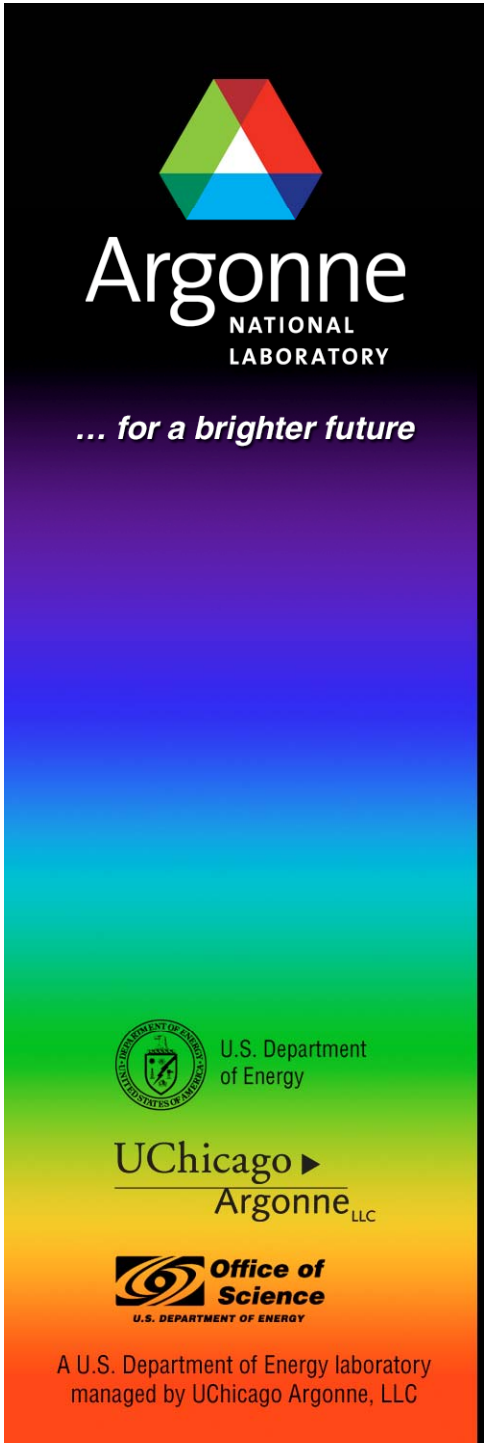


JOINT CASA / SRF INSTITUTE SEMINAR

Sponsored by the Accelerator Division

SRF Development for FRIB at Argonne

April 17, 2008

Speaker: Kenneth Shepard

"The moving target" or "the parade of the acronyms"

- **ISL** (IsoSpin Lab) **1992**
  - ~**200 $M** (Walter Henning)
  - *215 MV NC linac for protons & deuterons*
  - *265 MV SC linac for protons – xenon*

- **RIA** (Rare-isotope Accelerator) **1999-2004**
  - ~**1000 $M** (Hermann Grunder)
  - 1.4 GV SC linac with SNS e-cell high-energy section
  - 1.4 GV SC linac with triple-spoke high-energy section

- ½ • **RIA** → **AEBL** (Advanced Exotic Beam Laboratory) 2006
  - ~**550 $M**
  - 865 MV SC linac

- **FRIB** (Facility for Rare-Isotope Beams) 2008
  - ~**550 $M** (Walter Henning)

Status of FRIB

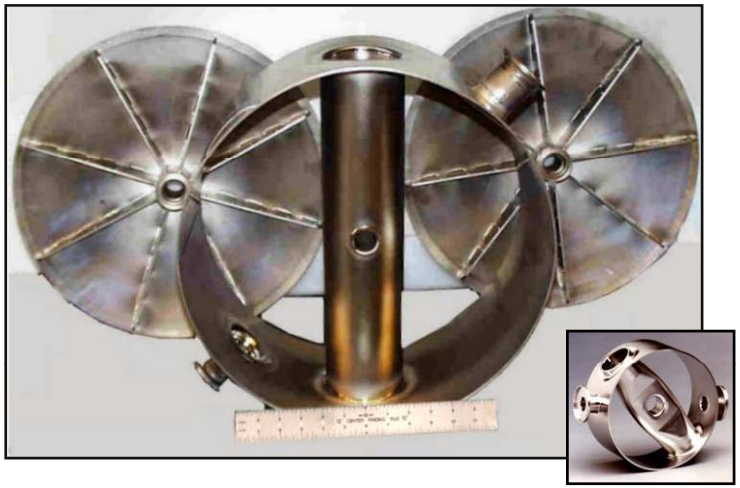
- Draft Funding Opportunity Announcement (FOA) issued by DOE in February
- 550 $M project, very modest funding to start in 2009
- Final FOA expected within weeks
- Proposals to be submitted within a few months
- Site selection by end of (fiscal) year?

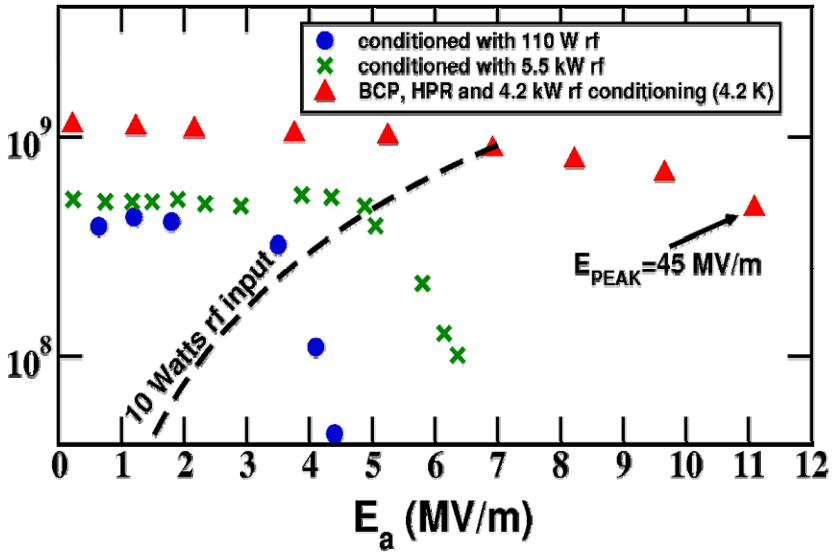
SRF R&D: Cavities, Couplers, Tuners, Cryomodules

FRIB SRF Systems			
	History	Status	Planned
Cavities	Dev. for FRIB	Shown feasible	R&D
Couplers	Dev. for FRIB	Dev. Req'd	R&D
Tuners	Dev. for FRIB	Shown feasible	Development
Cryomodules	Dev. for FRIB	Shown feasible	Development

- Will try to overview where we are, how we got here, what needs to be done
- Identify opportunities for enhancing performance, reducing costs
- Discuss (please feel free to question and interrupt!) options going forward

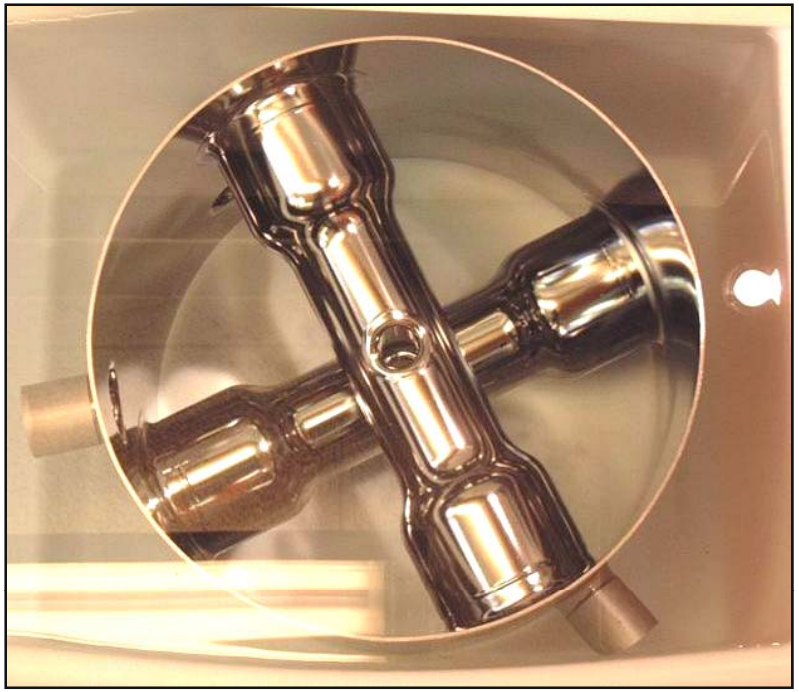
From the start, we believed spoke cavities were the way to a driver linac – following Delayen's 1992 β=0.3, 800 MHz demonstration, we tested a 350 MHz version at beta 0.4

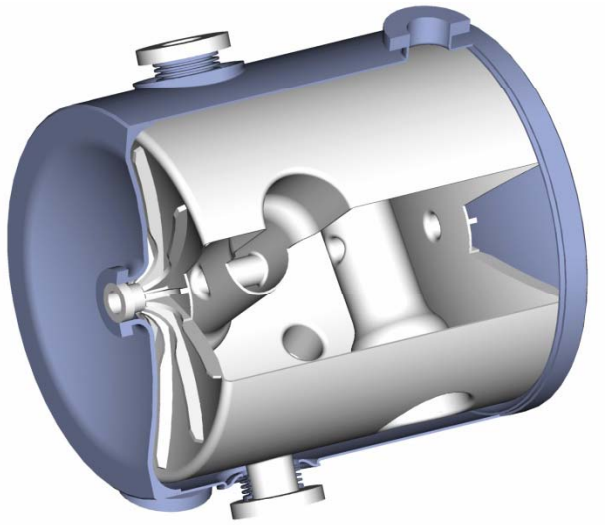


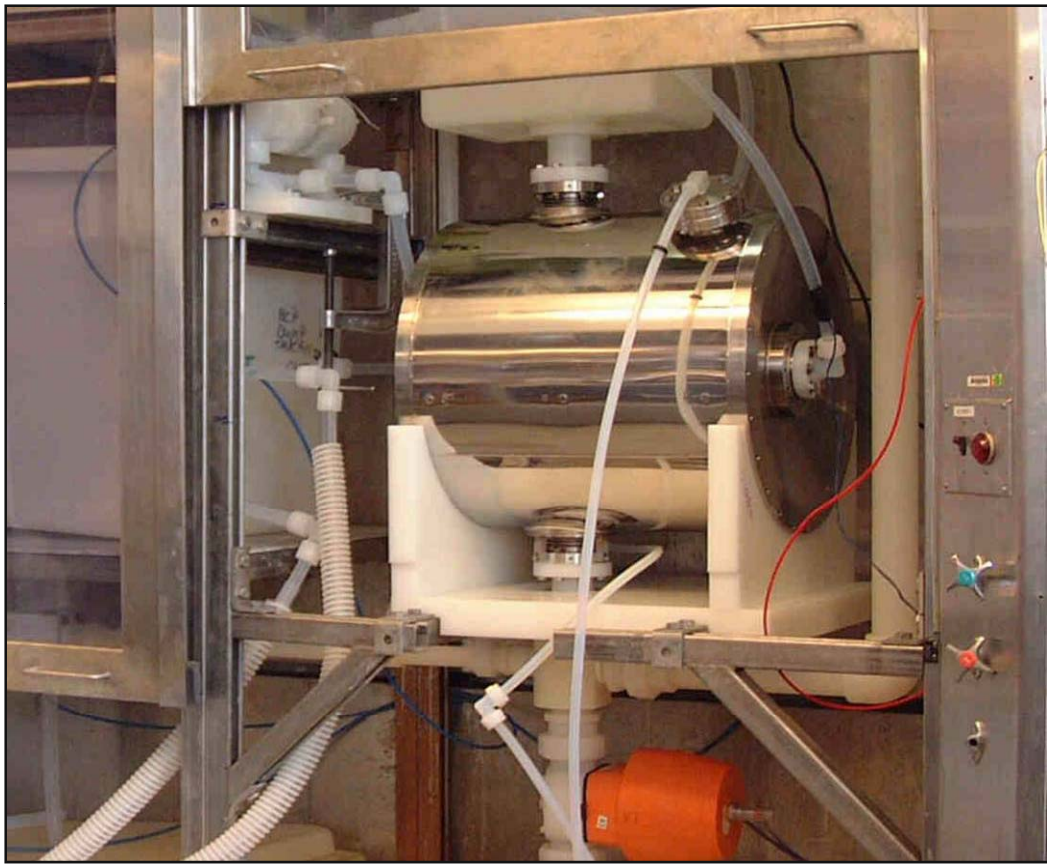


Mike Kelly, as a post-doc, took on developing high-pressure water rinsing for TEM cavities and in early 2001 dramatically improved single spoke cavity performance

Assembling and Processing

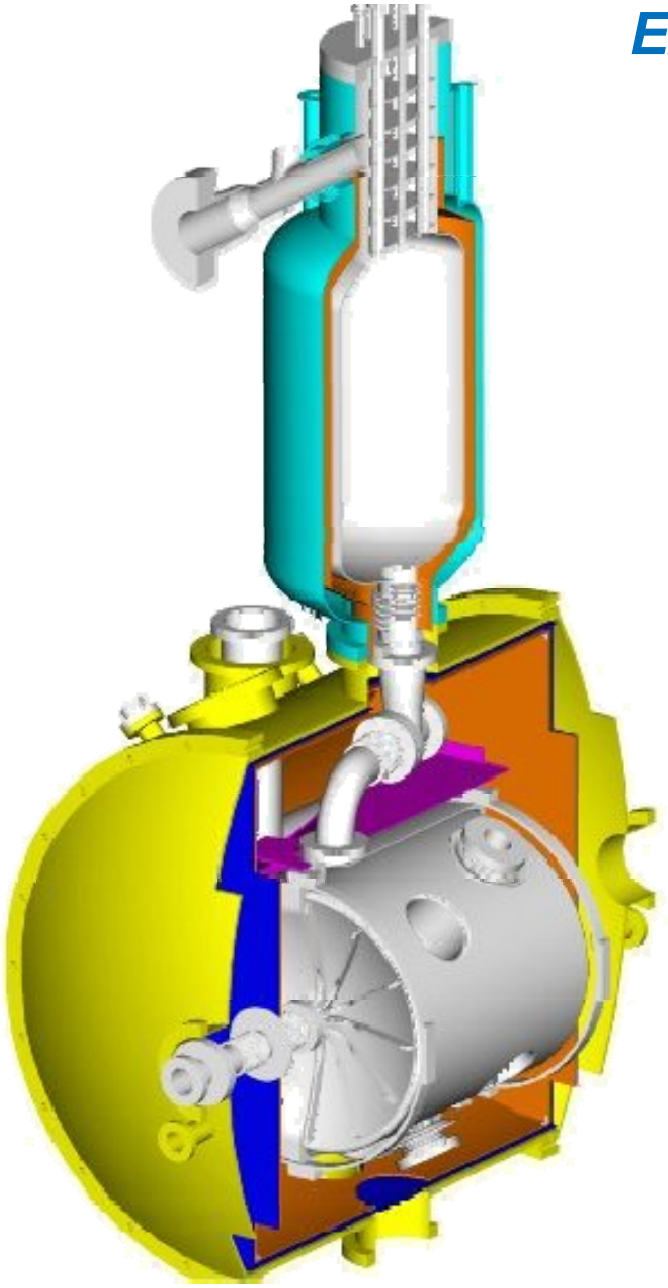


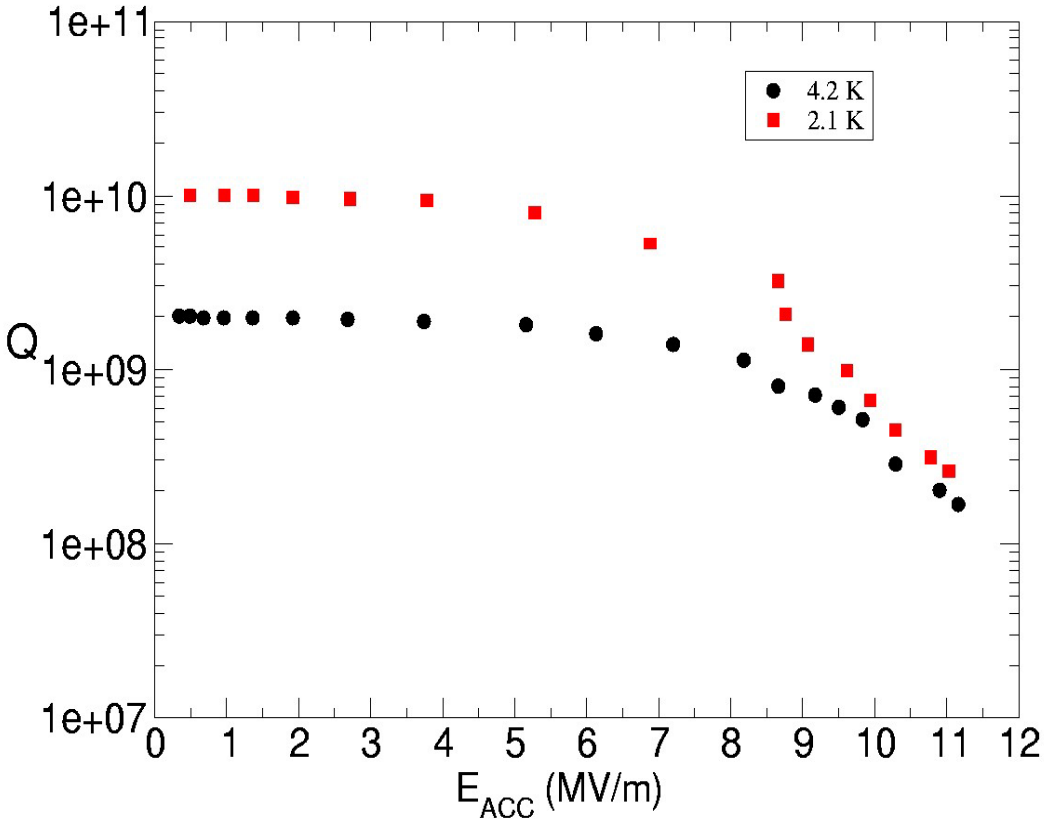




Welding a Dozen Support Gussets

Excellent Performance in Initial Tests

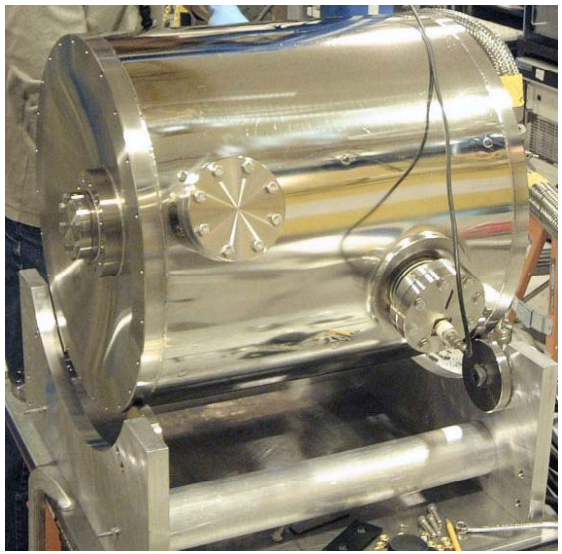


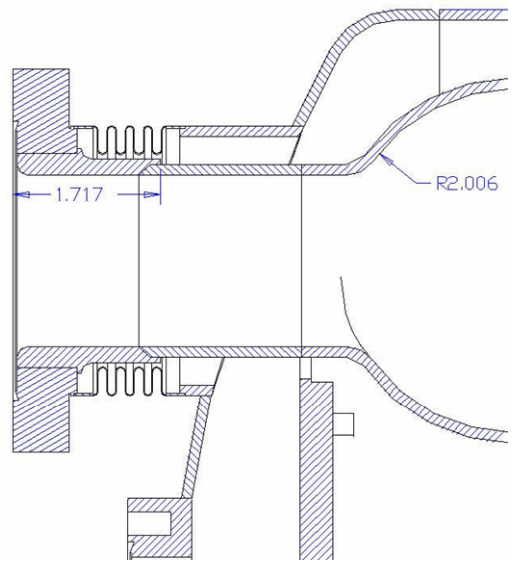


40 Years of SC Cavities at ANL

SC QWR Cavities for the NSC Linac (New Delhi)

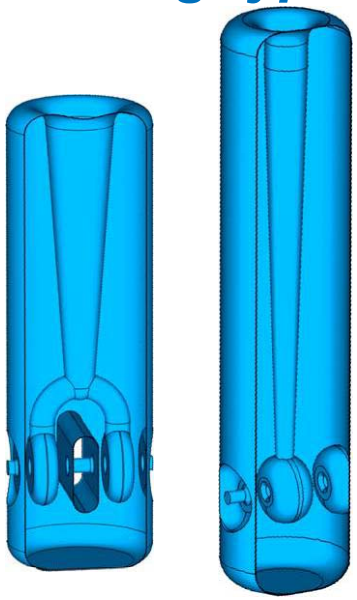
Niobium-to-Stainless Cu Braze Transition



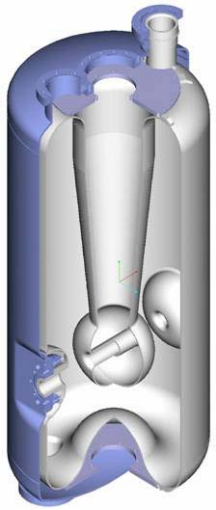


- Modification of established CERN Cu braze technique
- Single Cu wire at top flows through the joint producing a fillet on the back side
- Repeated cold shocks/mechanical loading tests verify joint integrity
- Dozens of units in service
- Adopted at Cornell, FNAL

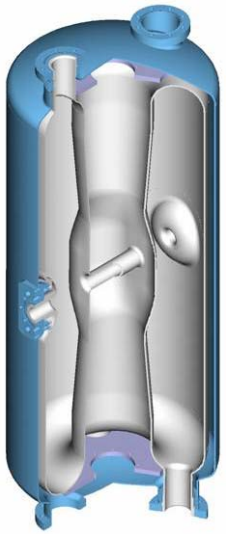
ANL has prototyped 5 types of TEM cavities required for the AEBL driver linac (the remaining two are similar to existing types)



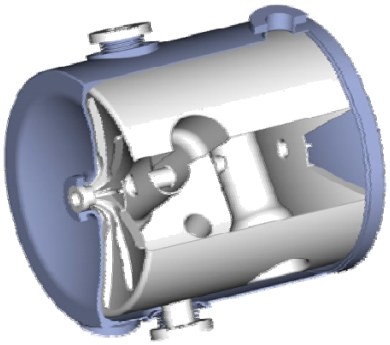
57.5 MHz QWR-based structures
0.03< β <0.14



115 MHz β=0.15 Steering-Corrected QWR

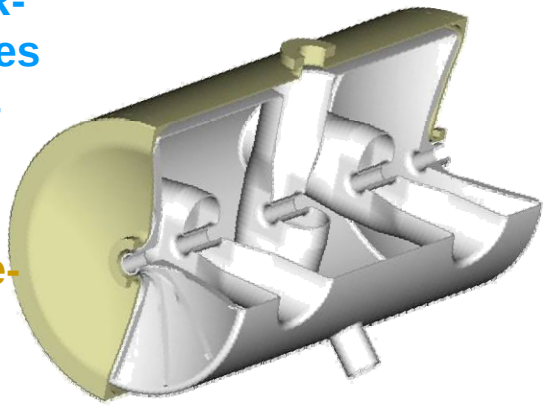


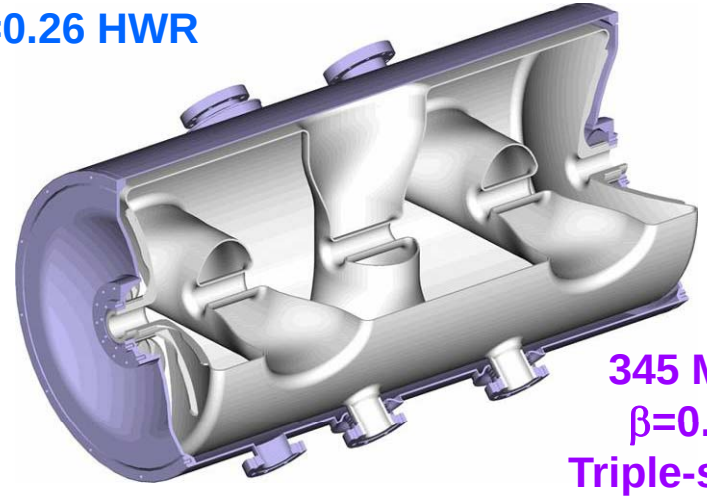
172.5 MHz β=0.26 HWR



345 MHz β=0.40 Double-spoke

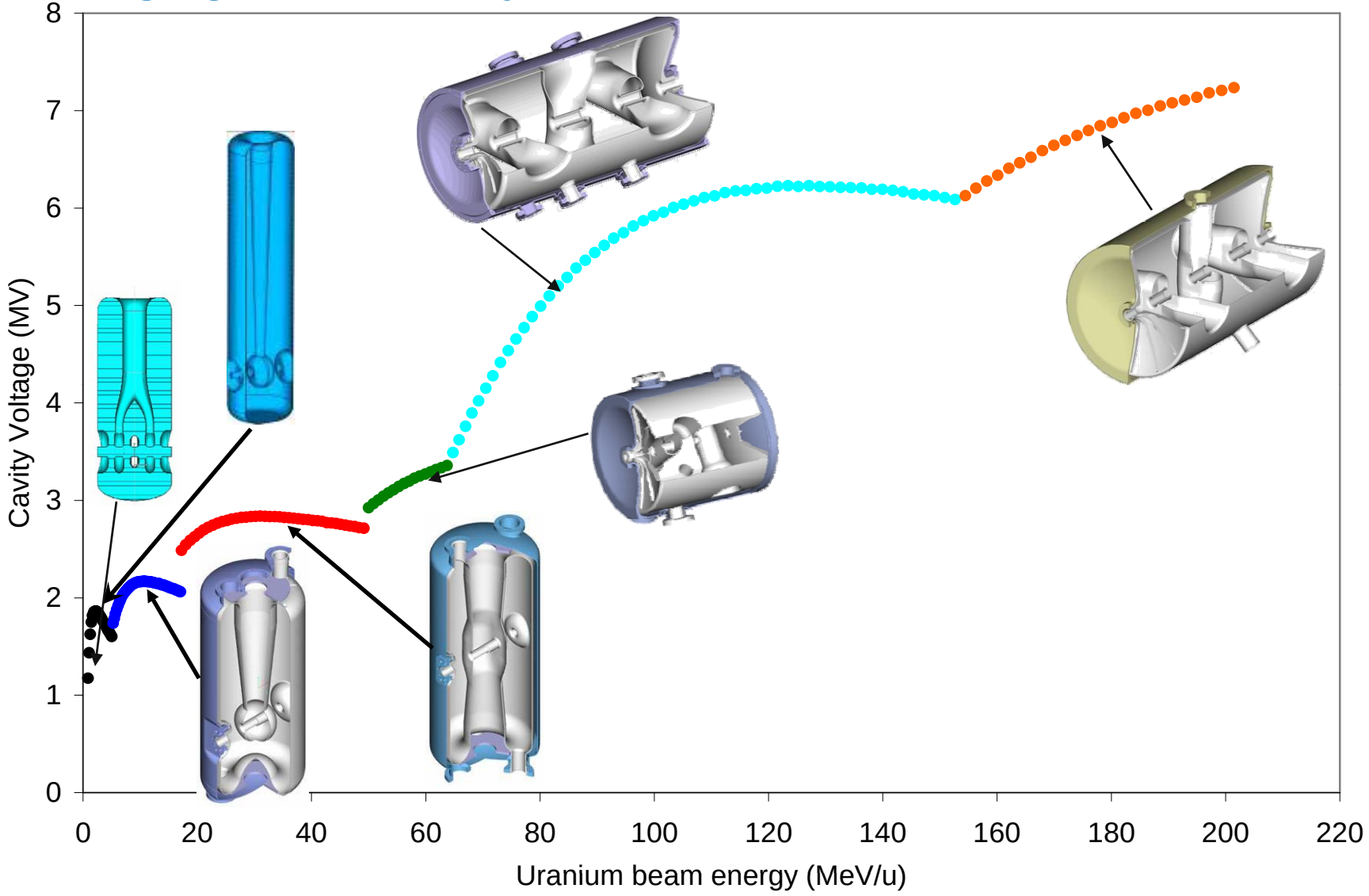
345 MHz β=0.5 Triple-spoke





345 MHz β=0.62 Triple-spoke

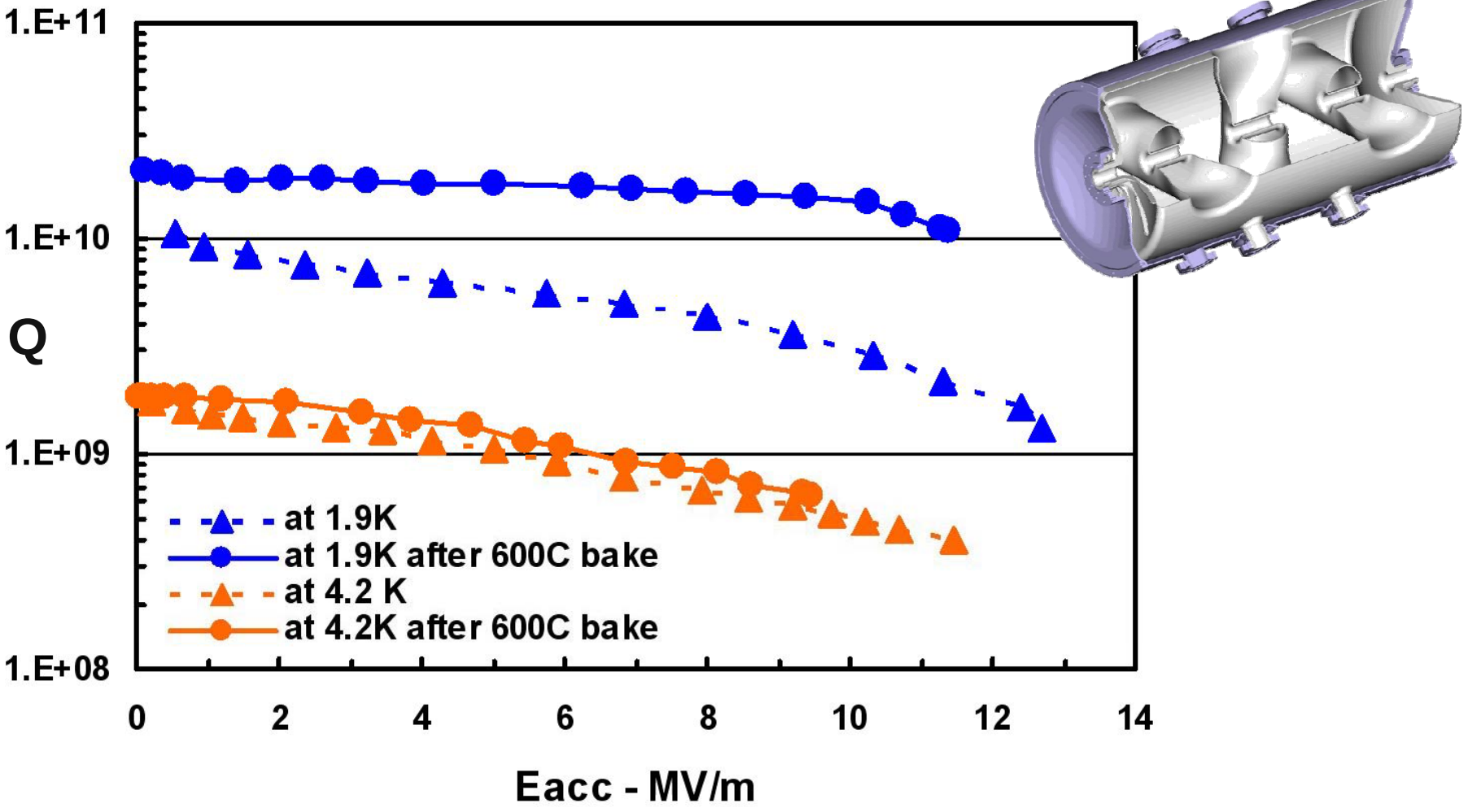
Voltage gain per cavity in the SC section



Niobium Parts Following Electropolish

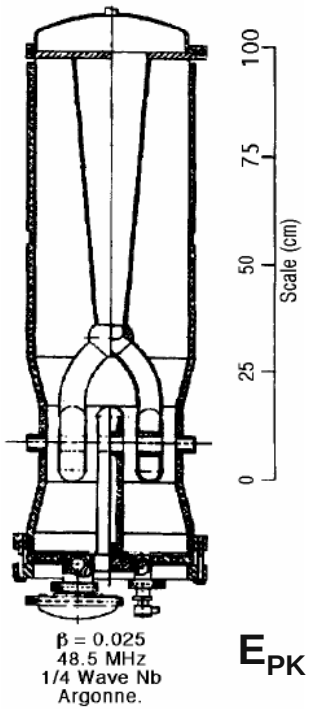
- EP major assemblies
- Closure welds post-EP
- Handling is critical

Current cavity performance (after removing hydrogen): 30-35 MV/m, 800 – 1000 G peak surface fields



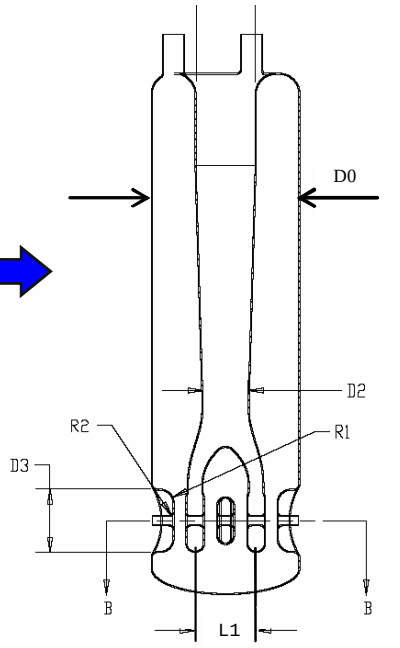
FRIB SC Cavity development (high priority)

- Finish getting the good out of existing prototypes
  - 600 C bake & re-process
  - Diagnose magnetic field limiting quench sites
  - Use as coupler and tuner development platform
- Build FRIB prototypes of low-beta QWR and Fork cavities



β = 0.025
48.5 MHz
1/4 Wave Nb
Argonne.

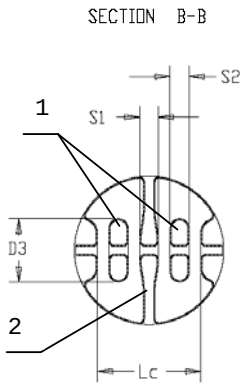
E_{PK} = 4.5, B_{PK} = 100 G



E_{PK} = 3.5, B_{PK} = 50 G

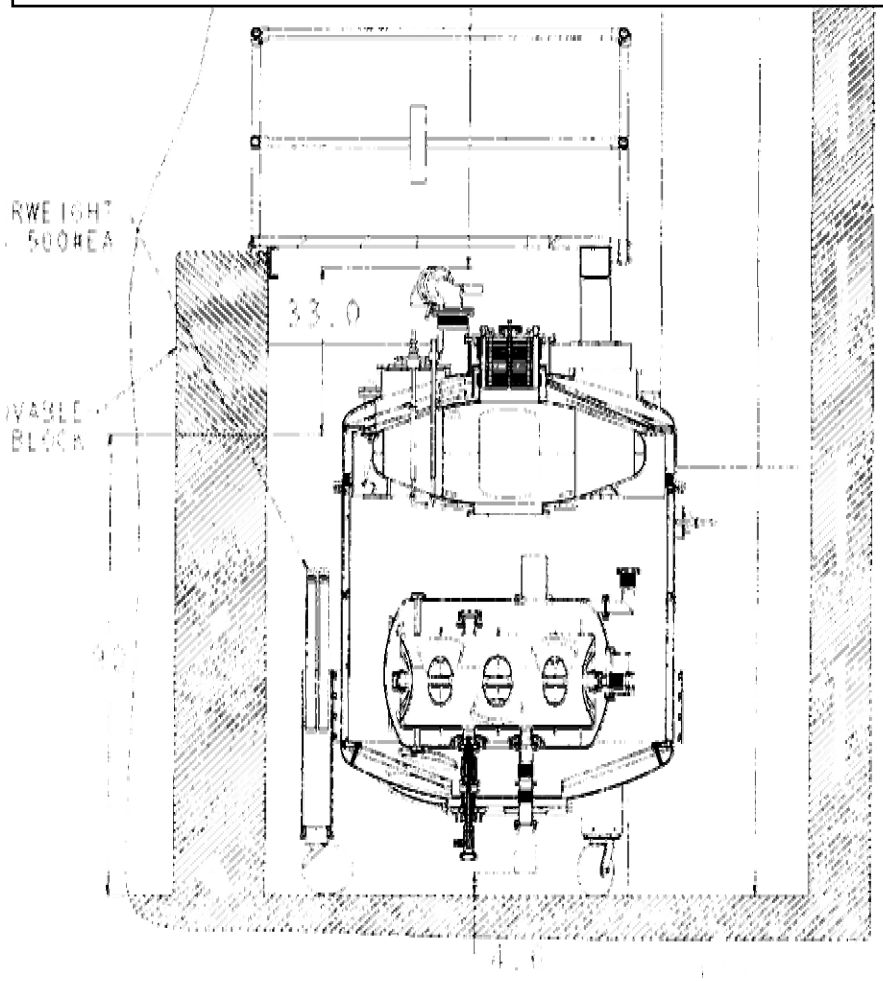
(per MV/m)

(Jin Xu, Peter Ostroumov, et al.)

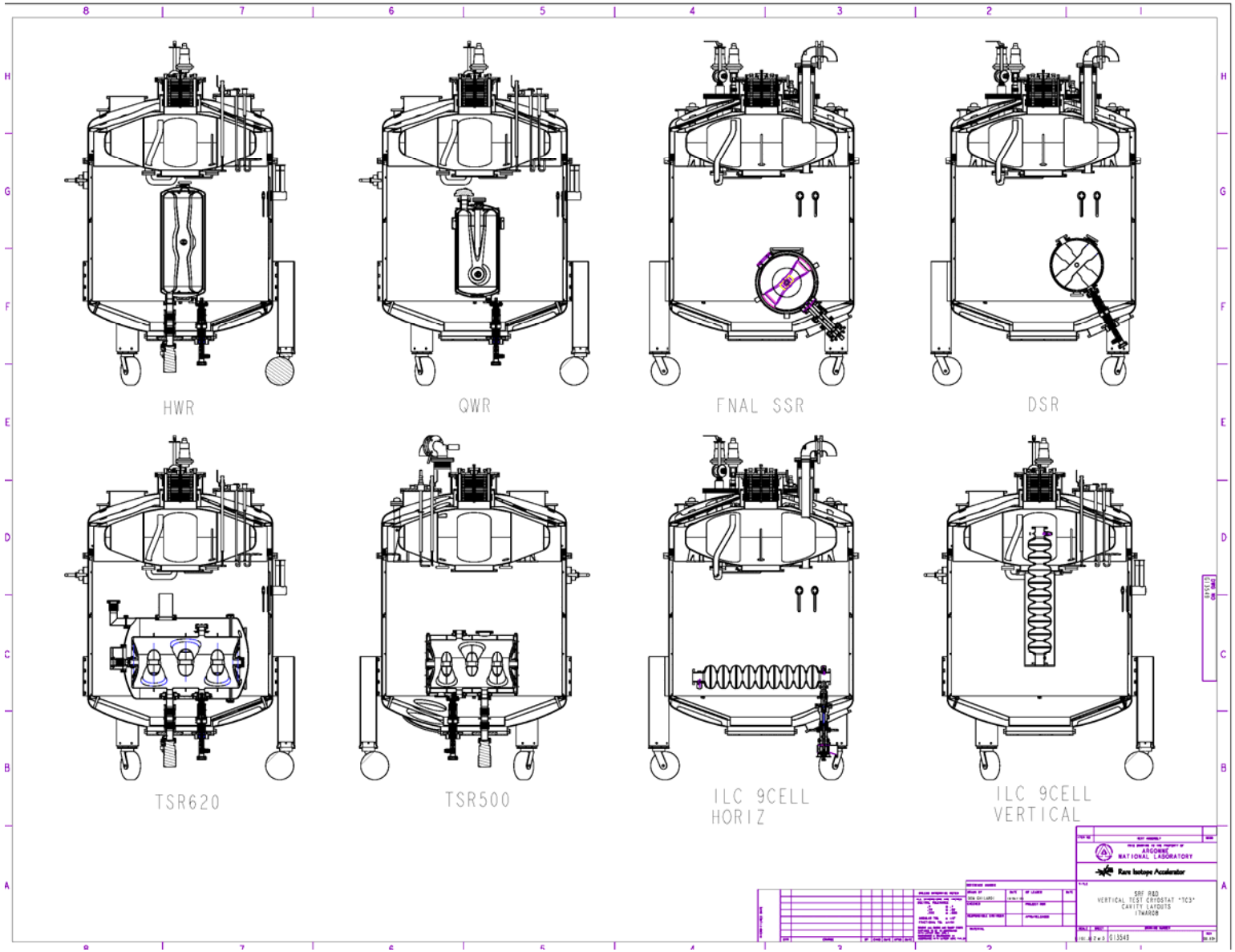


New single-cavity test cryostat (delivery in early May)

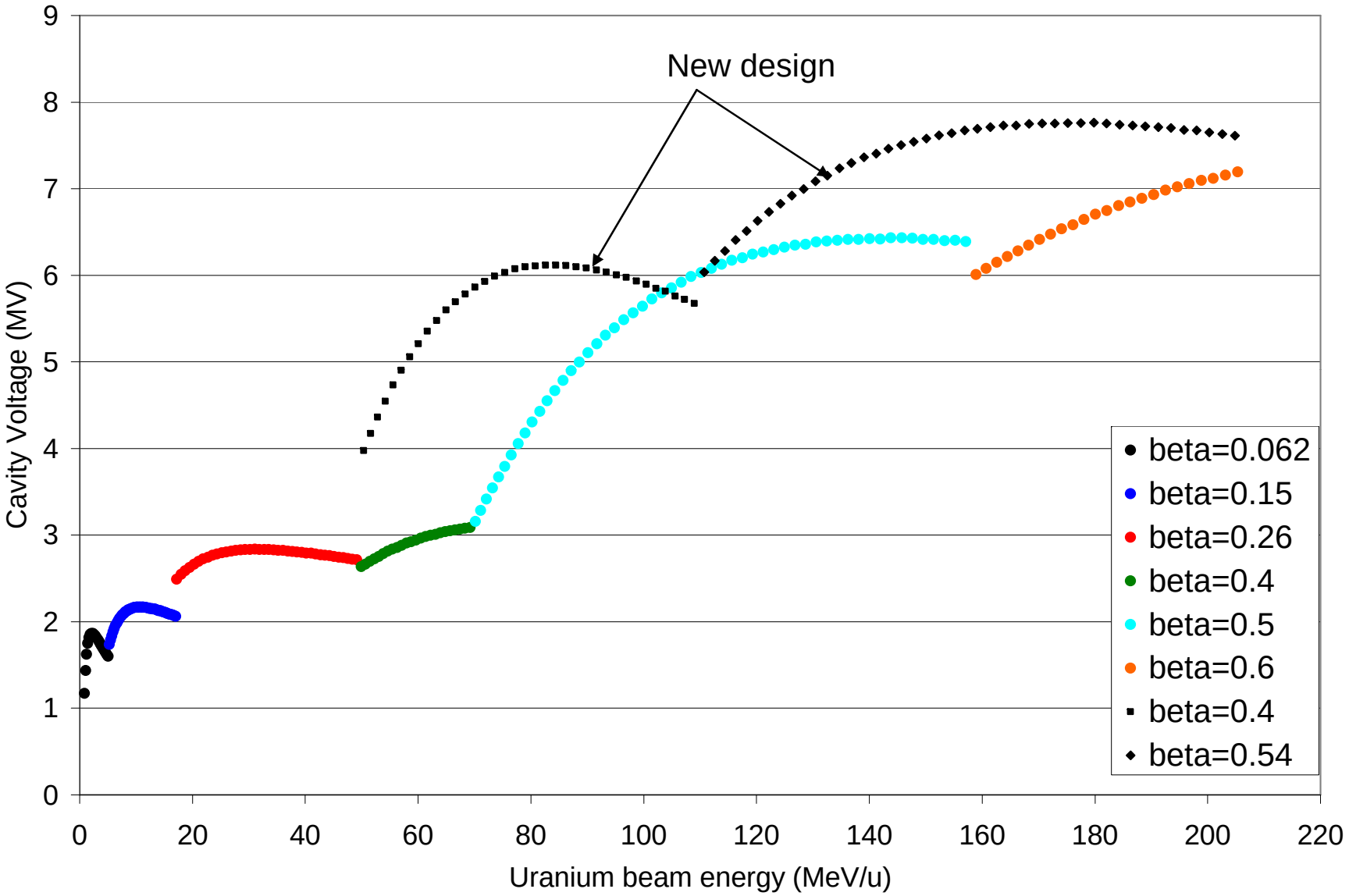
- Facilitates rapid clean assembly
- continuous 2K capability w/ ATLAS refrigerator
- Accommodates many types of cavity



TC3 – multiple configuration capability: FRIB, HINS, ILC



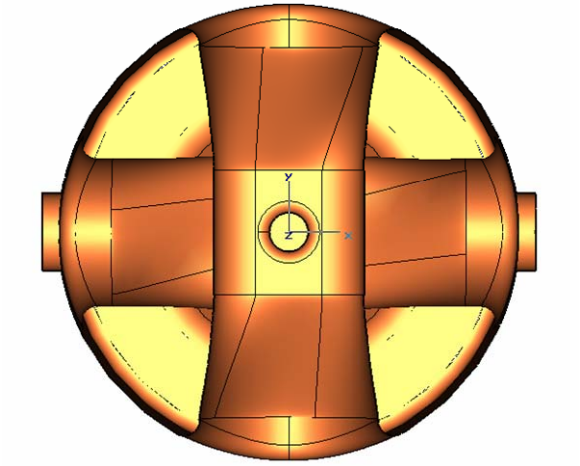
FRIB SC Cavity R&D – High opportunity triple-spoke option

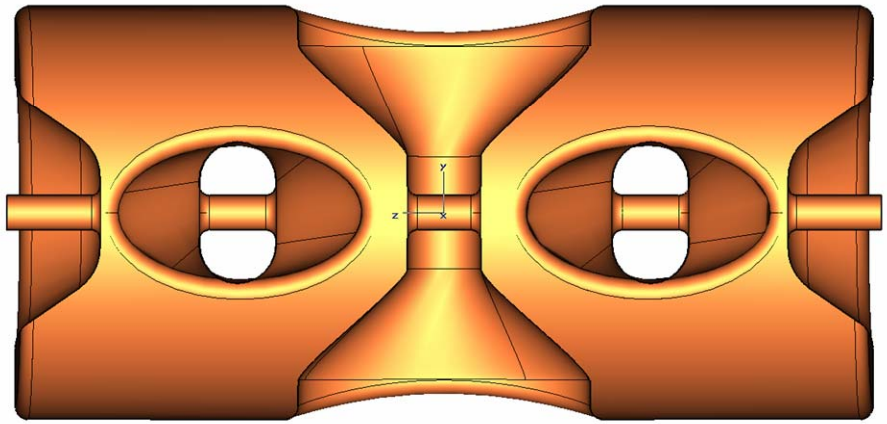


Ivan Gonin (FNAL - HINS) has devised a triple spoke cavity design with substantially reduced peak magnetic field

Petr Ostroumov and Jin Xu have adapted Gonin's design to FRIB

Triple-spoke options for FRIB					
Current			Proposed		
Beta	Epeak	Bpeak	Beta	Epeak	Bpeak
0.5	2.79	86 G	0.4	2.8	65
0.63	2.93	90 G	0.54	2.9	67
Peak fields at an accelerating gradient of 1 MV/m					



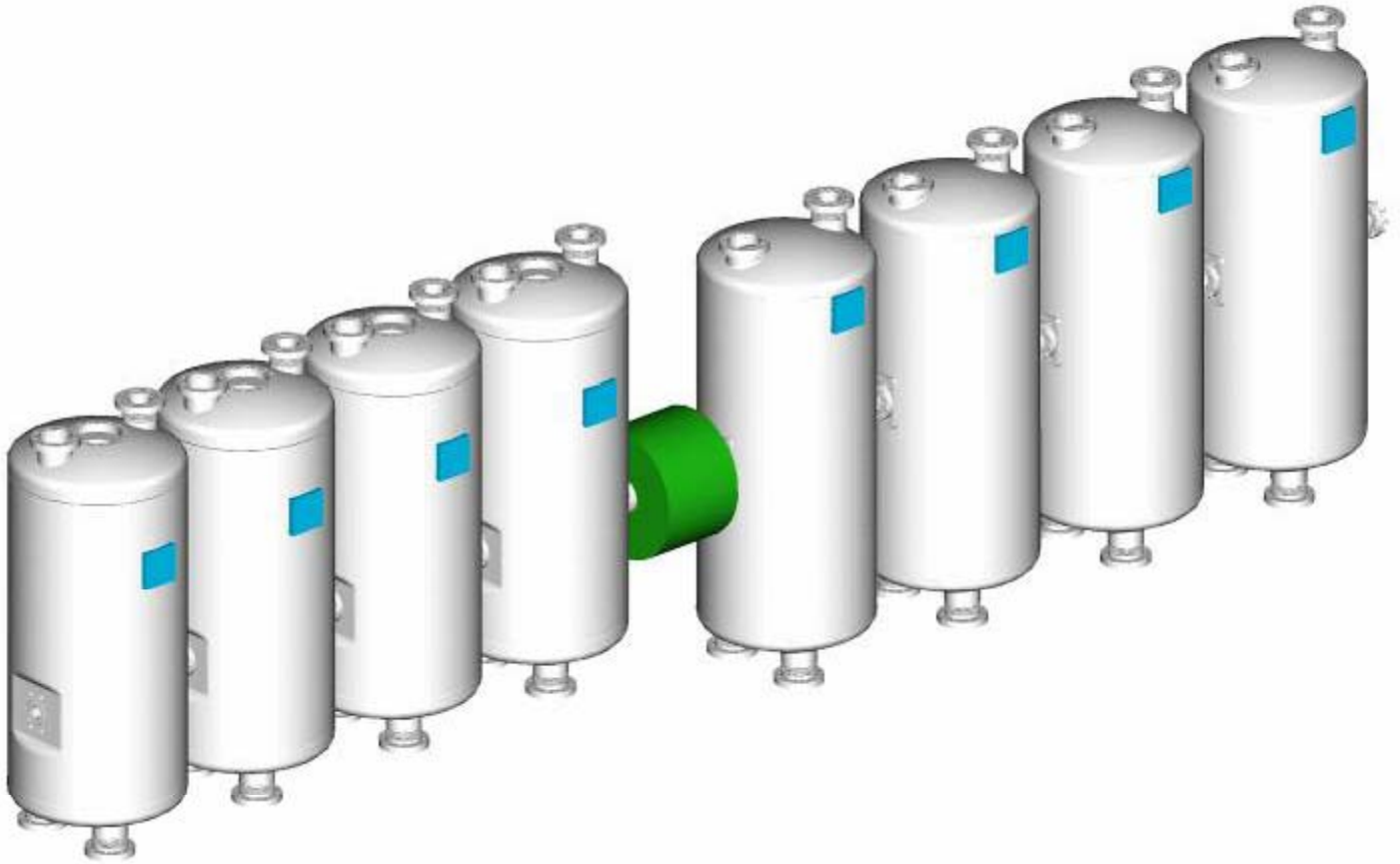


The FRIB Cryomodules

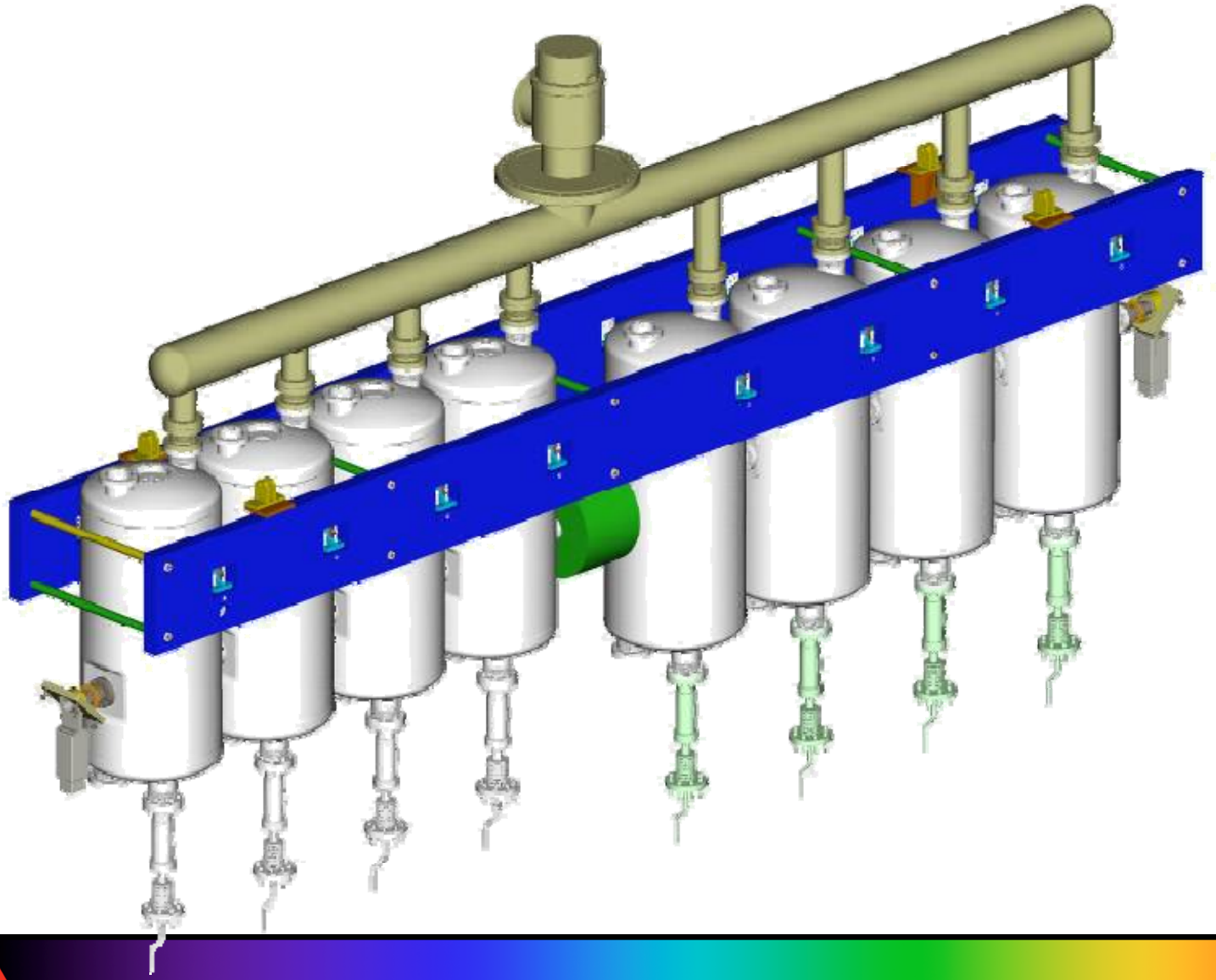
- Primary requirement - as far as possible a common design throughout linac:
  - 6 or 7 very different types of cavity
  - 4 different rf frequencies
- Minimize initial and operating costs:
  - Minimize clean room assembly time!
  - Maximize percentage of assembly done by vendor

- Our design and development process (to which JLAB people have contributed)
  - Considered ATLAS, JLAB, SNS, and many other cryomodule designs
  - Has arrived at a “generic” design which adapts easily to different lengths and heights

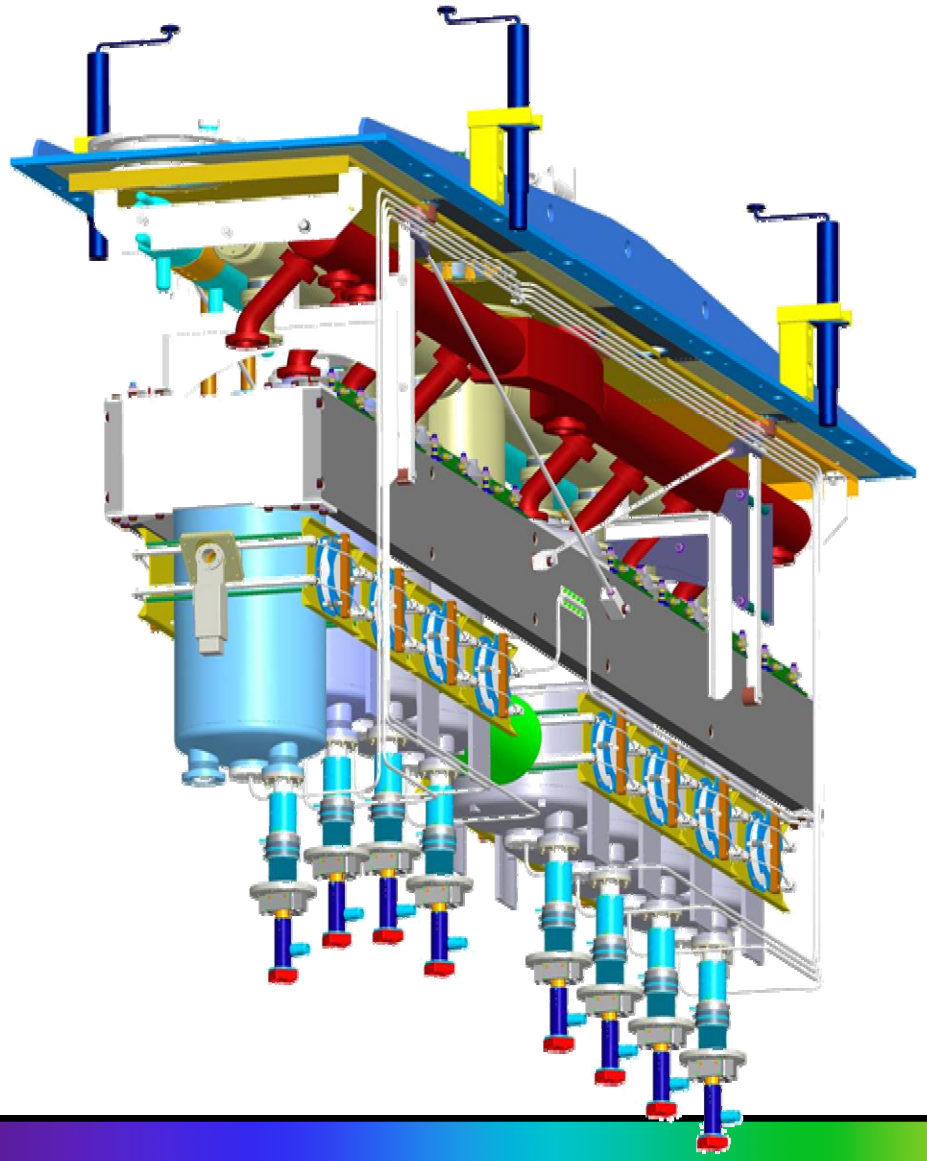
AEBL Cryomodule Assembly – typical active elements



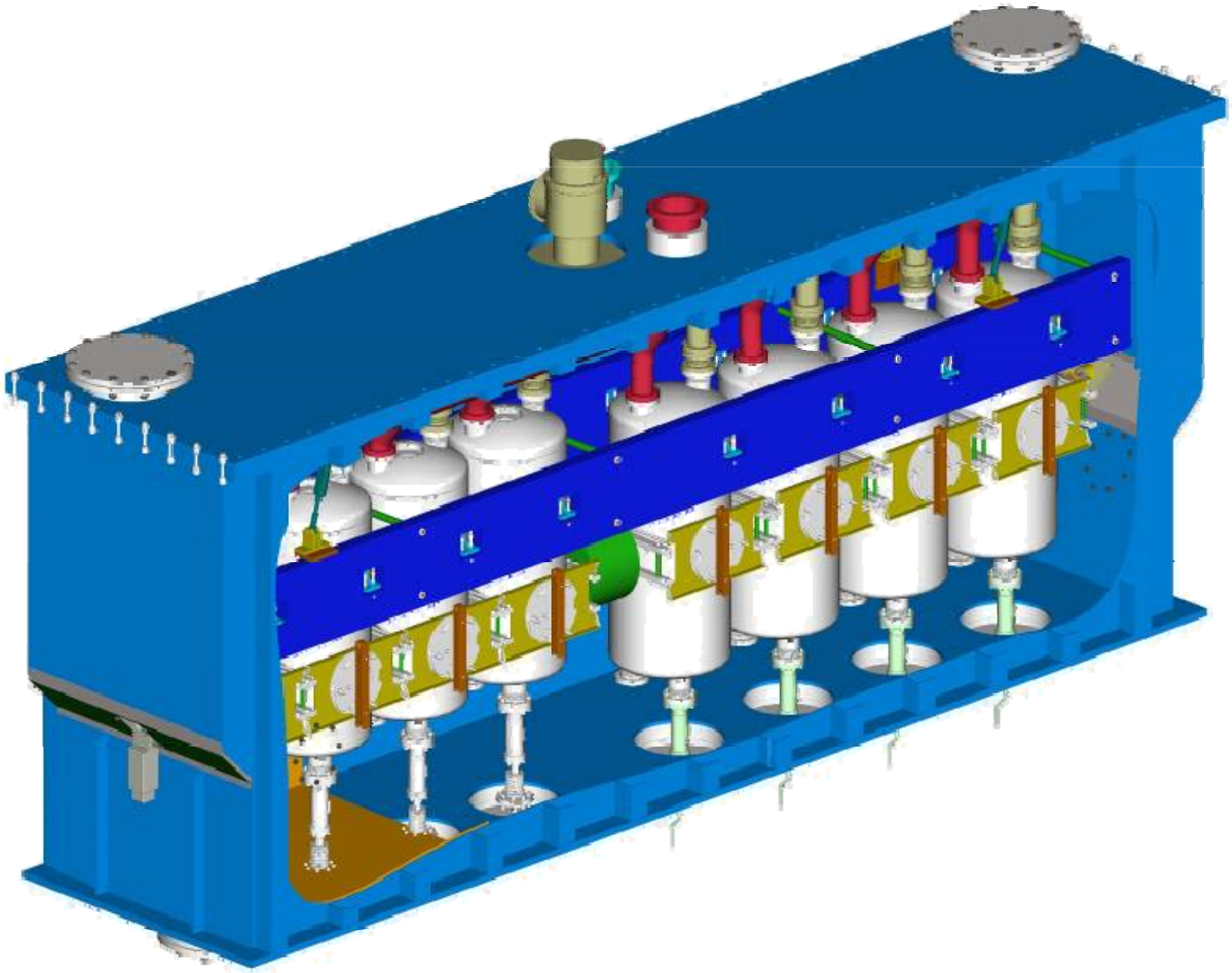
AEBL Cryomodule Assembly – the clean-room assembly (completes cavity vacuum system)



AEBL Cryomodule Assembly – all systems assembled and can be checked, except outer cryogenic vacuum box



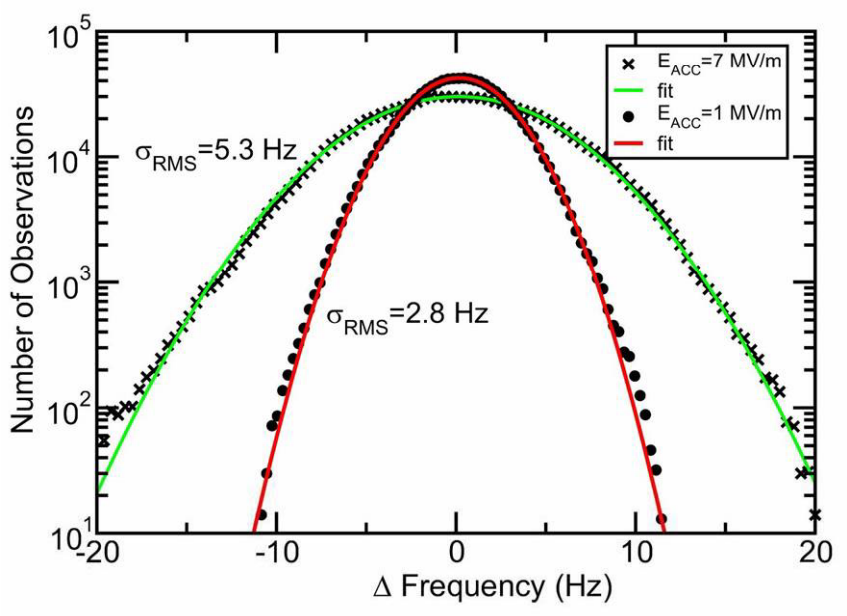
AEBL Cryomodule Assembly – the final step is simple and quick - - - in theory…

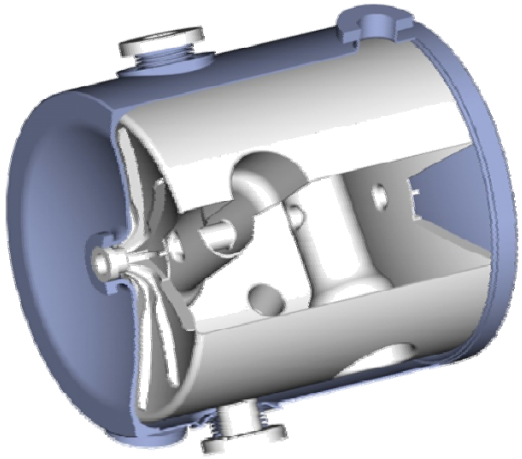


In fact, we'll find out next week…

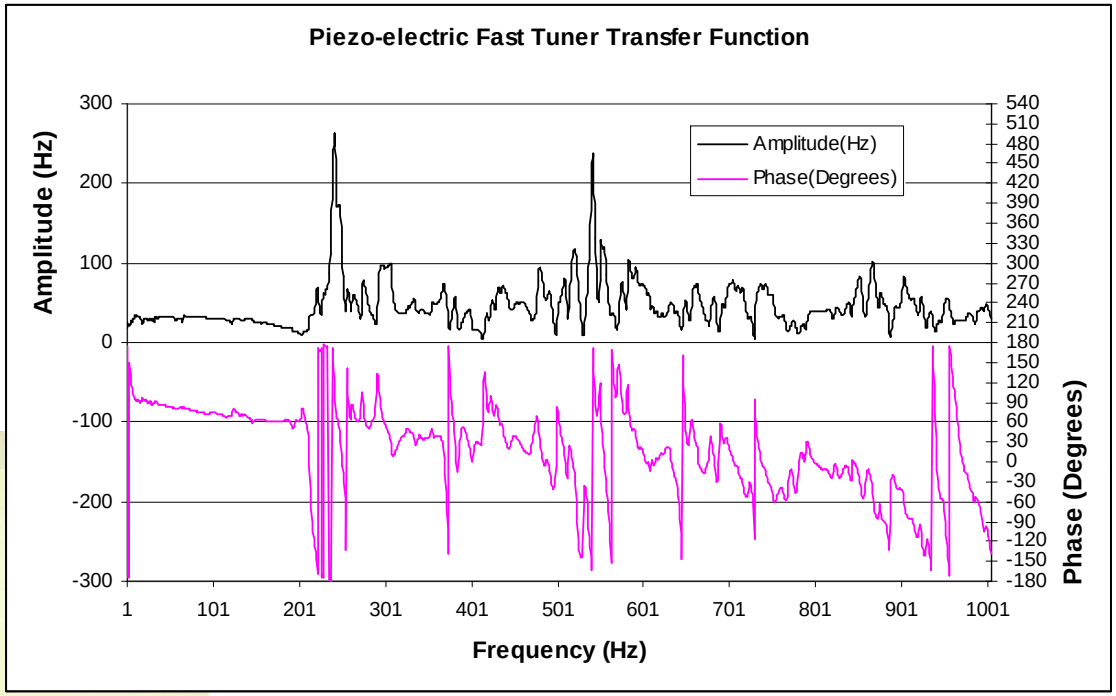
Microphonics, noise, and fast-tuners

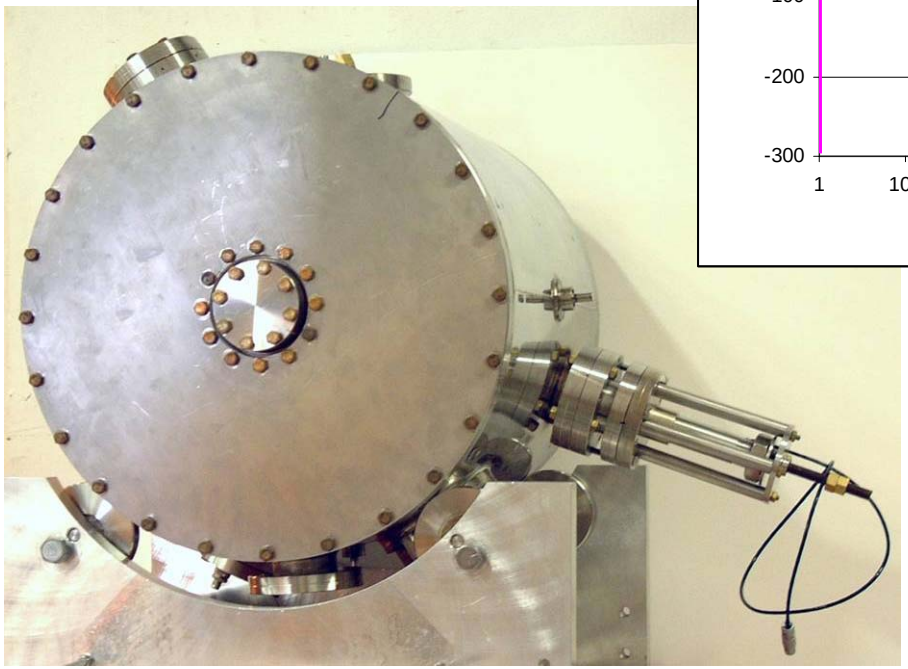
- We use reactive (PIN diode) tuners on ATLAS, but FRIB requires more (X10) tuning capacity
- Reduce microphonics by reducing df/dp
- Develop a mechanical fast-tuner





Fast tuner development – Zach Conway (now at Cornell) has proved the principle





Microphonics spectrum and piezo tuner test

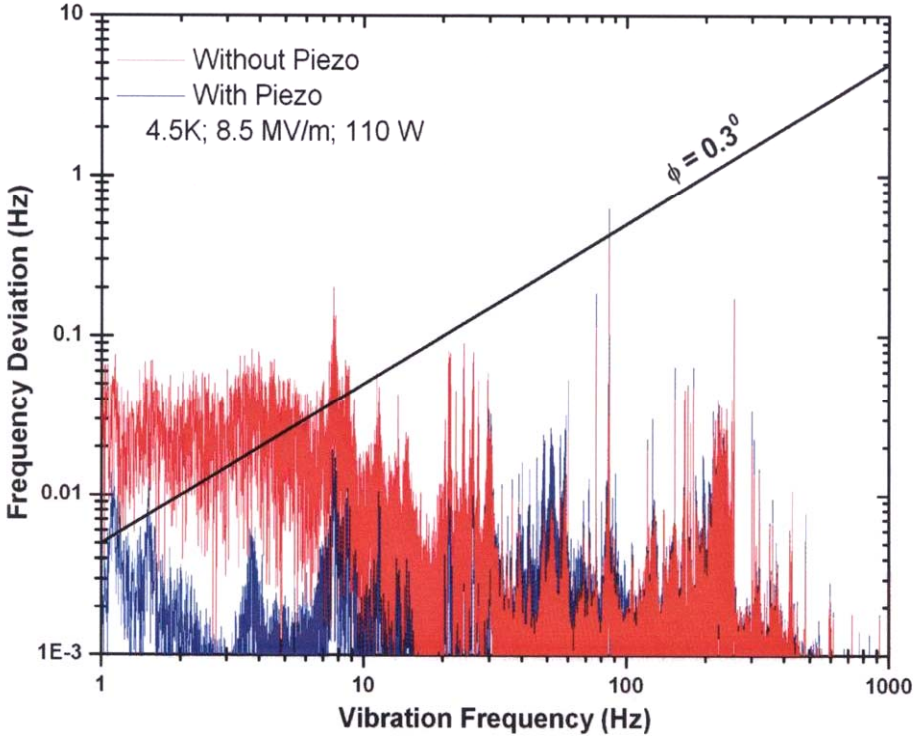


Figure 5.5: The β = 0.5 TSR cavity RF frequency variation vibration spectrums with the input power = 110 W (E_{acc} = 8.5 MV/m) at 4.5 K with and without piezoelectric damping of the RF frequency variations.

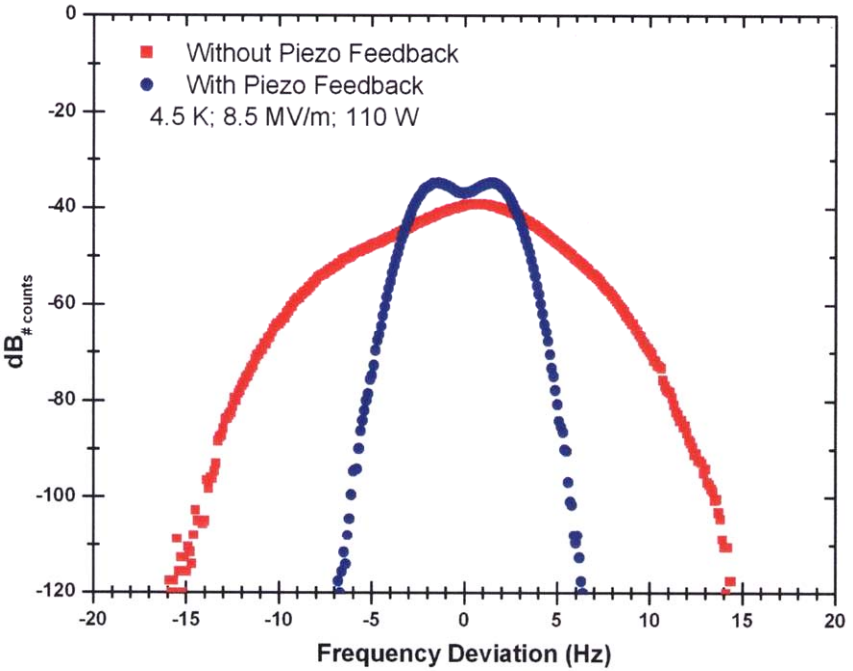
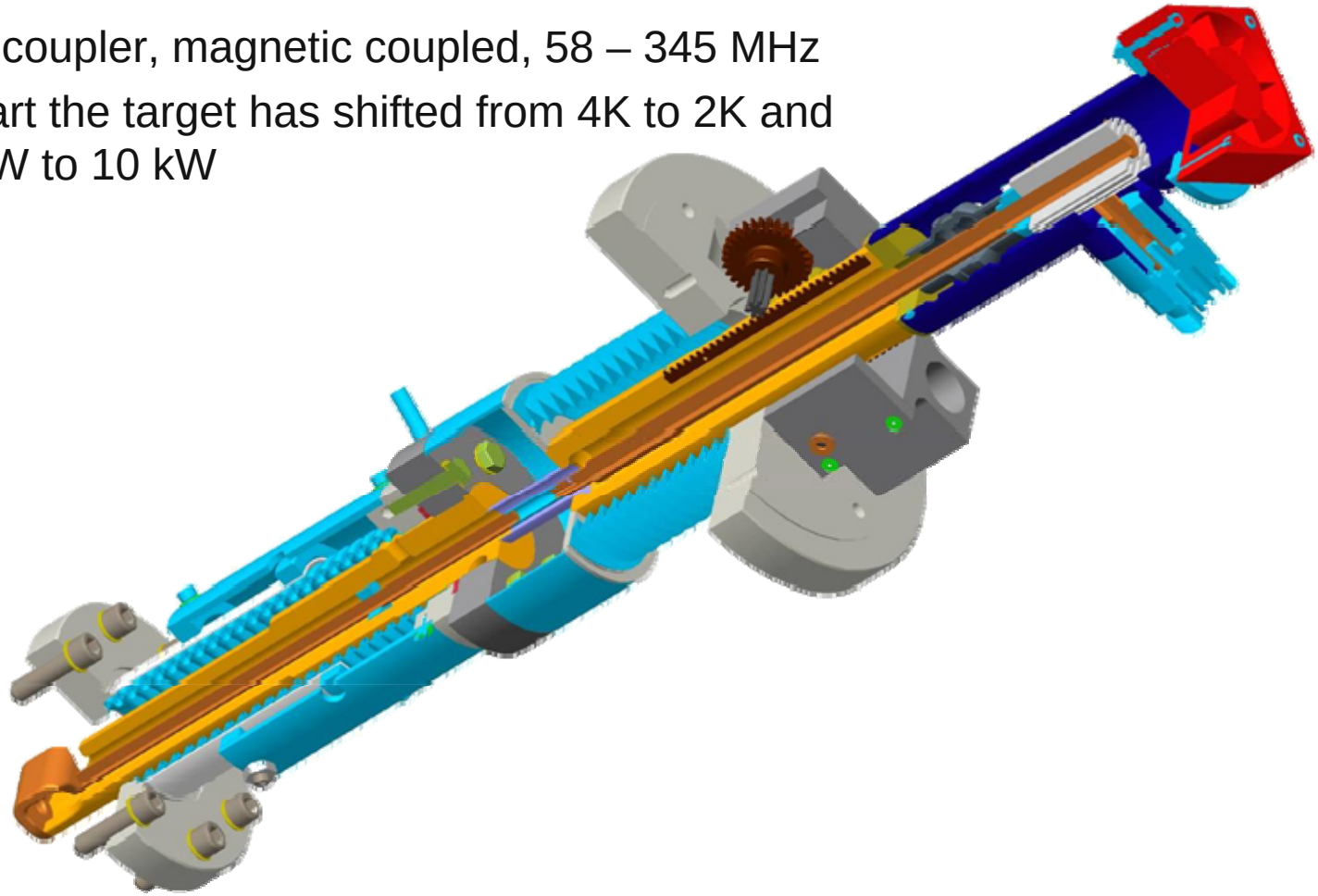
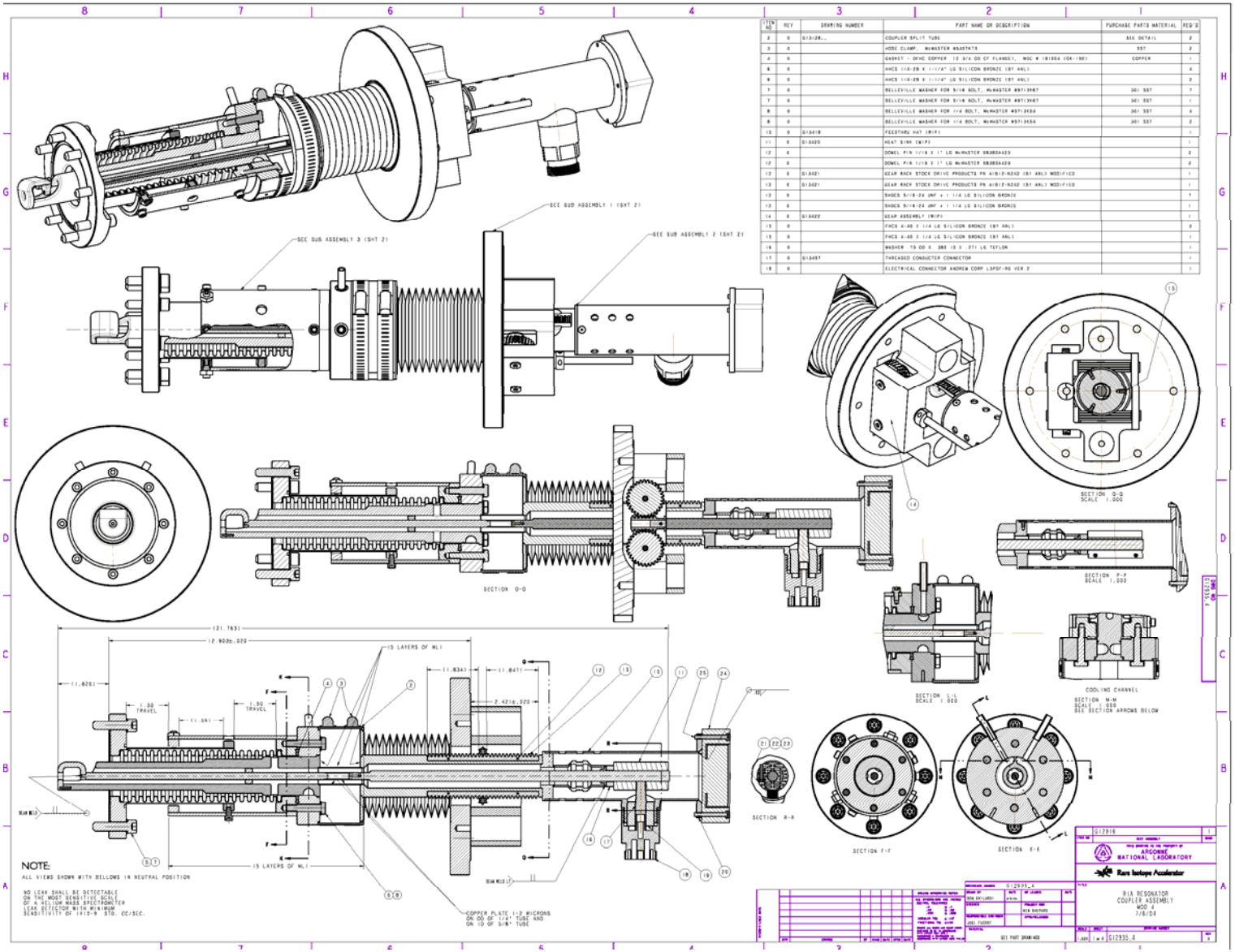


Figure 5.4: The β = 0.5 TSR cavity RF frequency variation spectral densities with the input power = 110 W (E_{acc} = 8.5 MV/m) at 4.5 K with and without piezoelectric damping of the RF frequency variations.

RF Coupler for FRIB

- Conceptual design with Anna Maria Porcellato (INFN Legnaro)
- Variable coupler, magnetic coupled, 58 – 345 MHz
- Since start the target has shifted from 4K to 2K and from 5 kW to 10 kW




NOTE:
ALL VIEWS SHOWN WITH BELLOWS IN NEUTRAL POSITION
NO LEAK SHALL BE DETECTABLE ON THE MOST SENSITIVE SCALE OF A HELIUM MASS SPECTROMETER LEAK DETECTOR WITH MINIMUM SENSITIVITY OF 1X10-9 STD. CC/SEC.
SECTION O-O
SECTION P-P
SECTION R-R
SECTION F-F
SECTION E-E
COOLING CHANNEL
ARGONNE NATIONAL LABORATORY
Rare Isotope Accelerator
RIA RESONATOR COUPLER ASSEMBLY
MOD 4
7/6/04

If FRIB at ANL then major JLAB participation

- My understanding of the present thinking is that JLAB:
  - Takes responsibility for
    - *the high-energy section of linac*
    - *Refrigeration system*
    - *Low-level RF system*
    - *Coupler development*
  - Is a partner in
    - *Fast-tuner development*
    - *Spoke cavity development*
    - *Cryomodule and other development as suitable*

- Lack of MOU is holding us back
  - Need confidentiality for participation in proposal
  - JLAB could participate now in ongoing work at ANL