Director's Review of the Project X Main Injector and Recycler RF

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Project X Director's Review
March 16, 2009

MI RF System Specifications

Parameter	Value	Units
Frequency	52.811-53.104	MHz
Max. Acceleration Rate	240	GeV/sec
Frequency slew rate	1.6	MHz/sec
Acceleration Voltage	2.7	MV
Beam Power	6.2	MW
Average Beam Power	3.0	MW
Peak Voltage	4.7	MV
Average Beam Current	2.3	A
Fundamental rf Current	3.7-4.1	A

MI Second Harmonic and Recycler RF Requirements

Main Injector Second Harmonic RF Requirements

- 1.2 MV of 106 MHz Tunable up to Transition

Recycler RF Requirements

- 1 MV of Fundamental (Fixed Frequency 53 MHz)
- 500 kV of Second Harmonic (Fixed Frequency 106 MHz)

Design Page

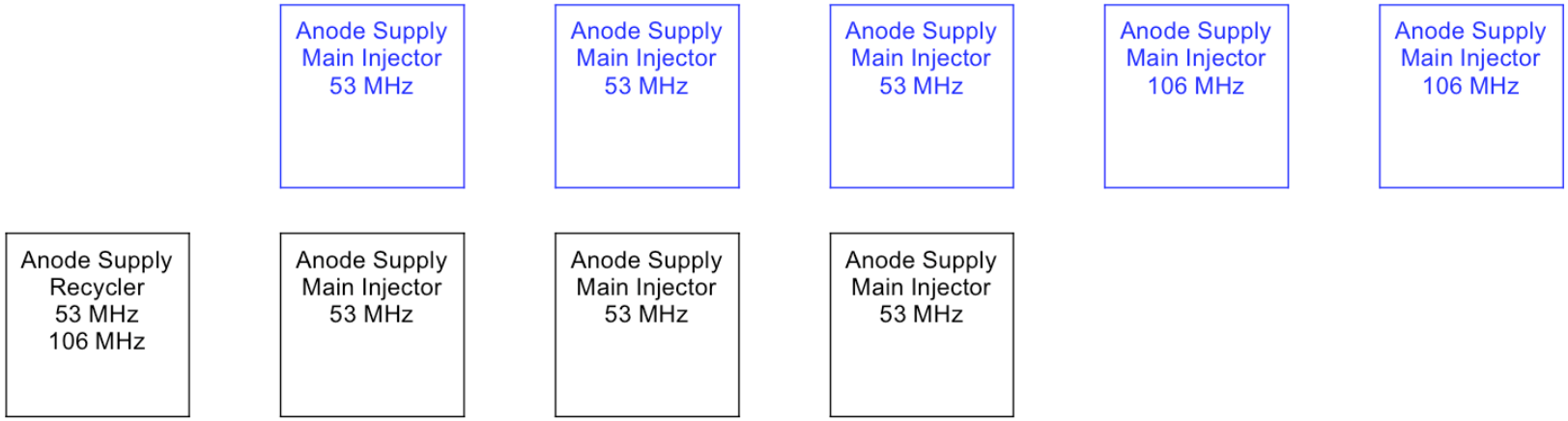
R/Q = 100 and Q = 4000 for all
Main Injector and Recycler RF Cavities

Main Injector
- 18 - 53 MHz Stations
- 5 - 106 MHz Stations

Recycler
- 4 - 53 MHz Stations
- 2 - 106 MHz Stations

•Reuse Main Injector and Booster Bias Supplies
•Reuse Main Injector and Booster Solid State Drivers
•No Modulators will be used in this Design

Anode Supplies



Anode Supplies in Black are existing.
Anode Supplies in Blue are new.

Main Injector
18 - 53 MHz Stations
5 - 106 MHz Stations

Recycler
4 - 53 MHz Stations
2 - 106 MHz Stations

MI 53 MHz
Anode Supplies M&S

Fundamental 53 MHz System Anode Supplies				Number of Stations	Total
			$607,250	**3**	**$1,821,750**
Anode Power Supply Transformer, 2.0 MVA	$125,000	1	$125,000		
Rectifier Stack	$37,500	1	$37,500		
Capacitor Bank	$20,000	1	$20,000		
Two Water Resistors	$35,000	1	$35,000		
Four Vacuum Switches	$25,250	1	$25,250		
Interphase Reactor	$25,000	1	$25,000		
13.8 kV Contactors	$227,500	1	$227,500		
Fused Disconnect	$50,000	1	$50,000		
Anode Power Supply Relay Rack Controls	$20,000	1	$20,000		
Crowbar Circuit	$15,000	1	$15,000		
DC Bus Work	$5,000	1	$5,000		
Mechanical Mounting Supports	$10,000	1	$10,000		
13.8 kV AC Current Sensor	$2,000	1	$2,000		
Miscellaneous Parts	$10,000	1	$10,000		

Updated Price Reflecting BOE Exercise

MI 53 MHz
Driver Amps M&S

Driver Amps				Number of Stations	Total
			450000	**18**	**8,100,000**
50 Kwatt Driver Amp	350000	1	350000		
Plate PS	40000	1	40000		
Screen PS	25000	1	25000		
Filament PS	25000	1	25000		
Controls	10000	1	10000		

MI 53 MHz
Final PA M&S

Final PA				Number of Stations	Total
			313500	**18**	**5,643,000**
Tube	128500	1	128500		
Socket	35000	1	35000		
Resonator	25000	1	25000		
Low voltage power supplies	50000	1	50000		
Coax high power + coupler	25000	1	25000		
Amplifier fabrication	50000	1	50000		

Updated Price Reflecting BOE Exercise

MI 53 MHz Cavity M&S

53 MHz Cavity				Number of Stations	Total
			490000	18	8,820,000
Major components	400000	1	400000		
Ceramic windows	50000	1	50000		
Cavity Stand	20000	1	20000		
Mode Dampers	20000	1	20000		

MI 106 MHz
Anode Supplies M&S

2nd Harmonic Anode Supplies				Number of Stations	Total
			$607,250	**2**	**$1,214,500**
Anode Power Supply Transformer, 2.0 MVA	$125,000	1	$125,000		
Rectifier Stack	$37,500	1	$37,500		
Capacitor Bank	$20,000	1	$20,000		
Two Water Resistors	$35,000	1	$35,000		
Four Vacuum Switches	$25,250	1	$25,250		
Interphase Reactor	$25,000	1	$25,000		
13.8 kV Contactors	$227,500	1	$227,500		
Fused Disconnect	$50,000	1	$50,000		
Anode Power Supply Relay Rack Controls	$20,000	1	$20,000		
Crowbar Circuit	$15,000	1	$15,000		
DC Bus Work	$5,000	1	$5,000		
Mechanical Mounting Supports	$10,000	1	$10,000		
13.8 kV AC Current Sensor	$2,000	1	$2,000		
Miscellaneous Parts	$10,000	1	$10,000		

Updated Price Reflecting BOE Exercise

MI 106 MHz Driver Amps M&S

2nd Harmonic Driver Amps				Number of Stations	Total
			450000	**5**	**2,250,000**
50 Kwatt Driver Amp	350000	1	350000		
Plate PS	40000	1	40000		
Screen PS	25000	1	25000		
Filament PS	25000	1	25000		
Controls	10000	1	10000		

MI 106 MHz
Final PA M&S

2nd Harmonic Final PA				Number of Stations	Total
			313500	**5**	**1,567,500**
Tube	128500	1	128500		
Socket	35000	1	35000		
Resonator	25000	1	25000		
Low voltage power supplies	50000	1	50000		
Coax high power + coupler	25000	1	25000		
Amplifier fabrication	50000	1	50000		

Updated Price Reflecting BOE Exercise

MI 106 MHz Cavity M&S

2nd Harmonic Cavity				Number of Stations	Total
			490000	5	2,450,000
Major components	400000	1	400000		
Ceramic windows	50000	1	50000		
Cavity Stand	20000	1	20000		
Mode Dampers	20000	1	20000		

Recycler RF
53 and 106 MHz M&S

		Number of Stations	Total
Recycler 53 MHz system Driver Amps	450000	4	1,800,000
Recycler 53 MHz system Final PA	313500	4	1,254,000
Recycler 53 MHz system Cavity	490000	4	1,960,000
Recycler 106 MHz system Driver Amps	450000	2	900,000
Recycler 106 MHz system Final PA	313500	2	627,000
Recycler 106 MHz system Cavity	490000	2	980,000

Updated Price Reflecting BOE Exercise

RF Installation

Installation				Number of Stations	Total
			3500000	**1**	**3,500,000**
Cabling	250000	1	250000		
LCW Modifications	2500000	1	2500000		
Renovation of Gallery	250000	1	250000		
Power Distribution	500000	1	500000		

Original Main Injector and Recycler M&S

HIGH LEVEL RF SYSTEMS MI	Unit Price	Number of Units	Total Cost
Fundamental rf system			
Anode supplies	$480,000.00	3	$1,440,000.00
Driver Amplifiers	$450,000.00	18	$8,100,000.00
Final PA	$285,000.00	18	$5,130,000.00
53 MHz Cavities	$490,000.00	18	$8,820,000.00
Second Harmonic rf system			
Anode supplies	$480,000.00	2	$960,000.00
Driver Amplifiers	$450,000.00	5	$2,250,000.00
Final PA	$285,000.00	5	$1,425,000.00
106 MHz Cavities	$490,000.00	5	$2,450,000.00
HIGH LEVEL RF SYSTEMS RR			
Fundamental rf system			
Anode supplies	$480,000.00	0	
Driver Amplifiers	$450,000.00	4	$1,800,000.00
Final PA	$285,000.00	4	$1,140,000.00
53 MHz Cavities	$490,000.00	4	$1,960,000.00
Second Harmonic rf System			
Anode Supplies	$480,000.00	0	
Driver Amplifiers	$450,000.00	2	$900,000.00
Final PA	$285,000.00	2	$570,000.00
106 MHz Cavities	$490,000.00	2	$980,000.00
Installation Costs (both MI & RR)	$3,500,000.00	1	$3,500,000.00
TOTAL MI & RR RF M&S COSTS			$41,425,000.00

Total Main Injector and Recycler M&S

HIGH LEVEL RF SYSTEMS MI	Unit Price	Number of Units	Total Cost
Fundamental rf system			
Anode supplies	$607,250.00	3	$1,821,750.00
Driver Amplifiers	$450,000.00	18	$8,100,000.00
Final PA	$313,500.00	18	$5,643,000.00
53 MHz Cavities	$490,000.00	18	$8,820,000.00
Second Harmonic rf system			
Anode supplies	$607,250.00	2	$1,214,500.00
Driver Amplifiers	$450,000.00	5	$2,250,000.00
Final PA	$313,500.00	5	$1,567,500.00
106 MHz Cavities	$490,000.00	5	$2,450,000.00
HIGH LEVEL RF SYSTEMS RR			
Fundamental rf system			
Anode supplies	$607,250.00	0	
Driver Amplifiers	$450,000.00	4	$1,800,000.00
Final PA	$313,500.00	4	$1,254,000.00
53 MHz Cavities	$490,000.00	4	$1,960,000.00
Second Harmonic rf System			
Anode Supplies	$607,250.00	0	
Driver Amplifiers	$450,000.00	2	$900,000.00
Final PA	$313,500.00	2	$627,000.00
106 MHz Cavities	$490,000.00	2	$980,000.00
Installation Costs (both MI & RR)	$3,500,000.00	1	$3,500,000.00
TOTAL MI & RR RF M&S COSTS			$42,887,750.00

Labor Year 1

	Q1		Q2		Q3		Q4	
	MI	RR	MI	RR	MI	RR	MI	RR
Engineer (RF)	2.1	0.34	2.1	0.34	2.1	0.34	2.1	0.34
Engineer(Mech.)	0.57	0.1	0.6	0.1	0.6	0.1	0.6	0.1
Scientist	0.08	0.02	0.08	0.02	0.08	0.02	0.08	0.02
Techician(RF)	2.12	0.3	2.12	0.3	2.12	0.3	2.12	0.3
Techician(Mech.)	0.13		0.13		0.13		0.13	
Design Drafter	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.3
Electrician	0.2		0.2		0.2		0.2	
Rigger								

Project X

Labor Year 2

	Q1		Q2		Q3		Q4	
	MI	RR	MI	RR	MI	RR	MI	RR
Engineer (RF)	1.9	0.4	1.9	0.4	1.9	0.4	1.9	0.4
Engineer(Mech.)	0.2	0.04	0.2	0.04	0.2	0.04	0.2	0.04
Scientist	0.2	0.04	0.2	0.04	0.2	0.04	0.2	0.04
Techician(RF)	4	0.7	4	0.7	4	0.7	4	0.7
Techician(Mech.)	0.14	0.02	0.14	0.02	0.14	0.02	0.14	0.02
Design Drafter	0.15	0.03	0.15	0.03	0.15	0.03	0.15	0.03
Electrician	0.5		0.5		0.5		0.5	
Rigger								

Project X

Labor Year 3

	Q1		Q2		Q3		Q4		Three
	MI	RR	MI	RR	MI	RR	MI	RR	Year Total
Engineer (RF)	1.4	0.1	1.4	0.1	1.4	0.1	1.4	0.1	24.96
Engineer(Mech.)	0.25		0.25		0.25		0.25		4.73
Scientist	0.08	0.014	0.08	0.014	0.08	0.014	0.08	0.014	1.74
Techician(RF)	2.9	0.4	2.9	0.4	2.9	0.4	2.9	0.4	41.68
Techician(Mech.)	1.3	0.014	1.3	0.014	1.3	0.014	1.3	0.014	6.42
Design Drafter	0.043		0.043		0.043		0.043		7.29
Electrician	1.53	0.2	1.53	0.2	1.53	0.2	1.53	0.2	9.72
Rigger	0.77	0.2	0.77	0.2	0.77	0.2	0.77	0.2	3.88