Rare Isotope Accelerator (RIA) Cryomodules

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Outline

- Rare Isotope Accelerator (RIA) specifications
- Comparison between RIA and ERL's
- RIA cavity designs
- RIA cryomodule designs
  - Elliptical cavity, coupler and tuner
  - Superconducting solenoids and quads
  - Construction and test results
- 805 MHz tetrode amplifier
- Summary

RIA Specs

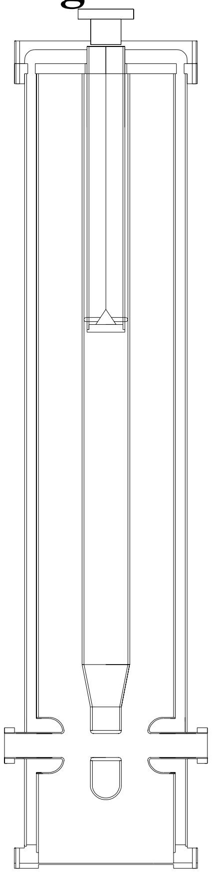
- Heavy ion linac (protons through uranium)
  - Beam energy greater than 400 MeV/u (v/c=0.72)
  - Beam power up to 400 kW (target limited/radiation)
- Continuous wave
  - Due to current limitations in ion source
  - $^{238}U^{88,89,90+}$ 0.37 mA at end of linac
- 1400 MV superconducting linac
  - v/c=0.025-0.72
  - Quarter, half-wave and elliptical cavities

Comparison between RIA and ERL's

- Similar
  - CW (tuner, lower peak fields, no dynamic Lorentz)
  - High loaded-Q (microphonics, power couplers, amplifiers)
- Different
  - Beam break up due to regenerative high current
    - HOM damping
  - Beam velocity
    - RIA longitudinal beam break up
    - LLRF vector sum control of energy gain
  - RF frequency
    - RIA 805 MHz based on SNS and longitudinal acceptance

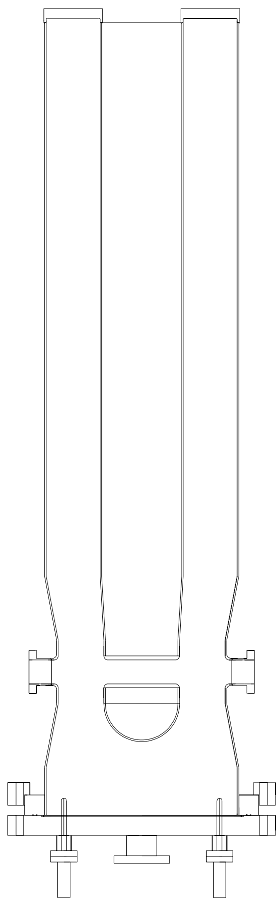
RIA SRF Cavities

Legnaro



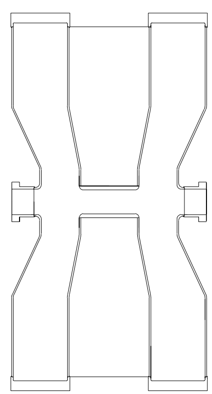
β_{opt}=0.041
80.5 MHz

MSU

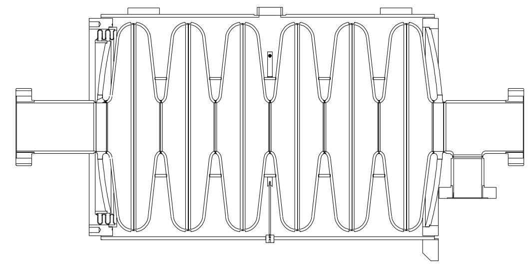


β_{opt}=0.085
80.5 MHz

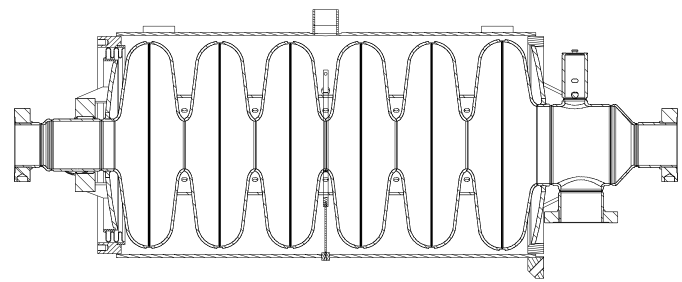
MSU



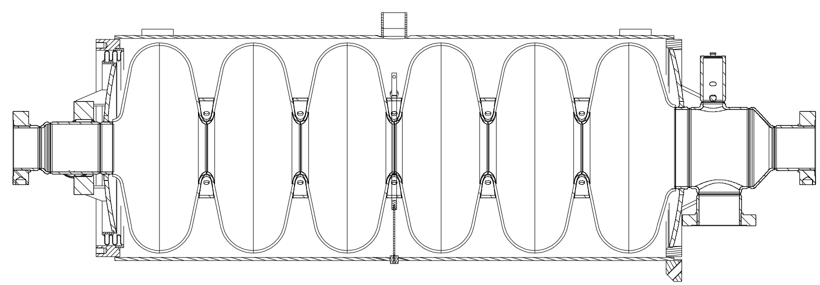
β_{opt}=0.285
322 MHz



β_{opt}=0.49
805 MHz
MSU/JLAB

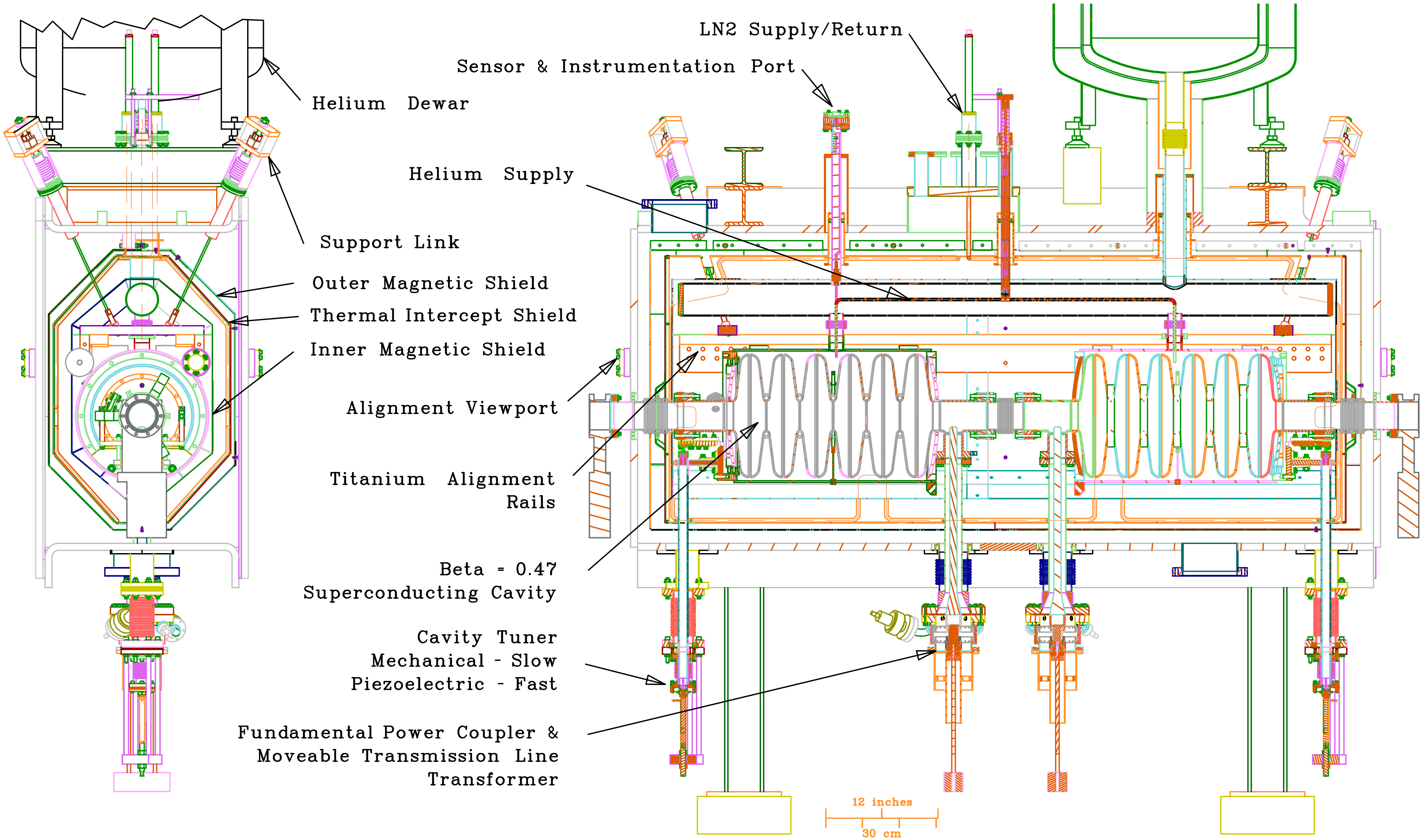


β_{opt}=0.63
805 MHz
SNS

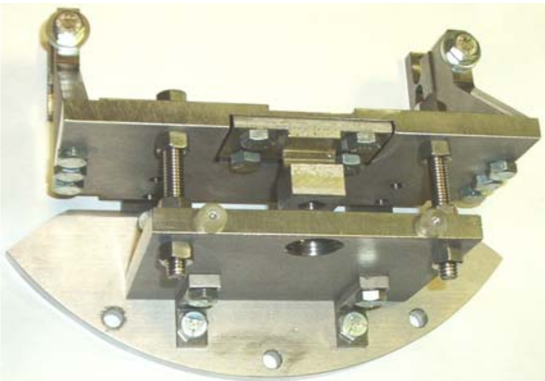


β_{opt}=0.83
805 MHz
SNS

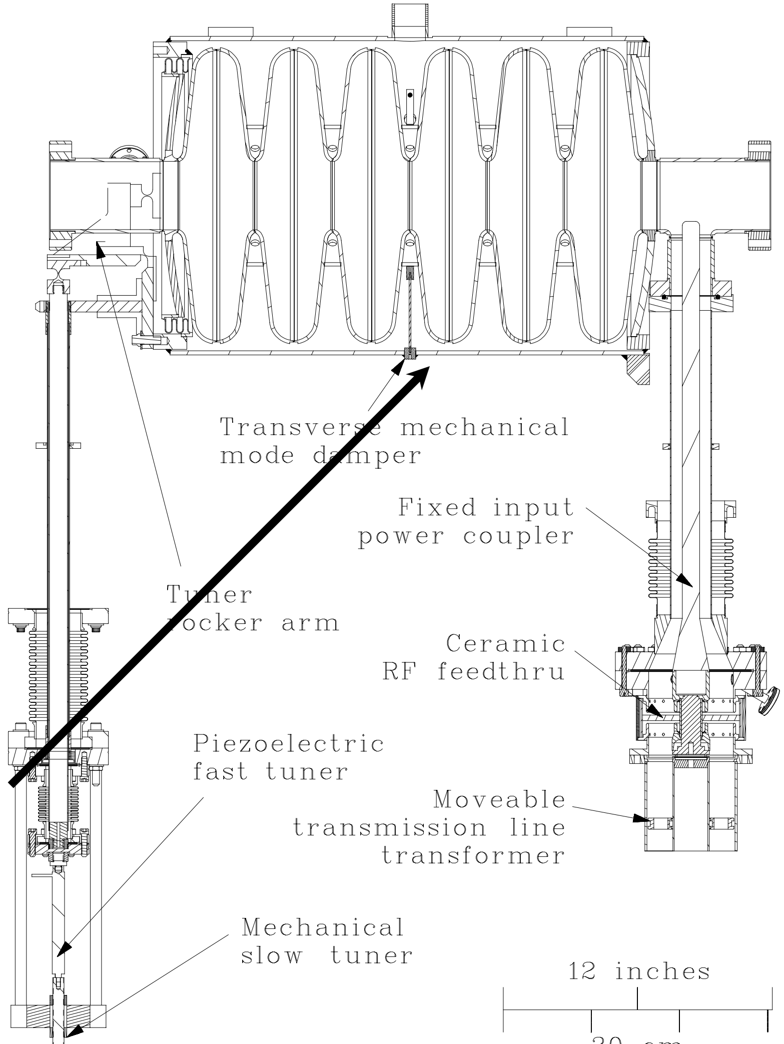
Prototype β=0.47 Cryomodule



β=0.47 Tuner-Cavity-Power Coupler



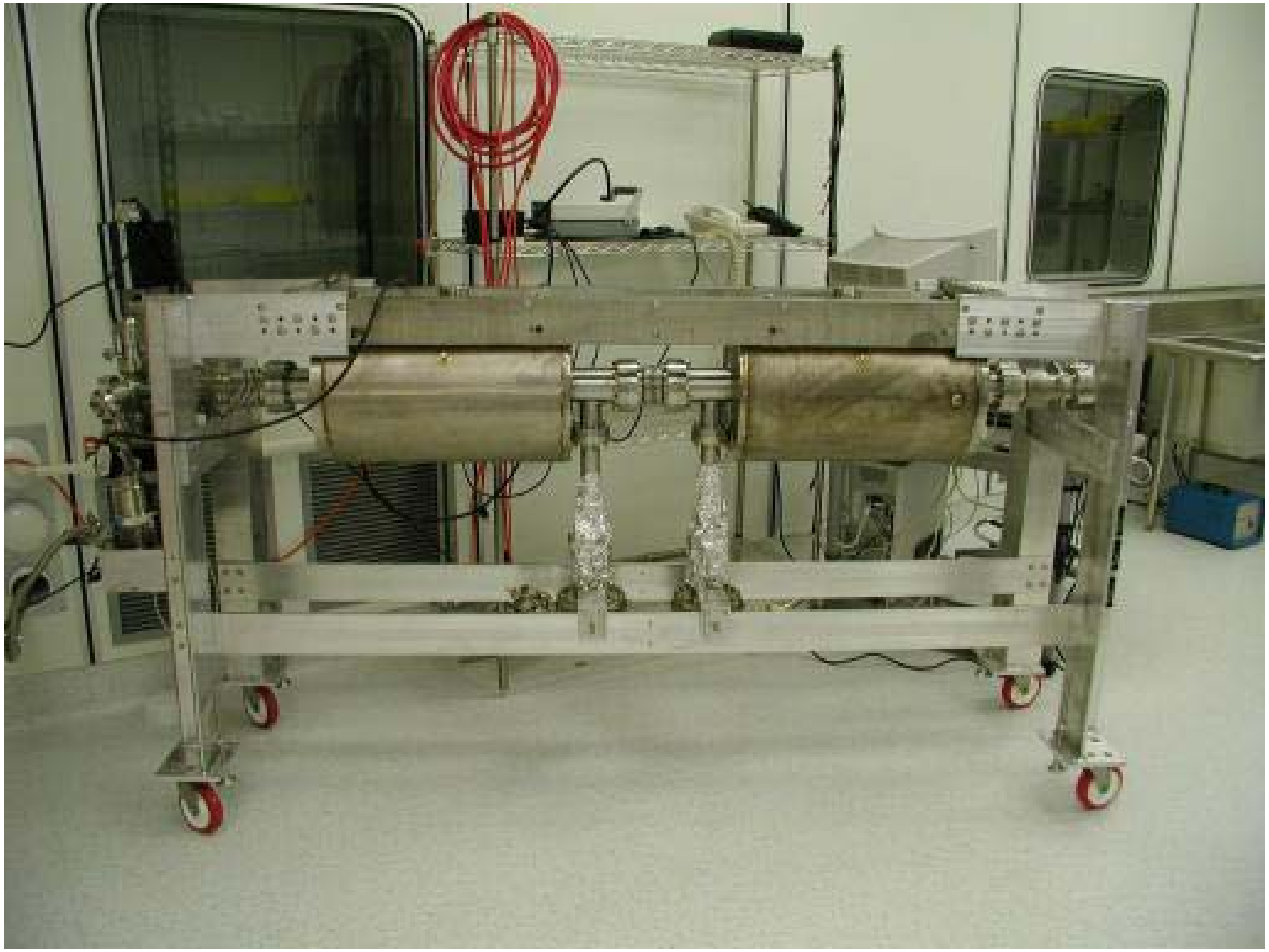
Tuner



He Vessel

Power Coupler

β=0.47 Module Assembly



β=0.47 Module Assembly

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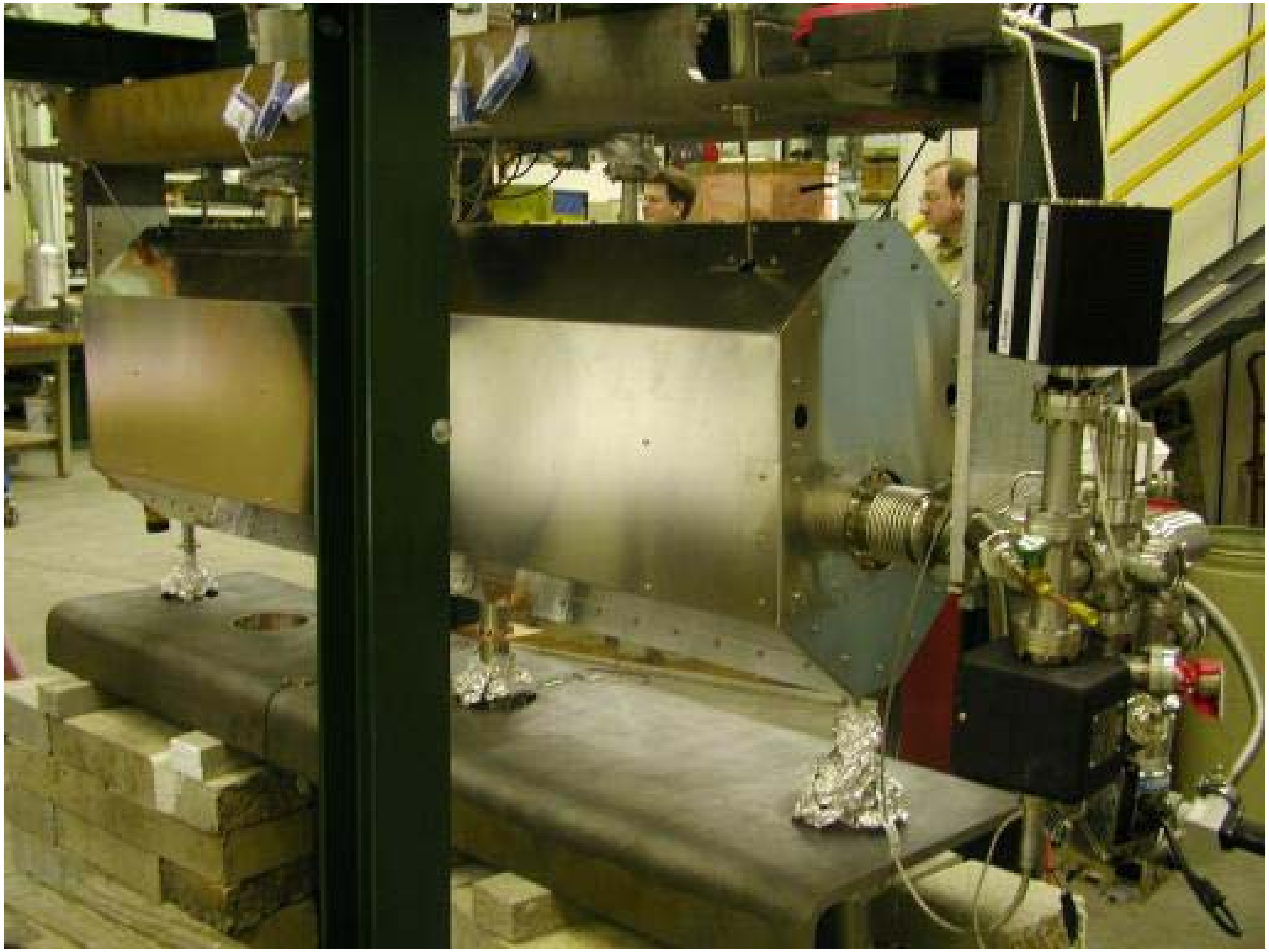

NSCL

β=0.47 Module Assembly (Feb 04)

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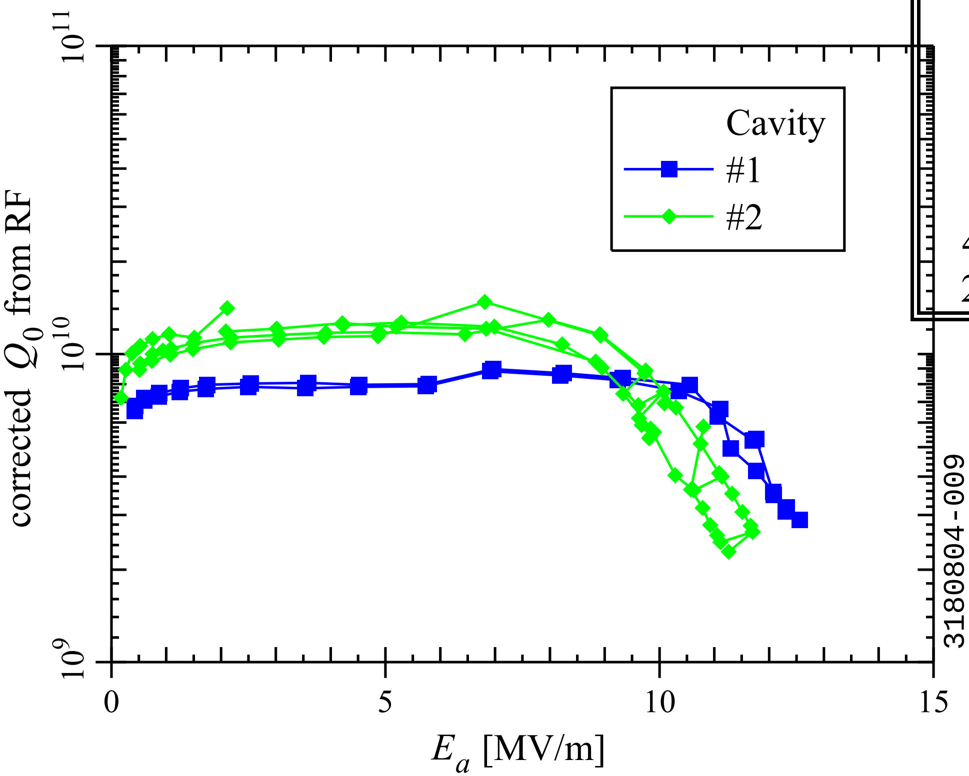
Experimental Results

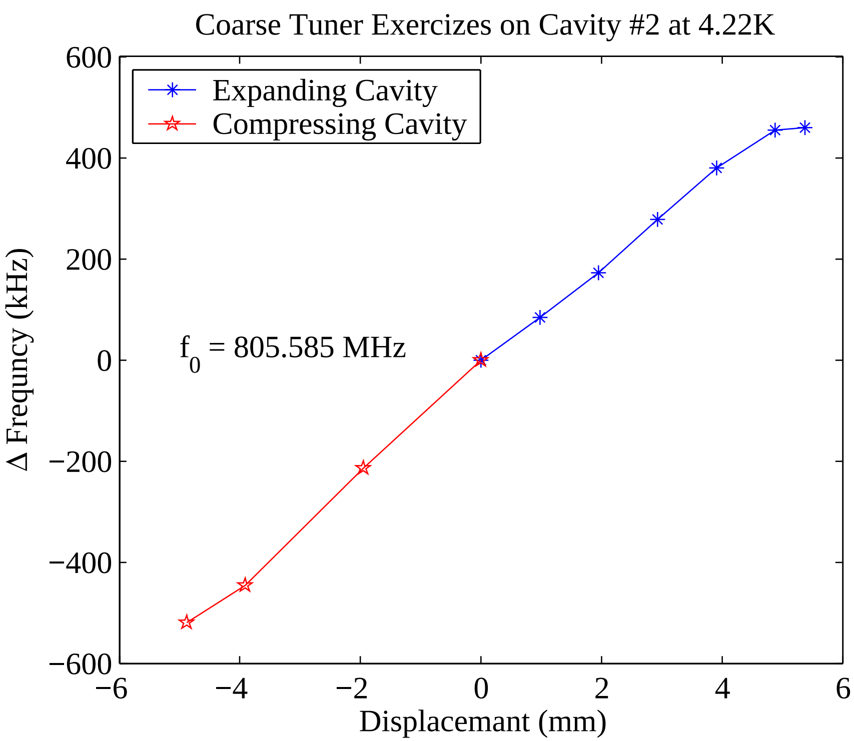
	Cavity #1	Cavity #2	Design
Q_{ext}, fixed	1.4×10^7	1.3×10^7	2×10^7
Q_{ext}, transformer	6×10^4 - 6×10^9		
df/dp (kHz/torr)	0.36	0.46	
Lorentz (2 K, Hz/(MV/m)^2)	-16		-14

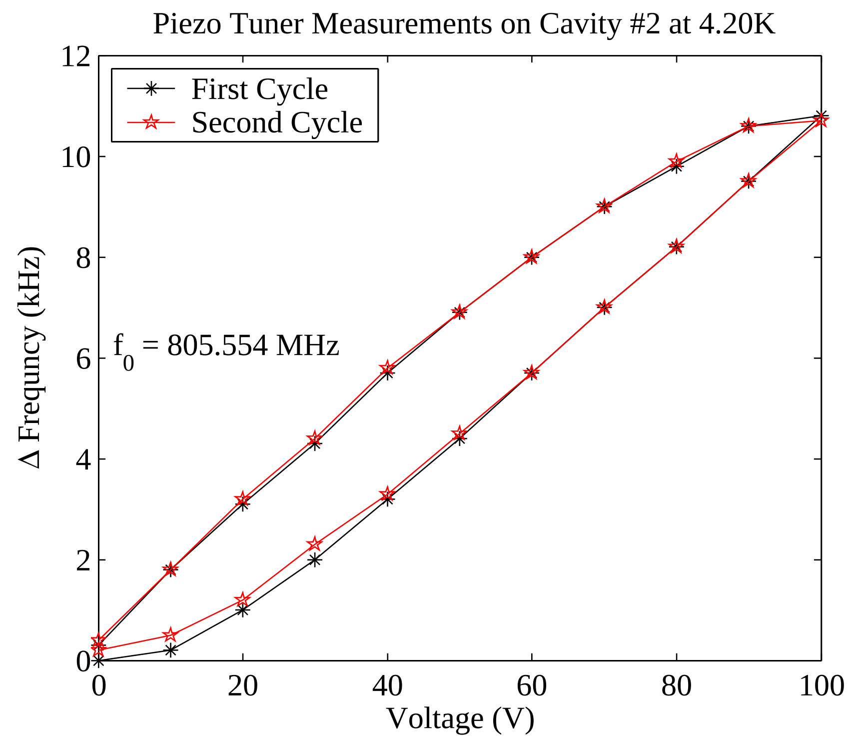
Static Heat Leak	RIA Design Gradients
10-11 W @ 2 K 9 W @ 4.3 K (includes L_{He} reservoir) **Design** 4-Cavity cryomodule 15 W 2-Cavity prototype 9 W	E_a = 10 MV/m E_p = 32.5 MV/m B_p = 64.2 mT Q_o = 7×10^9 P_o = 21.6 W



RF Measurements on the β=0.47 Cavities at 2 K after RF processing.

External/room temperature tuner





Coarse tuner ~ 1 MHz

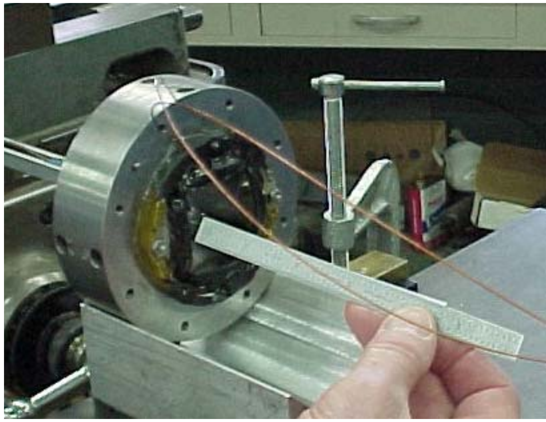
Fine tuner ~ 10 kHz

90 μm piezoelectric (PI)

SC Focusing Elements

Solenoid
9 Telsa
Bore: 4.0 cm
Effective Length: 10 cm
w/ 0.1 kG-m dipole
Shielding: Active,
Niobium, Cryoperm®10

Quadrupole
31 T/m
Bore: 4.0 cm
Effective Length: 5 cm
Built at MSU
Shielding: Iron,
Cryoperm®10



805MHz 10kW Amplifier

- **THALES TH382 air-cooled vacuum tetrode w/ a TH18482 cavity**

Summary

- Rare Isotope Accelerator (RIA) R&D deals with many of the same issues as ERLs
  - CW
    - Cryomodule designs
    - External tuners (no dynamic Lorentz detuning)
  - High loaded-Q
    - Low power amplifiers (~10 kW)
    - Power couplers
    - Microphonics control (more tomorrow)
  - Focusing elements (solenoid and quadrupole)