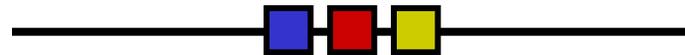
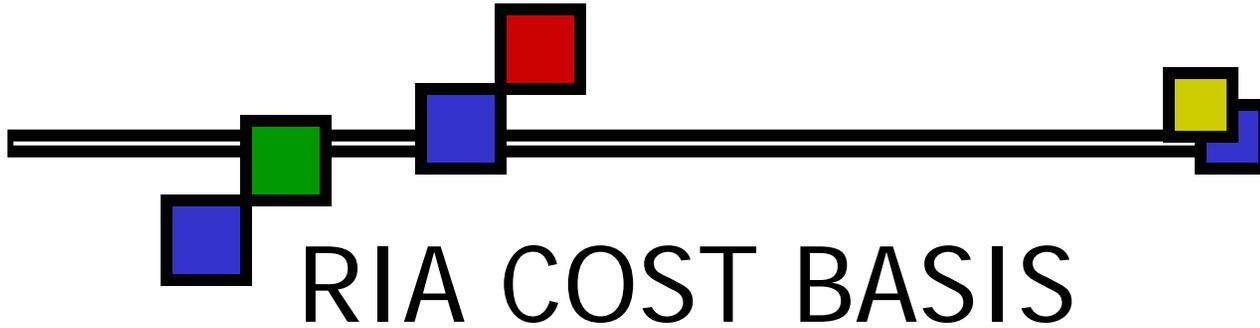


RIA High Energy Section Cryomodule and Refrigerator Design and Cost



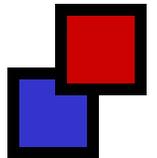
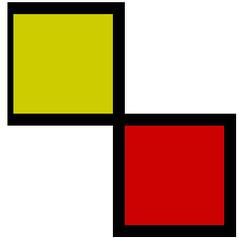
Bill Schneider

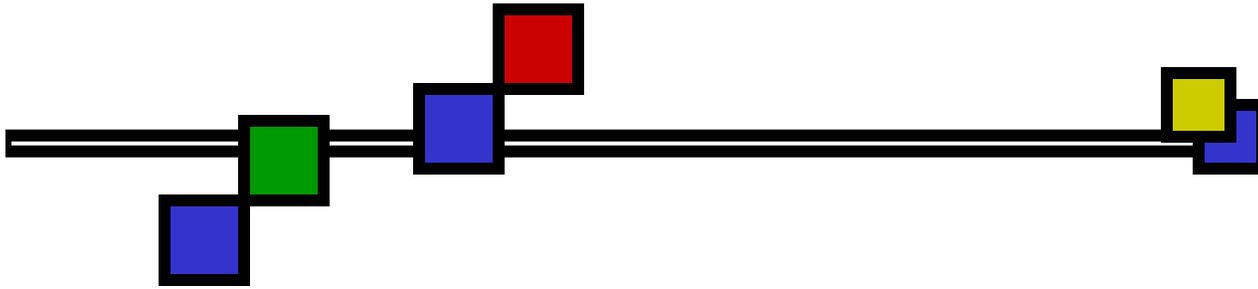


RIA COST BASIS

Make use on the RIA Project:

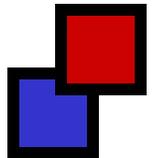
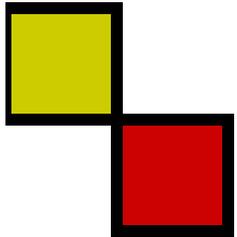
- SNS cavity designs.
- SNS FP coupler and HOM coupler designs.
- SNS cryomodule designs.
- SNS refrigerator system design.
- The knowledge gained through SNS R&D to reduce risk and time so as to minimize overall project costs.
- Utilize facilities and RF parts and test stands at JLab.



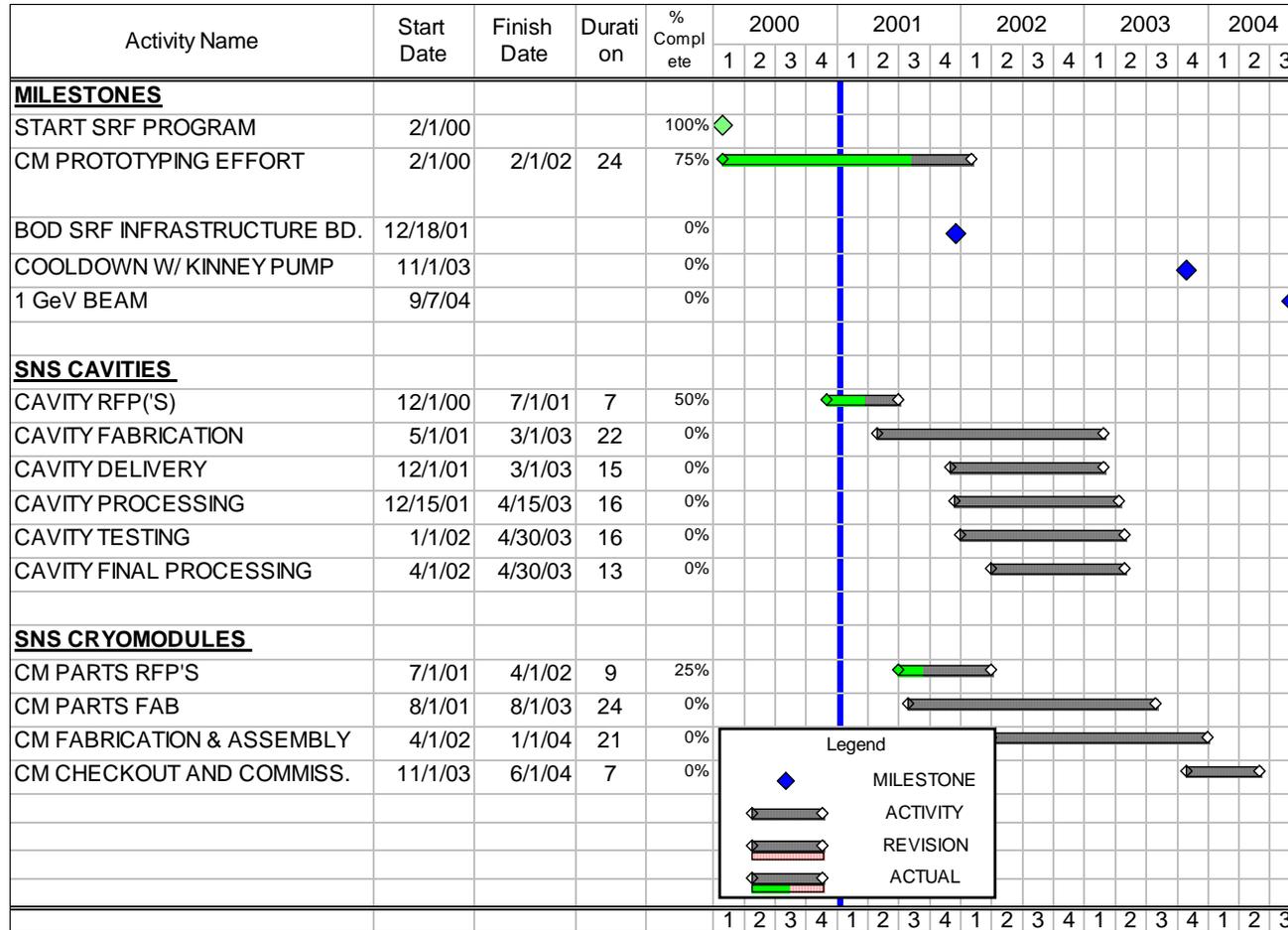


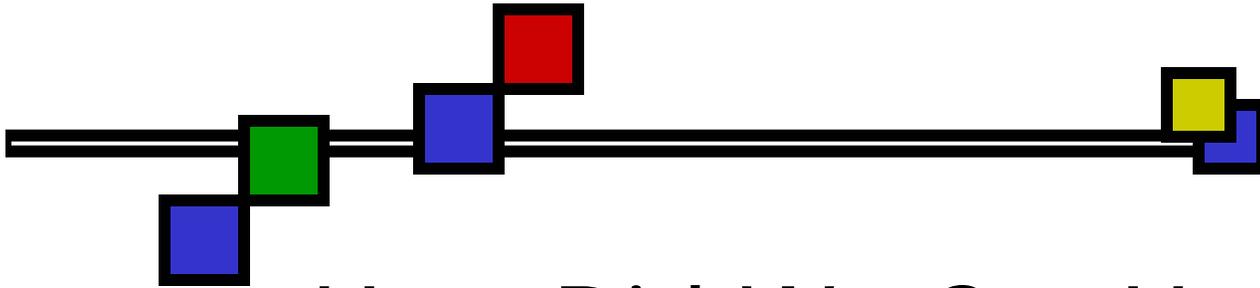
Today's Situation

- SNS cavities ($\beta = 0.61, 0.81$) are designed and are in prototyping.
- SNS refrigerator and transfer lines are designed and many components are on order.
- Jlab upgraded cryomodule, prototypical to SNS cryomodule design, is complete and parts are out on order and being manufactured.
- Engineering and design nearing completion on SNS cryomodule.

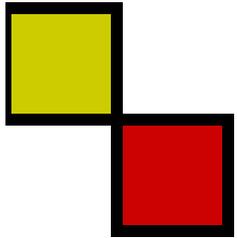


SNS Prototyping and Production Schedule

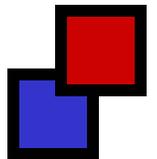


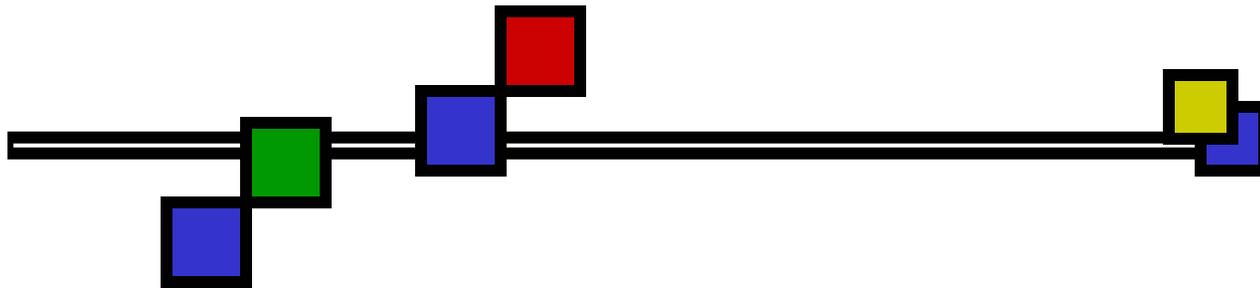


How Did We Get Here?



- The model for the JLab upgrade, for SNS and for RIA, is based upon the CEBAF model of fabrication in industry with assembly at JLab.
- Model for the refrigerator and transfer lines is based upon the CEBAF model and on the JLab upgraded cold box just completed for the CEBAF Upgrade.





Cavity Requirements

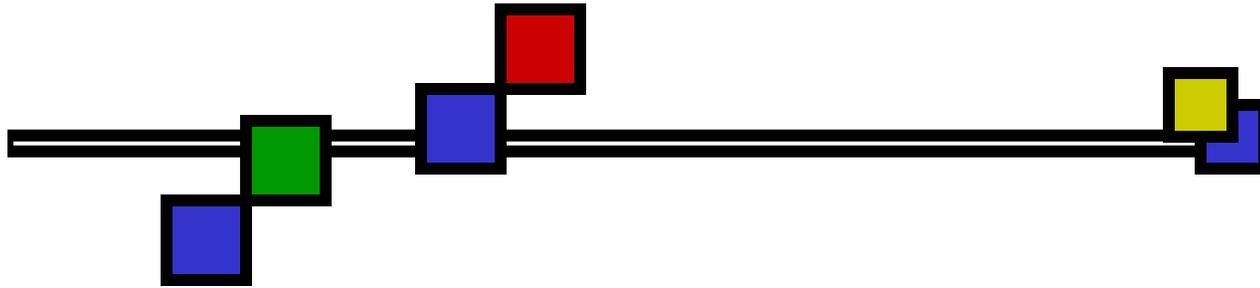
RIA High Beta @ 805 Mhz

- 19 ea. CM's w/ 4 cav/CM = 76 @ β 0.49
- 21 ea. CM's w/ 4 cav/CM = 84 @ β 0.61
- 7 ea. CM's w/ 4 cav/CM = 28 @ β 0.81

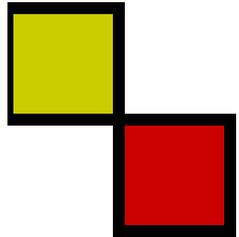
47 CM's

188 cav

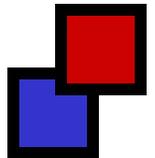
6

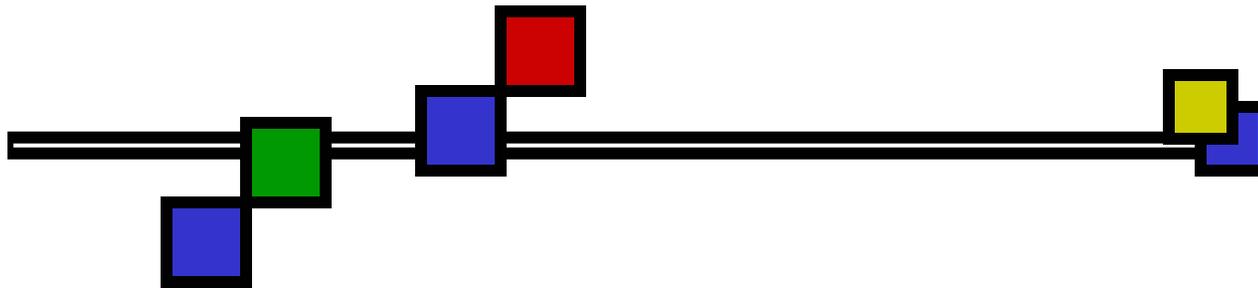


RIA SNS Synergy

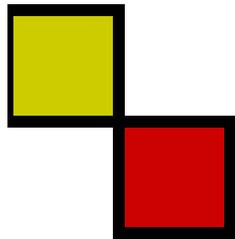


- R&D for β 0.61 and 0.81 complete but still requires R&D of β 0.49 but CM design is okay.
- Using SNS cavity and cryomodule saves time and reduces overall risk to the project.
- There are some net savings in cost by off setting R&D and potentially cryomodule components, like cavities and cryostat components.
- See attached spreadsheet for RIA costs.



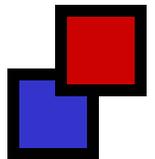


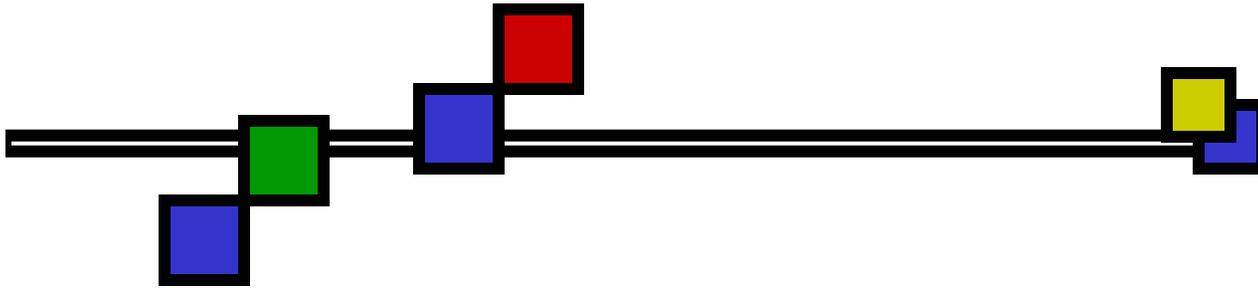
RIA High Beta Costs FY01



Production

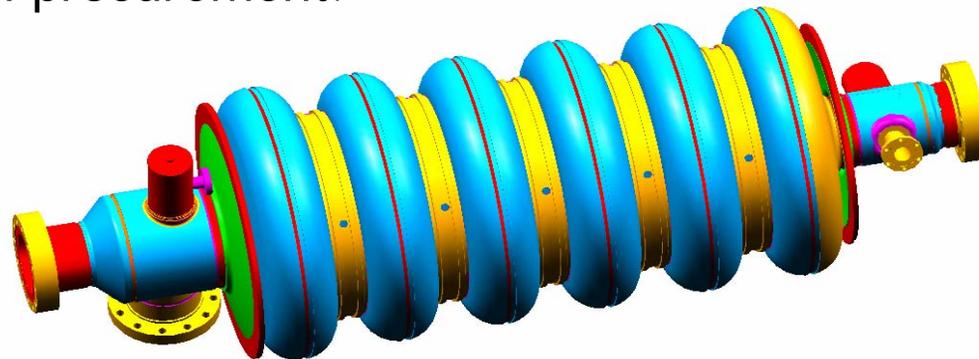
beta	Cost/CM K\$	#CM	Total Cost K\$	Design Cost K\$	Total K\$
0.49	1147.9	19	21810.1	964.4	22774.5
0.61	1174.5	21	24664.5	964.4	25628.9
0.81	1205.3	7	8437.1	964.4	9401.5
		47			57804.9

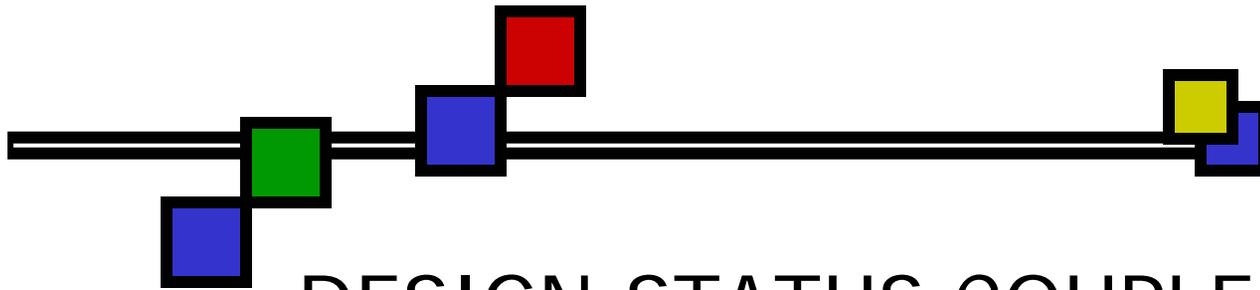




DESIGN STATUS CAVITIES

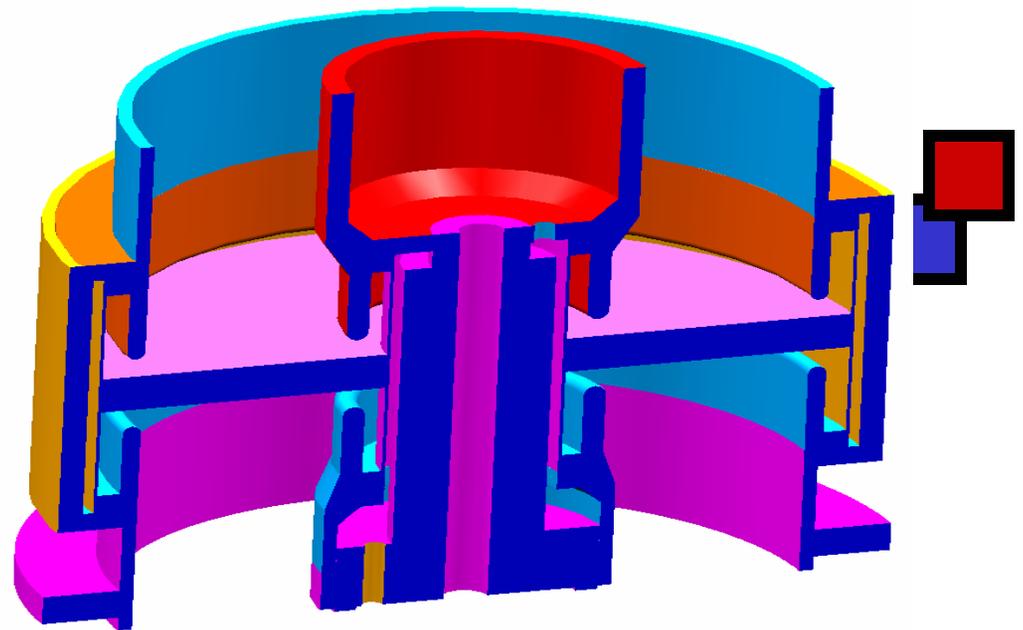
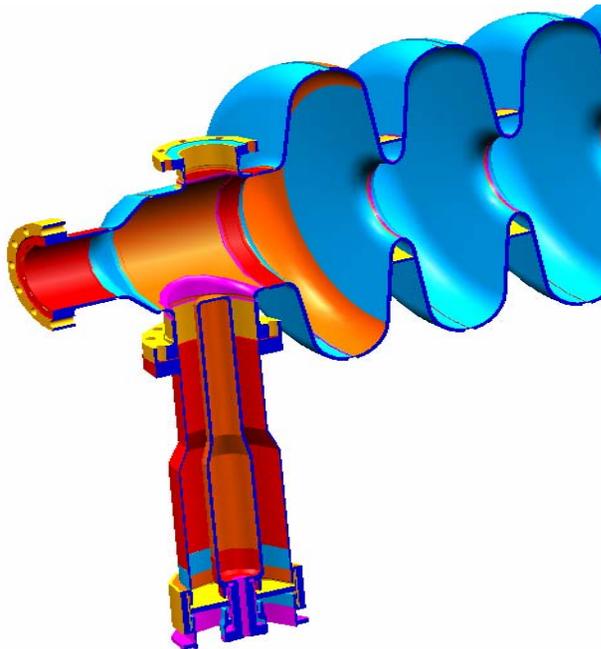
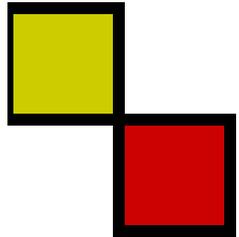
- Cavity design is complete. Drawings and specification are complete. Final Design Review is complete. Prototype cavities are manufactured and tested. Niobium and NbTi is on order. RFQ for 0.61 and 0.81 cavities are in procurement.



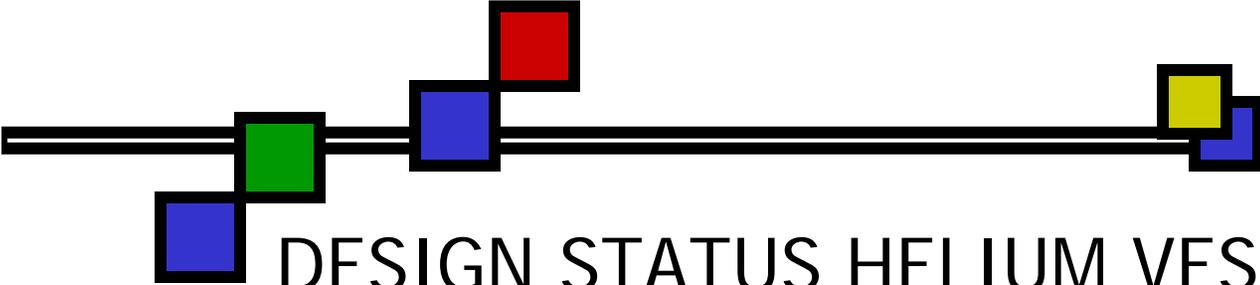


DESIGN STATUS COUPLERS

- Prototypical Coupler design is complete. Drawings for prototype are complete. Prototype parts are being manufactured for first articles. Has undergone Design Reviews in Aug. and Dec.

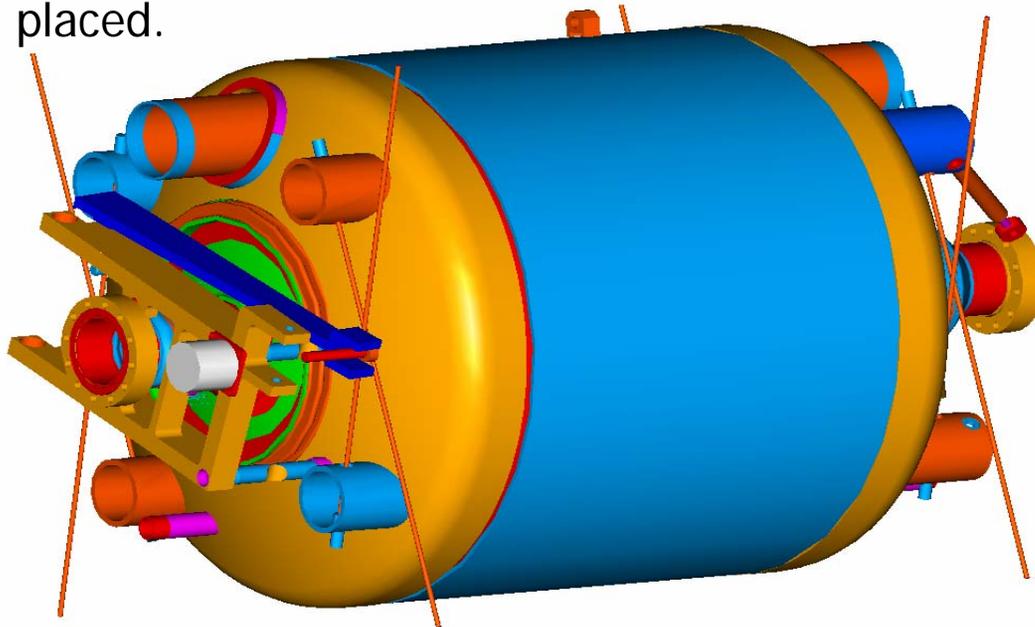


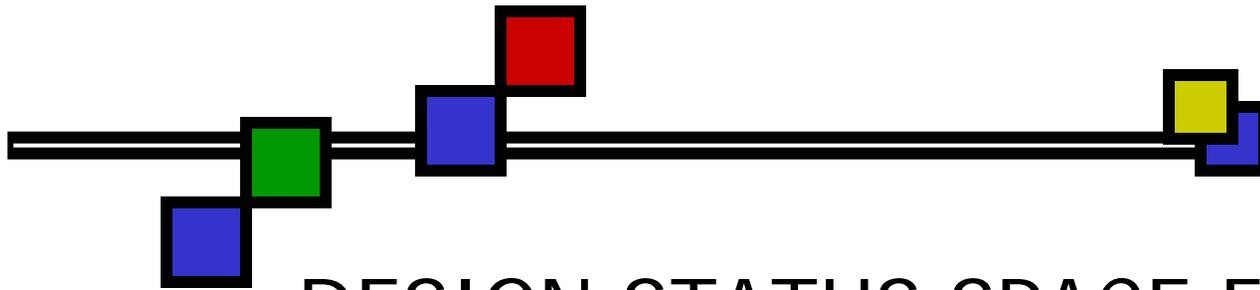
10



DESIGN STATUS HELIUM VESSEL & TUNER

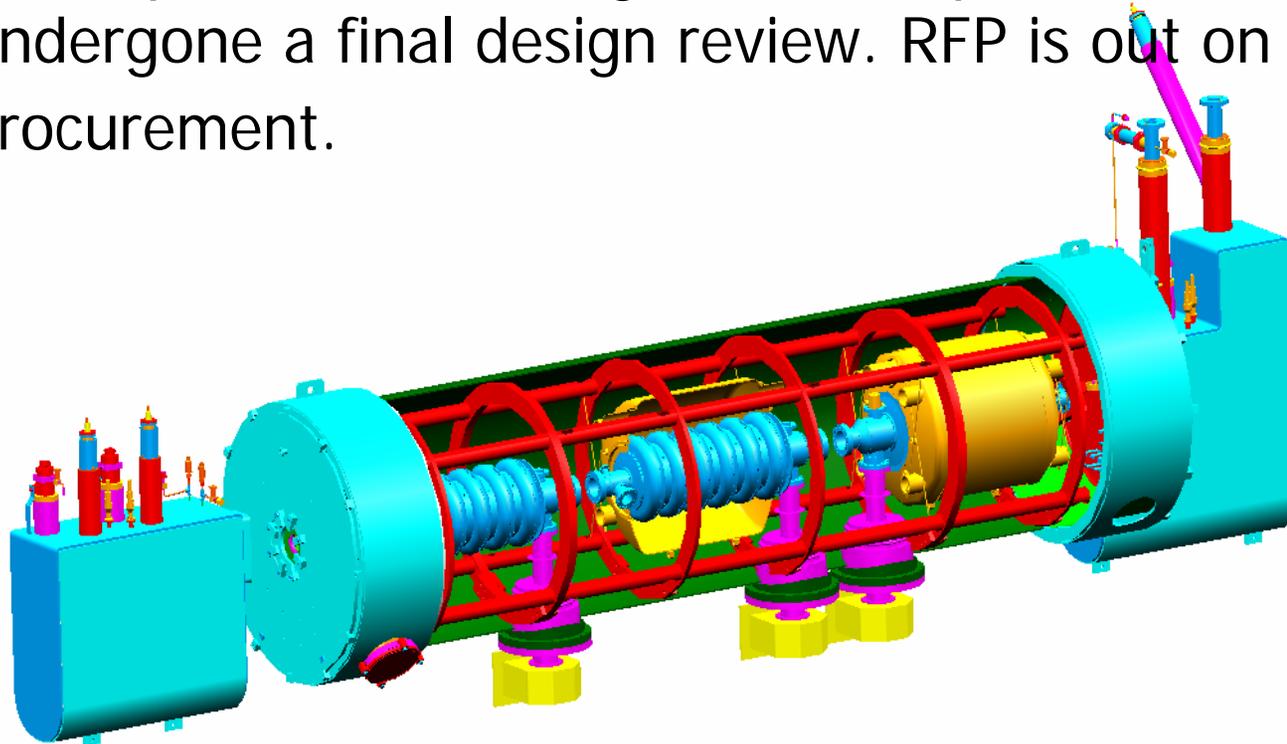
- Helium vessel and tuner designs are complete. Vessel and tuner drawings and specifications for both medium and high beta cavities are complete. Final Design Reviews complete for both. Bids received for the tuners and helium vessel order placed.

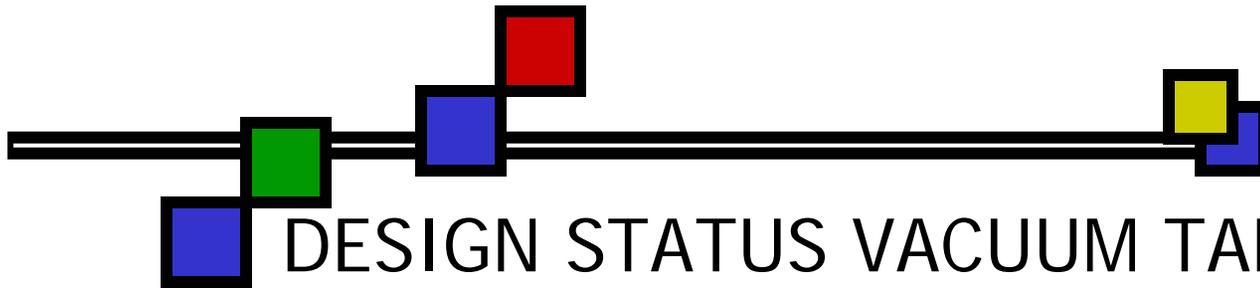




DESIGN STATUS SPACE FRAME

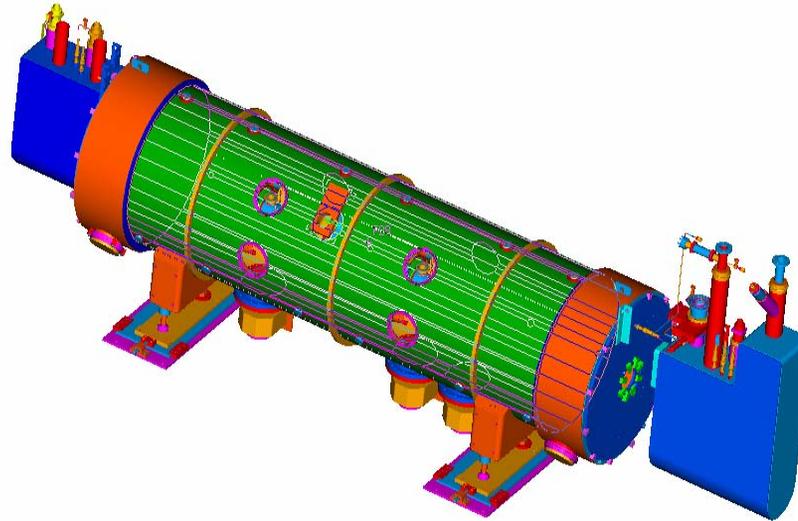
- Both Space Frame designs are complete. Has undergone a final design review. RFP is out on procurement.





DESIGN STATUS VACUUM TANK & STANDS

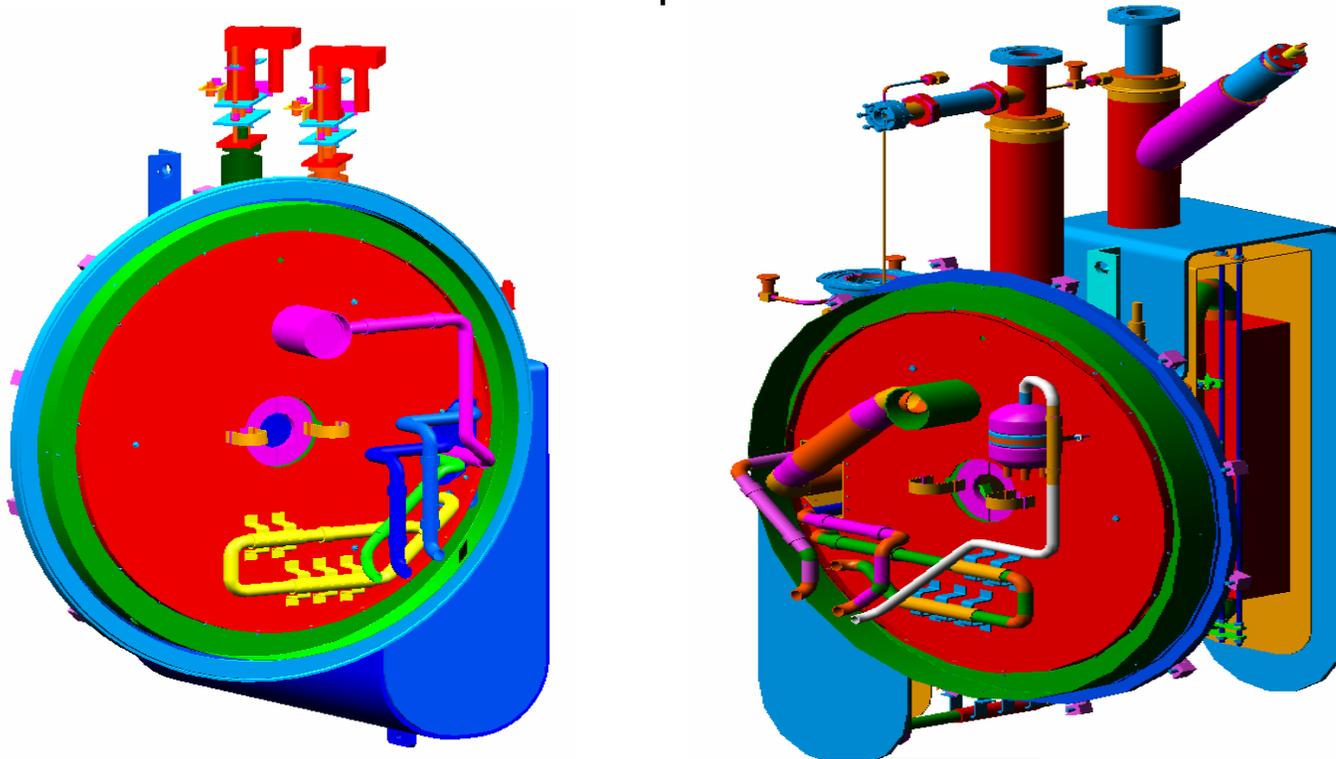
- Both Vacuum Tank and Stand designs are complete. Detail drawings and specifications for both are nearing completion. Has undergone a final design review. RFP to go out this month for vacuum tanks.



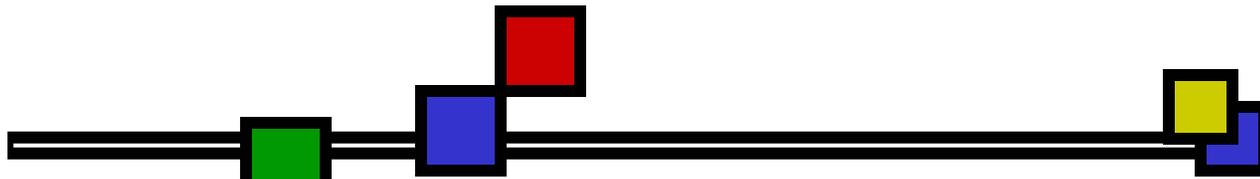


DESIGN STATUS END CANS

- Supply and Return End Can design is complete. Drawings and Specifications are complete. Final Design Review complete. RFP is under review. Order to be placed this month.

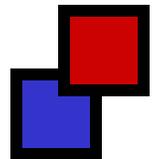
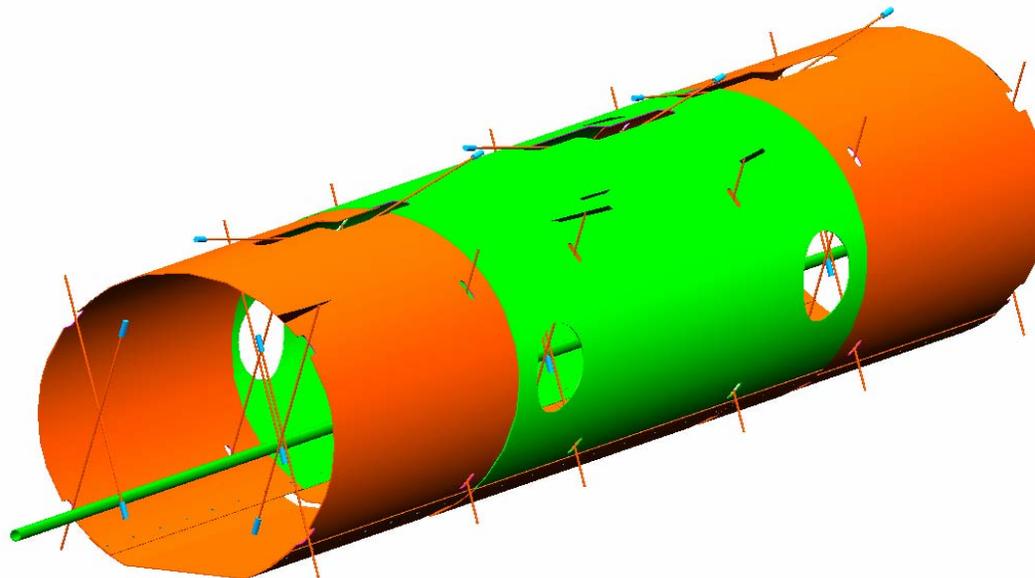
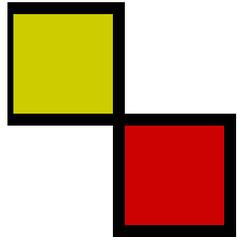


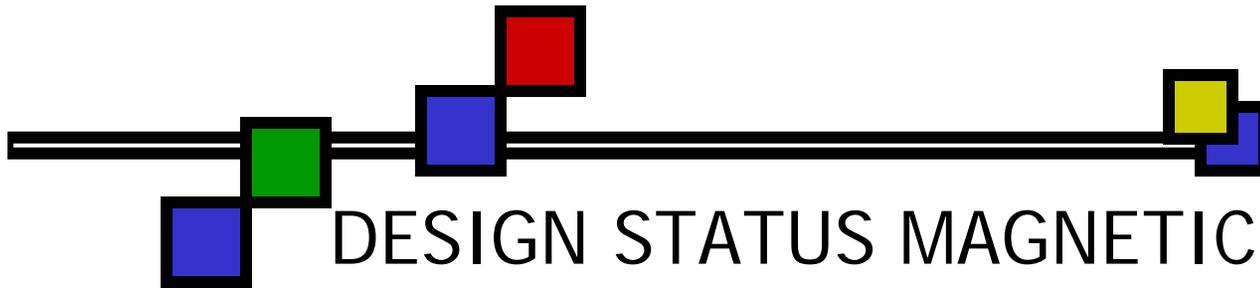
14



DESIGN STATUS THERMAL SHIELD

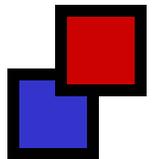
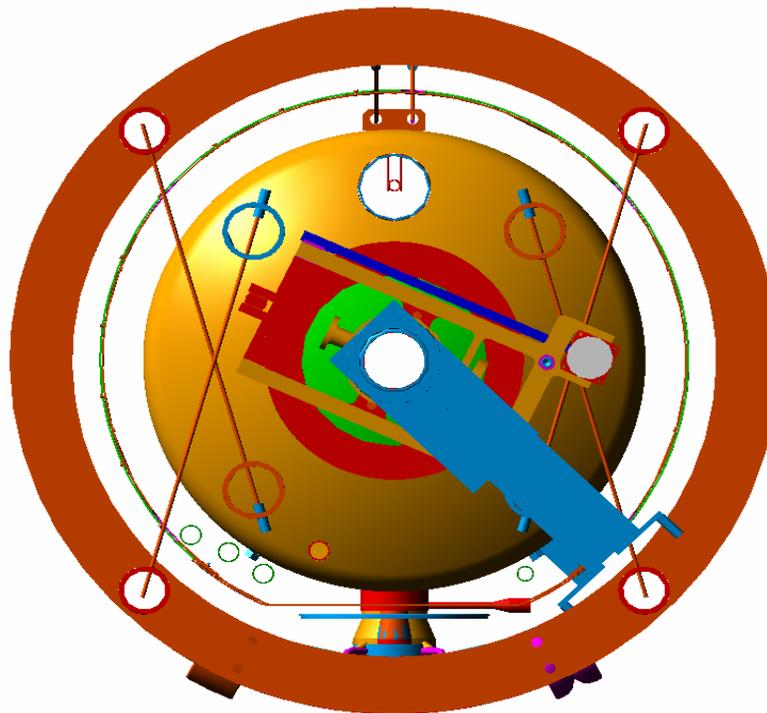
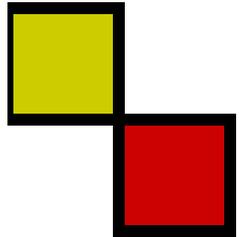
- Both Thermal Shield designs are complete. Detail drawings and specifications for both are nearing completion. Has undergone a final design review. RFP is underway.

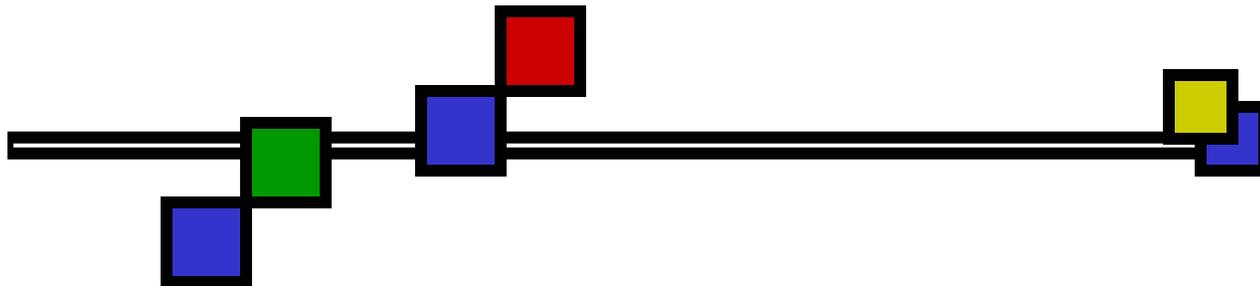




DESIGN STATUS MAGNETIC SHIELDS

- Both Magnetic Shield designs are complete. Detail drawings and specifications for both are complete. Shield has undergone a final design review. RFP out this month.





β 0.49

DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost	# Fab Cost	Fab Cost	Tot Cost	# RProd Cost	
					Prodt'n	seProduction	Production	Production	per per	CM
1000	400	\$81,522	\$32,609	\$114,130	\$45,000	1	\$45,000	\$45,000	4	\$180,000
150	60	\$12,228	\$4,891	\$17,120	\$18,860	1	\$18,860	\$18,860	4	\$75,440
100	40	\$8,152	\$3,261	\$11,413	\$17,000	1	\$17,000	\$17,000	4	\$68,000
50	20	\$4,076	\$1,630	\$5,707	\$2,000	1	\$2,000	\$2,000	4	\$8,000
					\$7,000	2	\$7,000	\$14,000	4	\$56,000
330	132	\$26,902	\$10,761	\$37,663	\$7,000	1	\$7,000	\$7,000	4	\$28,000
100	40	\$8,152	\$3,261	\$11,413	\$2,500	1	\$2,500	\$2,500	4	\$10,000
50	20	\$4,076	\$1,630	\$5,707	\$400	4	\$400	\$1,600	4	\$6,400
500	200	\$40,761	\$16,304	\$57,065	\$7,000	1	\$7,000	\$7,000	4	\$28,000
50	20	\$4,076	\$1,630	\$5,707	\$3,200	1	\$3,200	\$3,200	4	\$12,800
100	40	\$8,152	\$3,261	\$11,413	\$2,500	1	\$2,500	\$2,500	4	\$10,000
450	180	\$36,685	\$14,674	\$51,359	\$8,400	1	\$8,400	\$8,400	4	\$33,600
100	40	\$8,152	\$3,261	\$11,413	\$1,000	1	\$1,000	\$1,000	4	\$4,000
560	224	\$45,652	\$18,261	\$63,913	\$10,000	1	\$10,000	\$10,000	4	\$40,000
560	224	\$45,652	\$18,261	\$63,913	\$10,000	1	\$10,000	\$10,000	4	\$40,000
2000	800	\$163,043	\$65,217	\$228,261	\$90,000	1	\$90,000	\$90,000	1	\$90,000
350	140	\$28,533	\$11,413	\$39,946	\$10,000	1	\$10,000	\$10,000	1	\$10,000
400	160	\$32,609	\$13,043	\$45,652	\$6,000	2	\$6,000	\$12,000	1	\$12,000
50	20	\$4,076	\$1,630	\$5,707	\$1,500	2	\$1,500	\$3,000	1	\$3,000
50	20	\$4,076	\$1,630	\$5,707	\$1,200	2	\$1,200	\$2,400	1	\$2,400
120	48	\$9,783	\$3,913	\$13,696	\$1,300	1	\$1,300	\$1,300	1	\$1,300
20	8	\$1,630	\$652	\$2,283	\$2,300	2	\$2,300	\$4,600	1	\$4,600
20	8	\$1,630	\$652	\$2,283	\$2,500	3	\$2,500	\$7,500	1	\$7,500
20	8	\$1,630	\$652	\$2,283	\$3,000	2	\$3,000	\$6,000	1	\$6,000
20	8	\$1,630	\$652	\$2,283	\$2,200	2	\$2,200	\$4,400	1	\$4,400
200	80	\$16,304	\$6,522	\$22,826	\$90,000	1	\$90,000	\$90,000	4	\$360,000
					\$15,000	1	\$15,000	\$15,000	1	\$15,000
1000	400	\$81,522	\$32,609	\$114,130	\$25,000	1	\$25,000	\$25,000	1	\$25,000
100	40	\$8,152	\$3,261	\$11,413	\$6,500	1	\$6,500	\$6,500	1	\$6,500
5	2									\$598,500
8450	3380	\$688,859	\$275,543	\$964,402	\$398,360	1	\$398,360	\$427,760	1	\$1,147,940
DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost	NumFab Cost	Fab Cost	Tot Cost	NumCost	TOTALS
					Production	ReProduction	per CU	per CU	Reqper	CM

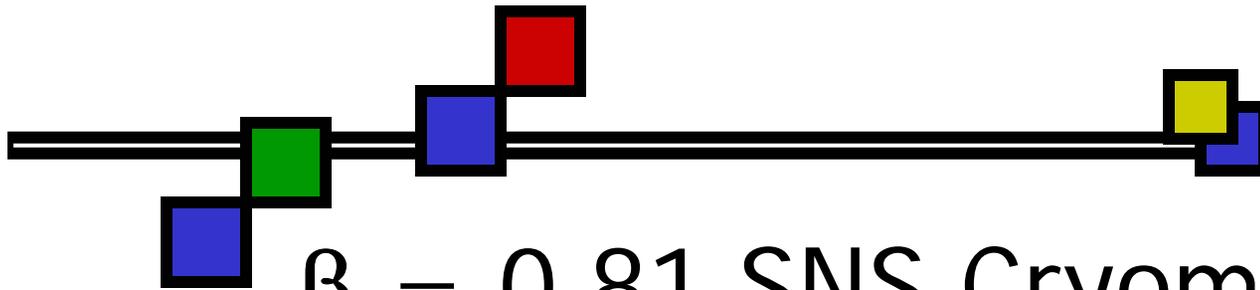
CAVITY
 Cavities
 Niobium
 Coupler Assy
 Misc Cavity 1
 HOM Assy
 \$7,361,360
 HV ASS'Y
 He Vessel
 Wiring
 Fd Thrus
 \$843,600
 SPACE FRAME
 Tuners
 Headers S&R
 Magntic Shd
 Thermal Shie:
 Seals/Misc Hc
 Space Frame
 \$2,439,600
 CRYOMODULE
 Vacuum Tk
 End Cans
 Heat Exchang:
 Stands
 \$2,888,000
 VACUUM
 Pumpdrops
 Connections
 Girders
 Slow Valves
 Coupler Inst
 40 l/s Pumps
 4" Vac Valve:
 \$554,800
 INTERFACE
 Assembly
 Installation
 \$7,125,000
 ELECTRICAL
 Interlocks
 Instrumentat:
 \$598,500
 TOTAL
 \$21,810,860

β 0.61

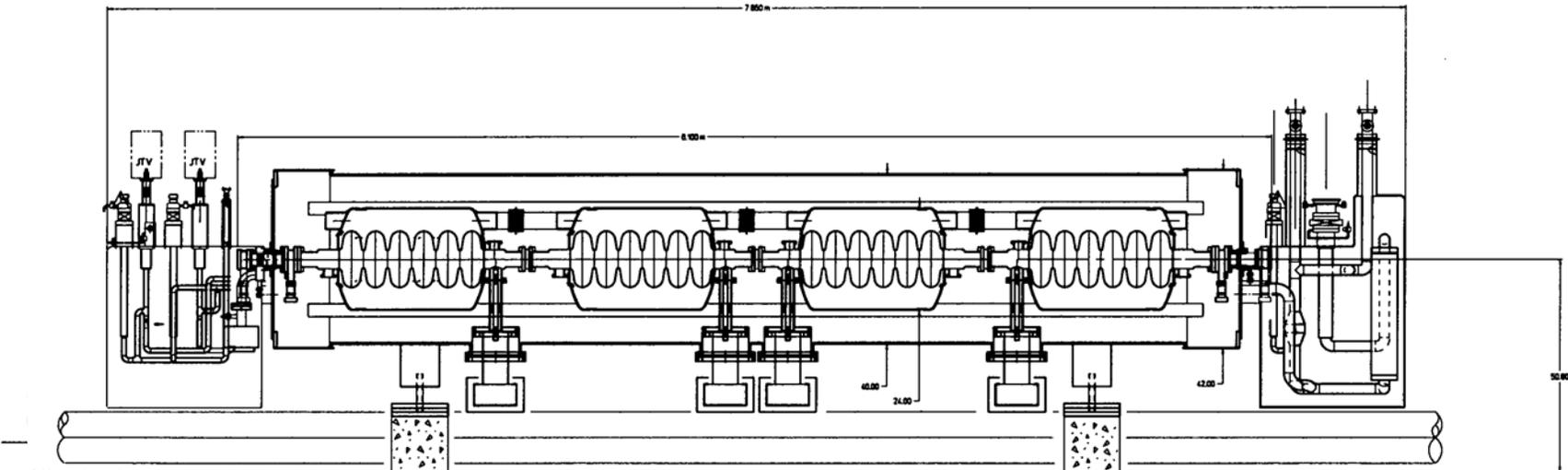
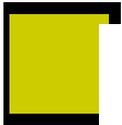
DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod'n	# Re-Production	Fab Cost Production	Tot Cost Production	# Req'd	Prod Cost per CM	
1000	400	\$81,522	\$32,609	\$114,130	\$45,000	1	\$45,000	\$45,000	4	\$180,000	CAVITY
					\$24,395	1	\$24,395	\$24,395	4	\$97,580	Cavities
150	60	\$12,228	\$4,891	\$17,120	\$17,000	1	\$17,000	\$17,000	4	\$68,000	Niobium
100	40	\$8,152	\$3,261	\$11,413	\$2,000	1	\$2,000	\$2,000	4	\$8,000	Coupler Assy
50	20	\$4,076	\$1,630	\$5,707	\$7,000	2	\$7,000	\$14,000	4	\$56,000	Misc Cavity 1
											HOM Assy
											\$8,601,180
											HV ASS'Y
330	132	\$26,902	\$10,761	\$37,663	\$8,000	1	\$8,000	\$8,000	4	\$32,000	He Vessel
100	40	\$8,152	\$3,261	\$11,413	\$2,500	1	\$2,500	\$2,500	4	\$10,000	Wiring
50	20	\$4,076	\$1,630	\$5,707	\$400	4	\$400	\$1,600	4	\$6,400	Fd Thrus
											\$1,016,400
											SPACE FRAME
500	200	\$40,761	\$16,304	\$57,065	\$7,000	1	\$7,000	\$7,000	4	\$28,000	Tuners
50	20	\$4,076	\$1,630	\$5,707	\$3,200	1	\$3,200	\$3,200	4	\$12,800	Headers S&R
100	40	\$8,152	\$3,261	\$11,413	\$2,500	1	\$2,500	\$2,500	4	\$10,000	Magnetic Shd
450	180	\$36,685	\$14,674	\$51,359	\$8,400	1	\$8,400	\$8,400	4	\$33,600	Thermal Shie:
100	40	\$8,152	\$3,261	\$11,413	\$1,000	1	\$1,000	\$1,000	4	\$4,000	Seals/Misc Hc
560	224	\$45,652	\$18,261	\$63,913	\$10,000	1	\$10,000	\$10,000	4	\$40,000	Space Frame
											\$2,696,400
											CRYOMODULE
560	224	\$45,652	\$18,261	\$63,913	\$10,000	1	\$10,000	\$10,000	4	\$40,000	Vacuum Tk
2000	800	\$163,043	\$65,217	\$228,261	\$90,000	1	\$90,000	\$90,000	1	\$90,000	End Cans
350	140	\$28,533	\$11,413	\$39,946	\$10,000	1	\$10,000	\$10,000	1	\$10,000	Heat Exchange
400	160	\$32,609	\$13,043	\$45,652	\$6,000	2	\$6,000	\$12,000	1	\$12,000	Stands
											\$3,192,000
											VACUUM
50	20	\$4,076	\$1,630	\$5,707	\$1,500	2	\$1,500	\$3,000	1	\$3,000	Pumpdrops
50	20	\$4,076	\$1,630	\$5,707	\$1,200	2	\$1,200	\$2,400	1	\$2,400	Connections
120	48	\$9,783	\$3,913	\$13,696	\$1,300	1	\$1,300	\$1,300	1	\$1,300	Girders
20	8	\$1,630	\$652	\$2,283	\$2,500	2	\$2,500	\$5,000	1	\$5,000	Slow Valves
20	8	\$1,630	\$652	\$2,283	\$2,500	3	\$2,500	\$7,500	1	\$7,500	coupler inst:
20	8	\$1,630	\$652	\$2,283	\$3,000	2	\$3,000	\$6,000	1	\$6,000	40 l/s Pumps
20	8	\$1,630	\$652	\$2,283	\$2,200	2	\$2,200	\$4,400	1	\$4,400	4" Vac Valve:
											\$621,600
											INTERFACE
200	80	\$16,304	\$6,522	\$22,826	\$90,000	1	\$90,000	\$90,000	4	\$360,000	Assembly
					\$15,000	1	\$15,000	\$15,000	1	\$15,000	Installation
											\$7,875,000
											ELECTRICAL
1000	400	\$81,522	\$32,609	\$114,130	\$25,000	1	\$25,000	\$25,000	1	\$25,000	Interlocks
100	40	\$8,152	\$3,261	\$11,413	\$6,500	1	\$6,500	\$6,500	1	\$6,500	Instrumentat:
											\$661,500
5	2										TOTAL
8450	3380	\$688,859	\$275,543	\$964,402	\$405,095	1	\$405,095	\$434,695	1	\$1,174,480	\$24,664,080
DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Production	Nu Re-Production	Fab Cost Production	Tot Cost per CU	Numbe Req'd	Cost per CM	TOTALS

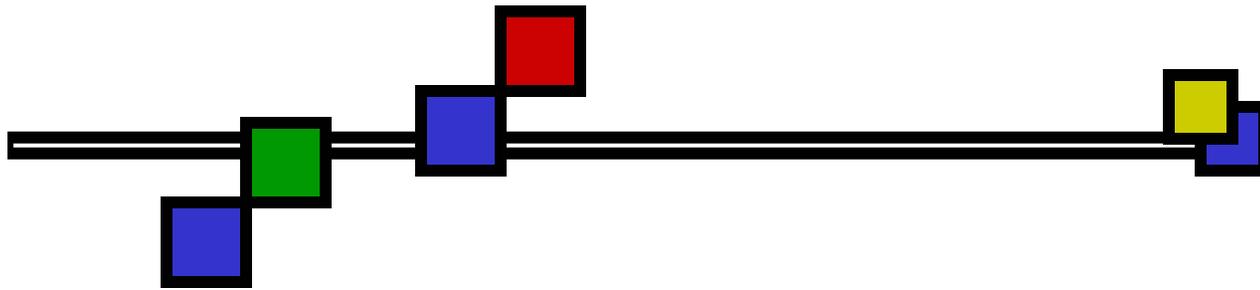
β 0.81

DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Prod't'n	# R sec	Fab Cost Production	Tot Cost Production	# Req per Cper	Prod Cost CM	
											CAVITY
1000	400	\$81,522	\$32,609	\$114,130	\$45,000	1	\$45,000	\$45,000	4	\$180,000	Cavities
150	60	\$12,228	\$4,891	\$17,120	\$29,520	1	\$29,520	\$29,520	4	\$118,080	Niobium
100	40	\$8,152	\$3,261	\$11,413	\$17,000	1	\$17,000	\$17,000	4	\$68,000	Coupler Assy
50	20	\$4,076	\$1,630	\$5,707	\$2,000	1	\$2,000	\$2,000	4	\$8,000	Misc Cavity Pt
					\$7,000	2	\$7,000	\$14,000	4	\$56,000	HOM Assy
											\$3,010,560
											HV ASS'Y
330	132	\$26,902	\$10,761	\$37,663	\$9,000	1	\$9,000	\$9,000	4	\$36,000	He Vessel
100	40	\$8,152	\$3,261	\$11,413	\$2,500	1	\$2,500	\$2,500	4	\$10,000	Wiring
50	20	\$4,076	\$1,630	\$5,707	\$400	4	\$400	\$1,600	8	\$12,800	Fd Thrus
											\$411,600
											SPACE FRAME
500	200	\$40,761	\$16,304	\$57,065	\$7,000	1	\$7,000	\$7,000	4	\$28,000	Tuners
50	20	\$4,076	\$1,630	\$5,707	\$3,200	1	\$3,200	\$3,200	4	\$12,800	Headers S&R
100	40	\$8,152	\$3,261	\$11,413	\$2,500	1	\$2,500	\$2,500	4	\$10,000	Magntic Shd
450	180	\$36,685	\$14,674	\$51,359	\$8,400	1	\$8,400	\$8,400	4	\$33,600	Thermal Shield
100	40	\$8,152	\$3,261	\$11,413	\$1,000	1	\$1,000	\$1,000	4	\$4,000	Seals/Misc Hdw
560	224	\$45,652	\$18,261	\$63,913	\$10,000	1	\$10,000	\$10,000	4	\$40,000	Space Frame
											\$898,800
											CRYMODULE
560	224	\$45,652	\$18,261	\$63,913	\$10,000	1	\$10,000	\$10,000	4	\$40,000	Vacuum Tk
2000	800	\$163,043	\$65,217	\$228,261	\$90,000	1	\$90,000	\$90,000	1	\$90,000	End Cans
350	140	\$28,533	\$11,413	\$39,946	\$10,000	1	\$10,000	\$10,000	1	\$10,000	heat exchanger
400	160	\$32,609	\$13,043	\$45,652	\$6,000	2	\$6,000	\$12,000	1	\$12,000	Stands
											\$1,064,000
											VACUUM
50	20	\$4,076	\$1,630	\$5,707	\$1,500	2	\$1,500	\$3,000	1	\$3,000	Pumpdrops
50	20	\$4,076	\$1,630	\$5,707	\$1,200	2	\$1,200	\$2,400	1	\$2,400	Connections
120	48	\$9,783	\$3,913	\$13,696	\$1,300	1	\$1,300	\$1,300	1	\$1,300	Girders
20	8	\$1,630	\$652	\$2,283	\$2,300	2	\$2,300	\$4,600	1	\$4,600	Slow Valves
20	8	\$1,630	\$652	\$2,283	\$2,500	4	\$2,500	\$10,000	1	\$10,000	coupler instr
20	8	\$1,630	\$652	\$2,283	\$3,000	2	\$3,000	\$6,000	1	\$6,000	40 l/s Pumps
20	8	\$1,630	\$652	\$2,283	\$2,200	1	\$2,200	\$2,200	1	\$2,200	4" Vac Valves
											\$206,500
											INTERFACE
200	80	\$16,304	\$6,522	\$22,826	\$90,000	1	\$90,000	\$90,000	4	\$360,000	Assembly
					\$15,000	1	\$15,000	\$15,000	1	\$15,000	Installation
											\$2,625,000
											ELECTRICAL
1000	400	\$81,522	\$32,609	\$114,130	\$25,000	1	\$25,000	\$25,000	1	\$25,000	Interlocks
100	40	\$8,152	\$3,261	\$11,413	\$6,500	1	\$6,500	\$6,500	1	\$6,500	Instrumentatio
											\$220,500
5	2										TOTAL
8450	3380	\$688,859	\$275,543	\$964,402	\$411,020	1	\$411,020	\$440,720	1	\$1,205,280	\$8,436,960
DESMHRS	ENGMHRS	Des Cost	Eng Cost	D/E Cost	Fab Cost Production	NumFab Req	Fab Cost Production	Tot Cost per CU	Numbe Req'd	Cost per CM	TOTALS

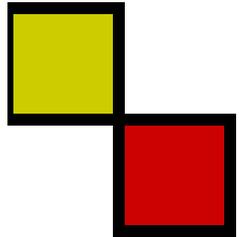


$\beta = 0.81$ SNS Cryomodule

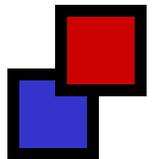


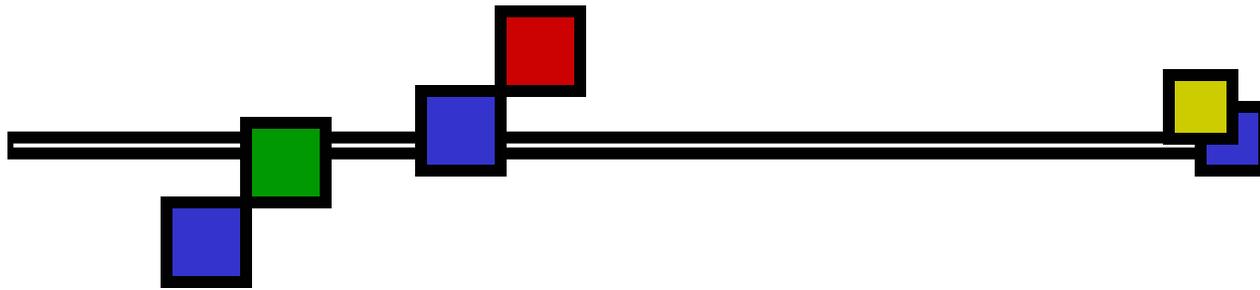


Refrigeration RIA SNS Comparison

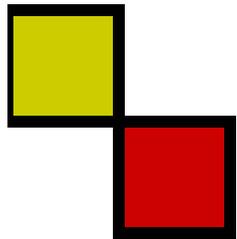


- There may be some savings ~ \$ 0.25 M such as utilizing transfer line drawings and duplicating designs and some of the ancillary equipment used on SNS.
- Refrigeration costs for RIA are approximately 50% more than SNS due to increased refrigeration loads attributable to the additional cryomodules and CW operation.





Refrigeration RIA SNS Comparison



SNS

Capacity 2400 W @ 2.1K

Liquefaction 15 g/s @ 5K

Shield 8300 W @ 50K

LN2 26000 W @ 77K

RIA

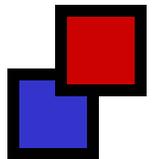
Capacity 6800 W @ 2.1K

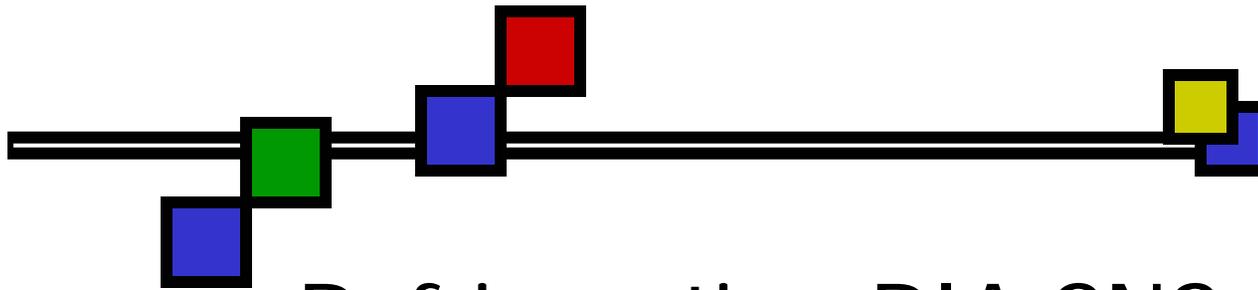
Liquefaction 25 g/s @ 5K

Capacity 3300 W @ 4K

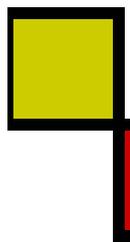
Shield 12000 W @ 50K

LN2 55000 W @ 77K





Refrigeration RIA SNS Comparison

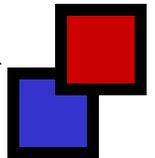


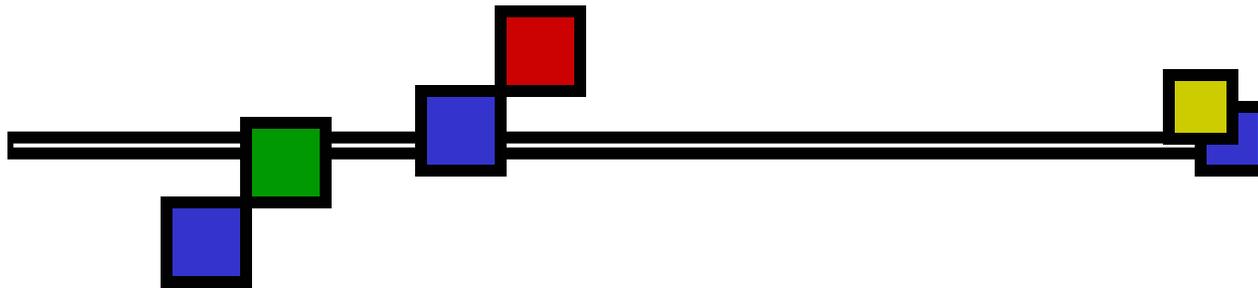
SNS

- ~210 m S&R Linac Length @ 2 K
- ~ 41 m S&R Branch Length @ 2 K

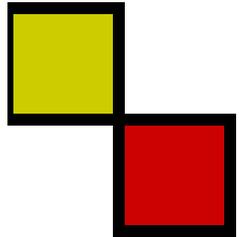
RIA

- ~ 320 m S&R Linac length @ 2 K
- ~40 m S&R Branch length @ 2 K
- ~170 m S&R Branch Length @ 4 K
- ~ 193 m S&R Linac Length @ 4 K

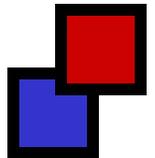


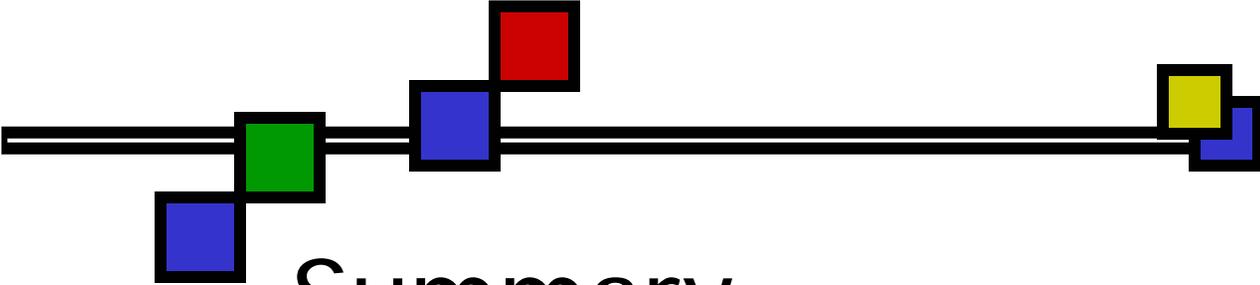


Refrigeration Cost (FY01)

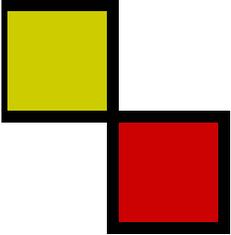


■	Cryogenics	35
1.	CHL RIA Labor	1.6
2.	Refrigerator System	22.9
3.	Controls, Refrigerator/Cryomodules	2.4
4.	Ancillary Equipment	2.8
5.	Transfer Lines, LINAC/Distribution	5.3





Summary

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- Cost of cryomodules and refrigerator are well categorized.
 - This reduces technical risk and requirement on contingency.
 - Design of cryomodules and refrigerator are nearing completion.
 - Refrigerator orders are in place and delivery is on schedule.
 - Cryomodule orders are being placed and a prototypical cryomodule is scheduled for the fall.
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