Poster ThP37

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CRYOMODULE DEVELOPMENT AT MICHIGAN STATE UNIVERSITY FOR THE RARE ISOTOPE ACCELERATOR

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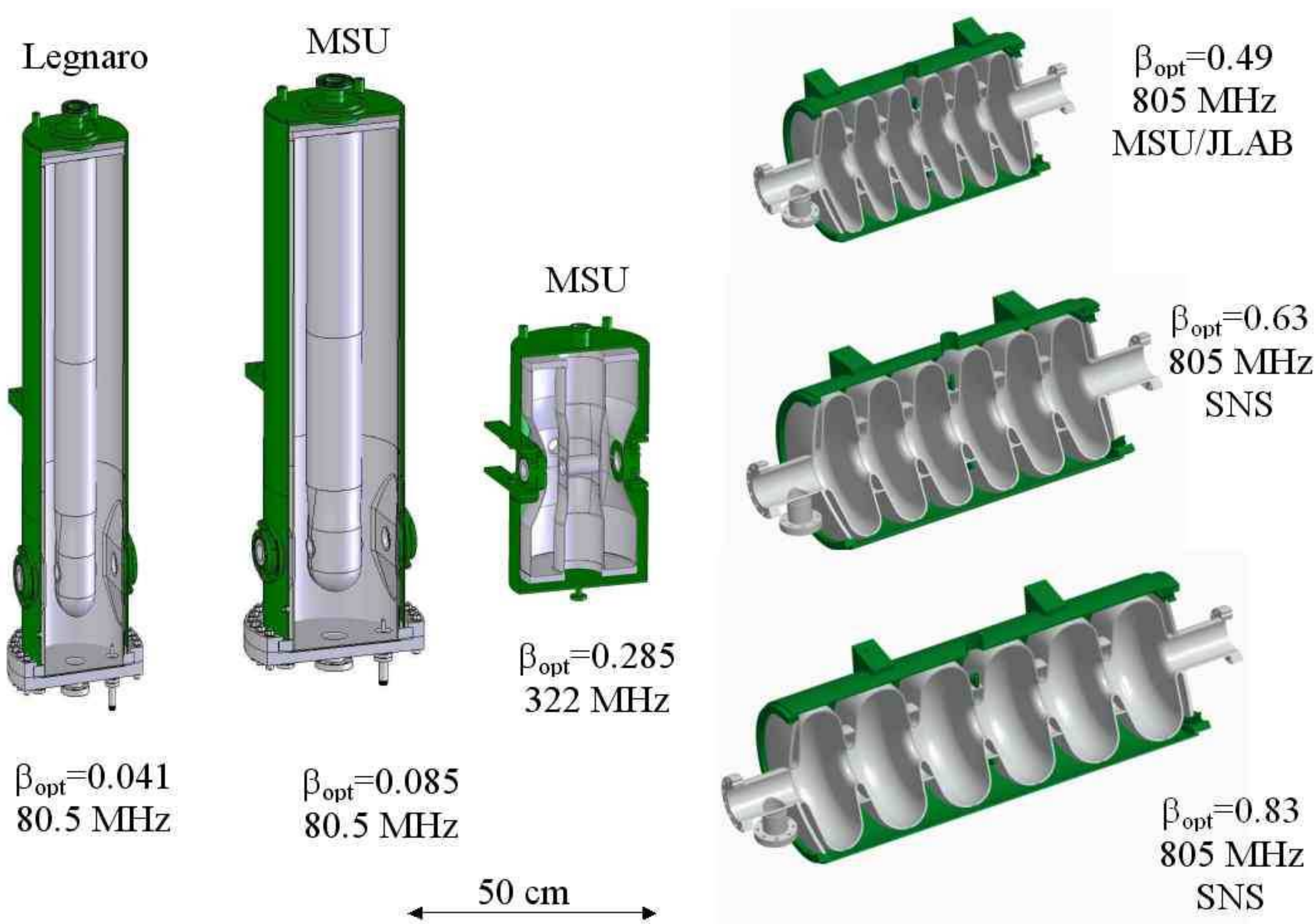
The Rare Isotope Accelerator (RIA) is being designed to supply an intense beam of exotic isotopes for nuclear physics research. Superconducting cavities are to be used to accelerate the CW beam of heavy ions to 400 MeV per nucleon, with a beam power of up to 400 kW. Because of the varying beam velocity, several types of superconducting structures are needed.

Cavity Parameters

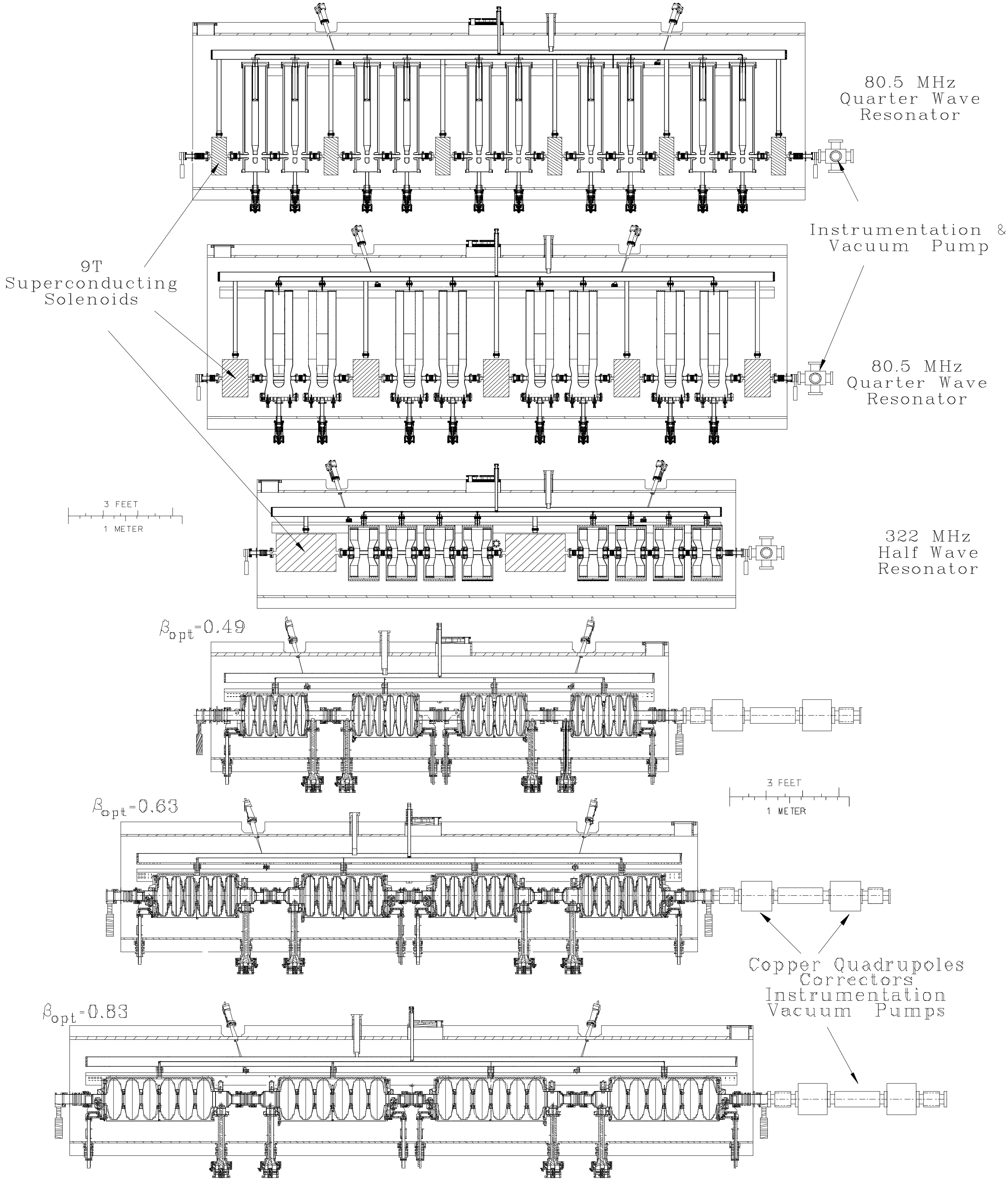
10th Harmonic Driver Linac for RIA

Type	$\lambda/4$		$\lambda/2$	6-cell elliptical		
β_{opt}	0.041	0.085	0.285	0.49	0.63	0.83
f (MHz)	80.5		322	805		
V_a (MV)	0.46	1.18	1.58	5.12	8.17	13.46
T (K)	4.5		2	2		
Q_0	$5 \cdot 10^8$		$5 \cdot 10^9$	$7 \cdot 10^9$	$1 \cdot 10^{10}$	$1.4 \cdot 10^{10}$
P_0 (W)	1.0	6.7	2.5	21.6	23.9	26.8
R/Q (Ω)	424	416	199	173	279	483
G (Ω)	15.7	19.0	61.0	136	180	260
Rs (nΩ)	31.4	38.0	12.2	19.4	18.0	18.6
E_p (MV/m)	16.5	20	25	32.5		
B_p (mT)	28.2	46.5	68.6	64.2	68.6	70.2
Aperture (mm)	30			77	86	98
Magnets	NbTi solenoids			Cu quads		
# cavities	18	104	208	68	64	32
# cryo-modules	2	13	26	17	16	8

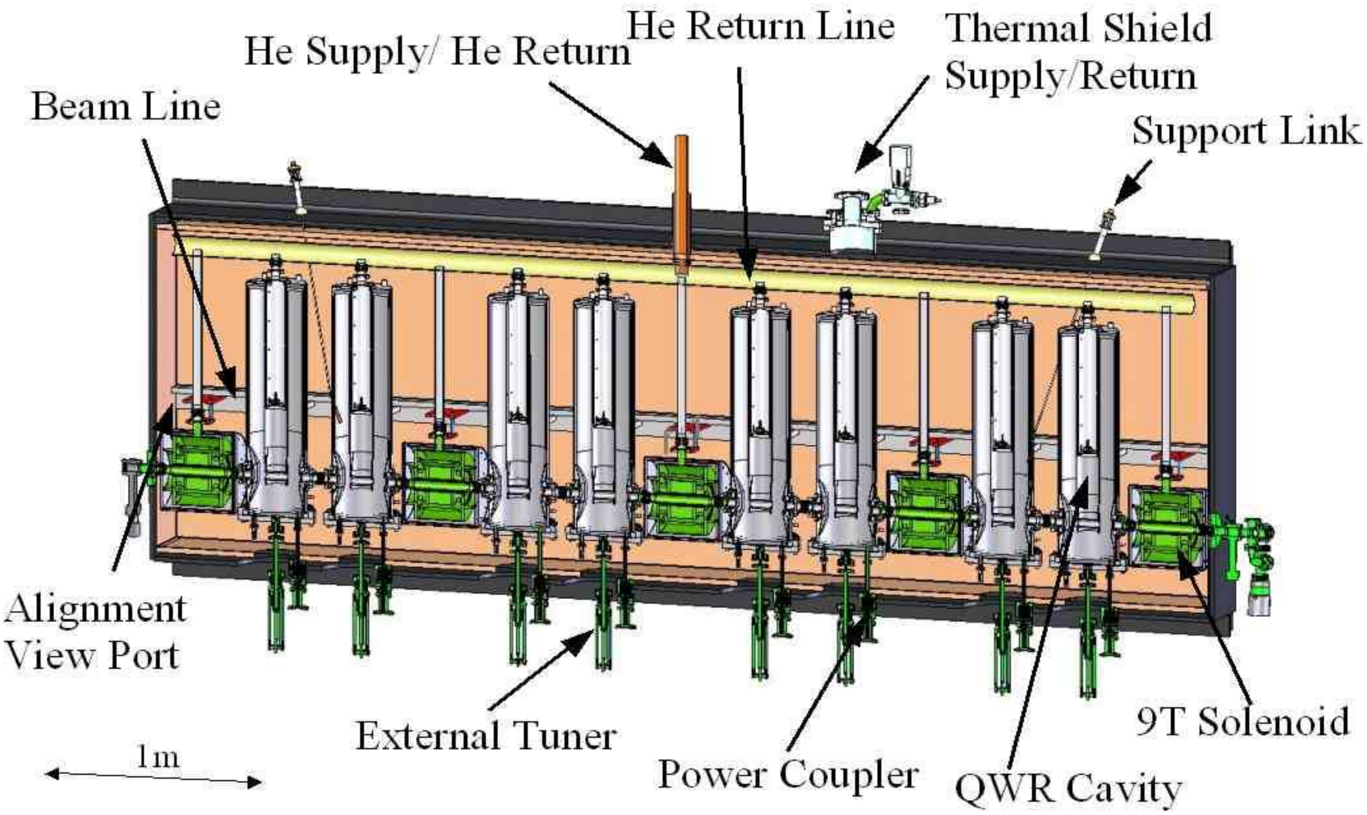


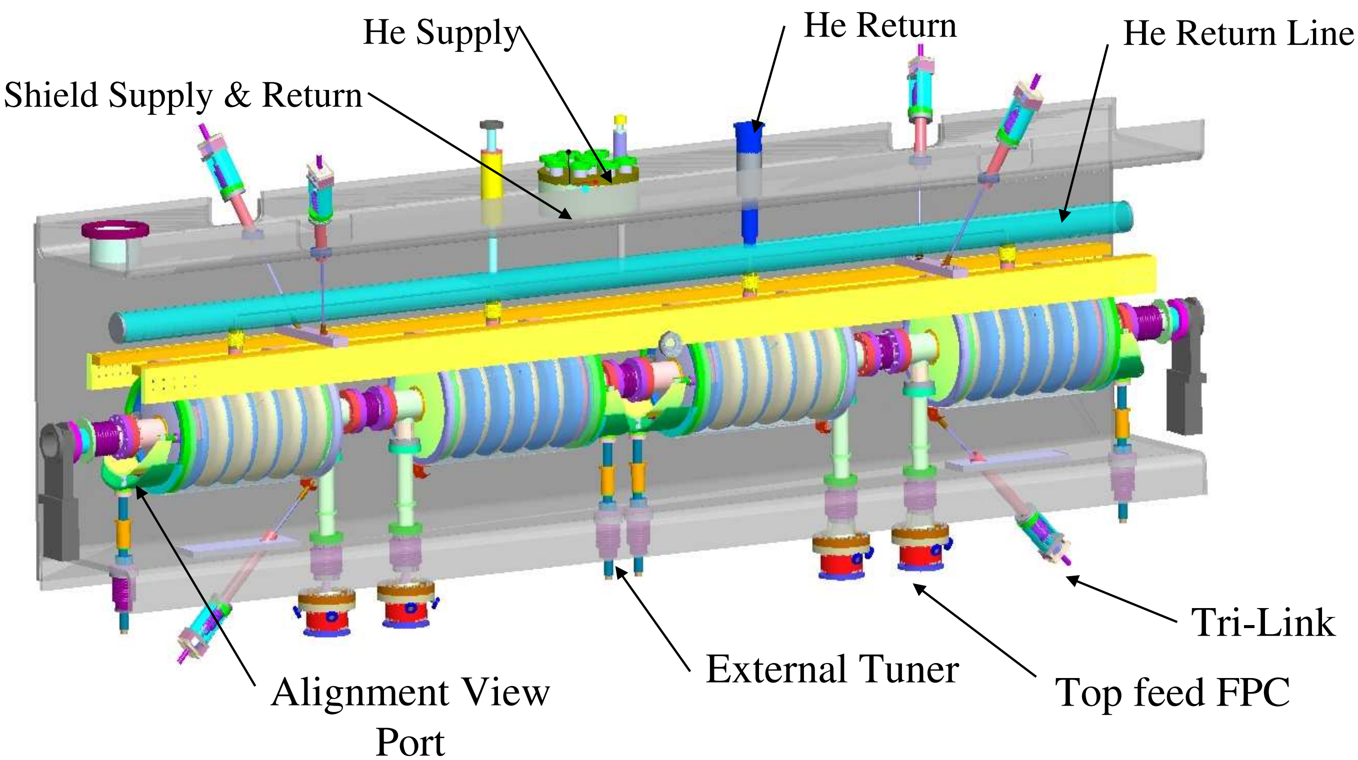
Cavities for RIA

Cavity and Cryomodule development was done in collaboration with Jefferson Lab (G. Ciovati, P. Kneisel, L. Turlington) and INFN-Legnaro (A. Facco).

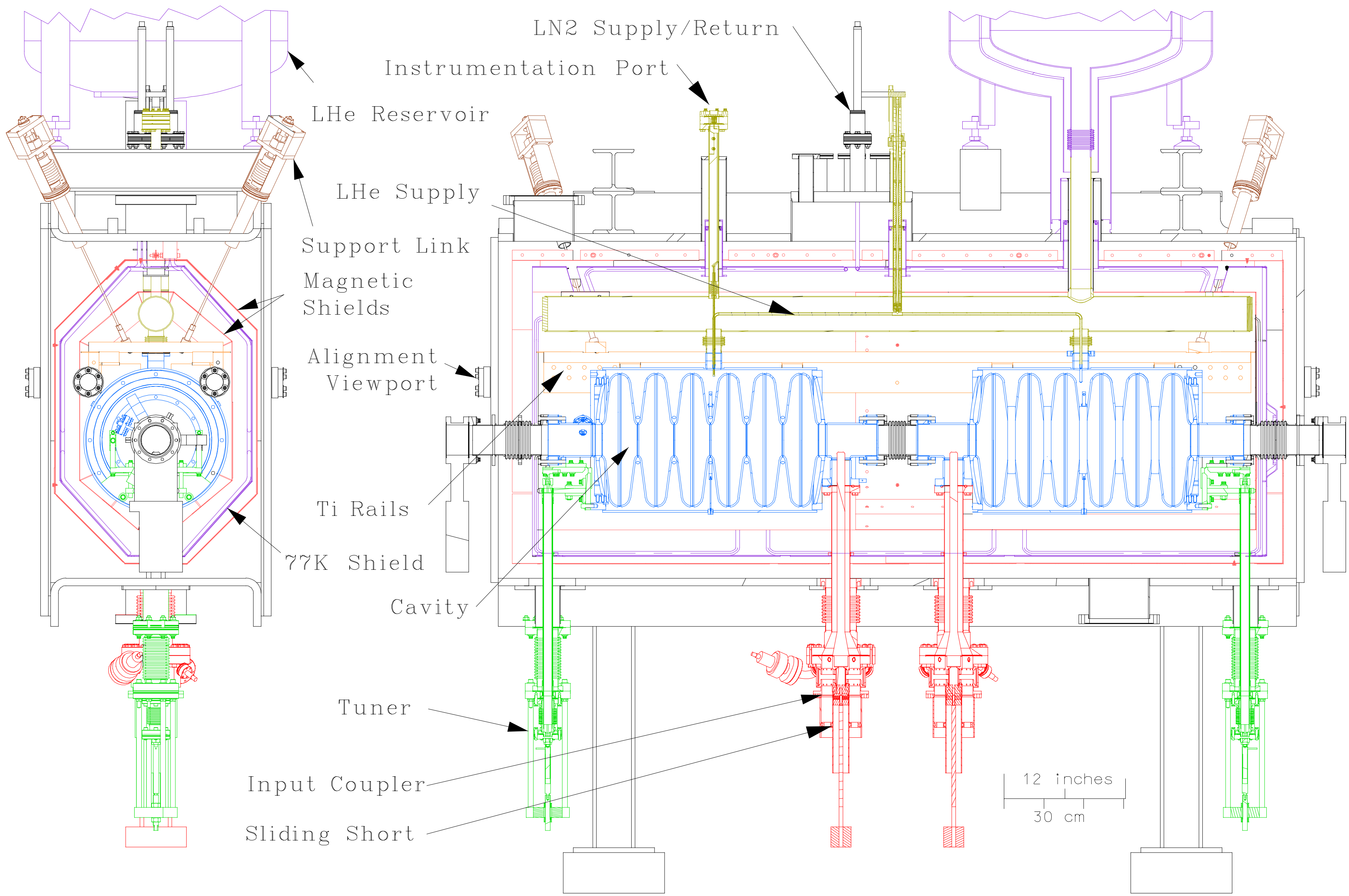


Production Cryomodules for RIA





Production Cryomodules for RIA



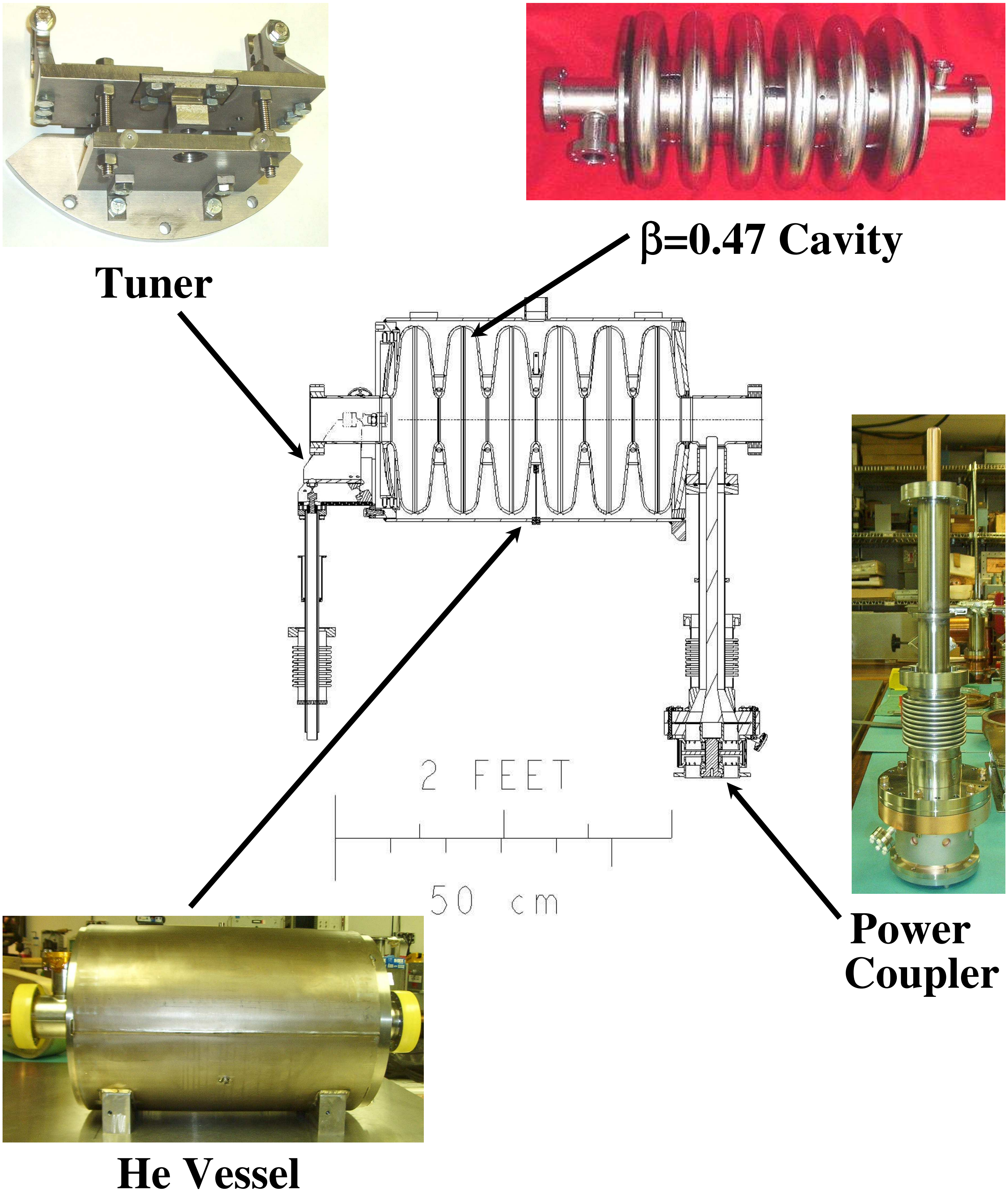
Prototype Medium-β Cryomodule

Medium-β Cryomodule Design Parameters

Item	Prototype	Production
Cavities	2	4
Length	2.1	4.0
2 K cold mass	210 kg	460 kg
Total mass	2200 kg	3600 kg
Bayonets	2	4
Support links	4	4
77 K heat load	$<$ 50 W	$<$ 100 W
2 K Heat Load		
Input coupler	1.6 W (each)	
Tuner	0.8 W (each)	
Total (RF off)	9 W	15 W
Total (RF on)	53 W	103 W

RF Input Coupler

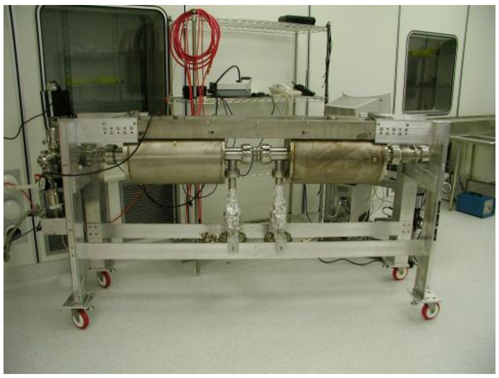
Impedance	50 Ω
Type	Planar Coax (KEK/SNS)
Cooling	conduction
Q_{ext}	$2 \cdot 10^7$
Bandwidth	40 Hz
Design power	5 kW
Max power	100 kW



Medium-β Prototype Cryomodule Components

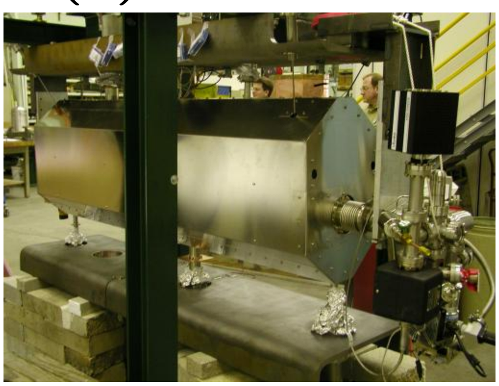
Construction of Medium-β Cryomodule

(Completed in February 2004)



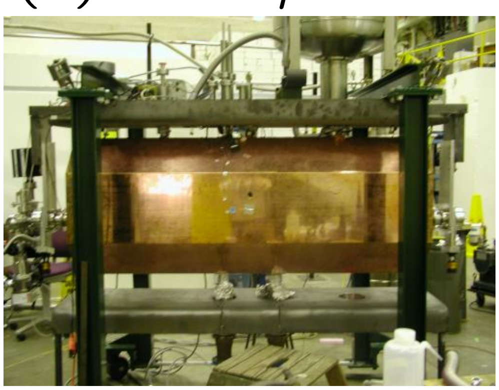
(1) Cold mass

(2) Top plate



(3) Inner μ-metal

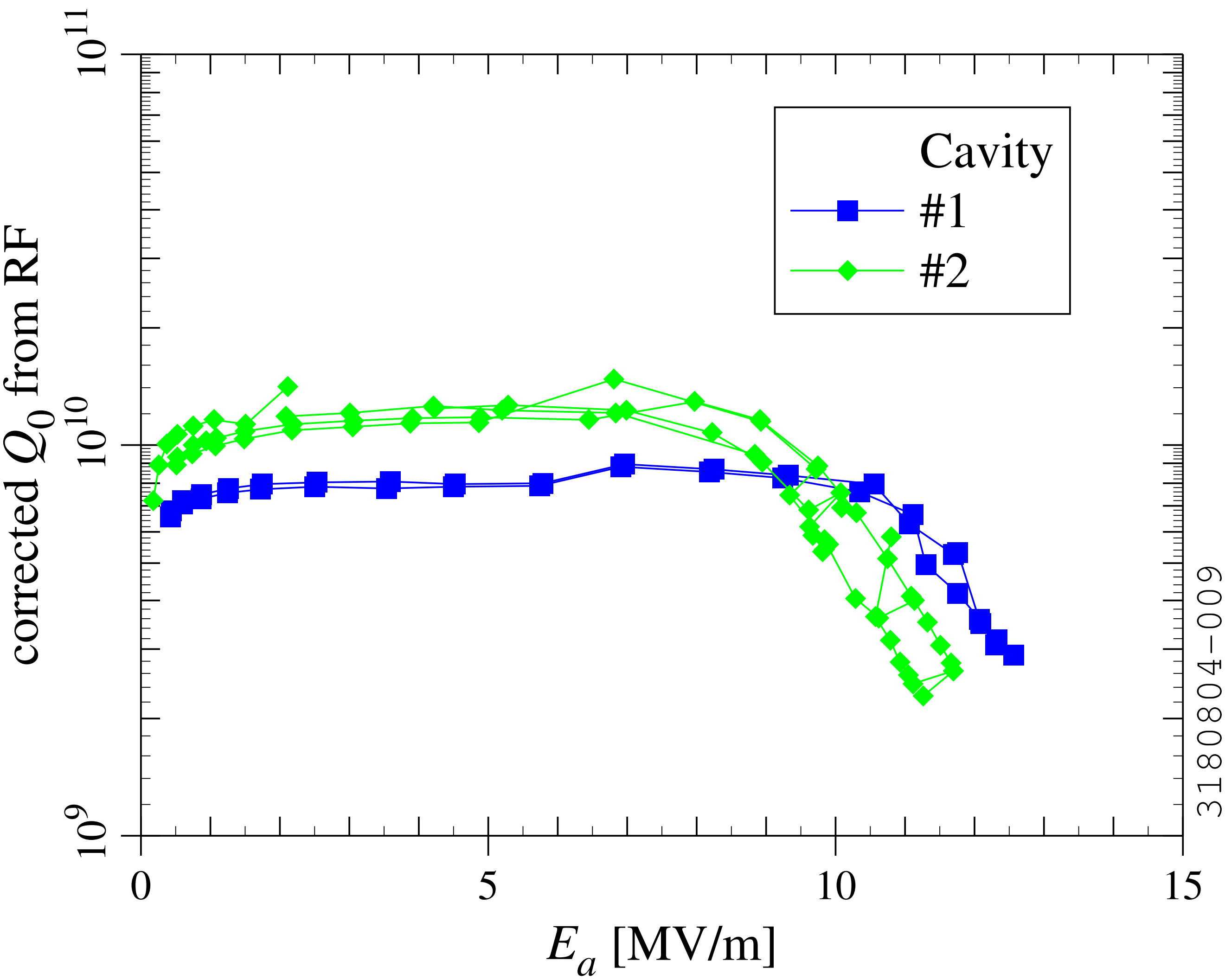
(4) Multi-layer insulation



(5) 77 K shield

(6) Completed module

Experimental Results: Medium-β Cryomodule

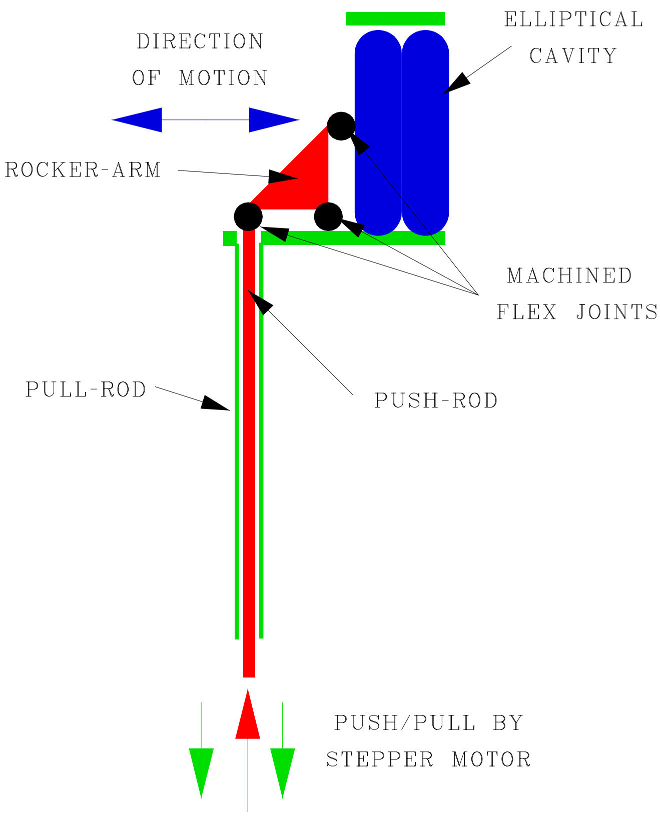


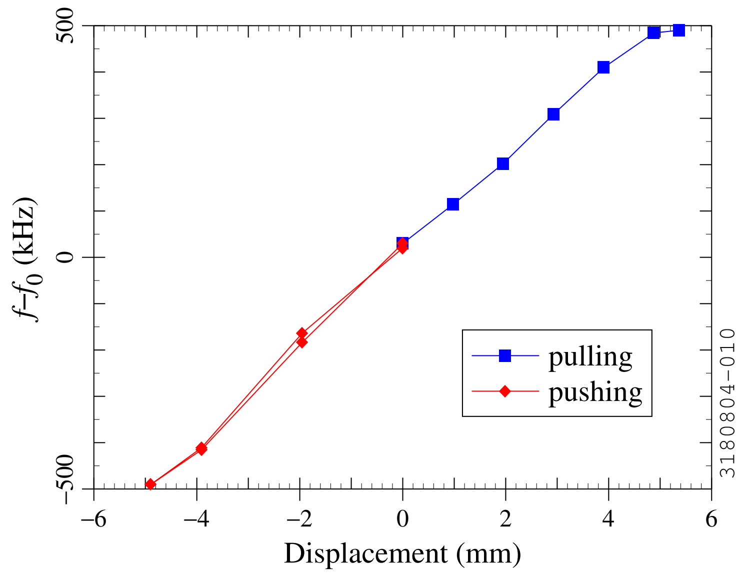
Item	Measured		Design
	Cavity #1	Cavity #2	
Fixed Q_{ext}	$1.4 \cdot 10^7$	$1.3 \cdot 10^7$	$2.0 \cdot 10^7$
Variable Q_{ext}	$6 \cdot 10^4$ to $6 \cdot 10^9$		
$\frac{df}{dP}$ (kHz/torr)	0.36	0.46	
$\frac{df}{dE_a^2}$ [Hz/(MV/m)^2]	-16		-14
Static load at 4.3 K	9 W		
Static load at 2 K	10–11 W		9 W

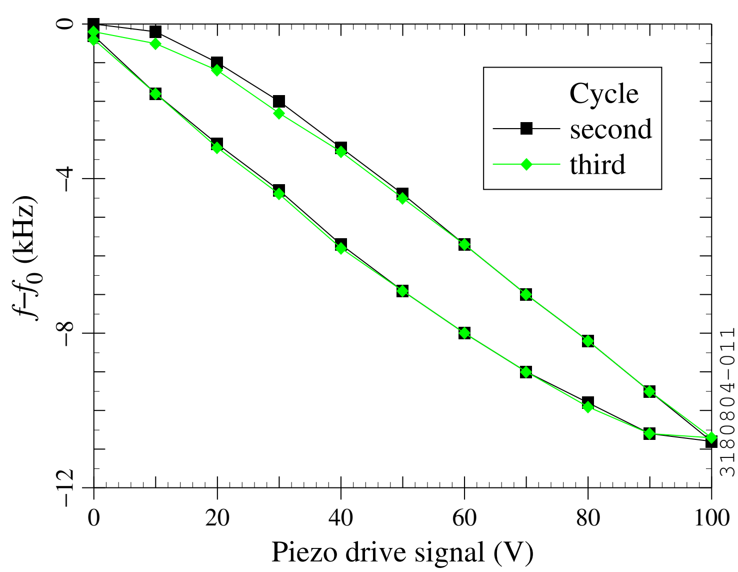
Variable Q_{ext} = standing wave in input coupler
Measured static load includes the liquid He reservoir

Tuner with Actuator at Room Temperature

Item	Design	Measured
Range	±250 kHz	±500 kHz
Tuning coefficient	$>$ 200 kHz/mm	208 kHz/mm
Cavity spring constant	$<$ 1750 N/mm	1910 N/mm
Resolution	1 Hz	
Compliance	0.7 (rigid)	0.5

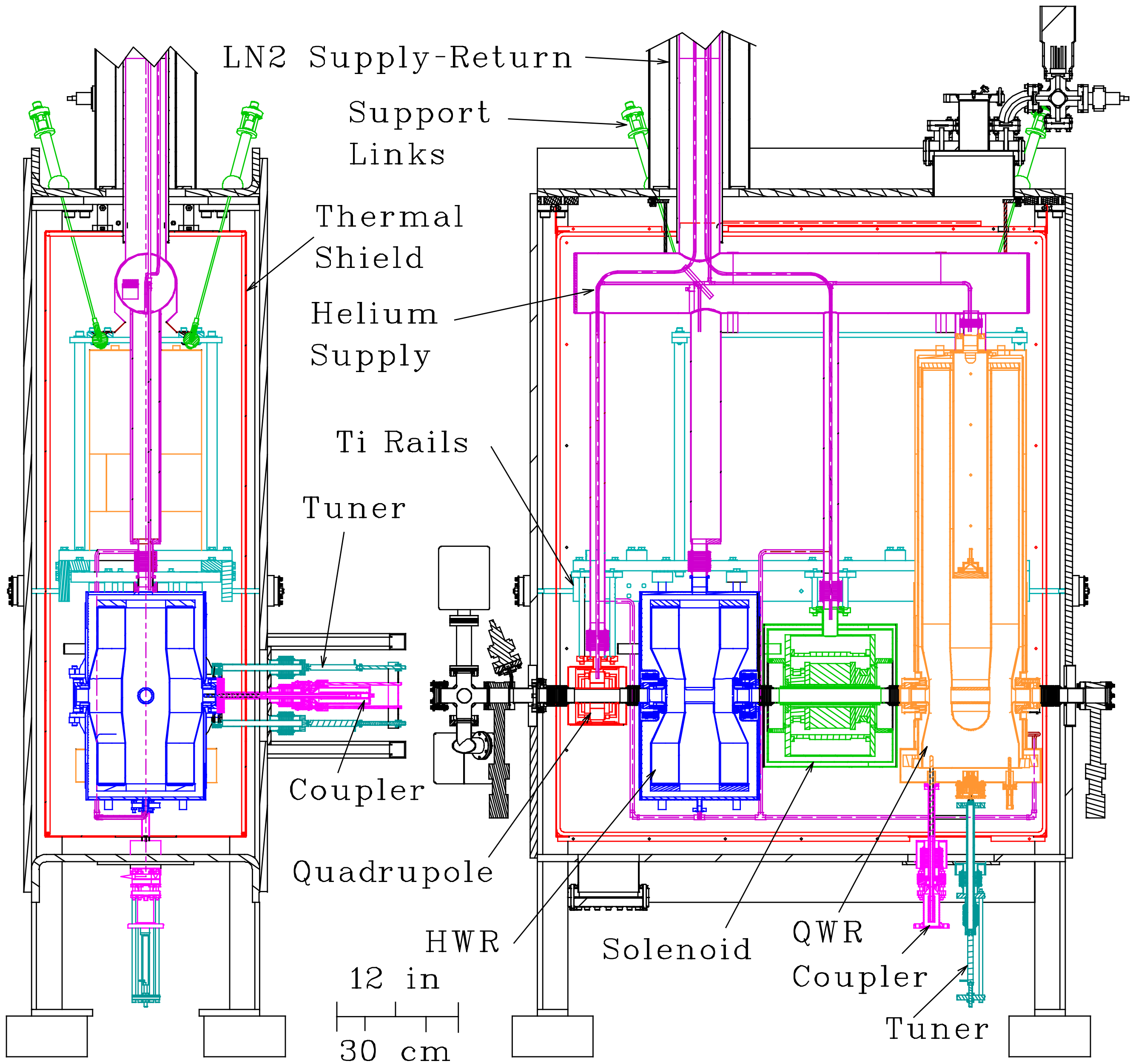




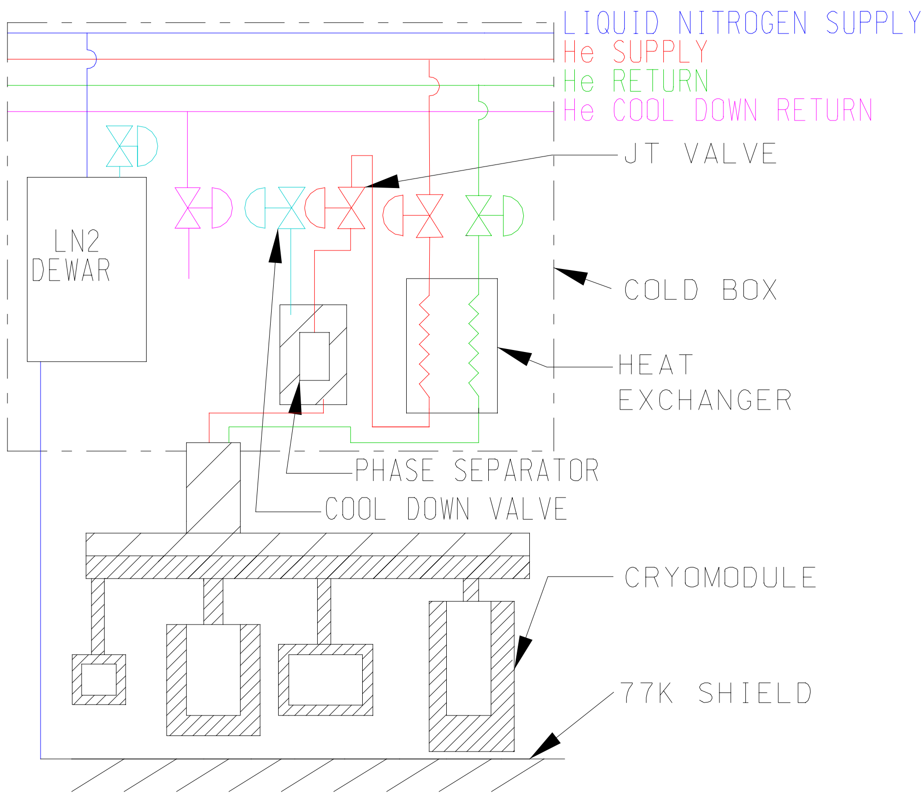


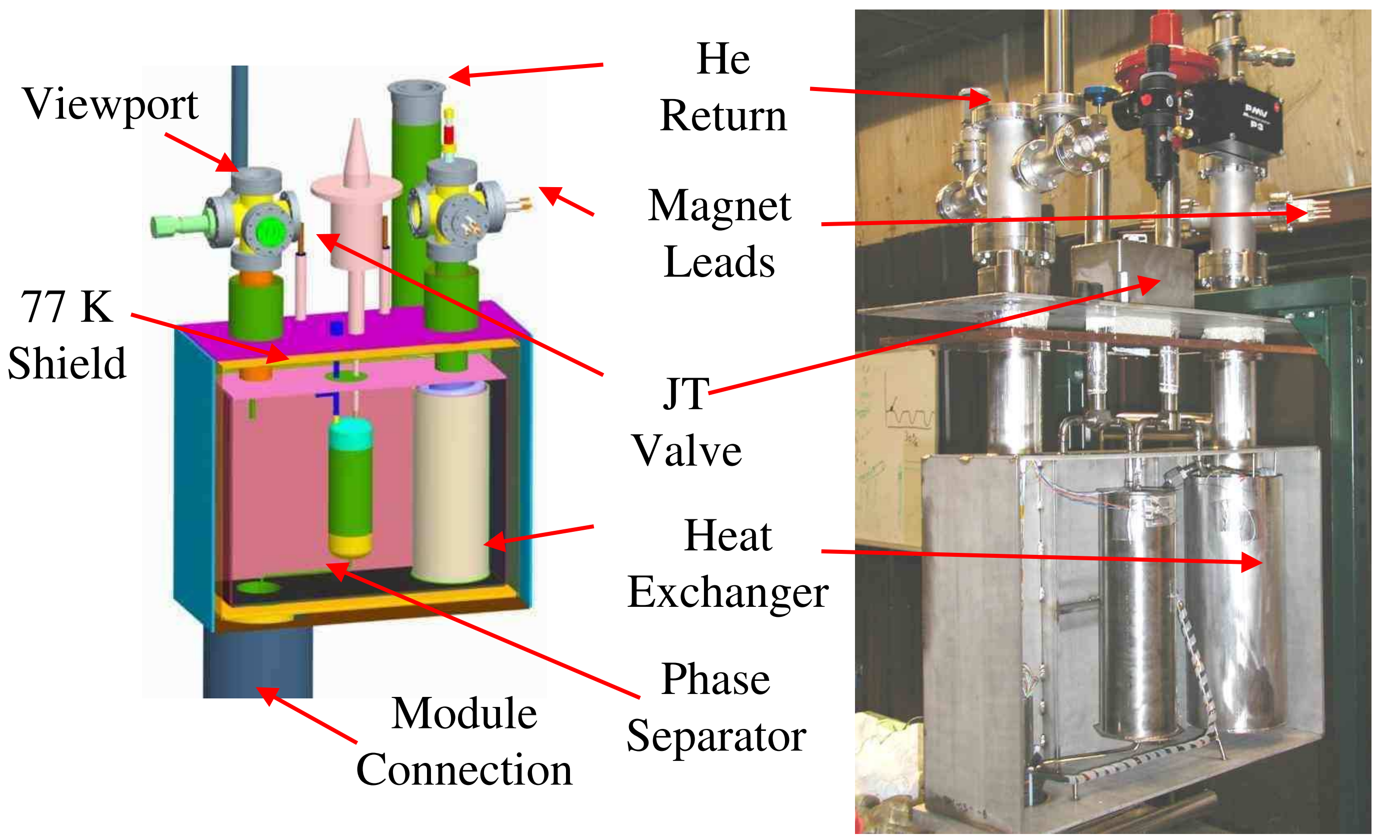
Prototype Low-β Cryomodule Design Parameters

Magnets		
Item	Quadrupole	Solenoid (Dipole)
Effective length	50 mm	100 mm
Aperture	40 mm	40 mm
Strength	31 T/m	9 T (0.01 T·m)
Turns	78	16 813 (40)
Current	63 A	68 A (50 A)
Heat Load to Liquid He		
Item	QWR	HWR
Input coupler	0.40 W	0.60 W
Tuner	0.63 W	0.38 W
Total/RF off	6 W	
Total/RF on	15.2 W	
Cryomodule		
77 K shield load	$<$ 100 W	
Length	1.54 m	
Cold mass	310 kg	
Total mass	2000 kg	

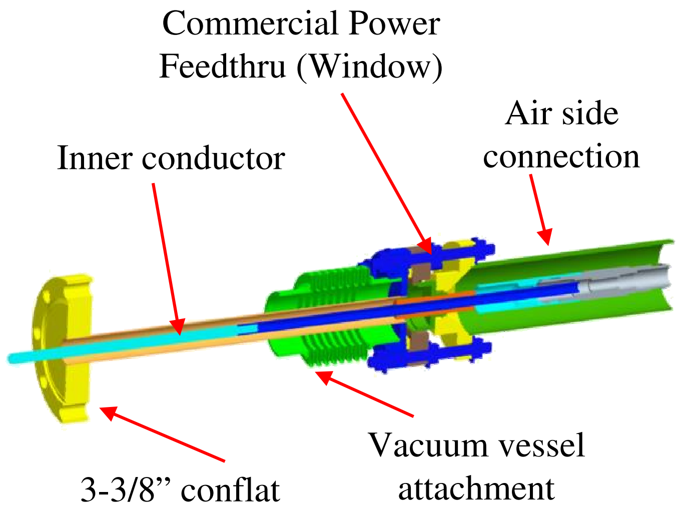


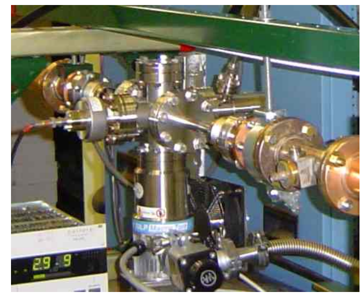
Prototype Low-β Cryomodule



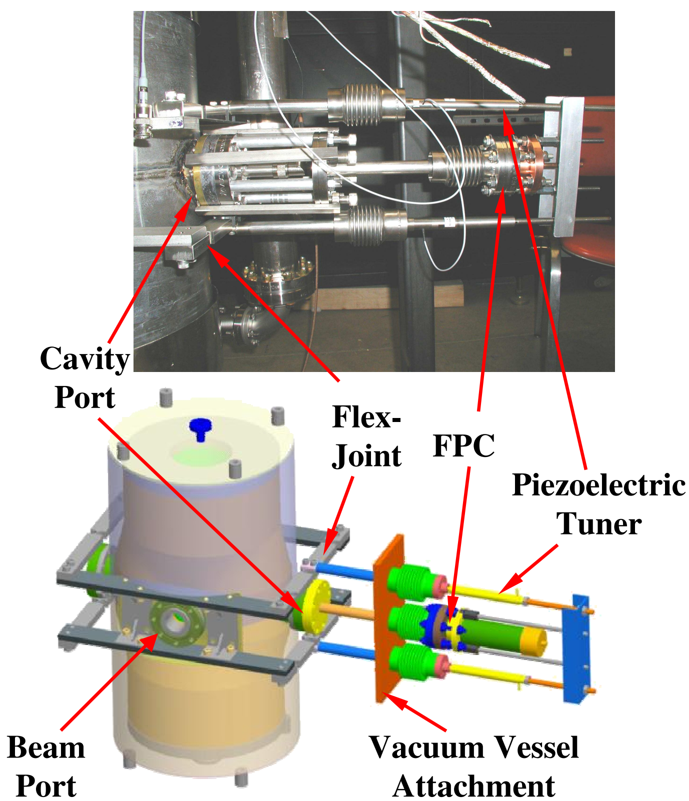


Cold Box: testing in progress

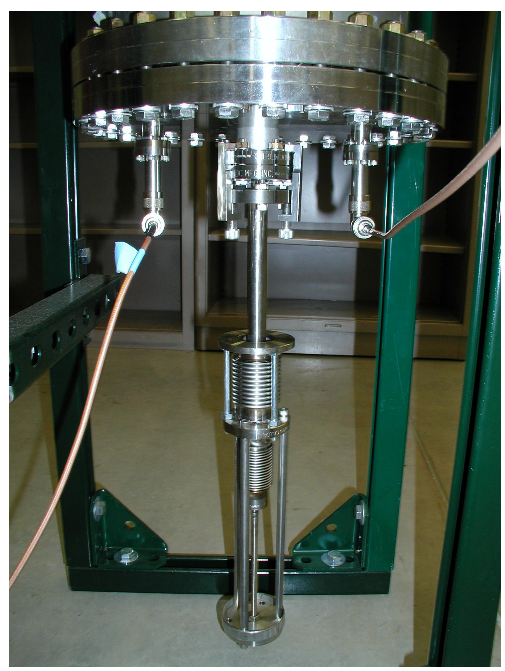




RF Couplers: conditioned to 1.1 kW (QWR) and 2 kW (HWR)



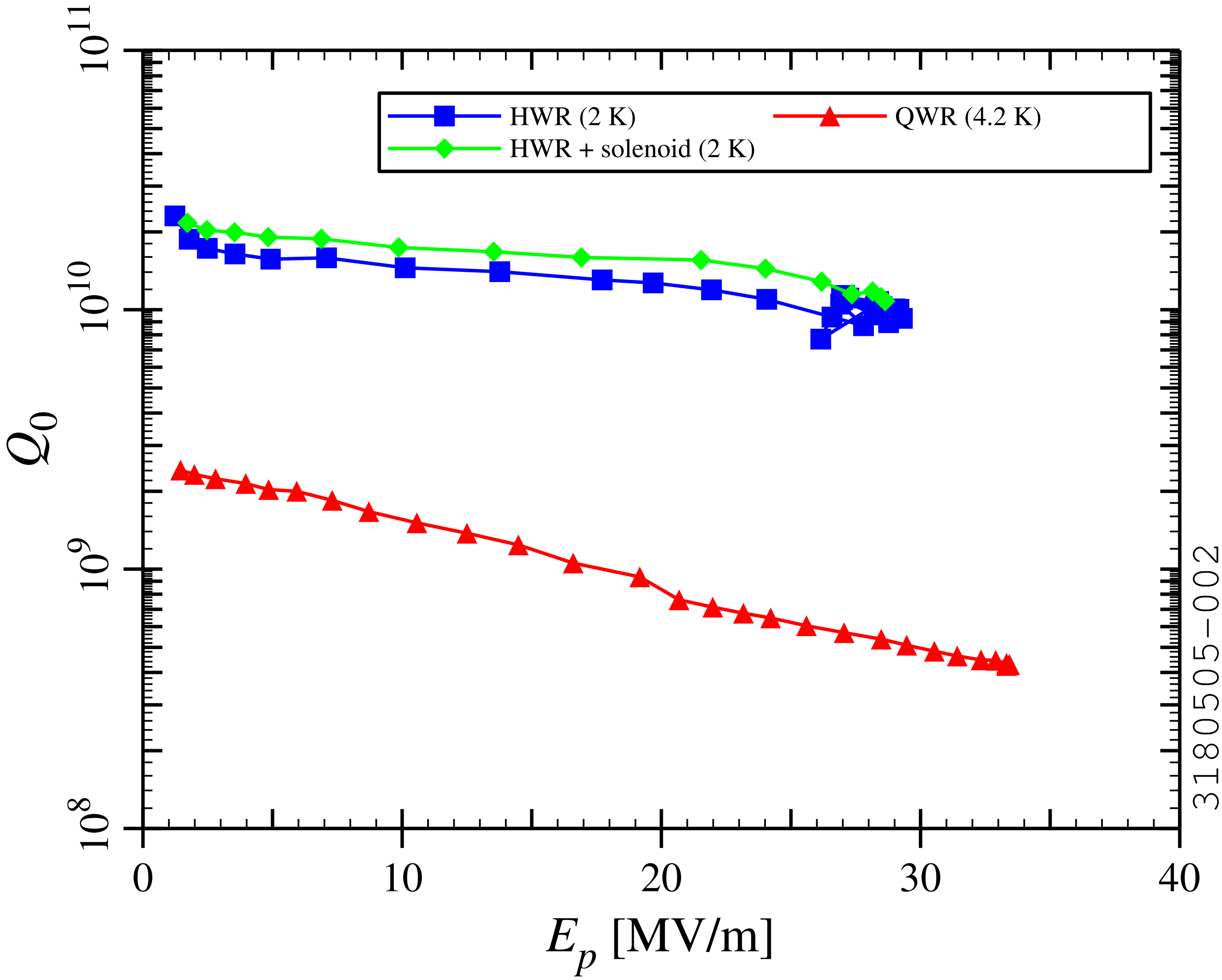
HWR tuner



QWR tuner

Tuners with Actuators at Room Temperature

Vertical tests: low-β cavities and magnets



HWR + Solenoid

HWR + Quadrupole

Construction of Low-β Cryomodule

(In progress)

(1) Cold mass

(2) Top plate

(3) 77 K shield

Future plans: complete the construction of the low-β cryomodule in 2005. Test the low-β cryomodule in 2006. Finish the RF control and microphonics studies on the medium-β cryomodule in 2006.