Director's Review of the Project X Cost Range Estimate: 8 GeV (Transport & Injection)

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Project X Director's Review

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Outline

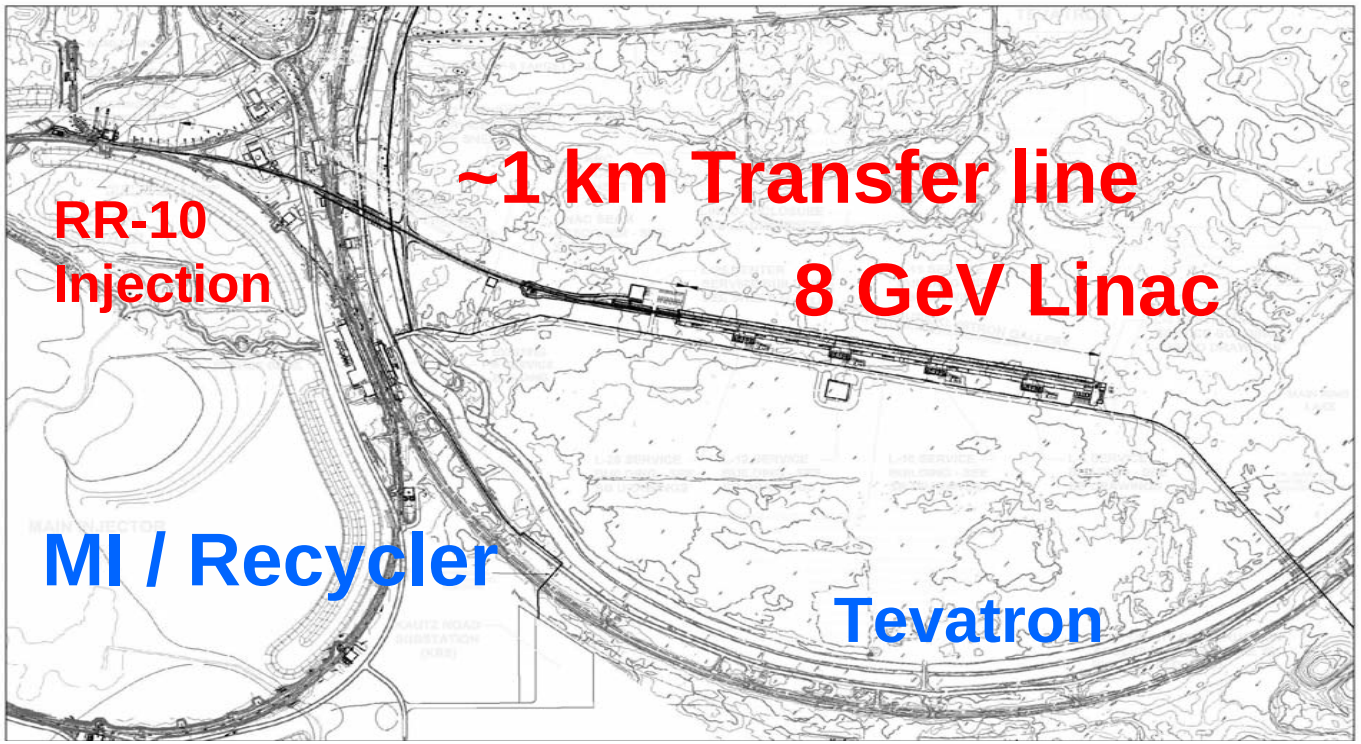
- Scope of Estimated Work
- Boundary Conditions /Assumptions
- Basis of Estimate
- Technical Risks/Associated Cost Exposure
- Potential Technical Revisions
- Role of Outside Collaborators
- Summary

Project X Scope of Estimated Work(1)

- Current estimate includes M&S in ’09 dollars and effort from CD0 to CD4
  - RD&D phase from CD0 to CD2
    - Design phase assumed to result in a Technical Design Report with preliminary engineering designs of all components
    - Technical review of RD&D phase completed 2/2009
  - Component Design, Construction, and Installation phase from CD2 to CD4
    - Transport line components from linac to injection chicane.
    - Injection straight section components
    - Waste beam components
    - Linac Dump
- RD&D labor effort for collaborators included in M&S
- In DCI phase, some construction and installation labor included in M&S and some assumed to be FNAL labor

Project X Scope of Estimated Work(2)

- Conceptual design based on a solution into MI with an added vertical bend to Recycler elevation – solution not optimized !

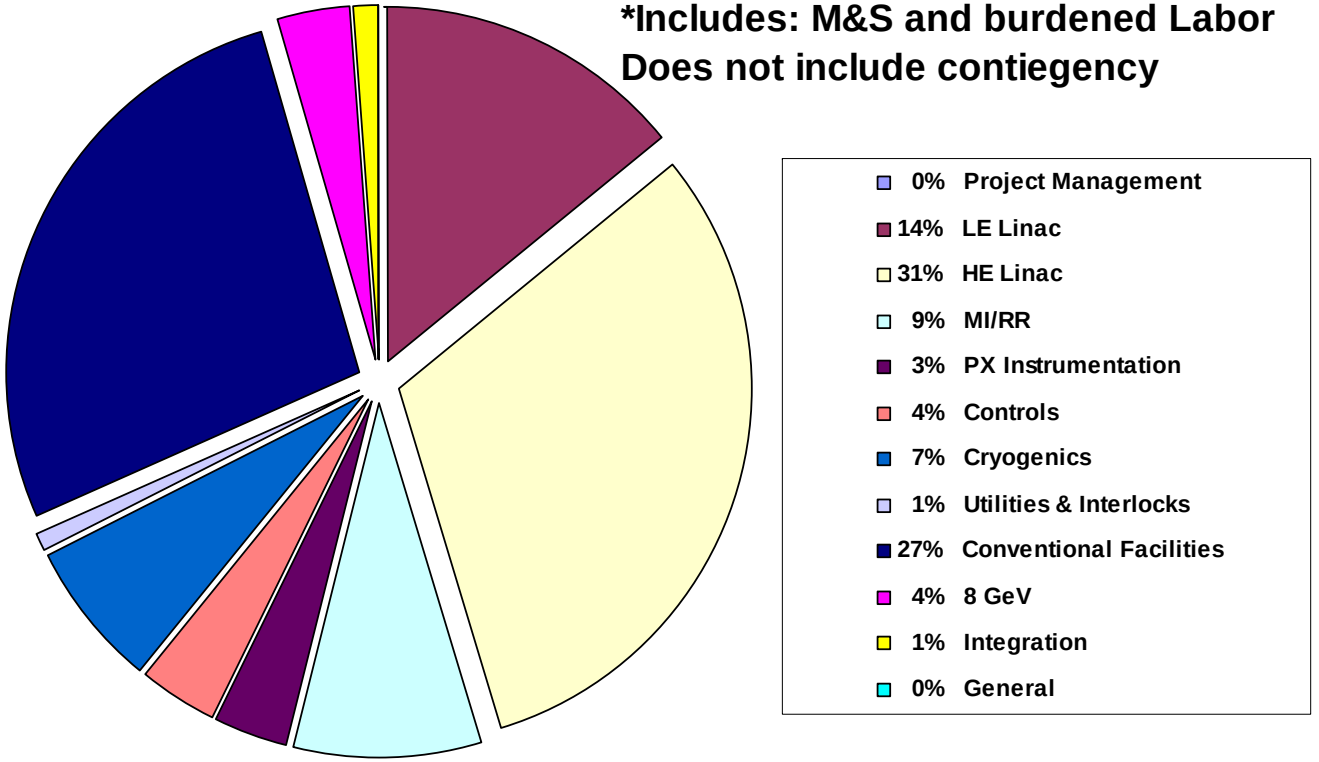


Scope of Estimated Work(3)

Project X: Cost Basis Summary*

Including :1) RD&D phase from CD0 through CD2 and
2) Technical design,construction and installation phase from CD2 through CD4

***Includes: M&S and burdened Labor**
Does not include contiegency



Project X Scope of Estimated Work(4)

- RD&D plan from CD0 to CD2
  - Project RD&D plan: Project X-doc-149
  - 8 GeV specific plan Project X-doc-171
- Effort assumed FNAL with collaboration effort as M&S

- **Transfer Line**
  - **Optics and footprint design**
  - ***Cryo screen and vacuum system design**
  - **Collimation system design**
    - **Transverse**
    - **momentum**
  - ***Energy correction/Phase rotator system design**
  - **Linac Dump design**

- **Recycler Injection**
  - **Lattice design**
  - ***Injection chicane design**
  - ***Foil charge exchange system design**
  - **Laser assisted Lorentz stripping (LALS) system design**
  - **Transverse painting system design**
  - **Longitudinal painting system design**
  - **Waste beam system design**

***Collaboration effort**

Project X Scope of Estimated Work(5)

- Technical Component Design/Construction/Installation (DCI) plan carries the project from CD2 through CD4 (completion of installation).

- Transfer Line
  - Magnets
  - Power supplies
  - Beam line vacuum
  - Beam line collimation
  - Energy Correction (warm cavity and RF system)
  - Linac Primary Dump

- Recycler Injection
  - Magnets
  - Power supplies
  - Injection vacuum
  - Foil changer
  - Injection absorber

Technical Assumptions

- Based upon the ICD, we make the following assumptions:
  - Use of permanent magnets for transfer line
  - Use of cryogenic beam shield in transfer line
  - Default method of H- injection is foil stripping
  - Assume 5 Hz rate with a 1.25 ms beam pulse with 1.6E14/pulse
  - Assume Energy Correction cavity is installed in beam line
  - Assume linac dump rated for <200 kW>
  - Assume injection absorber rated for <100 kW>
  - Assume momentum dump is rated for <10 kW>
  - Assume transverse collimator rated for <~10 kW>
  - Assume beam line elevation 48” above tunnel floor (at MI height)
  - Assume engineering design of components complete at CD2
  - Installation effort combination of contractor (included in M&S) and Fermi labor

Boundary Conditions

- In the RD&D phase, the tasks within the 8GeV require careful coordination with the efforts of other level 2 systems, engineering departments, and collaborators at other labs to assure the designs meet accelerator requirements
- Beyond CD2 much of the detailed engineering, construction, and installation will be performed in the engineering departments.
- Boundaries between level 2 systems- Examples:
  - Transfer line – cryo: it is assumed that the cryogenics will be distributed throughout the tunnel and the vacuum design must connect to this system and the transfer line task must specify cryogenic requirements.
  - Transfer line – Utilities: it is assumed that an air handling system is distributed in the tunnel (with specifications from the vacuum engineers)
  - Transfer line – instrumentation: The transfer design team is responsible for
    - delivering the detailed specifications to the instrumentation team for component design and construction
    - assure the component design meets specifications
  - Recycler Injection-ring: injection straight section elements, ring modifications

Basis of Estimate

- This is NOT a baseline estimate.
- This is NOT a technical review.
- The M&S and Labor estimates for both phases (pre & post CD2) of the Transfer line and Recycler Injection are based upon the following:
  - Estimate started as a top down estimate … with added detail
  - Estimates for M&S and design labor based upon previous design experience
  - Scaling from existing facilities and technical components (when possible)
  - Engineering estimates based upon preliminary conceptual designs for some technical systems
    - Magnets
    - Power supplies
  - Escalation from tasks or contracts in previous projects
- The following estimates are in FY09 dollars (for direct costs only) and FTE-years.

8GeV Cost Estimate

ITEM		Unit	M&S Cost $	Quantity	M&S Tot. $k		Sci FTE-yr	Eng. FTE-yr	Draft/Mach FTE-yr	Tech. FTE-yr
Transfer Line										
Preliminary Design					**$1,529**		**3.875**	**4.9375**	**1.1875**	**0**
Optics/footprint					$389		1.375	1.375	0.375	0
Vacuum System Design					$565		0.5	1	0.5	0.5
Collimation Systems Design					$0		1.875	2	0.4375	0
Energy Correction System					$575		0.75	1.125	0.5	0
Linac Absorber Design					$0		0.625	1.5625	0.375	0
Technical Component Design/Construction					**$8,780**		0	17	5.251	13.135
design/construction subtotal					**$8,170**		0.000	15.500	4.001	7.535
installation sub total					**$609**		0	1.5	1.25	5.6
Magnets	EE				$3,198	*	0	5.75	2.175	6.035
Power Supplies					$286		0	0.75	0.201	1.375
Vacuum System					$630		0	1.5	0.5	2.225
Transverse Collimation (10 kW ea)					$870		0	2	0.625	1.875
Momentum Collimation (10 kW)					$265		0	2	0.75	1
Linac Dump (200 kW)					$735		0	2.5	1	0.625
RF Phase Rotator					$2,715	*		2.5		
Instrumentation					$0					
Recycler Injection										
Preliminary Design					**$1,351**		**6.875**	**7**	**1.75**	**0**
Lattice Design					$0		1.25	1.125	0.5625	0
Injection Chicane Design					$664		0.75	1.5	0.5	0
Foil Charge Exchange					$687		0.875	1.5	0.4375	0
Laser Assisted Lorentz Stripping					$0		0.625	1.25	0.5	0
Transverse Painting Design					$0		2.75	1.5	0.1875	0
Longitudinal Painting Design					$0		1	1.375	0.0625	0
Waste Beam Design					$0		1.25	1.75	0.4375	0
Technical Component Design/Construction					**$5,047**		0.3	9.7	2.208	6.335
construction sub total					**$5,034**		0.3	6.95	1.833	4.795
installation sub total					**$13**		0	2.75	0.375	1.54
Injection Magnets					$444		0.3	3.95	0.458	4.545
Injection Power Supplies					$700		0	1.75	0.375	0.875
Injection Vacuum System					$100		0	1.25	0.375	0.04
Injection Foil Changer/E-catcher					$145		0	1.375	0.5	0.375
Injection Absorber (100 kW)					$3,650	*	0	1.375	0.5	0.5
Instrumentation (injection/abort)					$0					

Technical Risks(1)

- Technical risk classifications:
  - HIGH RISK: no technical solution with potential for not meeting project goals
  - MEDIUM RISK: technical solution exist with potential cost/schedule impact
  - LOW RISK: technical solution exist with minimal/no cost schedule impact
- Four "issues" were identified for 8 GeV Transport and Recycler Injection
  1. Losses due to single particle loss mechanisms in the transport line
  2. Uncontrolled losses in the injection region due to the injected and circulating ions interaction with stripping foil.
  3. Stripping efficiency and lifetime of the injection foil or the stripping efficiency of laser stripping injection system.
  4. Collection of the stripped electrons and neutrals from the injection process and safely disposing of them in the injection absorber.
- All are addressed in the RD&D Plan (Project X-doc 171)

Technical Risks(2)

- Goal of RD&D is to eliminate or reduce technical risk of each item to “LOW”
- The design of many of the technical components is straight forward and requires careful engineering but little technical risk.
- Most of the medium risk issues may be resolved through
  - Physics design
  - Choice of operational parameters
  - Engineering design
  - Careful manufacture process
- Item 1: can be reduced by selection of operational parameters
- Item 4: can be reduced by careful Physics and Engineering design
- Items 2&3: can be considered a MEDIUM risk which are related to Injection Stripping Issues:
  - Current plan to use foil stripping
  - Alternate approach to use Laser Assisted Lorentz Stripping
  - RD&D plans to address method, efficiency, and design
  - Collaboration with SNS,CERN,LBNL
- Bottom line: no outstanding HIGH technical risk components !

Cost Risk

- Footprint of beam line- optimized in RD&D plan to minimize cost and schedule impact
- Components where designs are conceptual (with little or no engineering) might have higher than average cost exposure.
  - Collimation absorbers
  - Cryogenic beam screen and vacuum system
  - Beam absorbers
  - Injection magnets (chicane and painting)
  - Injection foil changer / LALS
- Components with some preliminary engineering, modification of existing designs, or “off the shelf” items should have small cost exposure
  - Transfer line magnets & power supplies
  - Injection power supplies
- The cost drivers and their estimates will be discussed in the two related talks on the Transfer Line and Injection
  - Transfer line main dipole and quadrupole magnets
  - Energy correction cavity
  - Injection absorber

Potential Technical Revisions

- Transfer line
  - Transfer line magnets
    - Current design utilized new permanent magnet dipoles and quads with trim dipole and quads for steering and matching
    - Potential use of PEP II High Energy Ring dipoles and quads
    - Could lead to cost savings but added complexity
  - Energy Correction Cavity
    - Don't have a cavity design or a good estimate for warm cavity
    - Assume RF source/distribution is a duplicate of 1.3 Ghz system
  - RD&D effort to optimize foot print
    - Reduction in civil construction costs
    - Reduction in beam line length and number of magnets
    - Net cost saving and simplicity is the goal

Potential Technical Revisions

- Recycler Injection
  - Injection Stripping
    - Current foil stripping system
    - Revise to Laser stripping
    - RD&D program to address
    - Cost impact (probable increase, magnitude unknown)
  - Location of injection absorber
    - Current location inside tunnel alcove (requires massive shielding) but saves on civil construction costs
    - RD&D program to investigate impact of moving absorber further downstream with shielding and civil construction trade off
    - Cost impact could be a wash

Collaborators

- The transfer line and Recycler injection tasks have established a collaborative effort with other labs which range from information exchange to consulting to leading the R&D effort for some of the currently defined RD&D tasks.
  - LBNL: has agreed (in principal) to take the lead effort for the design of the energy correction system and the beam line vacuum system (including the cryogenic beam screen).
  - BNL: has agreed to take the lead in the design of the chicane injection insert and the foil stripping system.
  - CERN: as they are designing a 4 GeV H- transport and injection system, they face many of the same problems and we have agreed to informally share designs, ideas, and issues.
  - SNS: has agreed to consulting, as needed, for the ORBIT program, and other areas as needed, and have established a Laser stripping working group (first mini-workshop at SNS in Feb 09).
- Collaboration effort for the Component Design/Construction/Installation phase has not yet been defined.

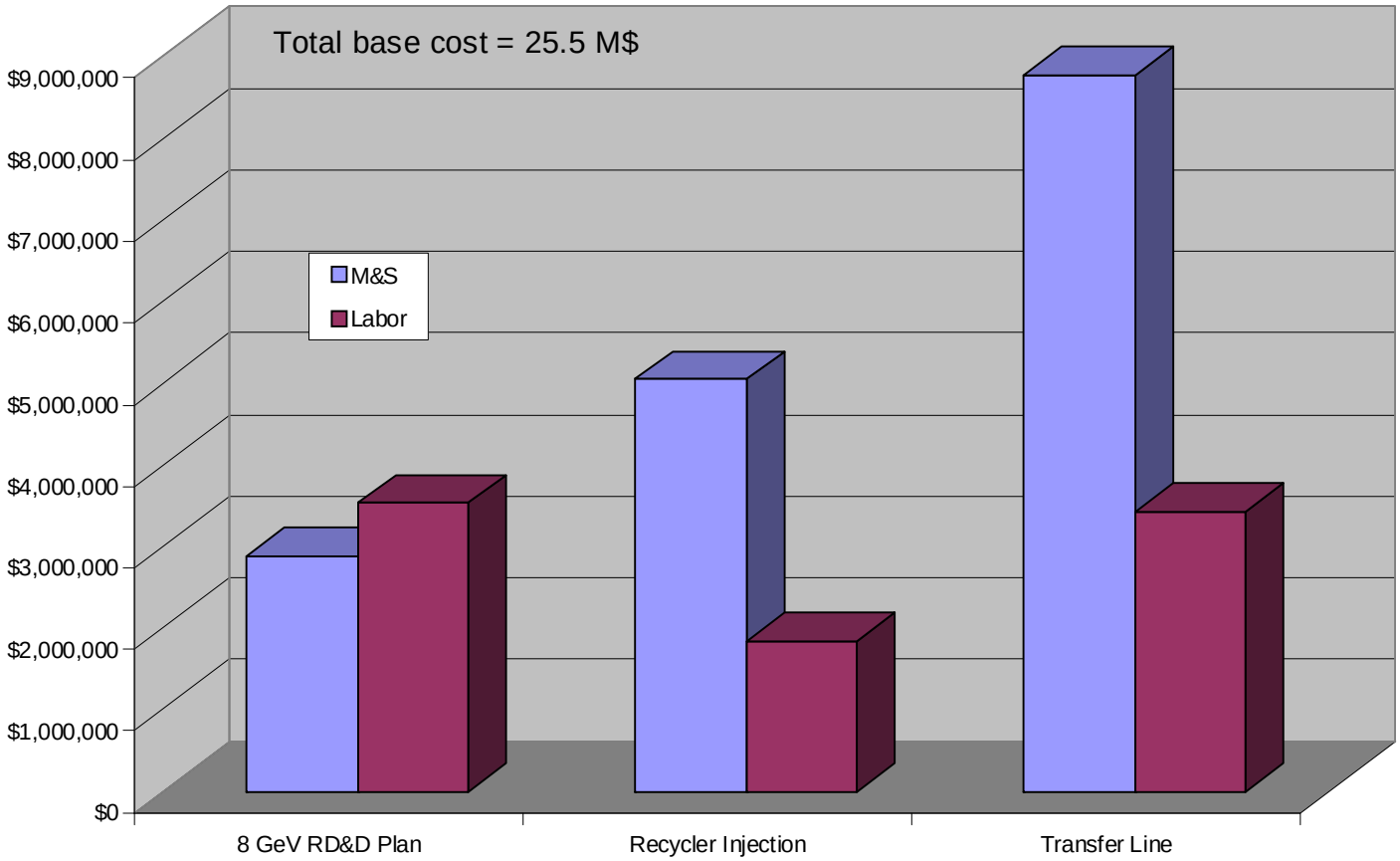
Summary

- The 8 GeV task includes the Transfer Line and Injection
- Cost estimate includes RD&D phase and Component DCI phase
- The 8 GeV task represents 4% TPC
- Technical risks are addressed by RD&D program
- Identified technical risk for foil stripping system
  - Addressed in RD&D plan
- Largest cost items include: transfer line magnets, energy correction system, injection absorber
  - Addressed in RD&D plan
- Identified potential revisions: transfer line electro- vs permanent magnets, transfer line footprint, location of injection absorber
  - Addressed in RD&D plan
- No high risk show stoppers have been identified

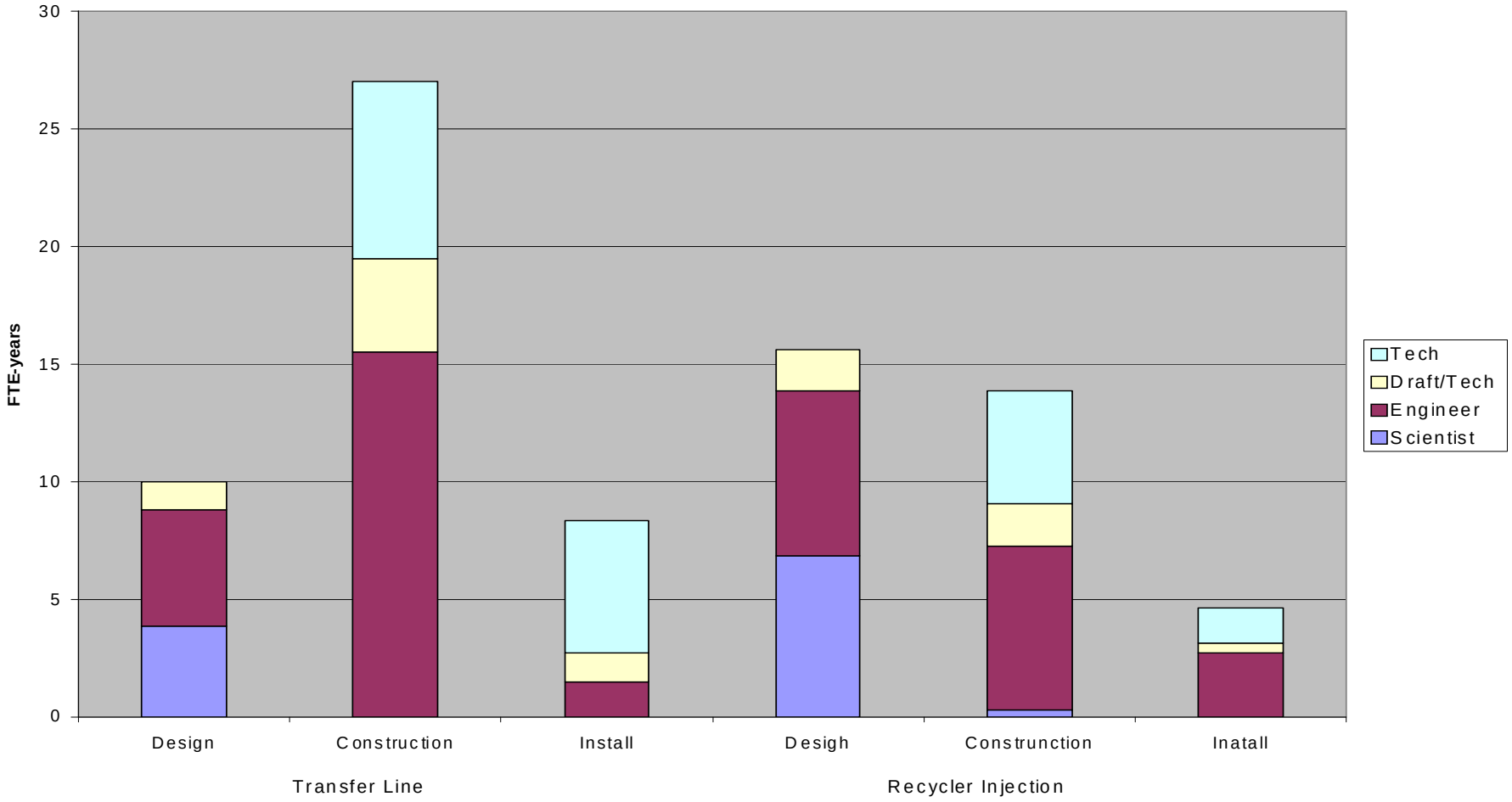
Back up Slides

Scope of Estimated Work

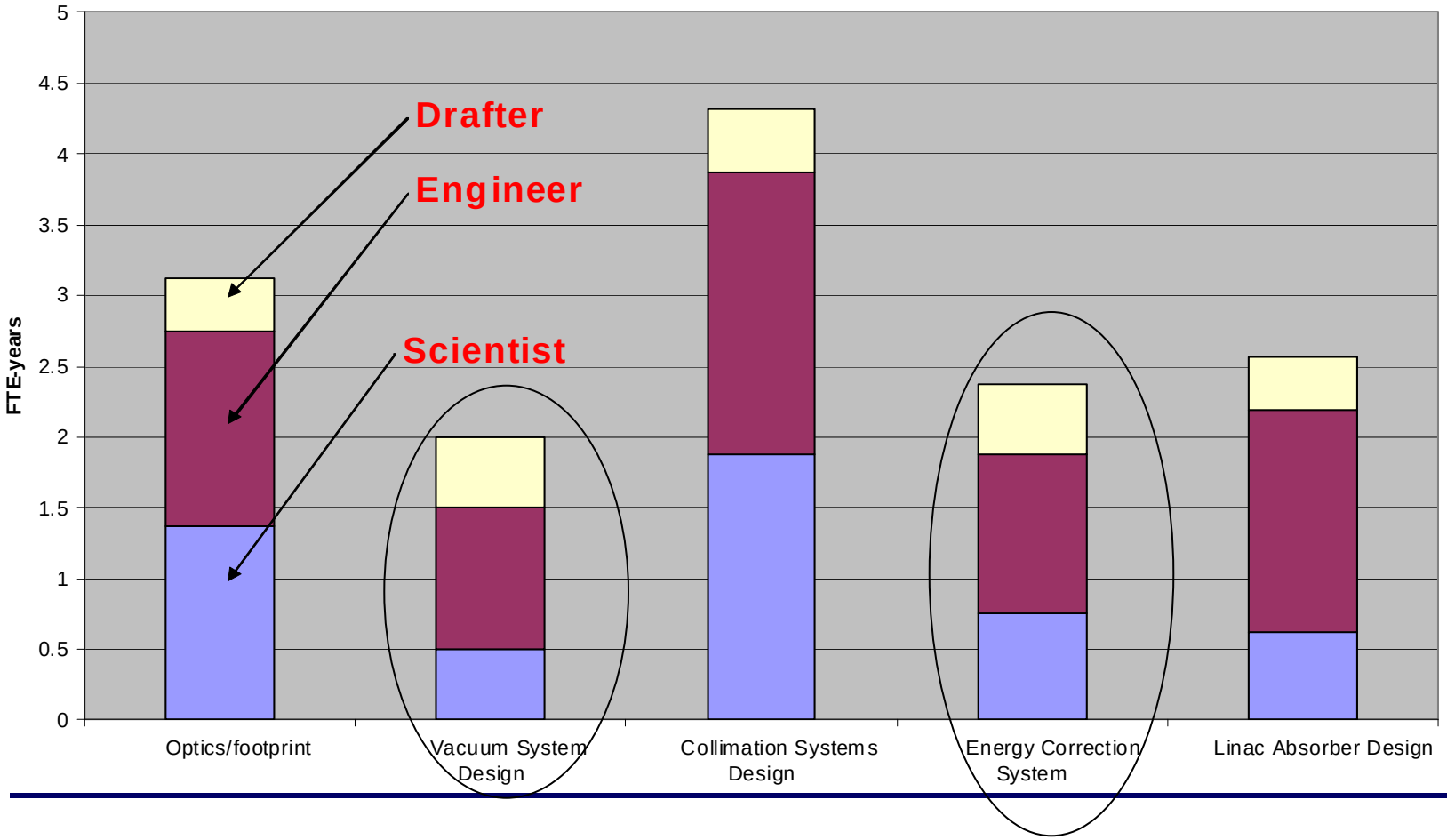
8 GeV Total Base Cost Breakout



Fermi Labor Resources



RD&D Phase Total Labor



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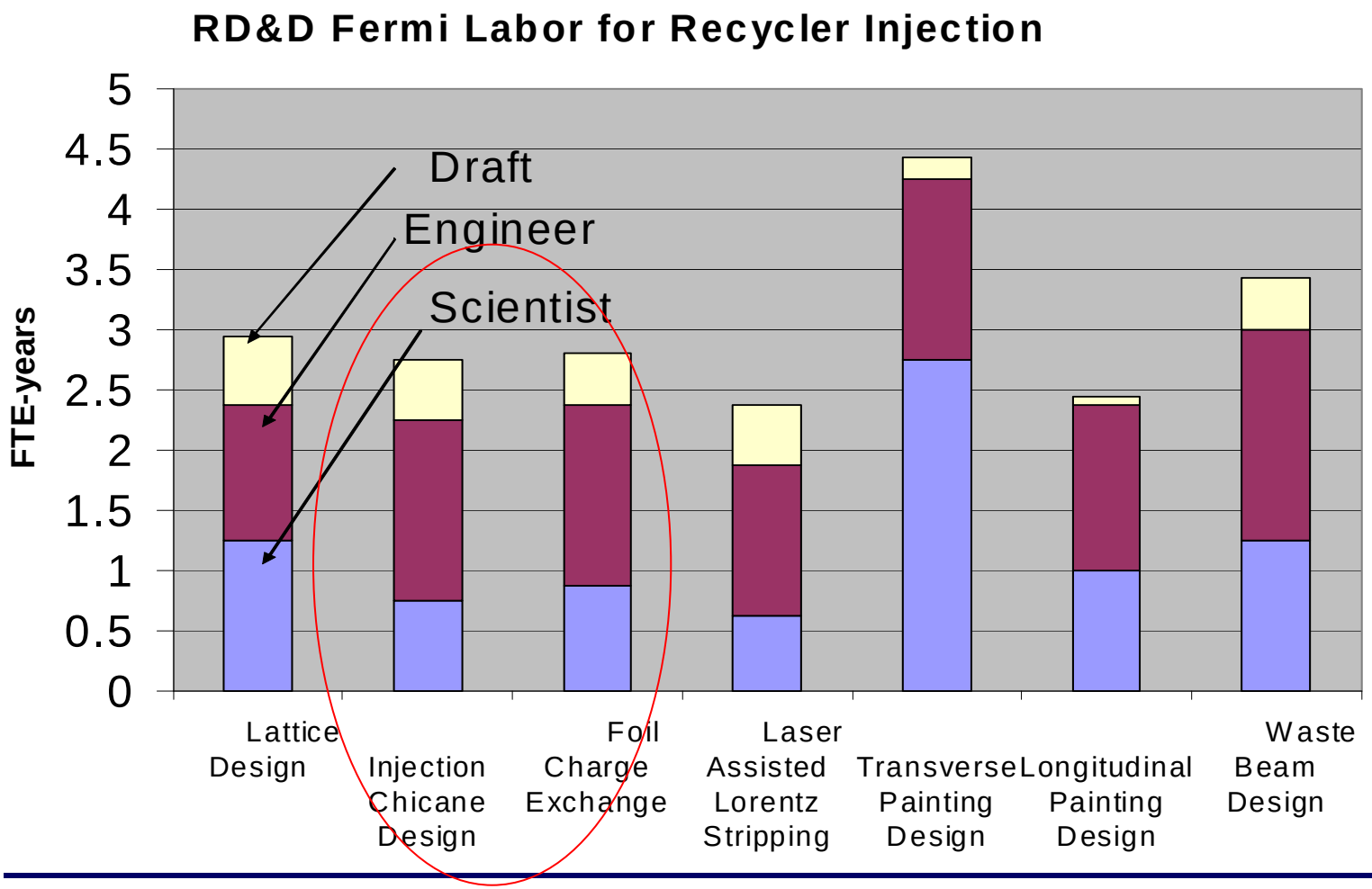
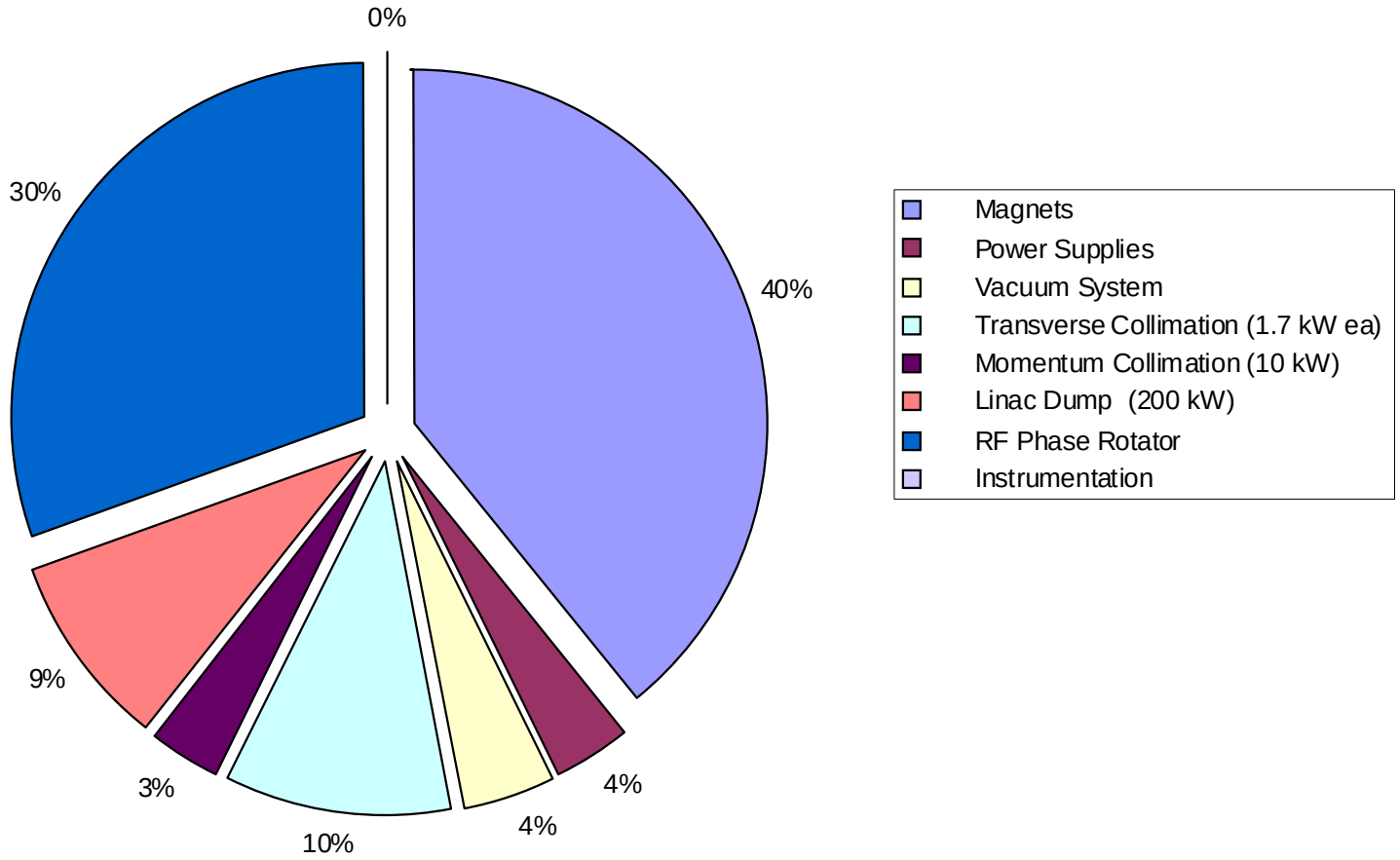


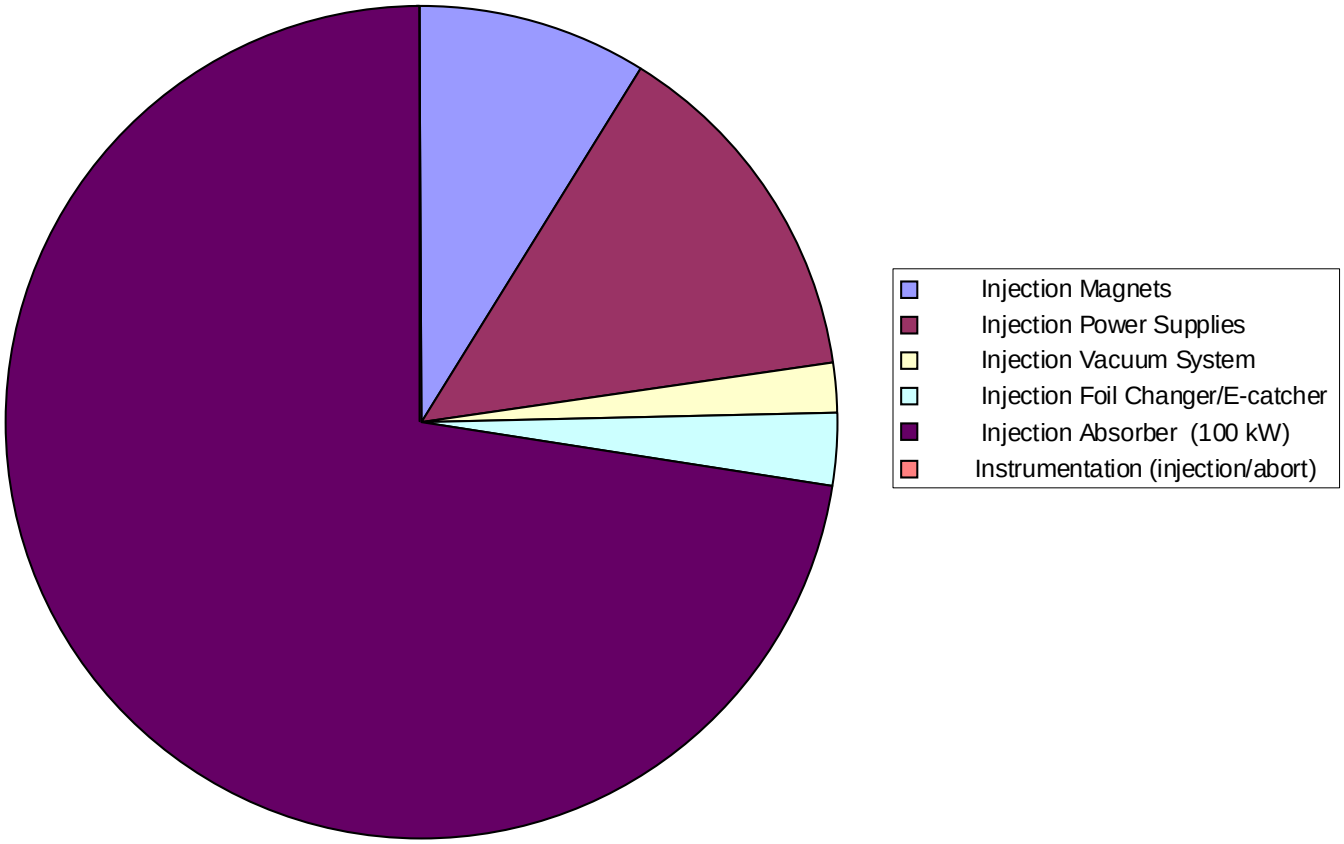
Component Design/Construction/Installation

Transfer Line Technical Component M&S



Component Design/Construction/Installation

Recycler InjectionTechnical Component M&S



Scope of Estimated Work

- RD&D plan from CD0 to CD2 (Project X-doc-171)
  - Transfer Line:
    - Includes:
      - Overall optics design and footprint, including all of the major components such as magnet systems (inc. power supplies), collimation and absorber systems, energy correction systems, and the cryogenic vacuum system.
      - Specification for all instrumentation needs.
    - Excludes:
      - Specific design and construction of beam instrumentation
      - Cryogenic distribution to tunnel, utilities, civil, etc.
  - Recycler Injection
    - Includes
      - Recycler injection straight section lattice design and Recycler lattice design, injection chicane, H- stripping system(s), transverse and longitudinal painting systems, and waste beam handling.
    - Excludes
      - Hardware/software required for Recycler modifications outside the injection region (RF, mods. for e-cloud, ring collimation, extraction systems, etc.)