Director's Review of the Project X Cost Range Estimate: Recycler Injection Components

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Project X Director's Review

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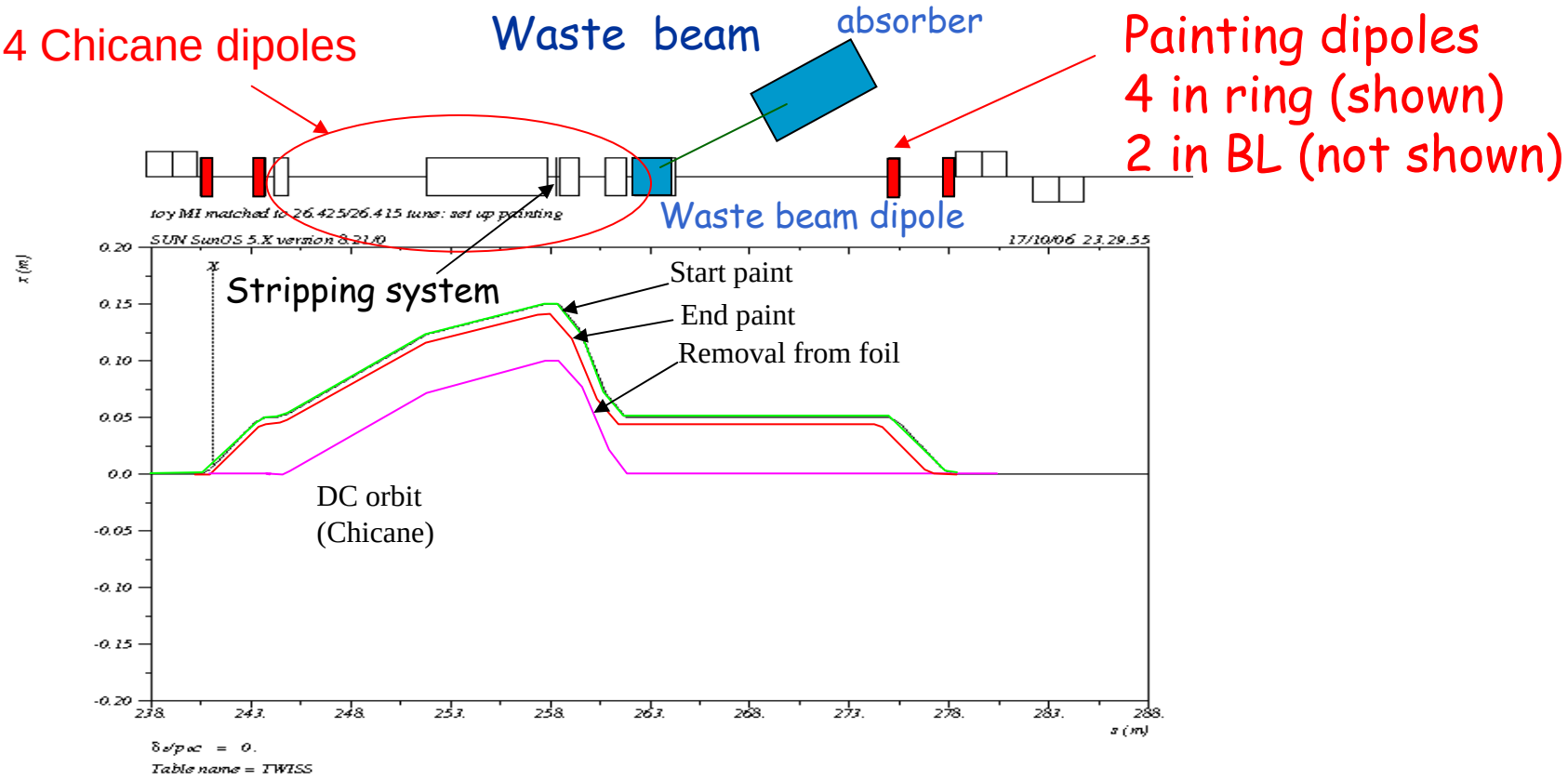
Outline

- Scope of Estimated Work
  - Based upon conceptual design for MI injection, expect general solution to remain, but details are likely to change for Recycler solution
  - Components within the injection straight section doublet
    - Injection magnets (chicane, painting & steering)
    - Injection magnet power supplies
    - Injection area vacuum
    - Foil changing system
    - Waste beam components
    - Beam instrumentation estimated in separate WBS
  - Does not include modification of Recycler ring
- Basis of Estimate
- Cost Estimate
- Summary

Scope of Estimated Work

Injection magnets



- Include: tooling, M&S, construction, EDIA, installation
- M&S 444K$ & Labor 9.25 FTE-years

Basis of Estimate

Injection Magnets

- Assume engineering design completed during RD&D phase
- Injection chicane (4)
  - Estimates performed by Technical Division
  - Estimate for chicane dipoles scaled from the production of an existing FNAL electromagnet
- Painting magnet (4)
  - No conceptual design of magnets
  - Pulsed magnet (1 ms waveform)
  - Based upon estimate of MI gamma-t quads and scaled for length
    - Approx same pole tip field, aperture, and dB/dt
- Vertical steering magnets (2)
  - Same design as painting magnets
- Waste beam dipole (1)
  - Missed in the initial cost estimate (should be same magnitude as chicane dipoles

Cost Estimate

Injection Magnets

ITEM		Unit	M&S Cost $	Quantity	M&S Tot. $k	Sci FTE-yr	Eng. FTE-yr	Draft/Mach FTE-yr	Tech. FTE-yr
Chicane Magnets	EE	ea		4	$294	0.05	0.575	0.083	3.545
Painting Magnets		ea	$25,000	4	$100	0.125	0.875	0	0.125
Vertical Steering Magnets		ea	$25,000	2	$50	0.125	2.5	0.375	0.875

Technical/Cost Risks

Project X

Injection Magnets

- Chicane magnets
  - End field design of the chicane dipoles (particularly dipole # 3) can directly influence efficiency of waste beam transport and losses.
  - This was estimated as FNAL Technical Division Project. BNL is currently taking lead on chicane design and could potentially estimate and build these magnets in house using BNL guidelines.
- Painting & steering magnets
  - No conceptual design of magnet exists.
  - Estimate represents costs of quantities of material and rough labor costs
- Waste beam dipole
  - Upon review it has been found that the single horizontal bend in the waste beam line has not been estimated. Cost impact ~53K$ M&S
  - Design of waste beam line likely to change
  - Inclusion of additional magnets

Scope of Estimated Work

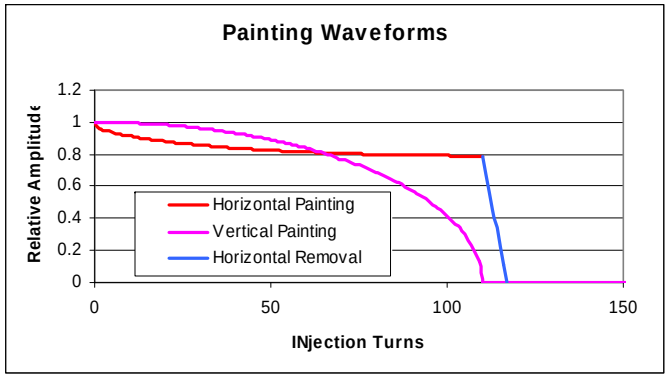
Injection Power Supplies

- Injection chicane individual power supplies
- Painting supply for 4 painting magnets
- Steering Supply for two steering magnets
- M&S 700K$ & Labor 2.85 FTE-years

Basis of Estimate

Injection Power Supplies

- Chicane
  - Rough guideline for kW power supplies of $1K/kW based upon FNAL EE Support experience.
- Painting
  - Conceptual designs for the two types of power supply waveforms, Horizontal-ring and Vertical-beamline, were generated based upon the magnet specifications to meet waveform specifications.
  - Estimate based upon EE Support experience



Cost Estimate

Injection Power Supplies

ITEM		Unit	M&S Cost $	Quantity	M&S Tot. $k	Sci FTE-yr	Eng. FTE-yr	Draft/Mach FTE-yr	Tech. FTE-yr
Injection Power Supplies					$700	0	1.75	0.375	0.875
Chicane Dipole Supplies		ea	$50,000	4	$200	0	0.25	0.125	0.125
Horizontal Painting Supplies	EE	ea	$250,000	1	$250	0	1	0.1875	0.625
Vertical Steering Supplies	EE	ea	$250,000	1	$250	0	0.5	0.0625	0.125

Technical/Cost Risks

Injection Power Supplies

- The chicane dipole supplies are “off the shelf “- no risk
- The painting magnets supplies are technically possible but represent a significant effort and could be considered for an R&D effort. This should proceed in conjunction with the painting magnet design effort.

Scope of Estimated Work

Injection Vacuum

- No engineering design for straight section vacuum
- Includes
  - the vacuum beam pipe in the straight section (approx 30 meters in length) and the waste beam line.
    - Pipe, flanges, seals, guages, etc.
  - Ion pumps
  - Ion pump ps assumed recycled, included small amount for incidentals
- M&S 100K$ & Labor ~2 FTE-years

Basis of Estimate

Injection Vacuum

- Educated guess with contingency- estimated $1000/m for beam pipe, flanges, seals, gages, etc.
- Assumes 8 ~150 lps ion pumps in the 50 m region for differential pumping (similar to configuration currently used in Recycler and beamlines)
  - Catalog est of $4200 rounded up to $6000

Cost Estimate

Injection Vacuum

ITEM	Unit	M&S Cost $	Quantity	M&S Tot. $k	Sci FTE-yr	Eng. FTE-yr	Draft/Mach FTE-yr	Tech. FTE-yr
Injection Vacuum System				$100	0	1.25	0.375	0.04
Vacuum Chamber	ea	$50,000	1	$50	0	1	0.25	0.04
Ion pumps	ea	$6,000	8	$48	0	0.125	0.0625	0
Vacuum power supplies	ea	$2,000	1	$2	0	0.125	0.0625	0

Technical/Cost Risks

Injection Vacuum

- No technical risk
- Although only conceptual, believe cost is within project contingency
- Better estimate requires better design

Scope of Estimated Work

Foil Changer

- It is assumed preliminary engineering design is completed in RD&D phase
- Estimate includes M&S with some final design and assembly labor and installation
- Estimate includes vacuum can, 3 axis motion control, carbon foils, e-catcher, and instrumentation
- M&S 145K$ & Labor 2.25 FTE-years

Basis of Estimate

Foil Changer

- Vacuum can
  - Looked at FNAL Booster foil changer.
  - Project X changer more complex
  - Applied a factor of 6.5 (arbitrary) to rough cost of FNAL Booster changer
- Motion Control
  - Cost for complete FNAL style motion system from engineer
  - Inflated to include motors
- Carbon foils
  - Estimate from SNS
- E-catcher
  - Educated estimate
- Instrumentation
  - Educated estimate

Cost Estimate

Foil Changer

ITEM	Unit	M&S Cost $	Quantity	M&S Tot. $k	Sci FTE-yr	Eng. FTE-yr	Draft/Mach FTE-yr	Tech. FTE-yr
Injection Foil Changer/E-catcher				$145	0	1.375	0.5	0.375
Vacuum can	ea	$65,000	1	$60		1	0.25	0.125
Motion Control	ea	$10,000	1	$30		0.25	0.125	0.125
carbon foils	ea	$1,500	4	$6				
e-catcher	each	$19,000	1	$19				
Instrumentation	set	$20,000	1	$25		0.125	0.125	0.125

Technical/Cost Risks

Foil Changer

- Checking ball park number
  - M&S with (my estimate of) labor ~ 500-600K$
  - FNAL changer ~10K$ (max)
  - SNS charges through FY08 for
    - "stripped foil" ~800K$
    - "diamond stripping foil" ~140K$
    - No details on either of these level 3 items
  - JPARC complete system (all three changers, vacuum, installation, etc. is reported to be roughly 1M$
- Although conceptual design does not exist current estimate should be in the ball park

Scope of Estimated Work

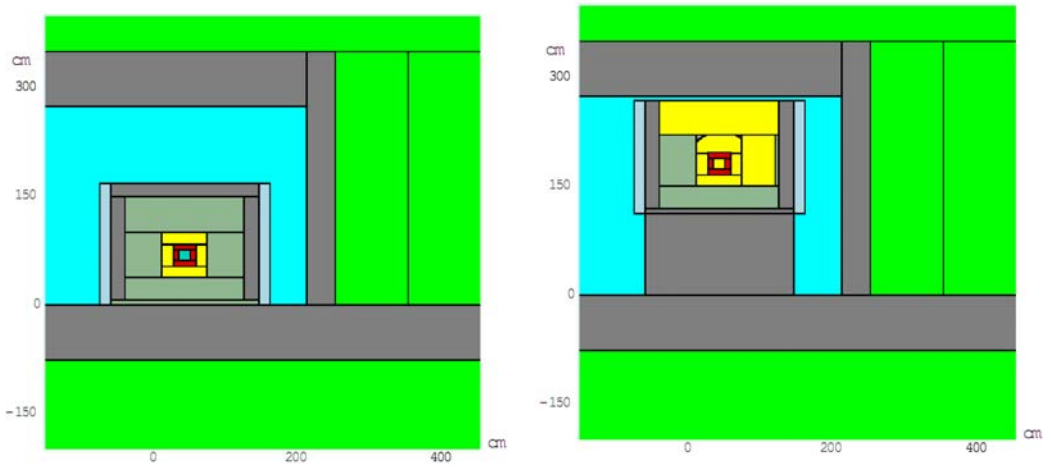
Injection Absorber

- Estimated M&S values for (non-optimized) absorber conceptual design which meets radiological constraints.
- Assume installation costs in M&S
- Included: core, shielding, RAW system, and absorber instrumentation
- M&S 3,650K$ & Labor 2.375 FTE-years

Graphite core is surrounded with tungsten, steel, concrete and marble

Proton Driver **(core elevation 27")** Project X **(core elevation 70")**

Cross section



Basis of Estimate

Injection Absorber

- Assume preliminary engineering design in RD&D phase
- Core
  - Educated guess
- Shielding
  - Based upon a non optimized conceptual absorber design for internal injection absorber
  - Amount of shielding averaged between MI and (1st look) Recycler solution (i.e. 2E4 lbs for MI and 1.2E5 lbs for RR)
  - Estimated current price of tungsten (from vendor) and steel (from previous projects
  - Assumed recycled concrete with funds for contingency
  - Estimated marble price from previous collimation projects
- Based upon engineering estimates for RAW skids/power
- Instrumentation (thermocouples, CCD's, etc.- absorber protect)
  - Educated guess

Cost Estimate

Injection Absorber

ITEM		Unit	M&S Cost $	Quantity	M&S Tot. $k	Sci FTE-yr	Eng. FTE-yr	Draft/Mach FTE-yr	Tech. FTE-yr
Injection Absorber (100 kW)					$3,650	0	1.375	0.5	0.5
Core		ea	$25,000	1	$25		0.5	0.25	0.1
Shielding		set	$3,500,000	1	$3,500		0.5	0.25	0.3
RAW System	EE	ea	$100,000	1	$100		0.25		0.05
Instrumentation/Controls		set	$25,000	1	$25		0.125		0.05

Technical/Cost Risks

Injection Absorber

- The waste beam line including absorber will be addressed in the RD&D phase
- Optimization of the location of the absorber (between shielding and civil construction issues) which meet physics design goals and radiological constraints will be addressed in RD&D phase
- Amount of required tungsten averaged between MI and Recycler conceptual designs
- Reduction in shielding and increased civil likely to produce a cost exposure wash.

Summary

- We have produced an estimate for Recycler injection components with an M&S of 5.047M$ and a FNAL labor estimate of 1.8M$ before contingency.
- Cost driver is the injection absorber tungsten shielding
- RD&D plan to address optimization of injection absorber placement and design in conjunction with civil construction issues.
- Although the waste beam magnet was omitted in this cost estimate exercise, the cost impact is negligible.