Project X Research, Design, and Development Plan

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AAC Meeting

May 6-8 2008

Project X RD&D Program Goals

- The goal of the Project X RD&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;
  - Development of all project documentation mandated by DOE 413.3;
  - Formation of a multi-institutional collaboration capable of executing both the R&D plan and the provisional construction project.
- The primary technical goal is completion of a Conceptual Design Report, followed by a fully developed baseline cost estimate and schedule, and supported by a technology development program.
  - Capability of delivering in at least 2 MW of beam power over the range 60 – 120 GeV, simultaneous with at least 200 kW of beam power at 8 GeV.

Project X RD&D Technical Goals

- Complete conceptual design and cost estimate for Project X:
  - technical and conventional construction elements,
  - systems integration, and
  - installation and commissioning plan.
- Supporting technology development program targeting key accelerator physics and engineering challenges
  - incorporating simulations, experiments, and prototype construction as appropriate.
- Alignment with the SRF/ILC program:
  - Primary goal is to develop a set of technologies applicable to both ILC and Project X
    - Common cavity/cryomodule design, rf sources, tunnel layout
  - 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.

Steps in Developing the RD&D Plan

- **Project Requirements** - Receive the general requirements that support the desired physics
  - Derived from the Nov. 2007 & Jan 2008 Physics workshops
  - Director's Guidance
- **Scope** - Determine the scope of the project that meets the project requirements
- **System Requirements** - develop major system requirements
  - 10 major systems
  - 17 base requirements
  - 68 derived requirements
- **Issues** - discuss issues arising from the requirements
- **Elements** - define the elements of an RD&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

Project X Requirements

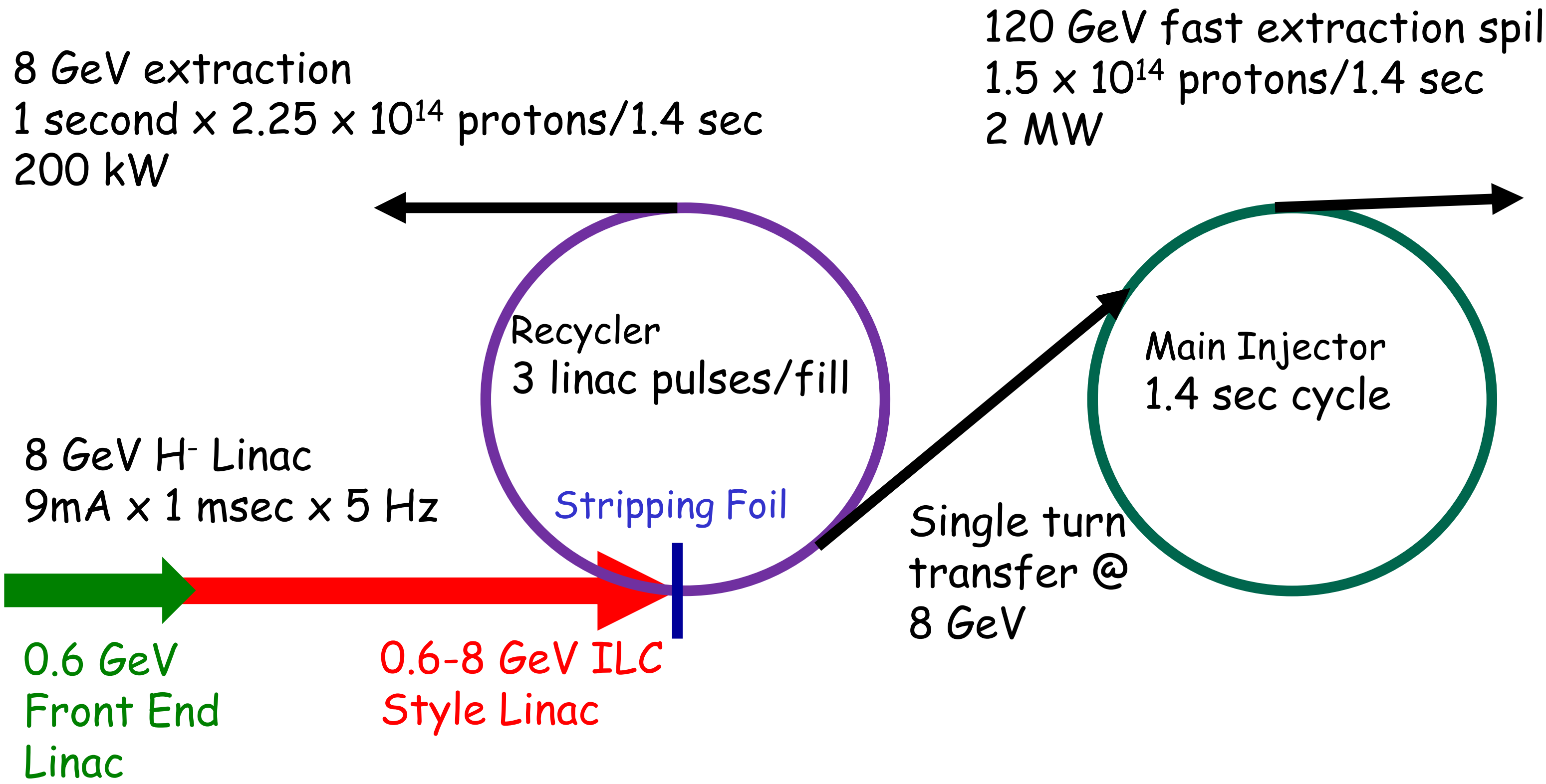
Req. No.	Description		Req.	Unit
1.0	**General**			
1.1		120 GeV Beam Power	2.3	MW
1.2		8 GeV Beam Power	360	kW
1.3		8 GeV Slow Spill Beam Power	200	kW
1.4		8 GeV Slow Spill Duty Factor	55	%
1.5		120 GeV Availability	75	%
1.6		8 GeV Availability	80	%
1.7		Upgradeable 8 GeV Beam Power for Civil, RF, & Cryo Systems	2	MW

- Notes:
  - Availability is defined as the percentage time that the complex is delivering beam
  - 8 GeV duty factor is the result of slow spill being done in the Recycler

Project X Scope

- The basic scheme of Project X is:
  - An 8 GeV Linac operating at ILC-like parameters
  - H- stripping and proton accumulation in the Recycler
  - Beam distributed to the Main Injector for acceleration to 120 GeV
  - Beam distributed to an 8 GeV slow spill program
- The major components that comprise Project X are:
  - A front end linac operating at 325 MHz (max energy 600MeV).
  - 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
  - Cryogenics

Project X Scope



Previous Work on Project X Scope

- Project X Preliminary Report - August 1, 2007
  - Delivered to Fermilab Directorate Long Range Steering committee
  - 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, 2007
  - attended by 175 people from 28 different institutions.
  - The workshop report can be found at:
  - http://projectx.fnal.gov/Workshop/ProjectXWorkshopReport.pdf

Collaboration with Other Institutions

- The intention is to organize and execute the Project X R&D Program via a multi-institutional collaboration, drawing significant participation from outside of Fermilab.
- The goal is to give collaborators complete and contained sub-projects, meaning
  - they hold responsibility for Design, Engineering, and estimating
  - and potentially construction if/when Project X proceeds.
- FNAL project responsibility ➔ overall coordination and organization of appropriate technical & cost reviews
- Collaboration Structure is outlined in the Project X Research, Design, and Development Plan. The plan can be found at:
  - http://projectx.fnal.gov/RnDplan/index.html
- Some initial expressions of interests from other institutions where discussed at the Project X Accelerator Physics and Technology Workshop - Nov. 12, 2007
  - attended by 175 people from 28 different institutions.
  - The workshop report can be found at:
  - http://projectx.fnal.gov/Workshop/ProjectXWorkshopReport.pdf

Project X Related Programs & Deliverables

- High Intensity Neutrino Source (HINS)
  - Bob Webber (APC)
  - Project X related deliverable: Prototype a 66 MeV Linac operating at 325 MHz providing 27mA of beam with a 1 mS pulse length
- Superconducting RF Infrastructure
  - Kephart (Directorate), Mishra (TD/Dir), Nagaitsev (AD/Dir)
  - Project X related deliverables:
    - Develop 1 cryo-module/ month capability
    - Three β= 1 ILC-like cryo-modules
    - NML RF unit test facility & CM test stand
      - System Integration test of ILC Cryo RF unit
- ILC Americas
  - Cavities and processing: Mark Champion (TD)
  - Cryomodule design & assembly: Carter (TD)

Project X Major System Requirements

- Once the scope of Project X was defined, a Fermilab team was formed to develop the major system requirements of Project X
- Fermilab Team:
  - Project Leader: Dave McGinnis (AD/RF)
  - Deputy Project Leader: Elaine McCluskey (AD/HQ)
  - 325 MHz Linac: Bob Webber (APC)
  - 1300MHz Linac: Sergei Nagaitsev (AD/HQ)
  - 8 GeV Injection System: Dave Johnson (APC)
  - Recycler Ring: Paul Derwent (AD/RR)
  - Main Injector: Ioanis Kourbanis (AD/MI)
  - 8 GeV Slow Extraction: Eric Prebys (AD/PS)
  - 120 GeV Targeting: Mike Martens (AD/EB)
  - Civil Construction and Utilities: Elaine McCluskey (AD/HQ)
  - Controls: Jim Patrick (AD/CD)
  - Cryogenics: Arkadiy Klebaner (AD/Cryo)

System Requirements

- Major system requirements
  - 10 major systems
  - 17 base requirements
  - 68 derived requirements

Examples of Major system requirements

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			

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			

RD&D Plan Write-up

- Once the major system requirements were formulated, a report was written that
  - Discussed issues arising from the requirements
  - Defined the elements of an RD&D plan that
    - Addresses the issues arising from the requirements
    - Are directed towards a completion of Conceptual Design Report
  - Estimated:
    - The resources required to complete the R&D plan
    - The schedule required to complete the R&D plan
- The plan is documented at:
  - http://projectx.fnal.gov/RnDplan/index.html

325 MHz Linac Requirements

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			

325 MHz Linac Issues

- Much of the work is being done in the HINS project
- No new accelerator physics issues are posed by a 420 MeV, 5.6E13 particles per pulse, 5 Hz, H- Linac.
- 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 project
  - RF power distribution and control
  - Cryomodules
  - Beam diagnostics

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.

1300 MHz Linac Requirements

Project X

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			

1300 MHz Linac Issues

- The requirements for cavity gradient for Project X are less stringent than the ILC.
- The more important issue is the production rate of cryo-modules.
  - The present ILC cryo-module production rate
    - one cryo-module per year
    - two year lead time on the procurement of cryo-module components.
  - The cryo-module production rate should be
    - one cryo-module per month
    - a lead time on the procurement of cryo-module components less than one year.
    - This goal is in line with the goal of developing ILC superconducting RF infrastructure at Fermilab.

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

8 GeV Transfer Line 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			

8 GeV Transfer Line Issues

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

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.

Recycler Requirements

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			

Main Injector 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			

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

Ring Technical Elements

- FY08
  - Begin design of a two harmonic RF system
  - Run simulations for e-cloud (EC)
  - Continue EC measurements in MI and begin EC measurements in other rings
  - 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.

8 GeV Slow Spill Requirements and Issues

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			

- 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.

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

Neutrino Beamline Requirements & Issues

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			

- Development of a proton target and magnetic horn system capable of handling 2.3 MW of beam power at 120 GeV
- increasing the beam power to an already existing facility.
  - Project X will place a factor of 5.7 more beam power into the NuMI facility than the original NuMI design.
  - Initial estimates predict 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 and uptime of the NuMI facility.
  - Limits on the decay pipe window
  - Residual radiation, airborne emissions, and ground water protection
  - Handling of radioactive components

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
  - 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.

Civil Construction Issues

- Existing design for Proton Driver facilities and PX requirements
- Wetland mitigation options
- Re-use of existing utility capabilities.
- Re-use of existing cryo facilities
- Large injection abort
  - Significant civil construction required
  - Existing tunnel near MI10

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

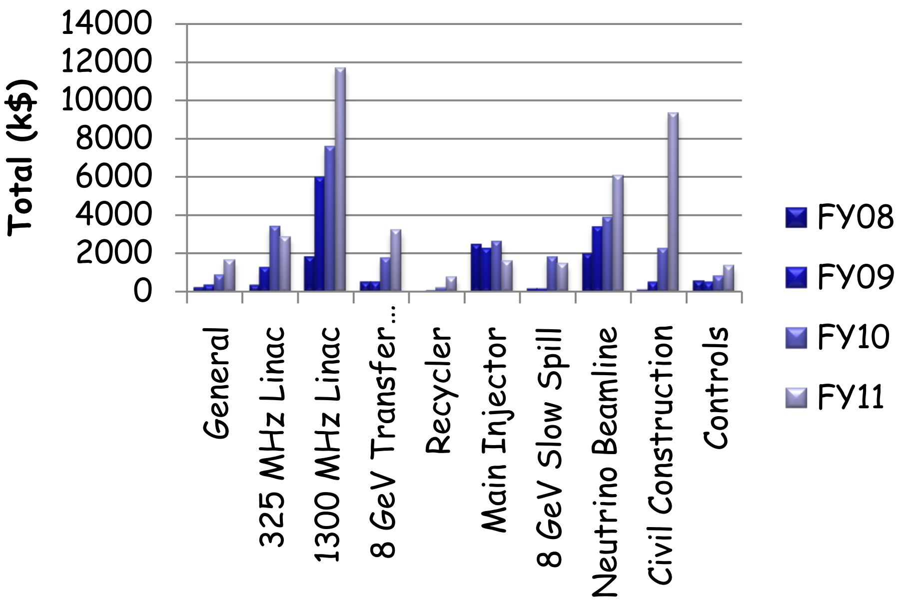
Controls Issues

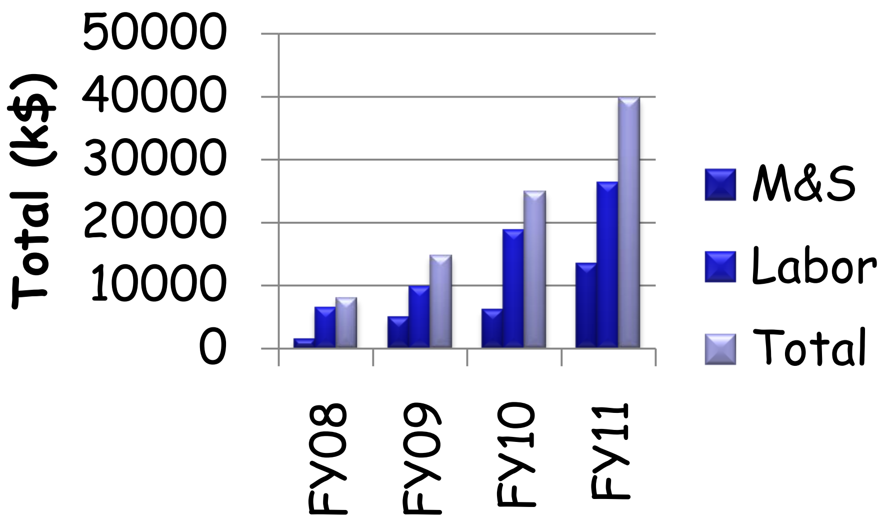
- Scale
  - One million properties
  - 200 users
- Availability
  - 2500-hr MTBF (mean time between failures)
  - 5-hr MTTR (meant time to repair)
  - 15 hours downtime per year
- Machine Protection and Safety
- Legacy Constraints

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

RD&D Plan Resource Requirements





		All Total k$	Labor FTE	M&S k$ (unburd.)
1	General	3009	33	0
2	325 MHz Linac	7809	40	1140
3	1300 MHz Linac	27022	130	6045
4	8 GeV Transfer Line	5942	41	100
5	Recycler	943	6	95
6	Main Injector	8890	49	2925
7	8 GeV Slow Spill	3452	28	0
8	Neutrino Beamline	15221	72	4440
9	Civil Construction	12107	15	6705
10	Controls	3134	14	75
	Total	87527	428	21525

FY08+ R&D PLAN

Project X RD&D Plan for FY08

- The main goal for the Project X RD&D Plan for FY08 is
  - to get an initial cost estimate for Project X for CD0.
  - Begin on long-term R&D items
- To prepare an initial cost estimate for CD0, the design of Project X must be further developed.
- To organize the labor resources in FY08, each level 2 manager reviewed the FY08 goals formulated in the RD&D plan.

Project X FY08 Goals

- Project Management:
  - Develop high level RLS with input from subproject managers, for input to CD-0 cost range and CD milestones
  - Develop collaboration tasks & identify potential collaborators
  - Develop individual collaborator MOU scope in advance of FY09 work
- 325 MHz Linac
  - Begin basic accelerator physics design of the Linac
    - Organize documentation of the present "Ostroumov" machine design and summarize current state of simulations
    - Define the high-level, implementation-independent specifications for the linac beam including upgrade paths that must be not excluded
    - Define the beam physics parameter interface between the Low Energy Linac and the High Energy Linac
  - Begin HINS vs. alternative technology study

Project X FY08 Goals

- 1300 MHz Linac
  - Physics Design: Establish beam requirements, design parameters, lattice model, interfaces to other Project x areas and on beam loss budget.
  - Linac technical design: Conceptual design of S-ILC cavities and cryomodules, magnets, instrumentation, and vacuum systems.
  - RF Power Systems: Determine requirements, initiate conceptual studies.
  - Integration: Initiate conceptual design of controls, LLRF, HLRF, civil, machine protection integration.
  - System Tests: Initiate conceptual design of RF unit system test.

Project X FY08 Goals

- 8 GeV Injection
  - Create a viable Recycler injection straight section and transport line interface to the injection straight section and injection absorber. Integrate solutions with the new Recycler ring lattice.
  - Revise Proton Driver Injection absorber design for Project X beam parameters.
  - Initialize simulations for transverse phase space painting
  - Evaluate the stripping efficiency, losses, impact on circulating beam, and technological feasibility of carbon foil stripping and laser stripping techniques for 98% to 99% stripping efficiency utilizing Project X beam parameters.
  - Begin Conceptual Design of transverse collimation absorbers

Project X FY08 Goals

- Recycler
  - Lattice flexibility options, in terms of distributed powered elements, be studied and completed.
  - Anticipate specifications on magnets/power supplies
  - Electron Cloud investigations: Begin studying mitigation methods specific to the Recycler such as beam pipe coating.
  - Begin simulation investigations of electron cloud by concentrating on the validation of a simulation package.
- Main Injector
  - Come up with preliminary 53MHz cavity design that meets beam-loading and beam power requirements.
  - Initiate second harmonic cavity design (106MHz).
  - Come up with a feasibility study of coating the MI beam pipe with Titanium nitride for suppression of electron cloud.
  - Continue with e-cloud simulations in MI. Compare the predictions of the two e-cloud generation codes (POSINST, ECLOUD) with MI beam observations and measurements.

Project X FY08 Goals

- 8 GeV Slow Spill
  - Establish the feasibility of slow extraction from the Recycler and choose between half integer and third integer resonance.
  - Specify beam bunching scenarios needed by the experiments.
  - Specify resonance driver and extraction system.
- 120 GeV Targeting
  - Begin advancing the design of the cylindrical graphite target developed by IHEP, Protvino.
  - Develop a conceptual design for the replacement of the decay pipe.
    - This would involve understanding the radiation levels expected,
    - proposing remote and/or robotic methods for removing the decay pipe
    - investigating the possibility of remote welding operations to install a new decay pipe window.

Project X FY08 Goals

- Civil Construction
  - Review existing conventional facilities requirements and conceptual design for alignment with Project X scope and update
  - Prepare RFP for Architect/Engineer Consultant Services
  - If M&S available , begin comparison review of ILC and Project X main linac process cooling systems
- Cryogenics
  - Begin Component thermal modeling
  - Begin over pressurization modeling
  - Specify Cryogenic Instrumentation
- Controls
  - Software requirements: Expand existing requirements document to include input from machine and support departments.
  - Hardware Requirements: Develop hardware requirements, Survey existing hardware in MI/recycler/NUMI against Project X era requirements and develop plan.
  - Timing system specification: Specify protocol for controls timing signals in the project X linac and how this interfaces to the existing complex. Should include list of required modules but no actual design.

Project X FY08 Resources

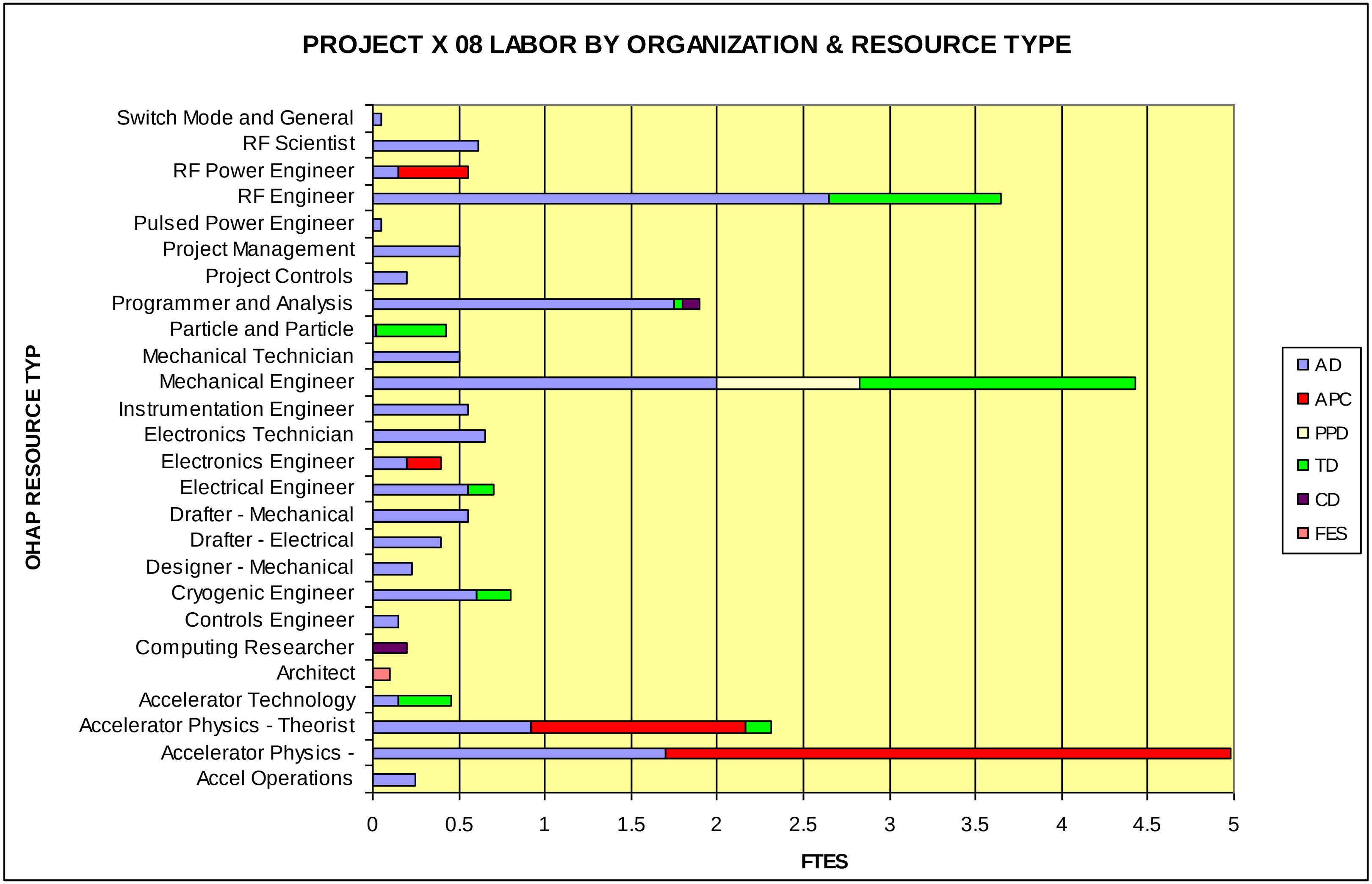
- For each FY08 goal, each level 2 manager was asked to provide a bottoms-up estimate of effort required, to include:
  - A list of names of people that would be best suited to accomplish the goal.
    - Note: We have not talked to the division heads or department heads if this person is available.
  - With each name there should be a description of the task the person is to do.
  - How much percentage effort the person will expend.
  - The duration of the task.
- The resource information was loaded into the Project X WBS using OHAP resource types, and summarized to provide an overall look at Project X 08 labor requirements
- In parallel, the related program labor effort (HINS, SCRF, NML) was tallied for a "big picture" summary

Project X FY08 Labor Needs

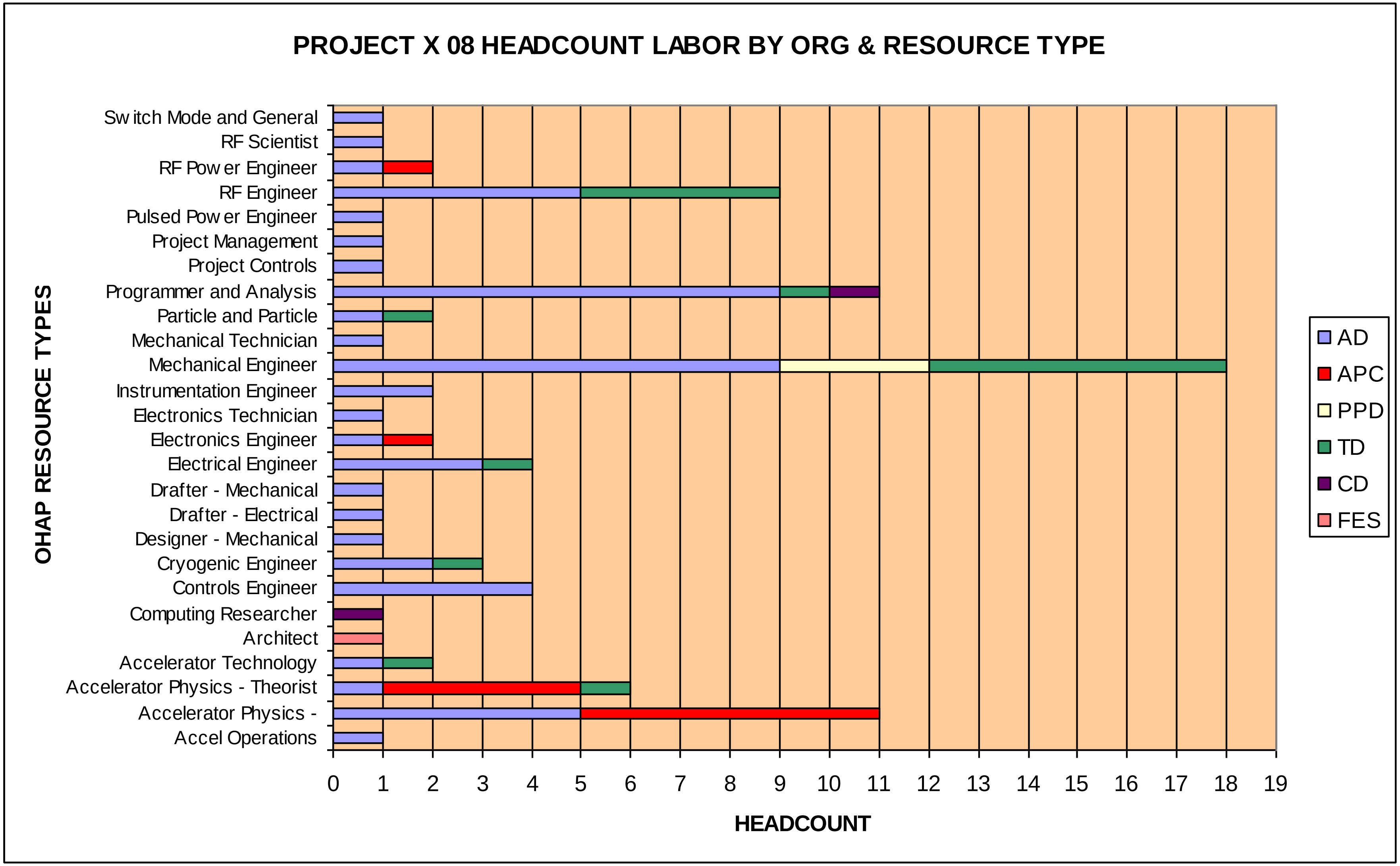
- Sample of resource summary information derived from WBS:

						Resource name	Department	OHAP resource type	% effort	Duration	FTE
1	**4**				**8 GeV H- Transfer Line and Injection**						
1	**4**	**1**			**R&D and Conceptual Design**						
1	4	1	1		Project Management						
1	4	1	1		High-level Resource Loaded Schedule Development						
1	4	1	1			D Johnson	APC-HINS	Accelerator Physics - Experimentalist	5%	6	0.05
1	4	1	2		Physics Design						
1	4	1	2	1	Transport Line						
1	4	1	2	1	Create viable transport line and interface to injection SS and injection absorber.						
1	4	1	2			D Johnson	APC-HINS	Accelerator Physics - Experimentalist	42%	3	0.21
1	4	1	2			M Xiao	AD-Recycler Department	Accelerator Physics - Theorist	50%	2.5	0.21
1	4	1	2	1		A Parker	AD-Mechanical Support	Designer - Mechanical	25%	2	0.08

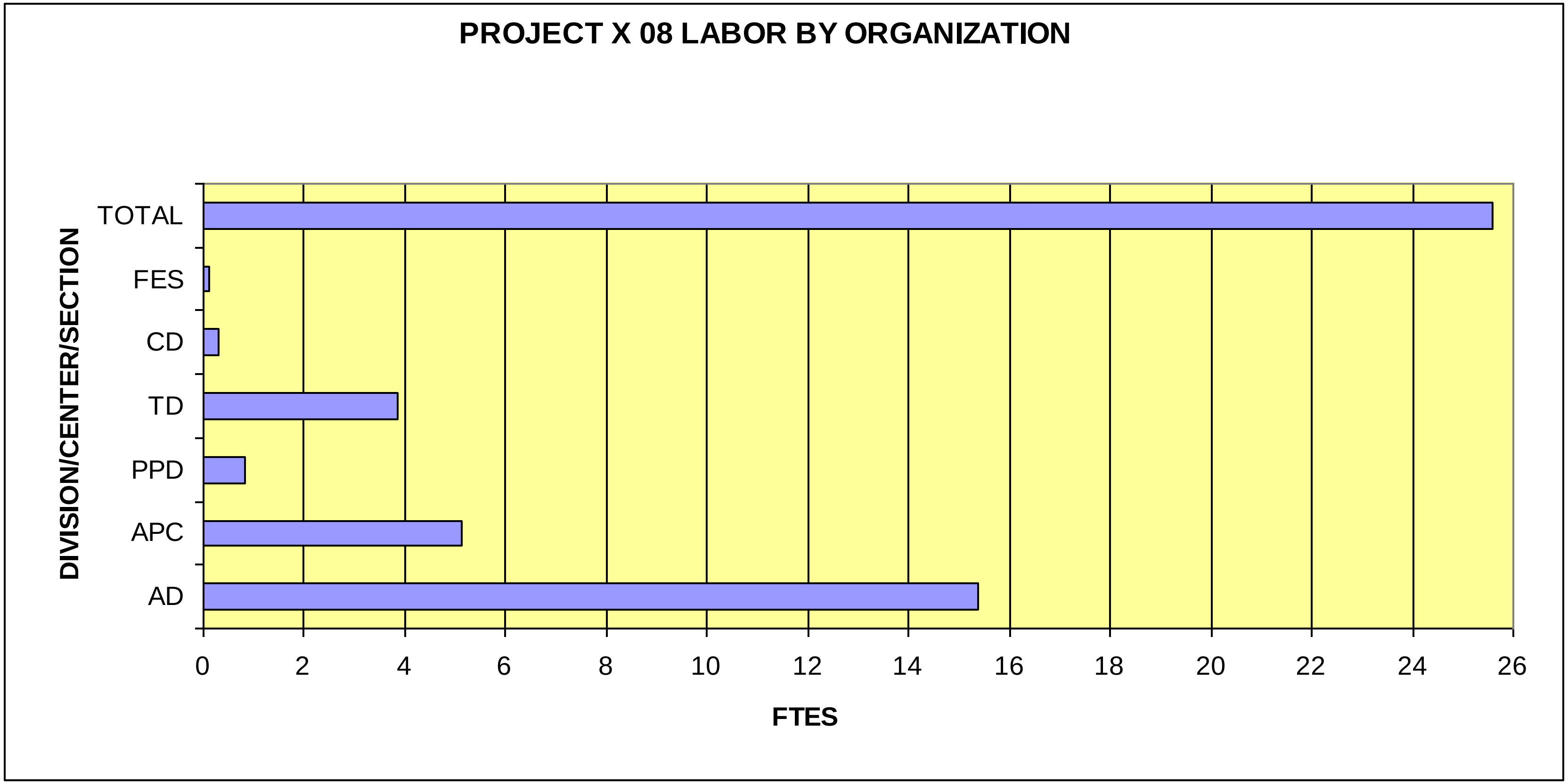
Project X FY08 Labor Needs



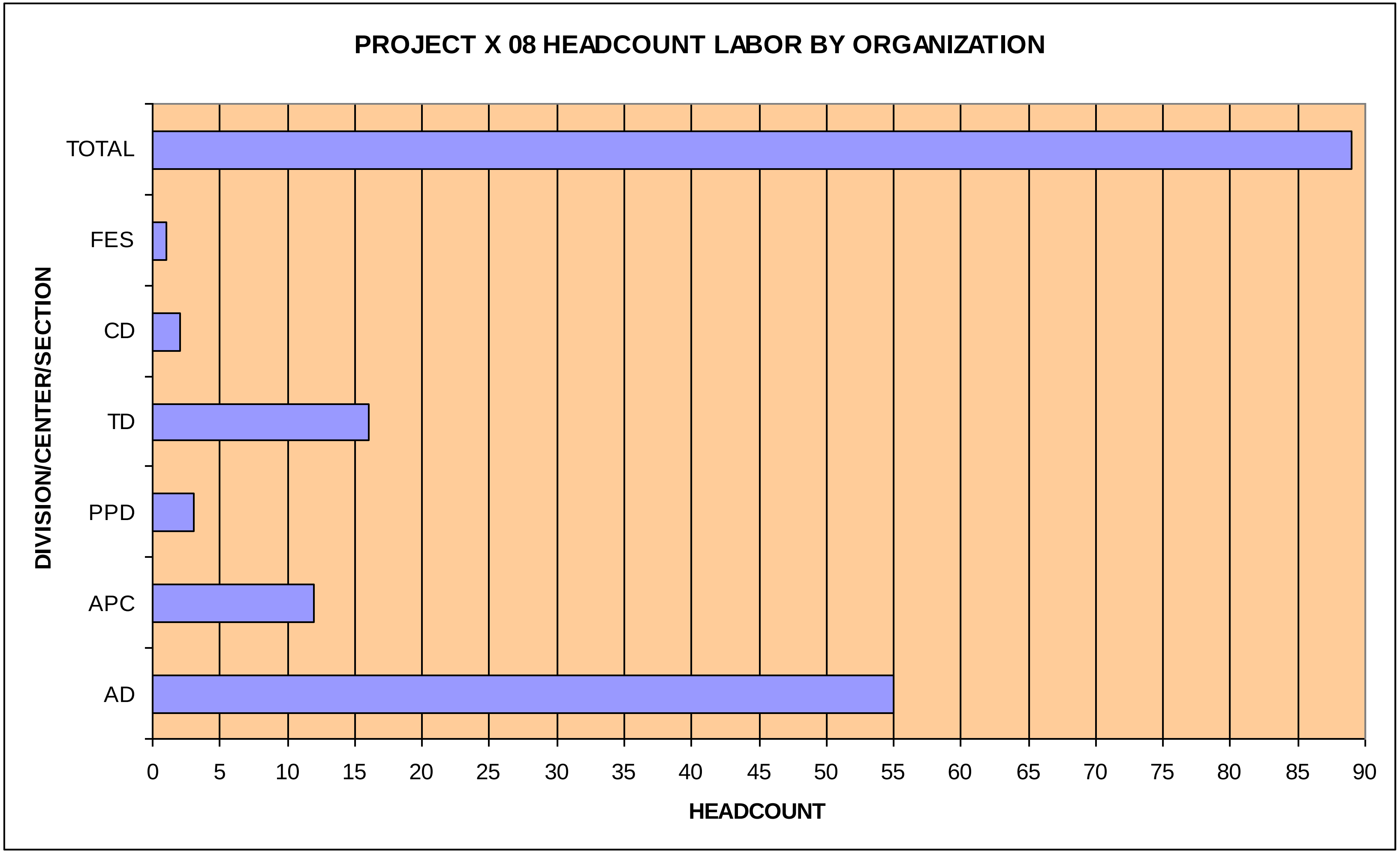
Project X FY08 Labor Needs



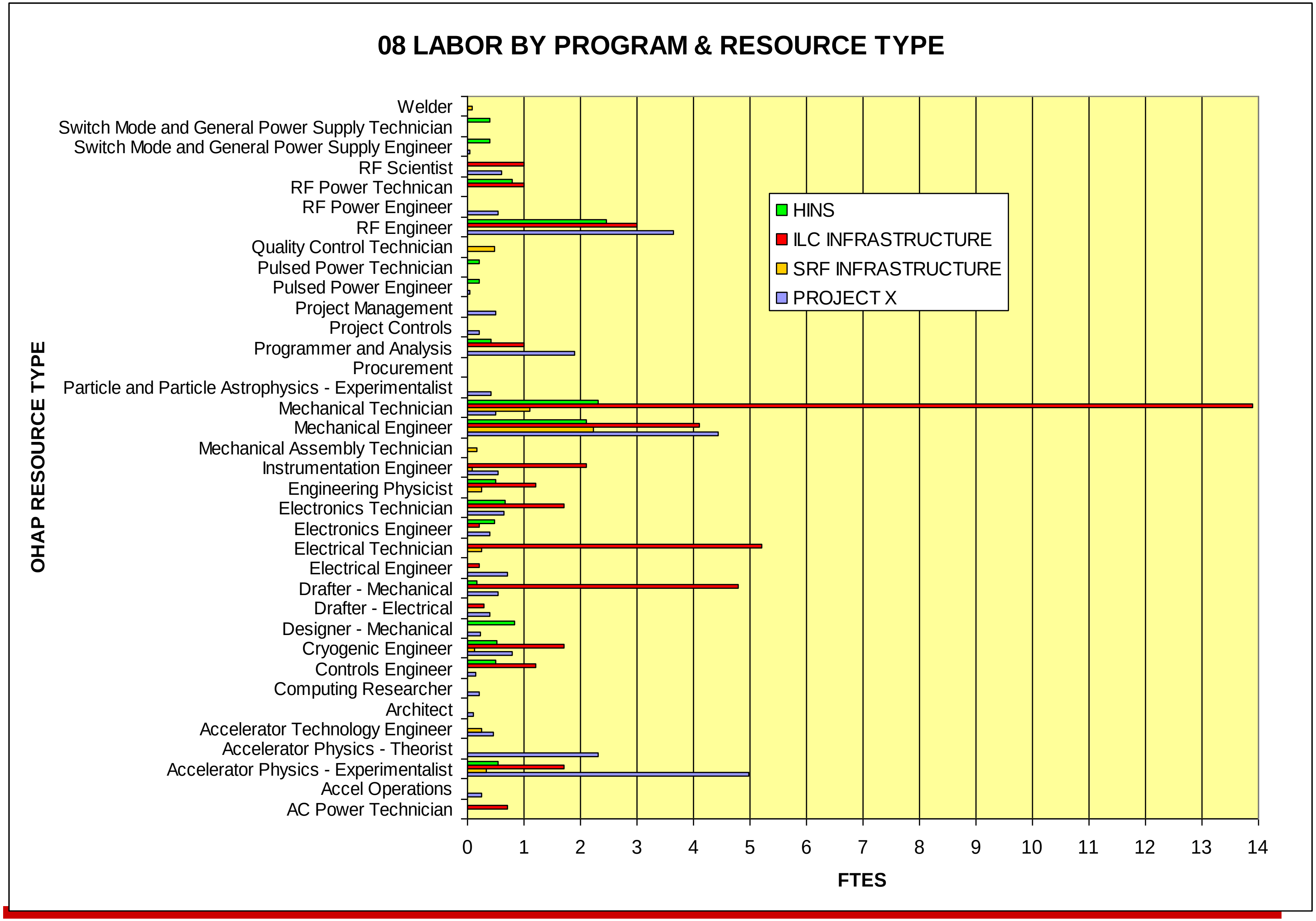
Project X FY08 Labor Needs



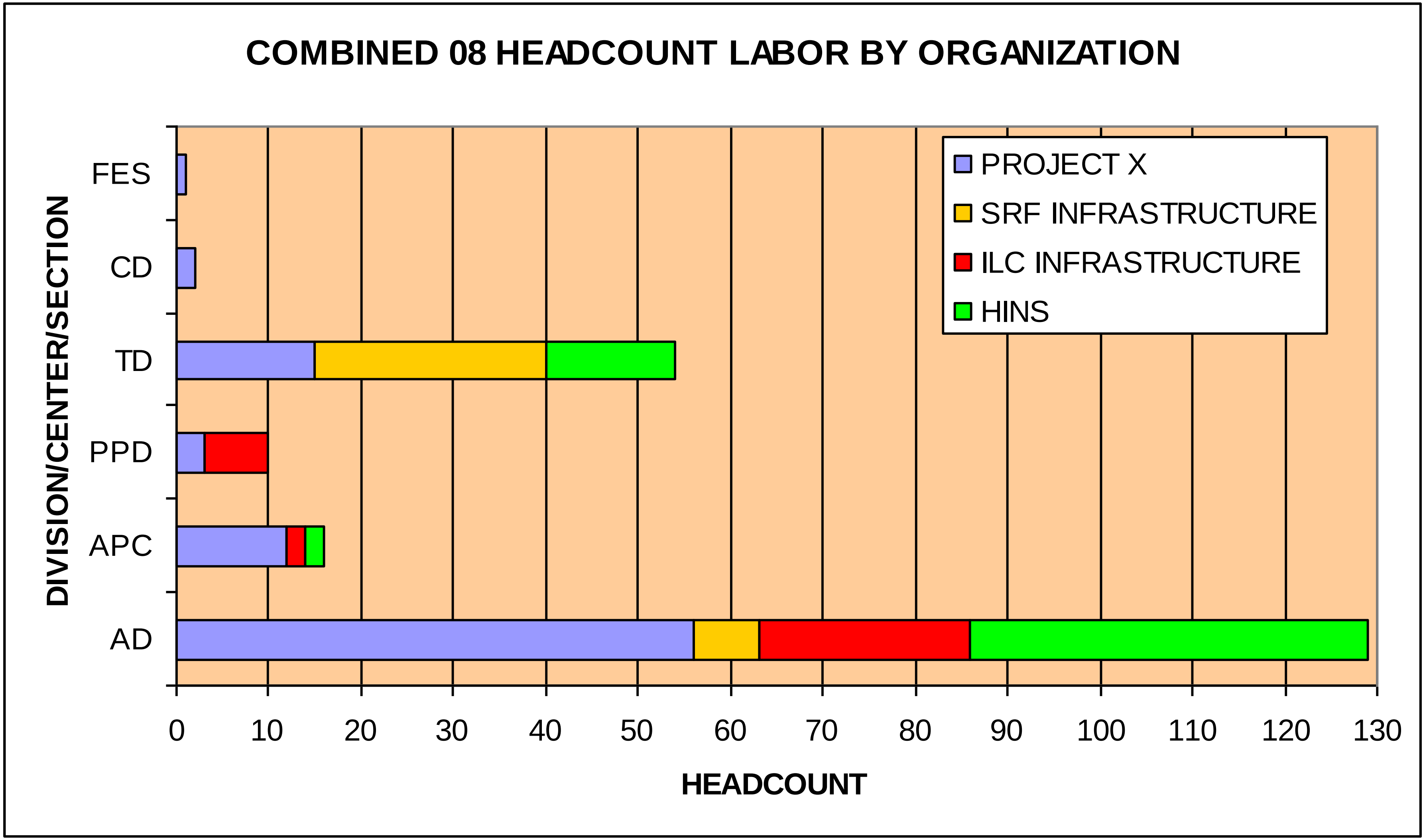
Project X FY08 Labor Needs



Combined 08 Labor Needs



Combined 08 Labor Needs



Summary

- The general requirements of Project X are defined
- From the general requirements:
  - The scope of Project X is defined
  - The requirements of the technical subsystems are derived
- The system requirements drive the design and development plan goals.
- A RD&D team was assembled to formulate and execute the design and development plan.
- Specific goals for each sub-system have been defined.
- The resources required to accomplish these goals have been defined.

Summary

- From the Directorate, we need:
  - Approval of the Project X general requirements
  - Approval of the FY08 RD&D plan goals
  - Approval of the Fermilab RD&D Team.
  - Understanding of the resource requests
  - Permission to execute the RD&D plan.
- The next steps are to:
  - Present the resource needs to the Fermilab Division Heads
  - Work with the to Fermilab Division Heads to organize the required resources.