

**Director's Review of the Project X  
Cost Range Estimate:  
Low Energy Linac**

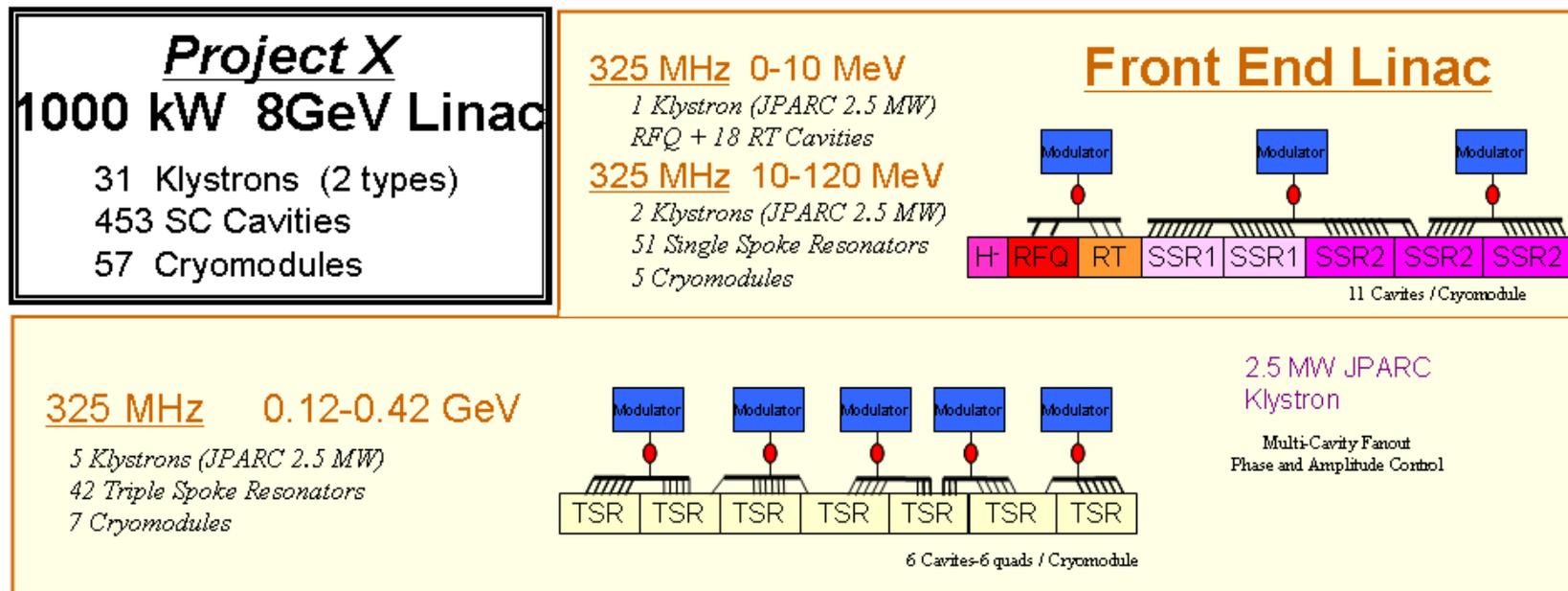
Thomas H. Nicol  
Project X Director's Review  
March 16, 2009



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



- Front end linac from the H- ion source through the triple spoke resonator (TSR) cryomodules, i.e. from 0 – 420 MeV.
- Where appropriate this work will replicate similar work done for HINS, not utilize it directly.



# Boundary Conditions & Assumptions

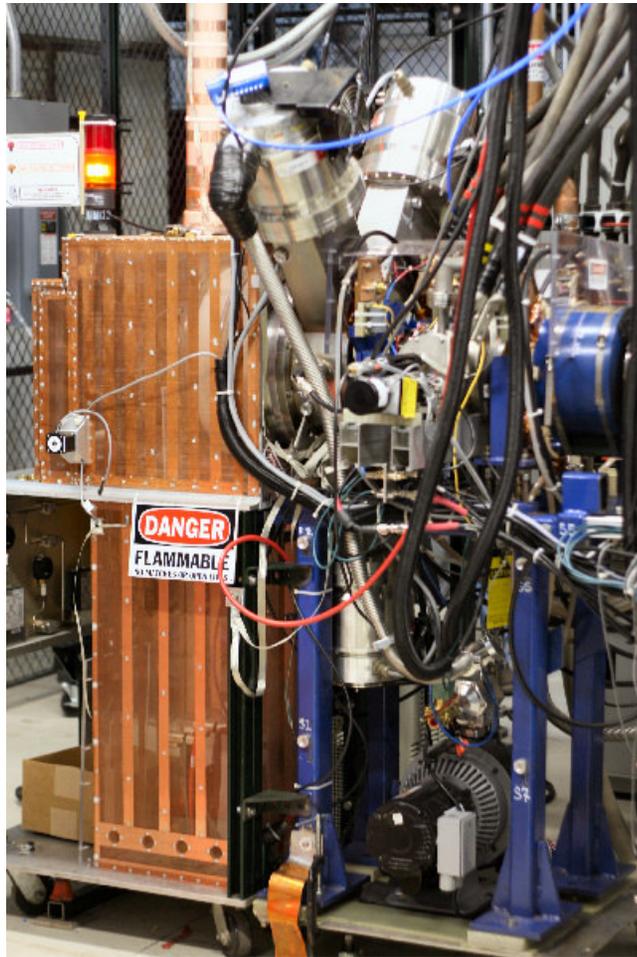


- RF input is from the 325 MHz RF system which is not part of this estimate.
- Beam instrumentation is distributed throughout the length of the front end linac and is not part of this estimate.
- Cryogenics are supplied by transfer lines, feed, and turnaround boxes which are not part of this estimate.
- Anticipated inputs from other efforts.
  - HINS front end linac is similar and, in places, identical to the Project X front end.
  - SRF Infrastructure support will be required for chemistry, clean room facilities, processing, etc.
  - Interfaces to instrumentation will be required from instrumentation and controls groups.



- Main bases of estimate.
  - Similar systems at other labs, e.g. ion source.
  - HINS front end hardware purchases and estimates.
  - ILC cryomodule estimates.
  - Earlier cost estimate study from February 2008 prepared as part of an Accelerator Advisory Committee presentation.
- Front end linac components that are part of HINS are not expected to become part of the Project X front end.
- Some utilization of HINS components as spares is possible.

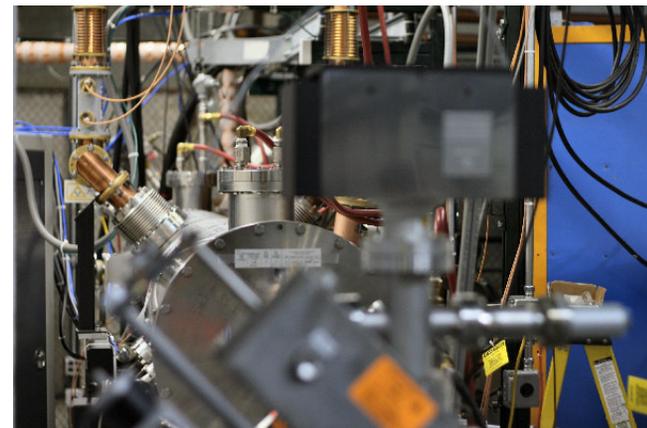
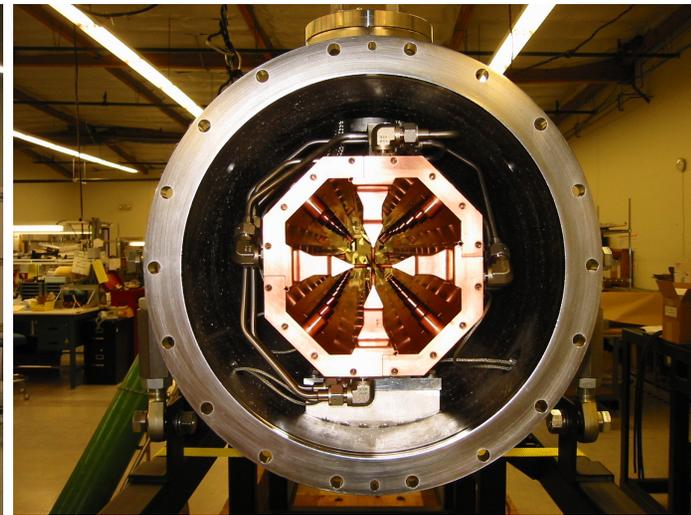
# Project X Ion Source and LEBT



# Project X Ion Source and LEBT



ITEM	Unit	M&S Cost	Qty	M&S Total	Labor	Total	Basis
<b>Ion source and LEBT</b>			<b>1</b>	<b>&lt;&lt; Number of units</b>			
Ion source and LEBT	ea	\$5,000,000	1	\$5,000,000		\$5,000,000	SNS (\$10M), Los Alamos (\$6.5M) systems
Parts, assy, install, etc.	ea			\$5,000,000		\$5,000,000	
Parts, assy, install, etc.	lot			\$5,000,000		\$5,000,000	
EDIA	lot				\$1,760,000	\$1,760,000	2 techs, 2 drftrs, 2 engrs, 2 phys for 2 years
Spares allocation						\$2,000,000	~40% of M&S
<b>Grand total Ion source and LEBT</b>						<b>\$8,760,000</b>	

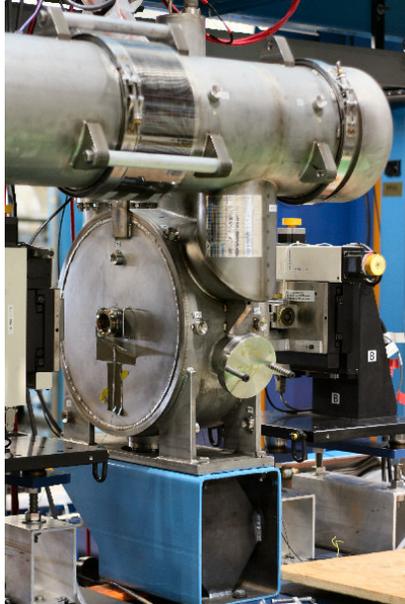




ITEM	Unit	M&S Cost	Qty	M&S Total	Labor	Total	Basis
<b>RF quad</b>			<b>1</b>	<b>&lt;&lt; Number of units</b>			
RF quad	ea	\$800,000	1	\$800,000		\$800,000	HINS purchase (1@\$648,239)
Parts, assy, install, etc.	ea			\$800,000		\$800,000	
Parts, assy, install, etc.	lot			\$800,000		\$800,000	
EDIA	lot				\$177,500	\$177,500	1 tech, 1 engr, 1 phys for 6 mos
Spares allocation						\$800,000	1 spare unit
<b>Grand total RF quad</b>						<b>\$1,777,500</b>	

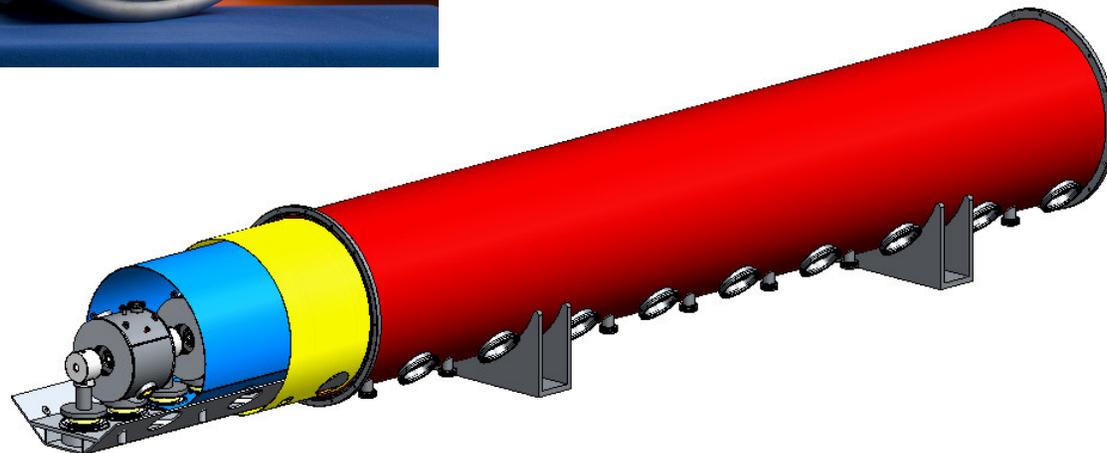
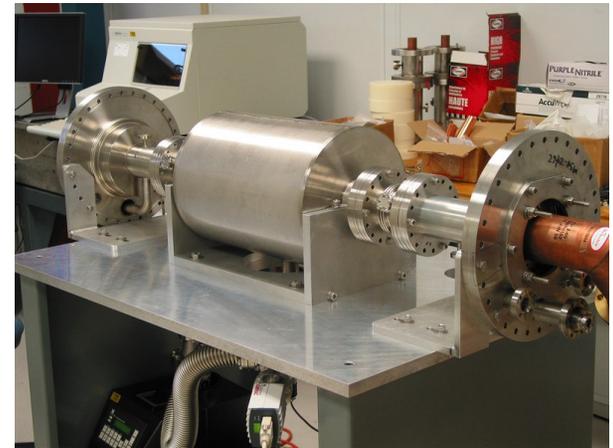


ITEM	Unit	M&S Cost	Qty	M&S Total	Labor	Total	Basis
<b>MEBT</b>			<b>1</b>	<b>&lt;&lt; Number of units</b>			
Solenoid cold masses	ea	\$17,500	3	\$52,500			HINS purchase (3@\$16,100 ea)
Solenoid cryostat parts	ea	\$45,000	3	\$135,000			HINS purchase (3@\$42,200 ea)
Interconnects	lot	\$5,000	1	\$5,000			Engineering estimate
Chopper	ea	\$1,500,000	1	\$1,500,000			Robyn Madrak estimate
Buncher cavities	ea	\$100,000	2	\$200,000			HINS purchase (2@\$100,000 from LBL)
Assembly	lot	\$10,000	1	\$10,000	\$287,500	\$297,500	2 techs, 2 engrs, 1 phys for 6 months
Parts, assy, install, etc.	ea			\$1,902,500	\$287,500	\$2,190,000	
Parts, assy, install, etc.	lot			\$1,902,500	\$287,500	\$2,190,000	
EDIA	lot				\$710,000	\$710,000	1 drafter, 1 engr, 1 phys for 2 years
Spares allocation						\$800,000	~40% of M&S
<b>Grand total MEBT</b>						<b>\$3,700,000</b>	





ITEM	Unit	M&S Cost	Qty	M&S Total	Labor	Total	Basis
<b>RT section</b>			<b>1</b>	<b>&lt;&lt; Number of units</b>			
RT CH cavities	ea	\$86,000	16	\$1,376,000			HINS purchase (16@\$70,000 avg)
RT CH solenoid cold masses	ea	\$17,500	16	\$280,000			HINS purchase (3@\$16,100 ea)
RT CH solenoid cryostats	ea	\$45,000	16	\$720,000			HINS purchase (3@\$42,200 ea)
Assembly	lot	\$10,000	1	\$10,000	\$287,500	\$297,500	2 engrs, 2 techs, 1 phys for 6 months
Parts, assy, install, etc.	ea			\$2,386,000	\$287,500	\$2,673,500	
Parts, assy, install, etc.	lot			\$2,386,000	\$287,500	\$2,673,500	
EDIA	lot				\$1,015,000	\$1,015,000	2 drftrs, 2 engrs, 1 phys for 2 years
Spares allocation						\$900,000	~40% of M&S
<b>Grand total RT section</b>						<b>\$4,588,500</b>	





ITEM	Unit	M&S Cost	Qty	M&S Total	Labor	Total	Basis
<b>SSR1 cryomodules</b>			<b>2</b>	<b>&lt;&lt; Number of units</b>			
Vacuum vessel	ea	\$105,000	1 /CM	\$105,000		\$105,000	ILC cost estimate
Internal piping	ea	\$55,000	1 /CM	\$55,000		\$55,000	ILC cost estimate
Raw niobium	ea	\$25,000	9 /CM	\$225,000		\$225,000	HINS SSR1 high RRR and reactor grade
Cavity fabrication	ea	\$100,000	9 /CM	\$900,000		\$900,000	HINS SSR1 fab at Zanon and Roark
Helium vessel	ea	\$10,000	9 /CM	\$90,000		\$90,000	Engr estimate, \$5K parts, \$5K fabrication
Processing	ea	\$5,000	9 /CM	\$45,000	\$266,250	\$311,250	1 tech, 1 engr, 1 phys, 1 month per cavity
Testing	ea	\$5,000	9 /CM	\$45,000	\$266,250	\$311,250	1 tech, 1 engr, 1 phys, 1 month per cavity
Solenoids	ea	\$17,500	9 /CM	\$157,500		\$157,500	<b>HINS purchase (3@\$16,100 ea)</b>
Supports	ea	\$4,500	18 /CM	\$81,000		\$81,000	<b>HINS purchase (3@\$3,500 ea)</b>
Magnetic shield	ea	\$120,000	1 /CM	\$120,000		\$120,000	<b>HINS purchase (1@\$44,000 ea) (shorter)</b>
Thermal shield	ea	\$16,000	1 /CM	\$16,000		\$16,000	ILC cost estimate
MLI	ea	\$11,000	1 /CM	\$11,000		\$11,000	ILC cost estimate
Couplers	ea	\$20,000	9 /CM	\$180,000		\$180,000	<b>HINS purchase (3@\$9,500+\$4,500)</b>
Tuners	ea	\$15,000	9 /CM	\$135,000		\$135,000	Engr estimate
Current leads	pr	\$2,800	13 /CM	\$36,400		\$36,400	<b>HINS purchase (15@\$2,700 pr)</b>
Instrumentation	lot	\$1,000	1 /CM	\$1,000		\$1,000	Engr estimate
Interconnect parts	ea	\$20,000	1 /CM	\$20,000		\$20,000	Engr estimate, bayonets, valves, etc.
Assembly	ea	\$10,000	1 /CM	\$10,000	\$372,500	\$382,500	4 techs, 2 engrs, 1 phys for 6 months
Installation	ea	\$10,000	1 /CM	\$10,000	\$124,167	\$134,167	4 techs, 2 engrs, 1 phys for 2 months
Parts, assy, install, etc.	ea			\$2,242,900	\$1,029,167	\$3,272,067	
Parts, assy, install, etc.	lot			\$4,485,800	\$2,058,333	\$6,544,133	
EDIA	lot				\$1,015,000	\$1,015,000	2 drftrs, 2 engrs, 1/2 phys for 2 years
Spares allocation						\$3,200,000	1 spare module
<b>Grand total SSR1 cryomodules</b>						<b>\$10,759,133</b>	



ITEM	Unit	M&S Cost	Qty	M&S Total	Labor	Total	Basis
<b>SSR2 cryomodules</b>			<b>3</b>	<b>&lt;&lt; Number of units</b>			
Vacuum vessel	ea	\$105,000	1 /CM	\$105,000		\$105,000	ILC cost estimate
Internal piping	ea	\$55,000	1 /CM	\$55,000		\$55,000	ILC cost estimate
Raw niobium	ea	\$33,000	11 /CM	\$363,000		\$363,000	Scaled from SSR1
Cavity fabrication	ea	\$125,000	11 /CM	\$1,375,000		\$1,375,000	Scaled from SSR1 (x1.25)
Helium vessel	ea	\$12,000	11 /CM	\$132,000		\$132,000	Scaled from SSR1
Processing	ea	\$5,000	11 /CM	\$55,000	\$325,417	\$380,417	1 tech, 1 engr, 1 phys, 1 month per cavity
Testing	ea	\$5,000	11 /CM	\$55,000	\$325,417	\$380,417	1 tech, 1 engr, 1 phys, 1 month per cavity
Solenoids	ea	\$17,500	6 /CM	\$105,000		\$105,000	<b>HINS purchase (3@\$16,100 ea)</b>
Supports	ea	\$4,500	17 /CM	\$76,500		\$76,500	<b>HINS purchase (3@\$3,500 ea)</b>
Magnetic shield	ea	\$120,000	1 /CM	\$120,000		\$120,000	<b>HINS purchase (1@\$44,000 ea) (shorter)</b>
Thermal shield	ea	\$16,000	1 /CM	\$16,000		\$16,000	ILC cost estimate
MLI	ea	\$11,000	1 /CM	\$11,000		\$11,000	ILC cost estimate
Couplers	ea	\$20,000	11 /CM	\$220,000		\$220,000	<b>HINS purchase (3@\$9,500+\$4,500)</b>
Tuners	ea	\$15,000	11 /CM	\$165,000		\$165,000	Engr estimate
Current leads	pr	\$2,800	12 /CM	\$33,600		\$33,600	<b>HINS purchase (15@\$2,700 pr)</b>
Instrumentation	lot	\$1,000	1 /CM	\$1,000		\$1,000	Engr estimate
Interconnect parts	ea	\$20,000	1 /CM	\$20,000		\$20,000	Engr estimate, bayonets, valves, etc.
Assembly	ea	\$10,000	1 /CM	\$10,000	\$372,500	\$382,500	4 techs, 2 engrs, 1 phys for 6 months
Installation	ea	\$10,000	1 /CM	\$10,000	\$124,167	\$134,167	4 techs, 2 engrs, 1 phys for 2 months
Parts, assy, install, etc.	ea			\$2,928,100	\$1,147,500	\$4,075,600	
Parts, assy, install, etc.	lot			\$8,784,300	\$3,442,500	\$12,226,800	
EDIA	lot				\$1,015,000	\$1,015,000	2 drftrs, 2 engrs, 1/2 phys for 2 years
Spares allocation						\$4,075,600	1 spare module
<b>Grand total SSR2 cryomodules</b>						<b>\$17,317,400</b>	



ITEM	Unit	M&S Cost	Qty	M&S Total	Labor	Total	Basis
<b>TSR cryomodules</b>				<b>7</b>	<b>&lt;&lt; Number of units</b>		
Vacuum vessel	ea	\$105,000	1 /CM	\$105,000		\$105,000	ILC cost estimate
Internal piping	ea	\$55,000	1 /CM	\$55,000		\$55,000	ILC cost estimate
Raw niobium	ea	\$57,000	6 /CM	\$342,000		\$342,000	Scaled from SSR1
Cavity fabrication	ea	\$150,000	6 /CM	\$900,000		\$900,000	Scaled from SSR1 (x1.5)
Helium vessel	ea	\$15,000	6 /CM	\$90,000		\$90,000	Scaled from SSR1
Processing	ea	\$5,000	6 /CM	\$30,000	\$177,500	\$207,500	1 tech, 1 engr, 1 phys, 1 month per cavity
Testing	ea	\$5,000	6 /CM	\$30,000	\$177,500	\$207,500	1 tech, 1 engr, 1 phys, 1 month per cavity
Quadrupoles	ea	\$17,500	6 /CM	\$105,000		\$105,000	<b>Assume same as HINS solenoid</b>
Supports	ea	\$4,500	12 /CM	\$54,000		\$54,000	<b>HINS purchase (3@\$3,500 ea)</b>
Magnetic shield	ea	\$120,000	1 /CM	\$120,000		\$120,000	<b>HINS purchase (1@\$44,000 ea) (shorter)</b>
Thermal shield	ea	\$16,000	1 /CM	\$16,000		\$16,000	ILC cost estimate
MLI	ea	\$11,000	1 /CM	\$11,000		\$11,000	ILC cost estimate
Couplers	ea	\$20,000	6 /CM	\$120,000		\$120,000	<b>HINS purchase (3@\$9,500+\$4,500)</b>
Tuners	ea	\$15,000	6 /CM	\$90,000		\$90,000	Engr estimate
Current leads	pr	\$2,800	12 /CM	\$33,600		\$33,600	<b>HINS purchase (15@\$2,700 pr)</b>
Instrumentation	lot	\$1,000	1 /CM	\$1,000		\$1,000	Engr estimate
Interconnect parts	ea	\$20,000	1 /CM	\$20,000		\$20,000	Engr estimate, bayonets, valves, etc.
Assembly	ea	\$10,000	1 /CM	\$10,000	\$372,500	\$382,500	4 techs, 2 engrs, 1 phys for 6 months
Installation	ea	\$10,000	1 /CM	\$10,000	\$124,167	\$134,167	4 techs, 2 engrs, 1 phys for 6 months
Parts, assy, install, etc.	ea			\$2,142,600	\$851,667	\$2,994,267	
Parts, assy, install, etc.	lot			\$14,998,200	\$5,961,667	\$20,959,867	
EDIA	lot				\$1,015,000	\$1,015,000	2 drftrs, 2 engrs, 1/2 phys for 2 years
Spares allocation						\$2,995,000	1 spare module
<b>Grand total TSR cryomodules</b>						<b>\$24,969,867</b>	



System	Mar 2009 estimate	Cost drivers
Grand total Ion source and LEBT	\$8,760,000	Ion source
Grand total RF quad	\$1,777,500	M&S purchase
Grand total MEBT	\$3,700,000	Chopper (> 50%)
Grand total RT section	\$4,588,500	Cavities and solenoid cryostats
Grand total SSR1 cryomodules	\$10,759,133	Raw niobium and cavity fabrication (> 50%)
Grand total SSR2 cryomodules	\$17,317,400	Raw niobium and cavity fabrication (> 50%)
Grand total TSR cryomodules	\$24,969,867	Raw niobium and cavity fabrication (> 50%)
<b>Grand total</b>	<b>\$71,872,400</b>	

February 2008 estimate + Spares + Ion source + Chopper = \$66,500,000 (2008 estimate is in FY05 \$).



- Spoke resonators are largely untested in an accelerator application.
  - Simulation and testing of individual components say it should work.
  - First two SSR1 prototypes achieved accelerating gradients of 19 and 32 MV/m respectively.
- Cavity to solenoid alignment is critical and needs a well-thought-out installation and adjustment scheme.
  - Needs design development and testing.
- Space along the beamline is very tight and leaves little room for installation of future components and instrumentation.
  - Instrumentation studies and revised simulations are under way.
  - Instrumentation workshop at Fermilab last week with collaborators from SNS and CERN.



- Argonne, SNS, and JLab
  - cavity development
  - cleaning
  - chemical processing
  - heat treating
  - beam dynamics (ANL)
  - TSR development
- SNS, LANL, and LBL, could play a key role in development of the ion source and special cavities.



- Good progress is being made on key components for HINS that will directly benefit development of their Project X equivalents, especially the ion source, RF quad, room temperature solenoids, superconducting solenoids and cryostats, and superconducting single spoke resonators.
- We need to continue moving forward in the design development, prototyping, testing, and production of HINS components.
- Sufficient resources must be allocated to all aspects of the project – R&D, engineering, design and drafting, prototyping, testing, and production...