RF Module Update

MICE Collaboration Meeting 44
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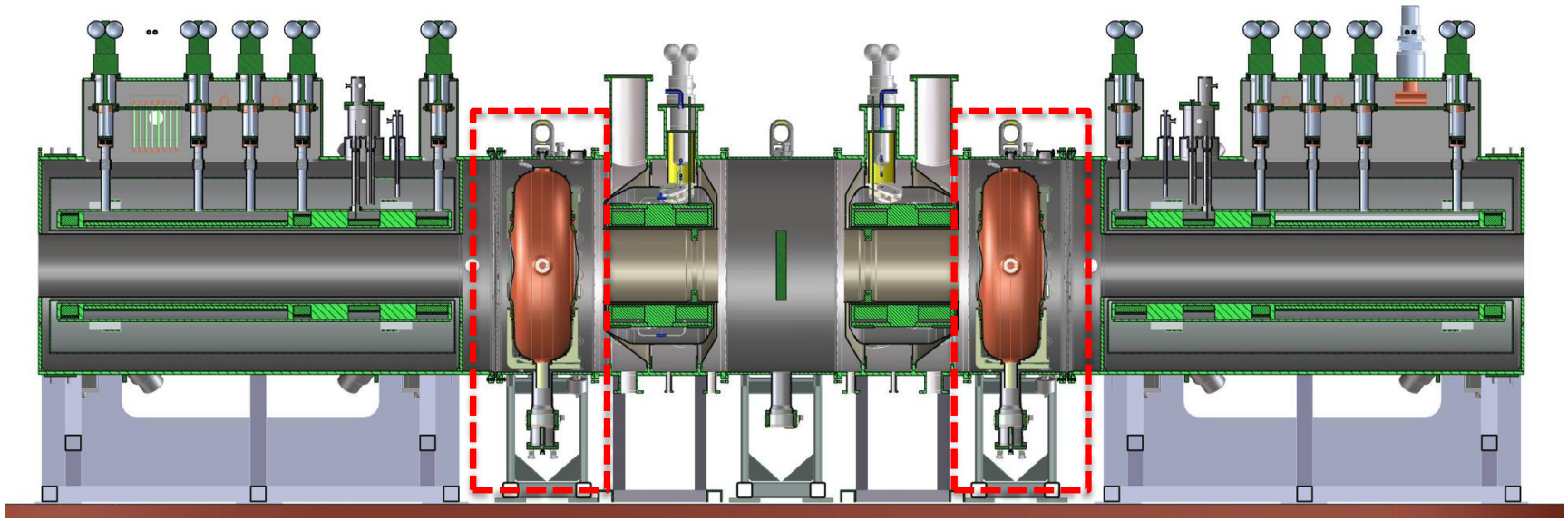
Lawrence Berkeley National Laboratory
March 30th, 2016

MICE Cooling Channel



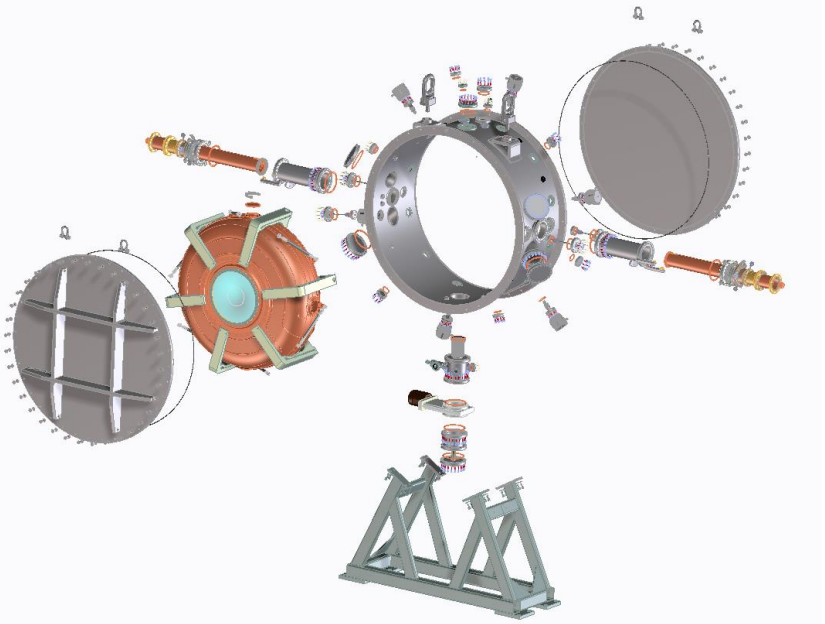
- **MICE cooling channel needs two RF modules**
- **Each MICE RF module has**
  - One 201 MHz RF cavity
  - Two Beryllium windows
  - Two RF power couplers
  - One vacuum vessel hosting the 201 MHz RF cavity
  - Six tuner arms and six actuators
  - Cavity support struts
  - Vacuum pump system and water cooling
  - Diagnostics and bypass lines

Current Status of MICE RF Module

- **Vacuum vessel for the RF Module**
  - Design complete
  - In fabrication at Keller, Inc., in Buffalo, NY; near complete, expect delivery to LBNL near May 1st, 2016
- **RF power coupler fabrication complete**
  - Updated design addressed issues identified at MTA assembly
  - Two couplers delivered to FNAL MTA – high power tested with and without B-field, meets MICE requirement
  - Four additional couplers assembled at LBNL
- **New tuner actuator design, prototype and fabrication complete**
  - Prototyping complete
  - Function testing (both functional and lifetime) complete
  - 12 production actuators completed + 2 spares completed
- **25 tuner arms shipped from University of Miss. to LBNL**
  - Received, tuner arms modified to nominal dimensions for each cavity
- **Vacuum system design (protection of Be windows) complete**
  - Bypass line with limited conductance
  - Differential pressure box to protect against fault
- **RF cavities**
  - 4 cavities selected; 2 for operation, 2 spares
  - Cavity EP complete
  - Water-feedthrough welding complete

Vacuum vessel

- Vessel under fabrication currently
  - Expected delivery to LBNL May 1st, 2016
  - Will add viewports for Be window inspection
    - received from FNAL
  - Vacuum system has been re-designed for Be window protection

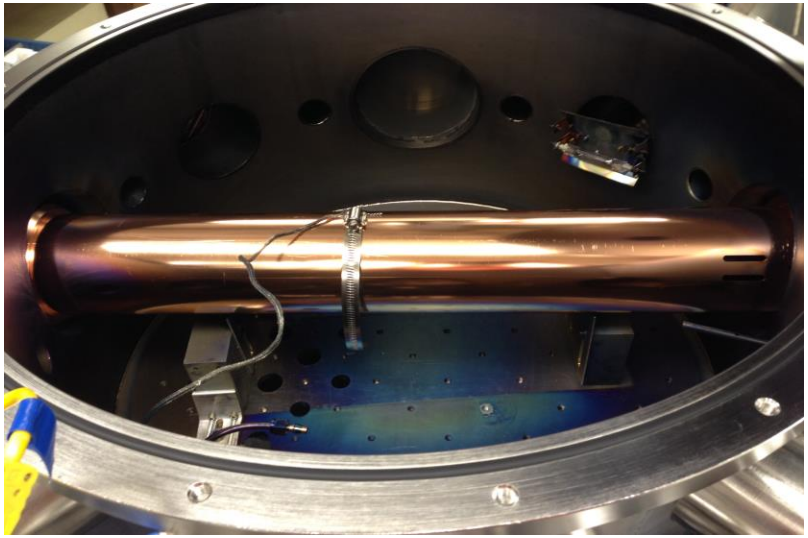


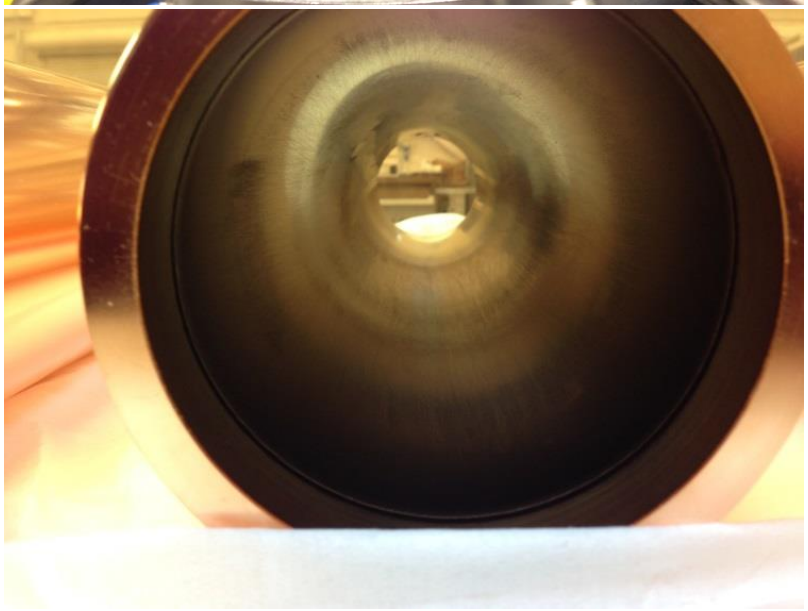
  - Keller will perform leak check pre-shipment
    -> LBNL will verify leak-tight status upon arrival
    - RGA scan as well to identify any possible contaminants (i.e. cutting fluid)
    - Steam clean if necessary
  - LBNL has all the fixturing required for assembly – shipped from FNAL MTA hall

RF Couplers

- Completed 2 couplers
  - Sent for FNAL MTA hall for testing
- 4 additional RF couplers
  - 2 per MICE RF module
- Inside surface of outer conductor and coupling loops are TiN coated at LBNL
- Assembled couplers cleaned and ready for assembly
  - Wrapped in cleanroom paper/foil
  - Stored in clean tent
  - Not handled until assembly
- Testing complete at MTA – successful

TiN Coating of Coupler





- TiN coating process done @ LBNL

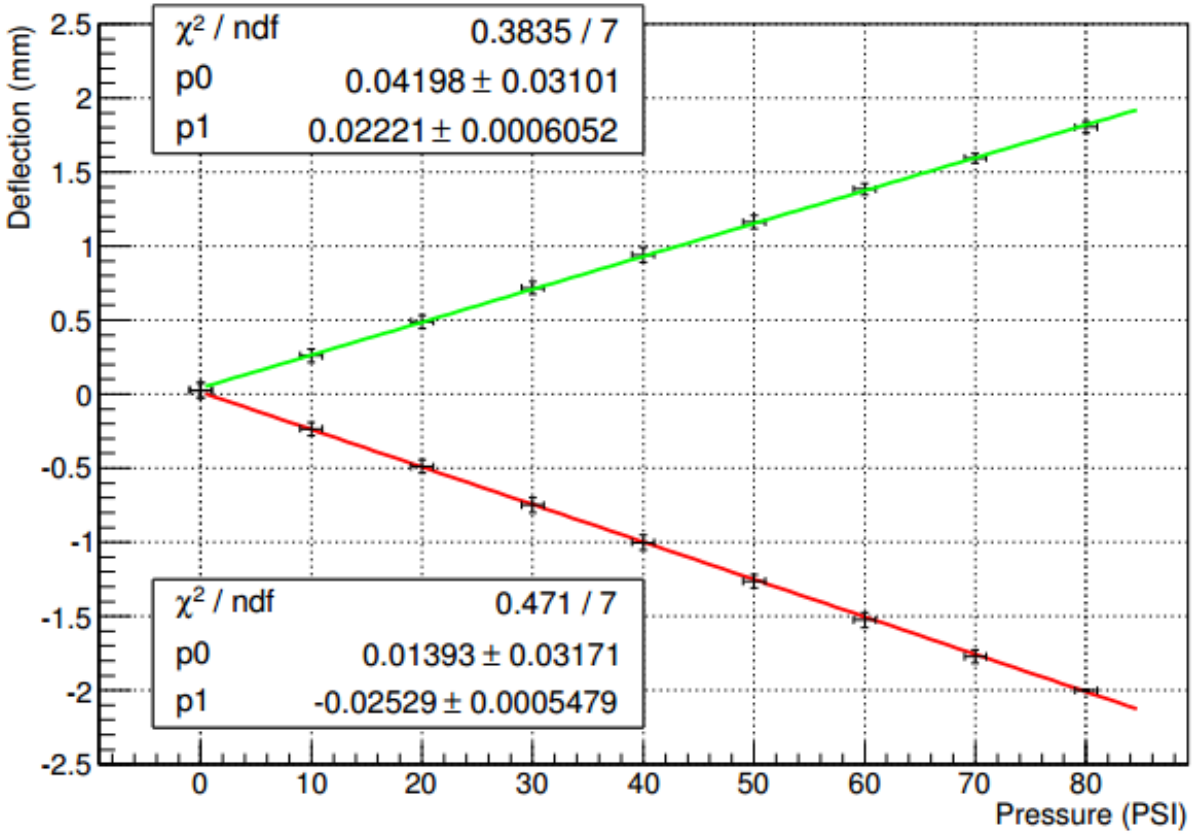
Actuators

- Actuators re-designed to avoid previous issues with N2 leak into vacuum
  - N2 lines are now outside of vacuum

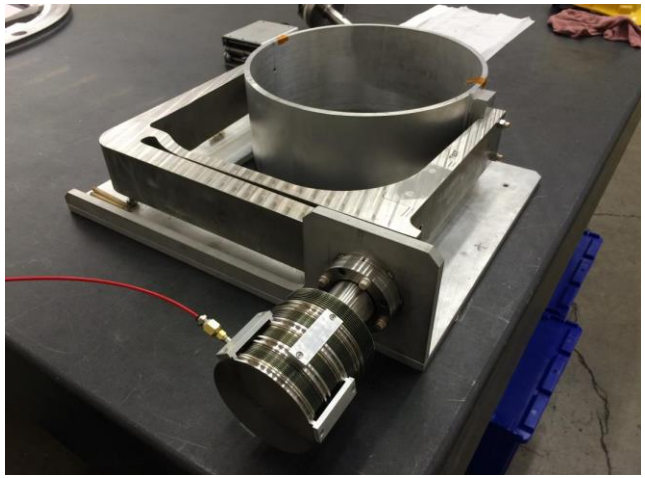
- Completed 12 production units
  - 2 spares
  - 2 additional units need re-work
- Prototype unit successfully fabricated and tested
- Production units cleaned, ready for assembly

Functional Test of the Actuator

Agree well with previous testing results at Fermilab, lifetime testing started early May 2015, but a leak was developed at one of the bellows after 1200 cycles at ± 80 psi (± ~ 200 kHz). A more meaningful and realistic testing plan was developed and the testing resumed in June 2015.

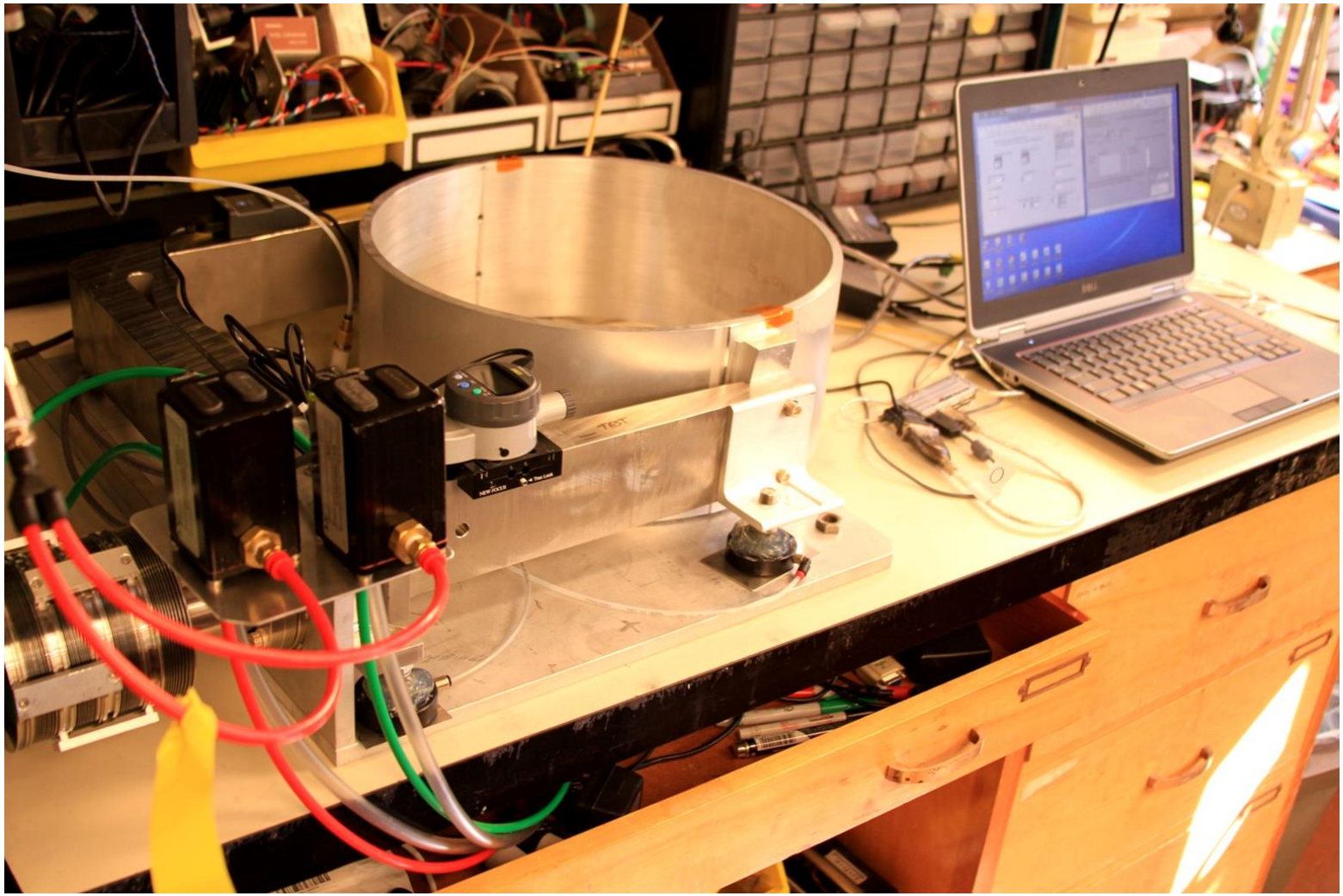


The actuator has been repaired: broken bellows has been replaced and welded.



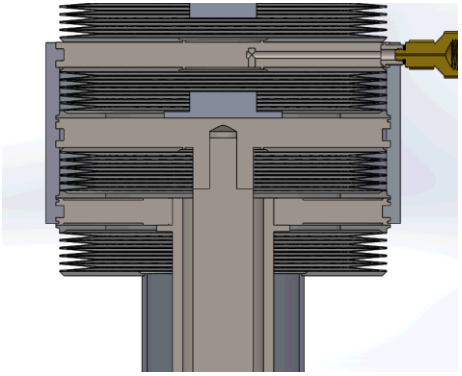
Lifetime Testing of the New Actuator

- **Testing setup at LBNL**

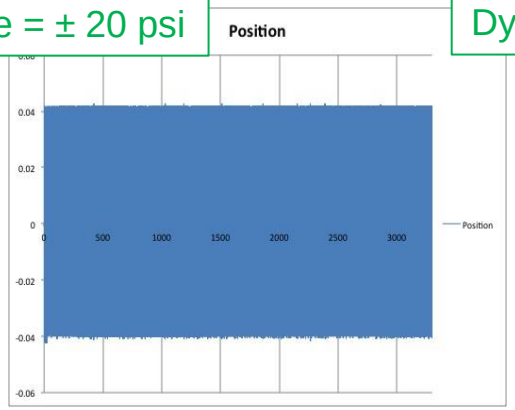


Successful Lifetime Testing

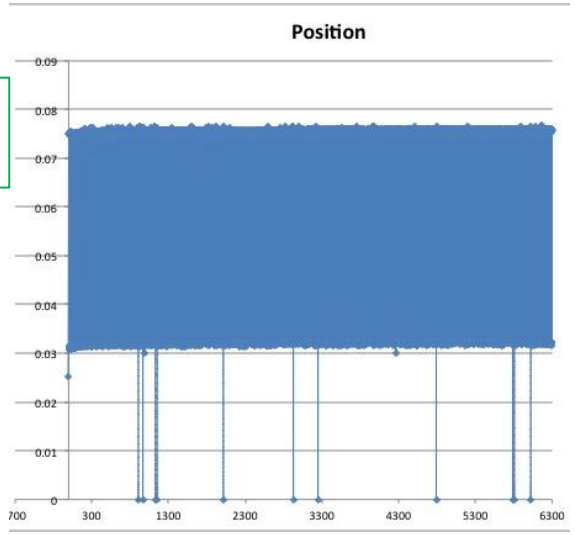
- **Lifetime testing programs**
  - ± 20 psi (± 50 kHz) at base pressure of 0, 15 and 30 psi for 10,000 cycles (each compartment) + 40 hours operation
    - Base pressure equivalent to a frequency offset
    - Pressure variation ➔ dynamic tuning
  - All 3 sets of the testing complete
    - Very smooth operation
    - No hysteresis observed
  - 40 hours lifetime test complete & successful



Base pressure = 0 psi
Dynamic range = ± 20 psi

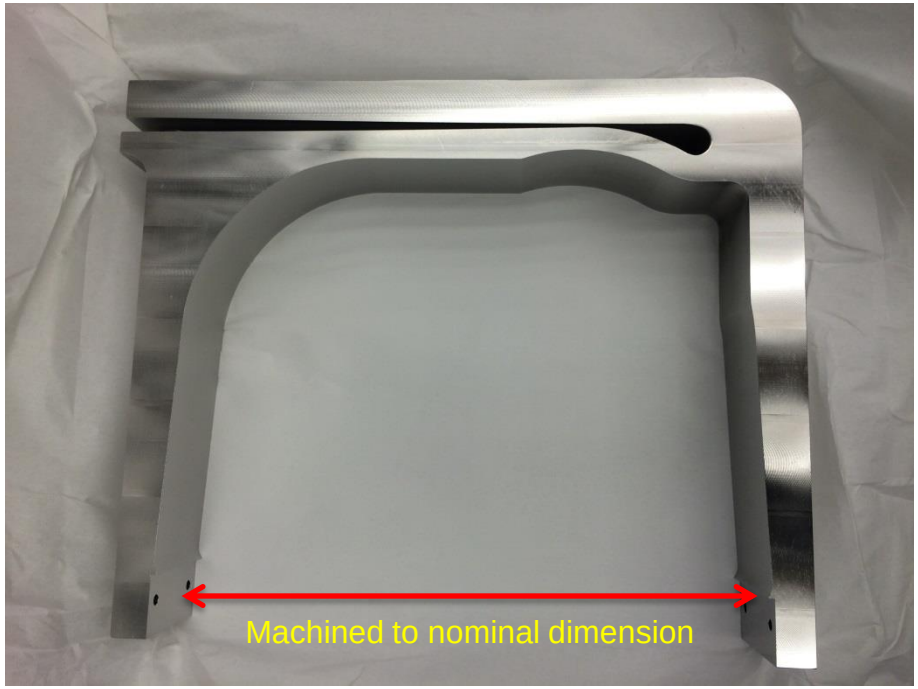


Base pressure = 15 psi
Dynamic range = ± 20 psi



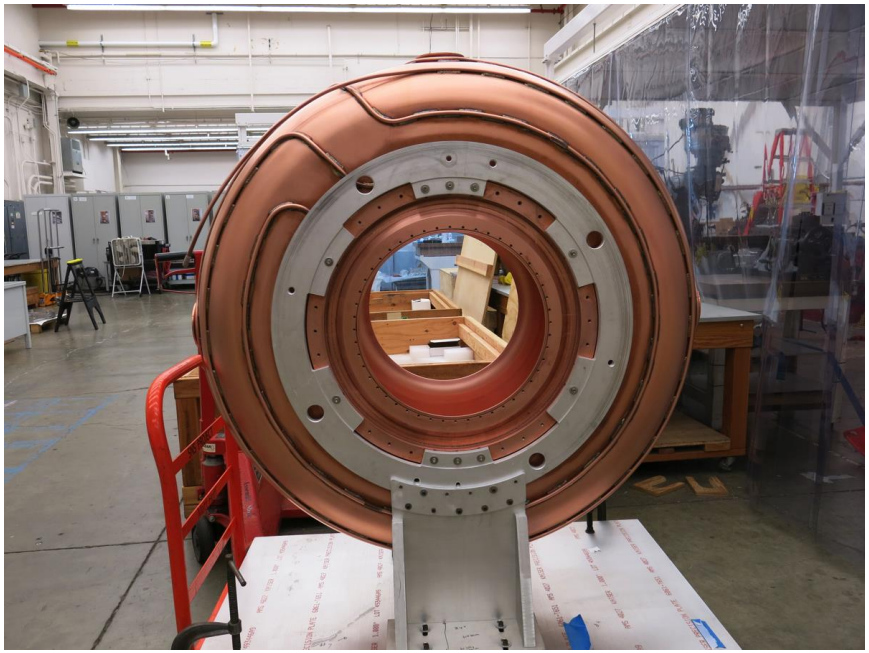
Tuner arms

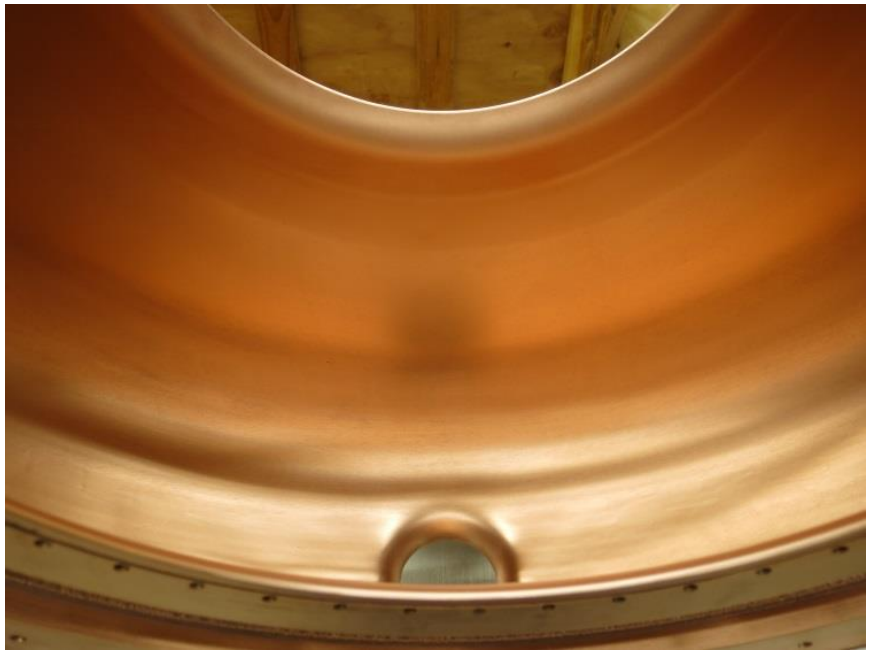
- Received 25 tuner arms from University of Mississippi
  - Need 12 total (6 per cavity)
  - Surveyed the selected RF cavities to find nominal dimension between mount points
  - Machined each set of 6 to nominal dimension, cavity specific, stamped parts to ID
  - Made custom shims to help position during assembly
  - UHV cleaned and ready for assembly



MICE RF Cavities

- **Cavity (with beryllium windows) selection complete**
  - Four cavities selected (two spares)
  - In combination with different Be windows, additional ~ 100 kHz frequency tuning range
- **EP of the four cavities complete**
- **Production cavities are stored in clean tent in assembly shop**

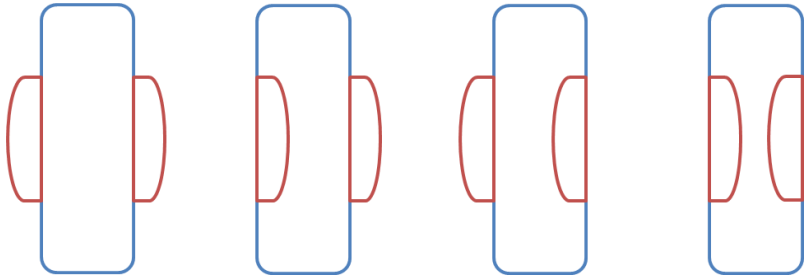




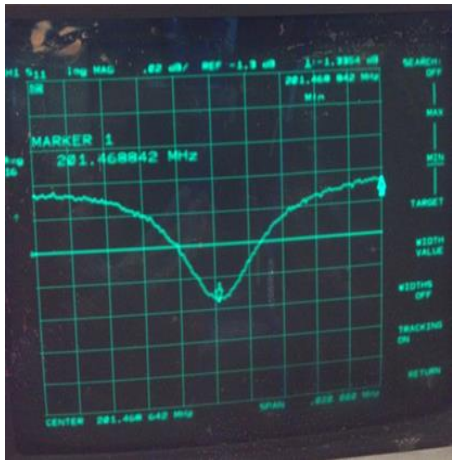
Frequency Measurement

- Cavity Frequency:

$$f = f_{body} \pm f_{window\ 1} \pm f_{window\ 2}$$

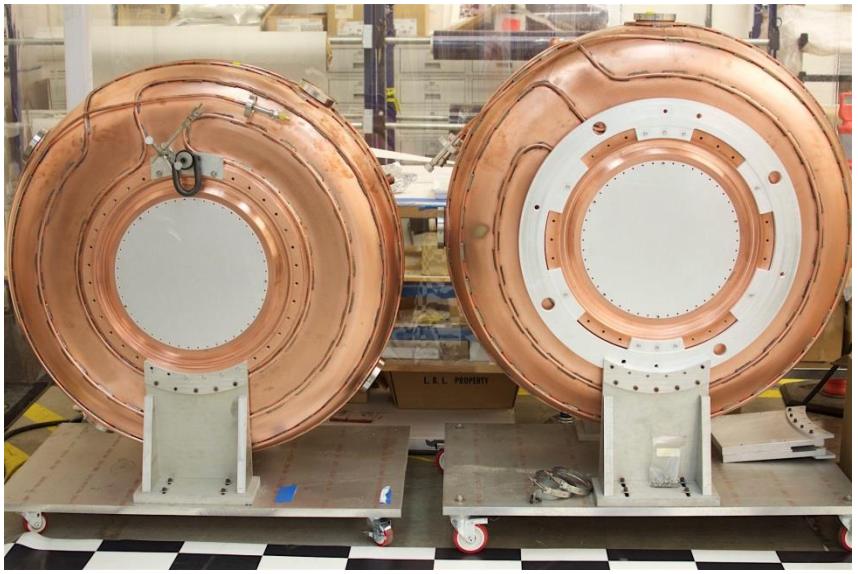


- For a cavity body and a pair of Be windows, measure three different configurations and solve f_body and f_windows.
- Cavity selection procedure: pick 4 cavity bodies out of 9 based on their surface conditions and body frequencies. Then pick Beryllium window pair for each body.



MICE RF Cavities

- Water feedthrough welding is complete
  - Two feedthroughs per cavity
  - Vacuum and leak checks completed, weld is successful
- Cavity interiors sealed with aluminum blanks to keep inside free of contaminants/dust
  - Will not remove until installation of Be window
- Will clean exterior of cavities before installation into vacuum vessel



Clean room setup

- Completed clean tent setup
  - Portable clean tent
  - 6’ x 6’ changing tent – need to add sticky flooring
  - New curtains
  - Increased ceiling filter coverage
  - Linoleum flooring
  - Need to add table with gowns, booties, gloves, etc.
- Particle count - Both changing tent and clean tent passed Class 1000 standard

Schedule

Date	Task
Mid April	Complete assembly of FNAL cavity installation fixtures
Beginning of May	Receive 1st vacuum vessel from Keller, 2nd vessel arrives ~ 2 weeks later (Originally January 2016)
	Complete vessel leak checks, RGA scan
	Begin cavity strut alignment for installation
	Install first cavity into vacuum vessel
End of May	Cavity installation complete, begin installation of RF couplers, actuators, water feed through flanges, etc.
	Begin installation of vacuum systems components; NEG pump and vacuum spool piece, bypass lines, pumpdown lines, differential pressure box
End of June	Vacuum system pump-down, RF system testing, tuning system testing
	Complete pre-shipment testing
End of July	RF module shipping prep
Late August	Target date for 1st RF module to arrive at RAL, 2nd to arrive ~ 1 month later (Originally Mid June 2016)

Summary

- LBNL has completed all fabrication steps in preparation for the RF module assembly
- Received assembly fixturing and vacuum system components from FNAL
- Vacuum vessel fabrication is near complete
- Assembly shop clean tent is setup, space is reserved
- LBNL is ready to receive the vacuum vessel and begin assembly