56 MHz SCRF Cavity Mechanical Design

Full-time Engineer: Daniel Chenet

Design Support: Manny Grau

Engineering Support: Roberto Than, Chien-Ih Pai, Joseph Tuozzolo, Gary McIntyre, Steve Bellavia

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BROOKHAVEN NATIONAL LABORATORY

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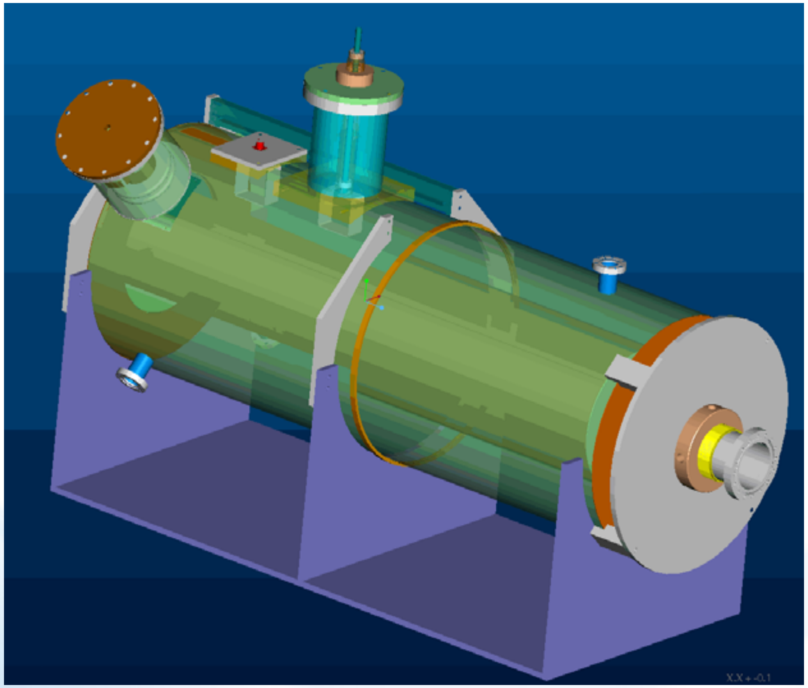
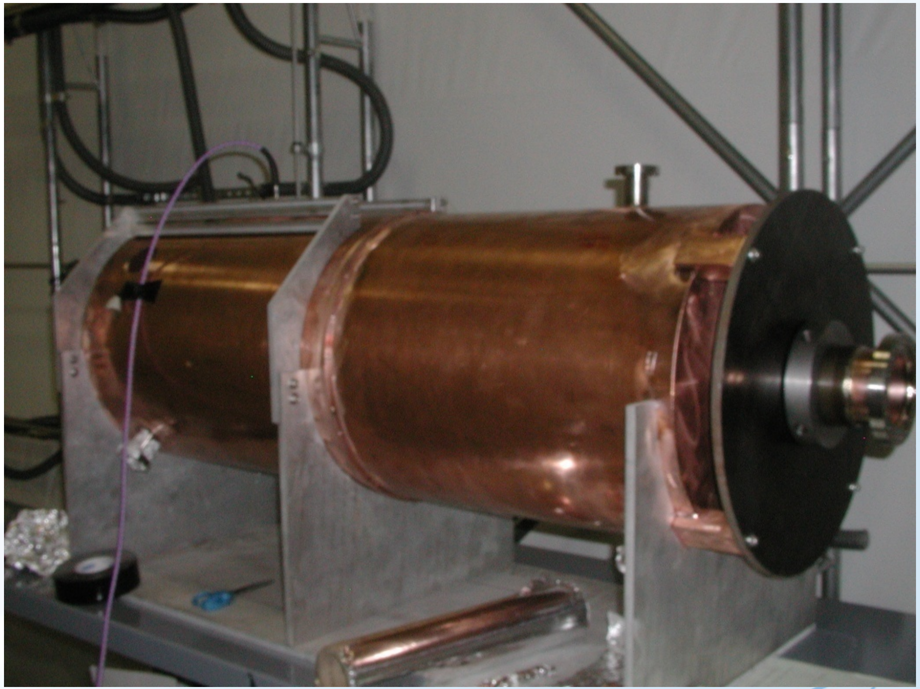
56 MHz SCRF Cavity Mechanical Design Topics for Discussion

- Current design and status of:
  1. Prototype I
  2. Prototype II
  3. SCRF cavity
- Design issues and analysis

56 MHz SCRF Cavity Mechanical Design Prototype I

- Copper cavity – fabricated and assembled. Located in Building 905.
- Fundamental damper – 80% complete
- HOM dampers – 20% complete



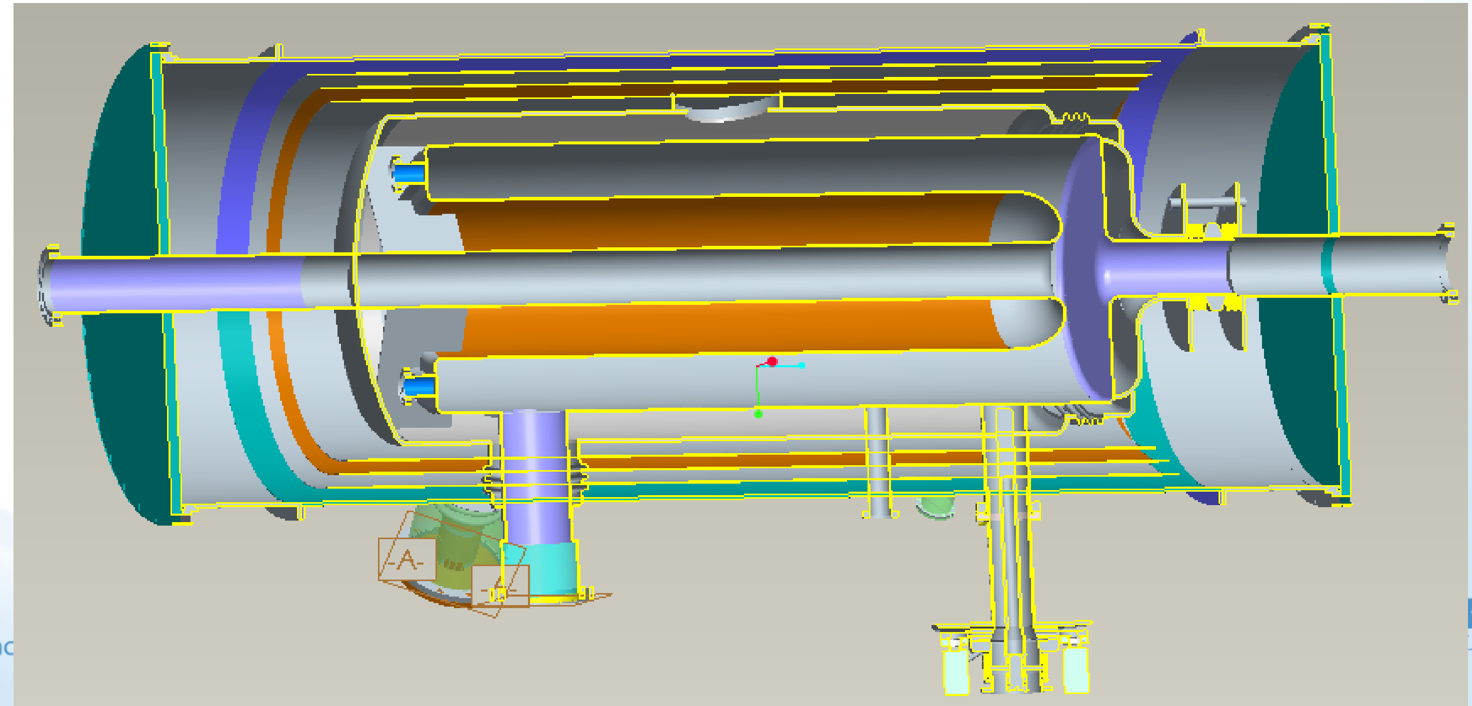


56 MHz SCRF Cavity Mechanical Design Prototype II

- Purpose: to determine how couplers change the frequency of the cavity and to test for multipactoring.
- Status: awaiting the exact dimensions of the final production cavity.
- Material: copper-plated steel or Nb?
- Room temperature high vacuum system.

56 MHz SCRF Cavity Mechanical Design Production Cavity

- Tasks completed:
  - Cavity designed for “tunability” and compliance with ASME Boiler and Pressure Vessel Code.
  - Preliminary thermal and acoustic analysis of cavity.
- Tasks in progress:
  - Cavity supports within He vessel and feedthrough design for couplers.
  - Stiffening of cavity to shift mechanical resonant frequencies and reduce sensitivity to liquid He pressure fluctuations.



56 MHz SCRF Cavity Mechanical Design Production Cavity Challenges

- ASME Boiler and Pressure Vessel Code
- RF Heating/trapped vapor volumes
- Thermal shrinkage/support/feedthrough design
- Mechanical reliability of fundamental damper
- Acoustic Vibrations
  - Center conductor
  - Tuning plate
- Tuner Design

56 MHz SCRF Cavity Mechanical Design Code Compliance

- ASME Boiler and Pressure Vessel Code
  - Maximum allowable stress: 2/3 S_y
  - S_y of high RRR niobium must be evaluated at room temperature
  - S_y @ 293K << S_y @ 4K (factor of 10)

- Optimal design for physics and tuning of the cavity ≠ optimal design for a pressure vessel

- Solutions:
  - Tuning plate is no longer a pressure boundary
  - Cavity is stiffened with ribs

* $S_y \equiv$ yield strength

56 MHz SCRF Cavity Mechanical Design
RF Heating/Trapped Vapor

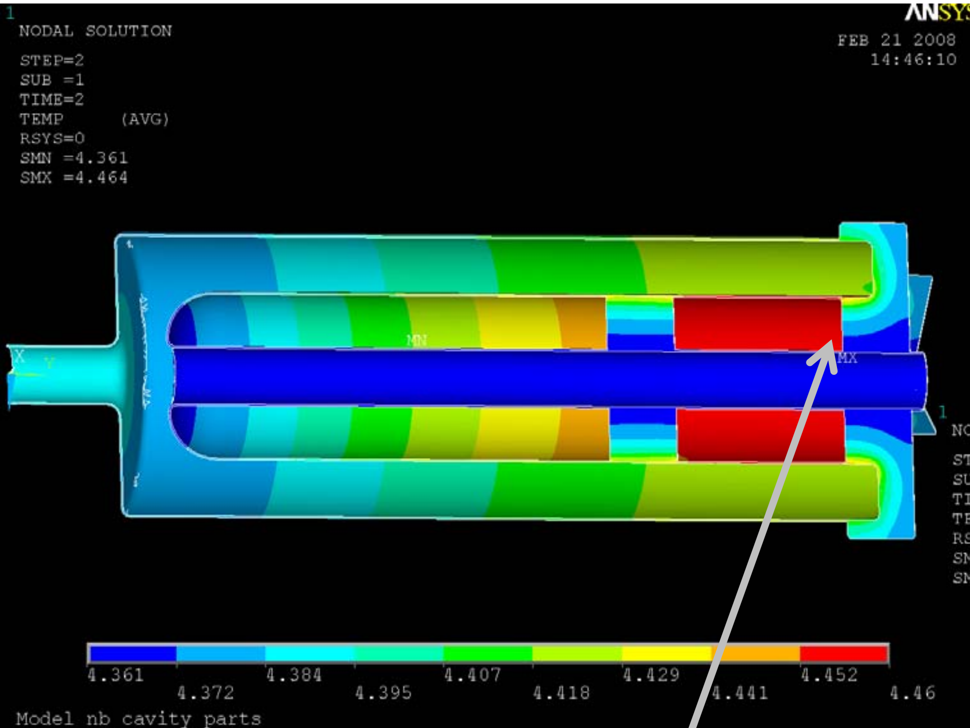


Figure 2 (below)

Simulation: cavity in a 4.35 K liquid He bath with a trapped vapor volume at 12:00 on the inner conductor

Peak temp: 8.348 K

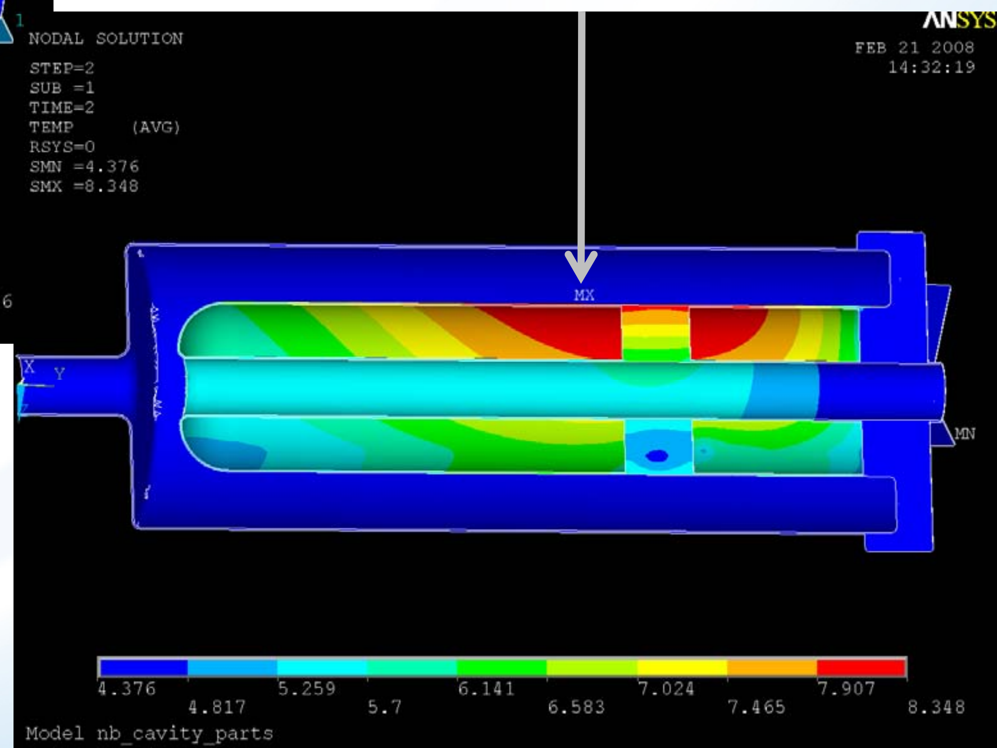


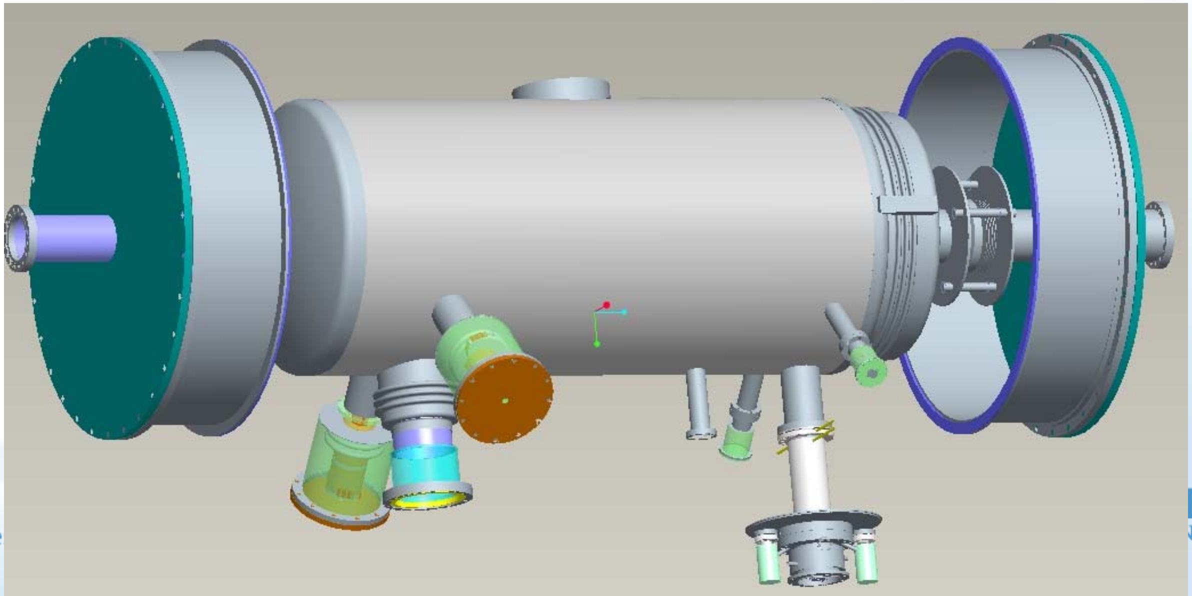
Figure 1 (above)

Simulation: cavity in a 4.35 K liquid He bath

Peak temp: 4.464 K

56 MHz SCRF Cavity Mechanical Design
Thermal Shrinkage/Support/Feedthrough Design

- Challenge
  - Currently 7 penetrations from the Nb cavity through the He vessel.
  - Differential thermal contraction→thermal stresses in Nb penetrations.
- Decisions made thus far
  - Titanium He vessel (similar integrated CTE).
  - Cavity should be supported/fixed near the center.



56 MHz SCRF Cavity Mechanical Design Fundamental Damper

Concern: mechanical reliability of a damper that will be cycled several times a day.

Possible Solutions:

1. Cam drive
   1. No abrupt stop
   2. Velocity profile can be chosen
2. Pneumatic drive
   1. Can adapt the damper design from the 197 MHz cavity for cryogenic use
   2. No abrupt stop
   3. Motion control air cylinders

* Damper design can be tested and evaluated before incorporating into the final SCRF cavity.

56 MHz SCRF Cavity Mechanical Design Acoustic Vibrations

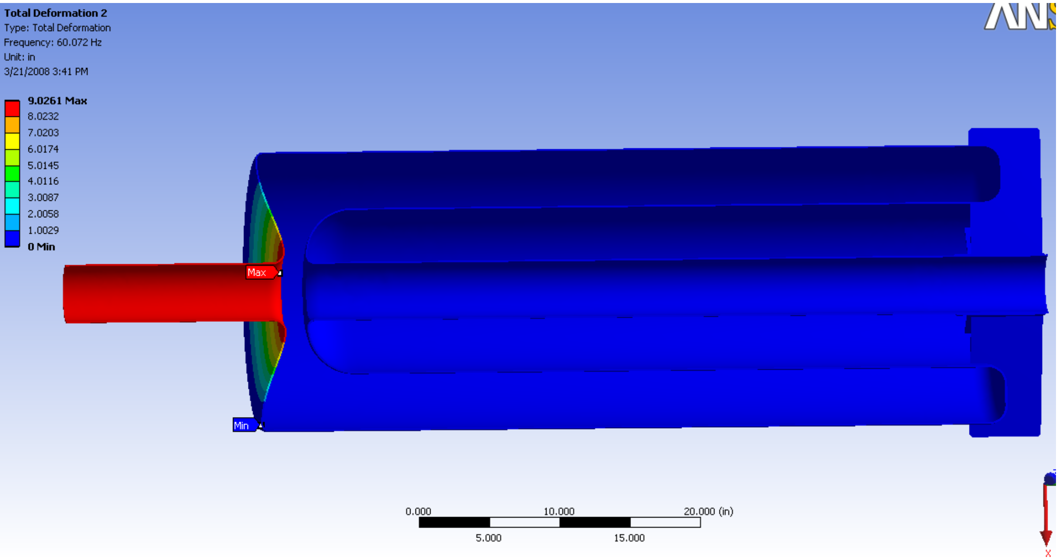
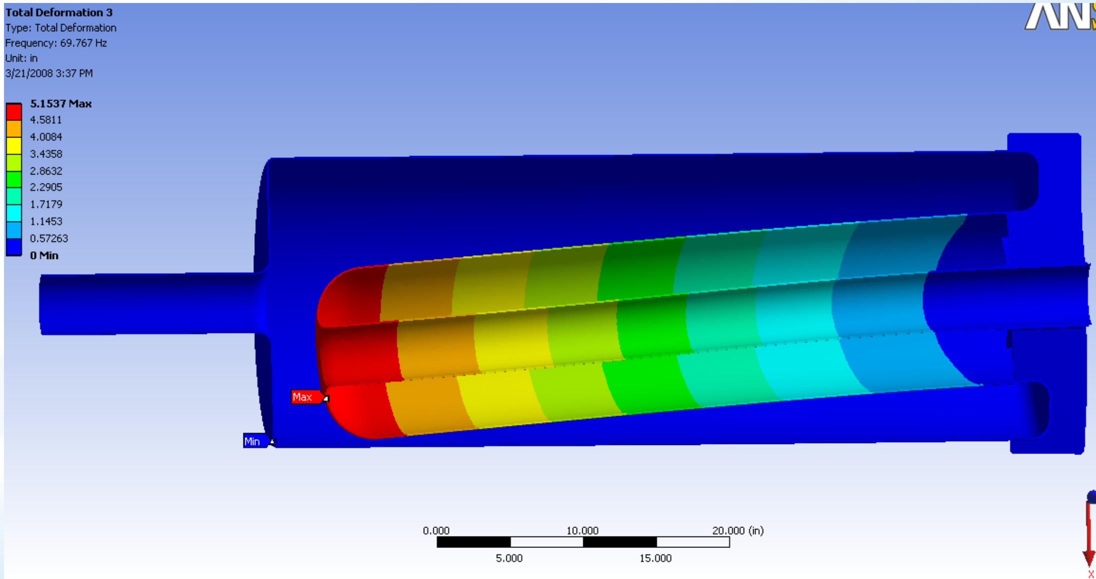


Figure 2 (below)

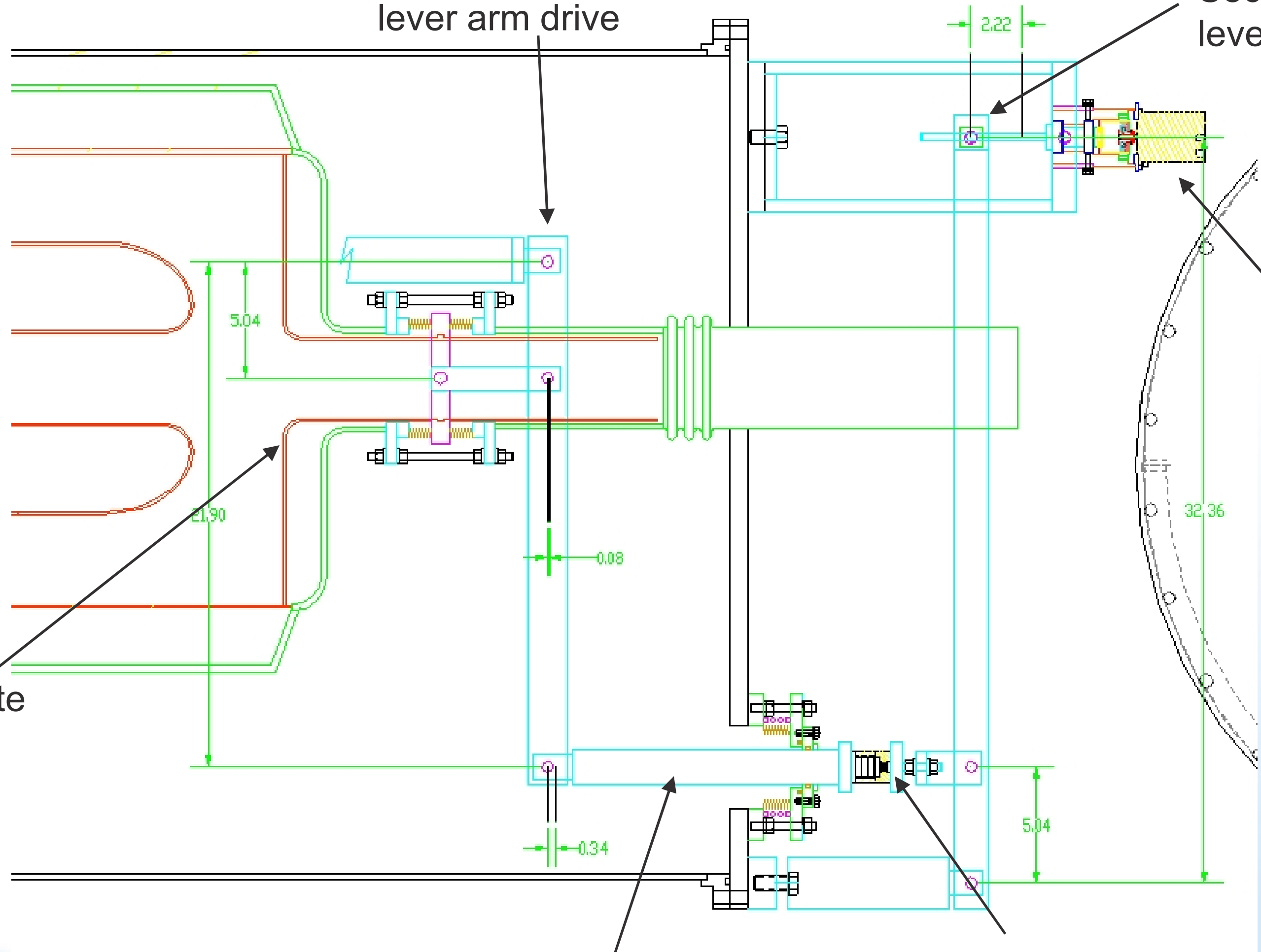
2nd mechanical resonance mode occurs at 69.767 Hz Vibrating inner conductor

Figure 1 (above)

1st mechanical resonance mode occurs at 60.072 Hz Vibrating tuning plate



56 MHz SCRF Cavity Mechanical Design
Tuner Design



56 MHz SCRF Cavity Mechanical Design Summary

- Full-time engineer: Daniel Chenet
- Design support: Manny Grau
- Engineering support: Roberto Than, Chien-Ih Pai, Joseph Tuozzolo, Gary McIntyre, Steve Bellavia

1. **Prototype I Status:** cavity is complete; more work to do on dampers.

2. **Prototype II Status:** awaiting specifications.

3. **SCRF Cavity Status:** mechanical engineering work underway on the final SCRF cavity to define and solve all issues.

❖ **No major engineering or mechanical design showstoppers are apparent at this time**