in common with ILC (power distribution, HVAC, cooling, cryogenics, etc.)
  - Involved Fermilab resident expertise can be shared between the ILC and Project X efforts.

  ⇒ Opportunity for shared development of cost effective designs in these areas.

Project X R&D Strategy
Civil Construction Technical Elements

- FY08
  - Update existing Proton Driver design
  - Revise cost estimate to match revised scope
  - Determine best approach for hiring of architect/engineer consultant
- FY09
  - Begin NEPA process
  - Apply for ACOE 404 wetlands permit
  - Perform architect/engineer selection to help with drafting and graphics for CDR work in this phase
- FY10
  - Work through iterations of EA
  - Finalize conceptual design and drawings
  - Contract with A/E for T1 work
  - Perform Construction Manager selection
- FY11
  - Perform preliminary design
  - Perform soil borings for facilities
  - Provide cost estimate and schedule information
  - Develop site preparation package
  - Begin advanced conceptual design for other construction packages

Project X R&D Strategy
Controls Issues

- Scale
  - One million controllable properties
  - Up to 200 system users
- Availability
  - 2500-hr MTBF (mean time between failures)
  - 5-hr MTTR (meant time to repair)
  - 15 hours downtime per year
- Machine Protection and Safety
- Legacy Constraints

Project X R&D Strategy
Controls Technical Elements

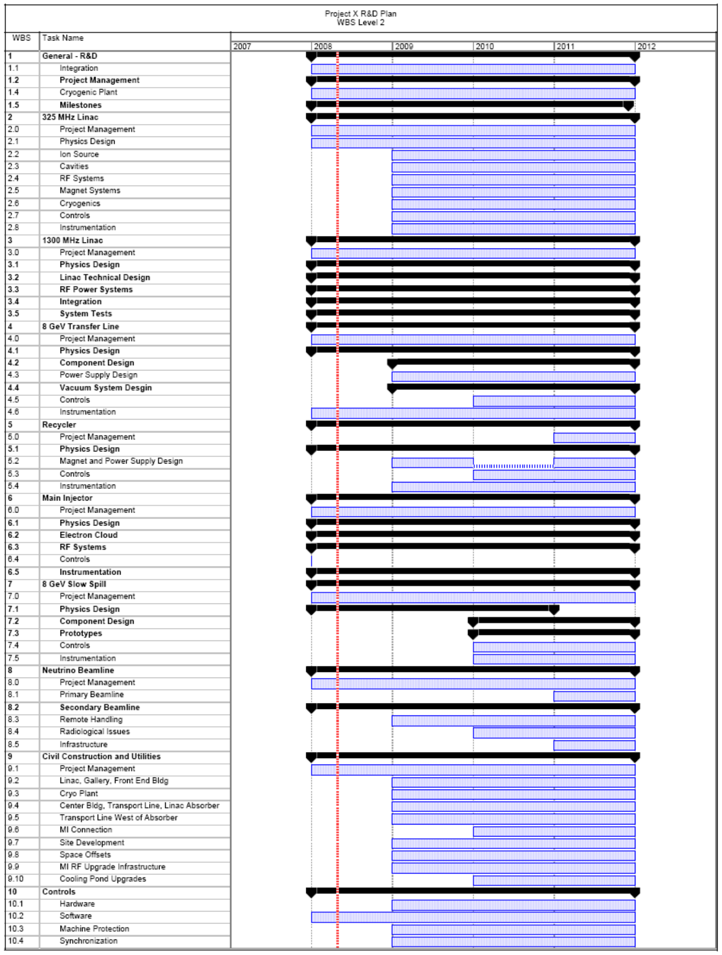
- FY08
  - Do the requirements and design to modernize the controls software infrastructure. This includes front-end software, central services, the applications framework, and the software build environment.
- FY09
  - Machine Protection System R&D starts in parallel
  - Work on the controls software infrastructure begins implementation.
- FY10
  - Controls software infrastructure design and development is finished
  - Begin system testing
  - Development of the Machine Protection System and beam feedback system begins.
- FY11
  - Complete the infrastructure upgrade
  - New features are being designed and developed.
  - The Machine Protection and Beam Feedback systems finished and tested

Project X R&D Plan

Master Schedule

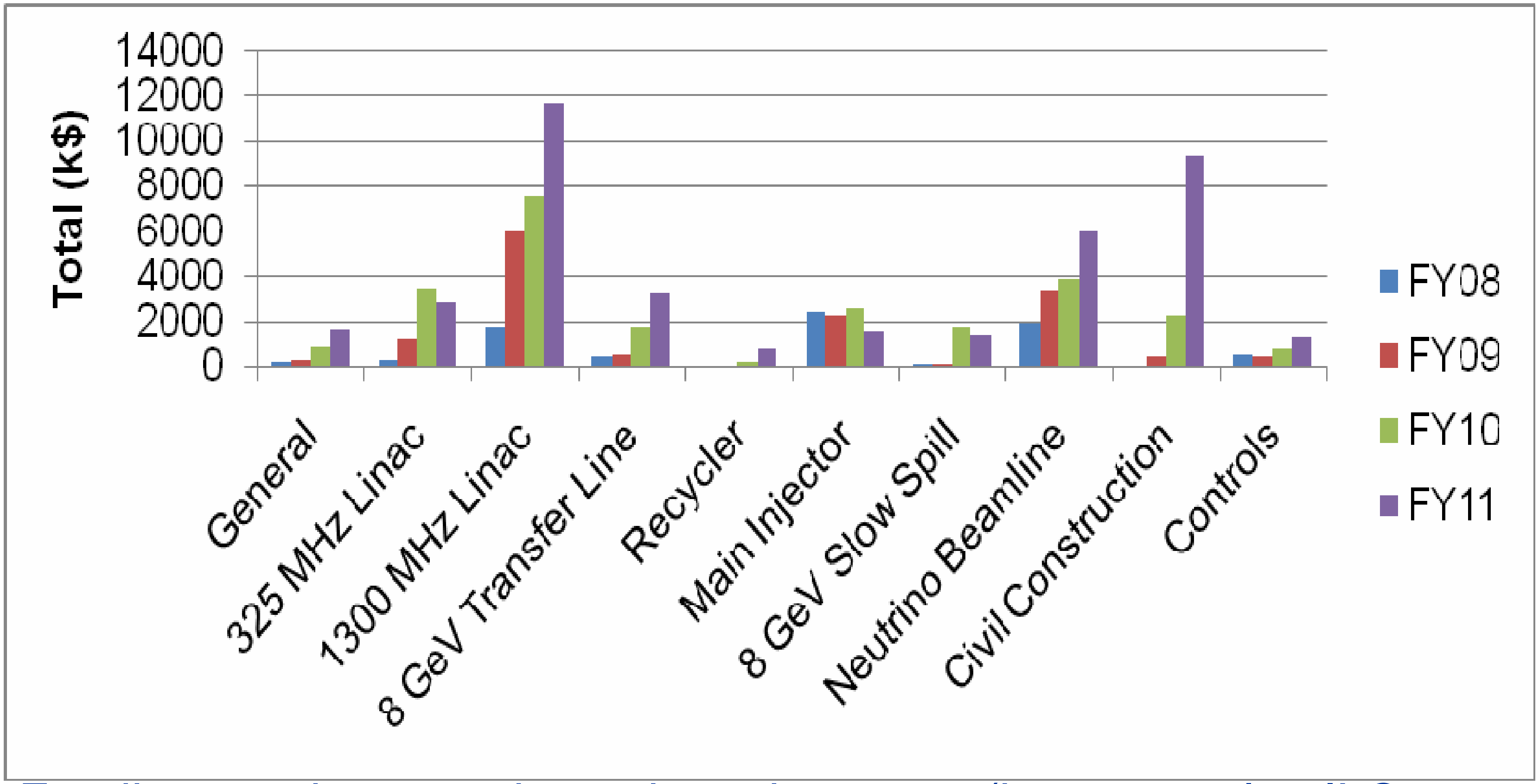
- Based on resource loaded schedule (RLS – see report for readable version)
- Covers FY2008-2011
- Incremental to ILC, SRF, HINS
- Major Milestones

CD-0 Approved	8/1/08
Start CD-1 Documentation	9/1/08
Complete CD-1 Document.	4/1/10
Start CD-2 Documentation	5/3/10
CD-1 DOE Review	6/1/10
CD-1 Approved	8/2/10
Complete CD-2 Document.	4/1/11
Start CD-3 Documentation	5/2/11
CD-2 DOE Review	6/1/11
CD-2/3a Approved	9/1/11



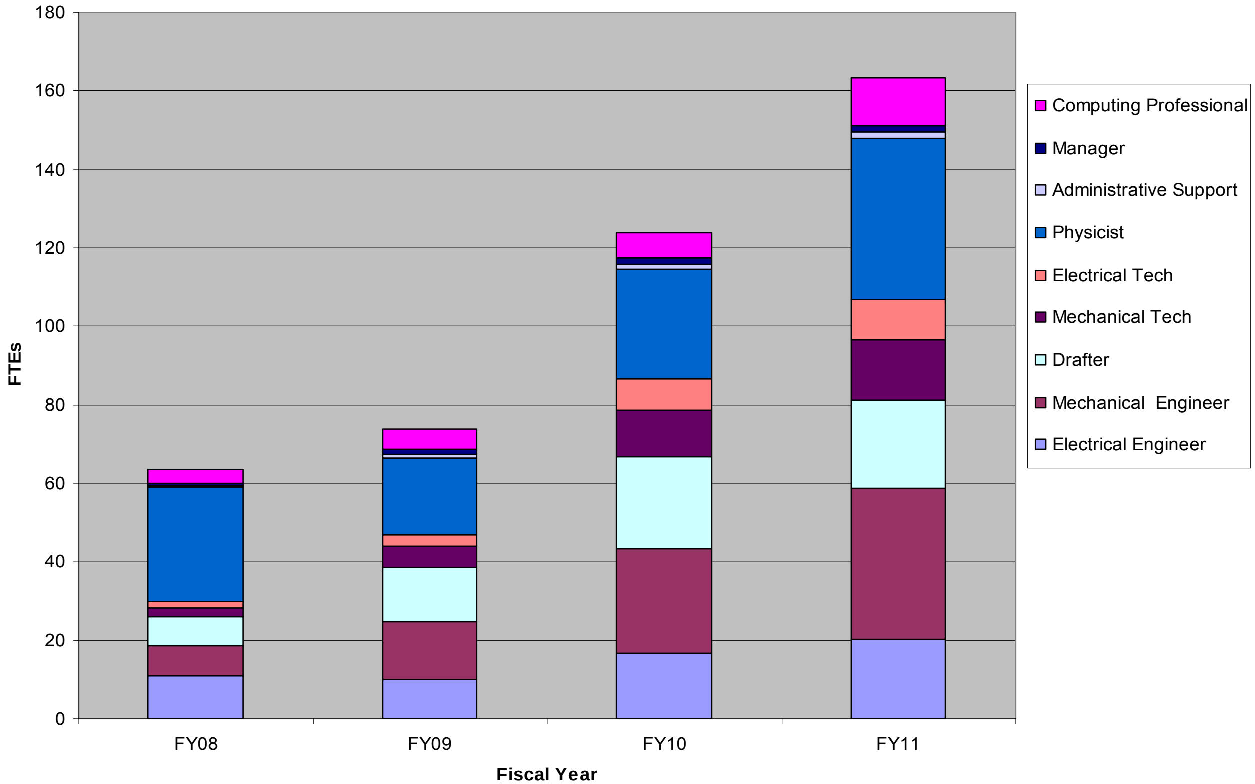
Project X R&D Plan

Resource Requirements and Profile



Funding requirements by major sub-system (incremental to ILC, SRF, HINS programs)

Project X R&D Plan
Resource Requirements and Profile



Personnel profile by skills types

Note: This includes total resources, not just Fermilab.

Incremental to ILC, SRF, and HINS programs

Project X R&D Plan
Budget Profile

		Project X R&D Plan Budget Profile						
		(Dollar amounts in millions, fully burdened)						
		FY08	FY09	FY10	FY11	FY12		TOTAL
SWF		$6.7	$10.5	$19.1	$26.3			$62.6
M&S		$1.5	$4.9	$6.2	$13.7			$26.3
TOTAL		$8.1	$15.5	$25.4	$40.0			$88.9
					PED			
		CD-0		CD-1	CD-2/3a			

Project X R&D budget profile

- Scientists not included
- Can produce this table with any combination of scientists in or out, FY08 or AY$, burdened or unburdened
- Incremental to ILC, SRF, and HINS programs

Project X R&D Plan

An Integrated Plan

	FY08	FY09	FY10	FY11	FY12	FY13
ILC C+CM	CM1	CM2	CM3 (Type IV)		CM4 rf unit syst.tst	
ILC RF Power		MBK	PFN modulator			
SRF Infra.				NML complete		CAF complete (1 CM/month)
HINS				60 MeV beam tests		
Project X			CDR	FE decision Gradient decision baseline docs	rf unit sys.tst	
	CD-0		**CD-1**	**CD-2/3a**		

Project X R&D Plan
Collaboration Plan

Disclaimer: This is not formally agreed to, although institutions have been invited to comment as this has been developed.

- Intention is to organize and execute the R&D Program via a multi-institutional collaboration.
  - Goal is to give collaborators complete and contained sub-projects, meaning they hold responsibility for design, engineering, estimating, and potentially construction if/when Project X proceeds.
  - Project X R&D Collaboration to be established via a Collaboration Memorandum of Understanding (MOU) outlining basic goals of the collaboration, and the means of organizing and executing the work.
  - It is anticipated that the Project X R&D Program will be undertaken as a "national project with international participation". Expectation is that the same structure of MOUs described above would establish the participation of international laboratories.

Project X R&D Plan
Management Plan

- Fermilab responsible for management of the Project X R&D program.
  - Program managed by a Project X R&D Program Leader, assisted by a Program Team. Deliverables:
    - reviewable/defensible accelerator physics and engineering design, cost estimate, and schedule to achieve CD-2/3a;
    - including identification of possible upgrade paths;
    - organization of a supporting R&D program.
- Collaboration Council established for the primary purpose of advising/assisting the Project Leader in inter-laboratory coordination.
- Project X Technical Advisory Committee.
- Fermilab 1.3 GHz program managed and coordinated jointly via the Assoc. Director for Accelerators and the ILC Program Director.

Project X R&D Plan
Institutional Expressions of Interest

- Goal of the November 2007 Project X Accelerator Workshop was to discuss accelerator physics and technology issues of Project X, and to explore possible areas of overlap and interest between potentially interested institutions.
  - Participation in the workshop included 175 individuals from 28 institutions in the U.S., Europe, and Asia.
- The Workshop report contains a record of discussions and a complete compilation of "expressions of interest" from the participating institutions.
  - Purpose of these EOIs is to provide an initial step in understanding how capabilities at interested institutions could be brought to bear in the R&D phase of Project X.

Summary

- Design concept exists for a facility capable of delivering in excess of 2 MW beam power over the energy range 60 – 120 GeV, simultaneous with 8 GeV beam power in the range 100 – 200 kW.
  - Major sub-system performance goals established
  - Potential upgrade paths to mulit-MW at 8 GeV exist
  - Design aligned with needs of ILC development
- R&D plan developed covering the period through CD2/3a (2011)
  - Integrates effort on Project X, ILC, and HINS
  - Resource plan exists
- Working towards organizing as a national project with international participation.