# MICE RF System Overview

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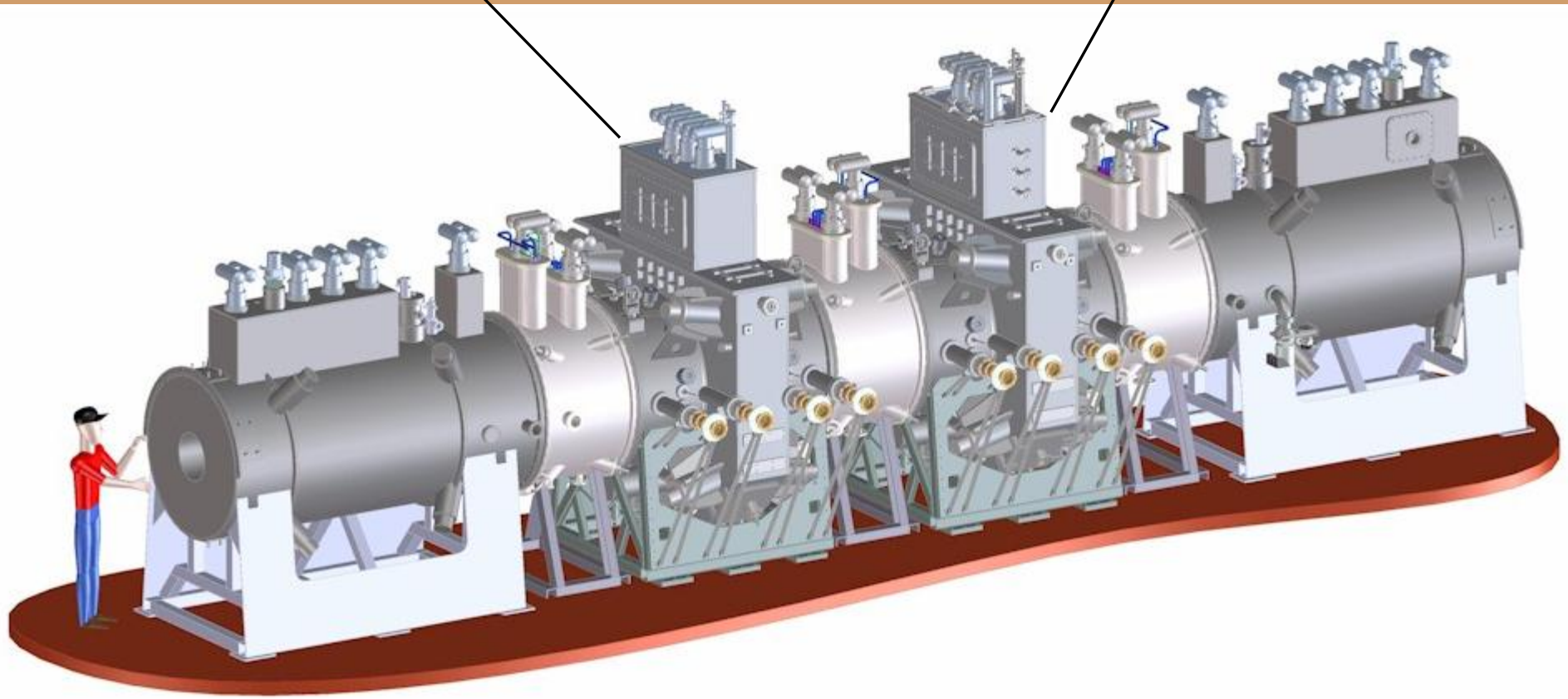
# MICE RF System Overview

- Hardware
  - Two RFCC modules: two pairs of four 201-MHz RF cavities with 16 coaxial loop RF couplers and ceramic RF windows (two per cavity) - LBNL
  - Amplifiers and power distribution systems - DL
  - *Vacuum and water cooling systems* - RAL
  - Diagnostics and control systems
- Software
  - LLRF firmware and cavity tuning
- MICE data analysis
  - Controls and correlation between detectors and RF amplitude/phase
- RF design review held in December 2011

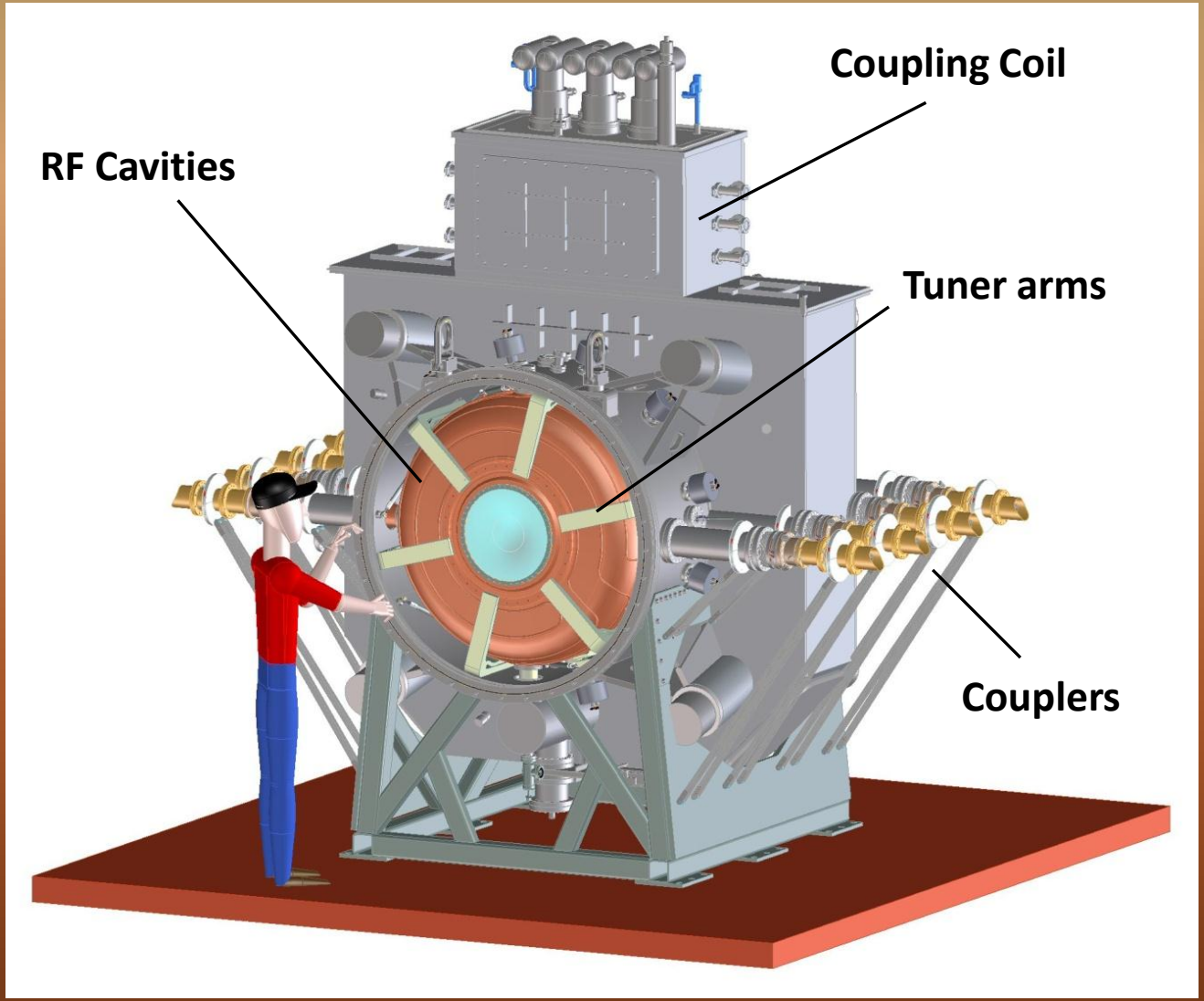
# 2 RFCC Modules in MICE Channel



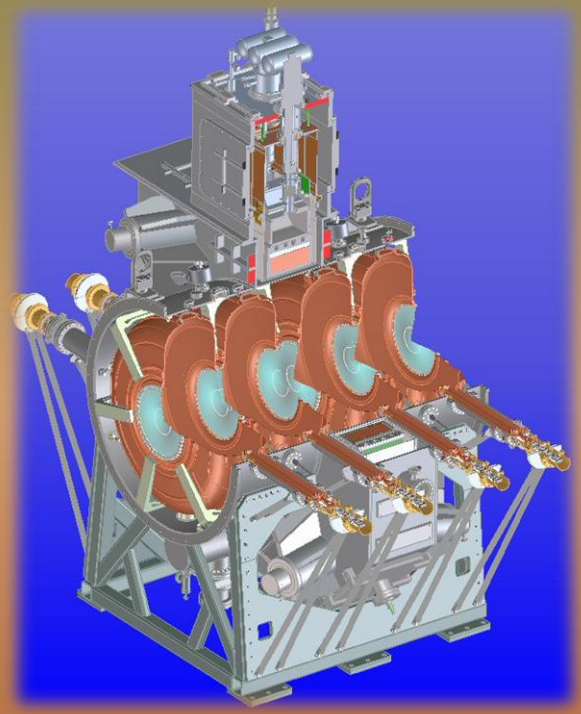
# RFCC Module Overview

- The MICE RF and Coupling Coil Module has been designed by LBNL and our collaborators
- The MICE cooling channel incorporates two RFCC modules to be provided by LBNL
- Each module consists of a single superconducting Coupling Coil integrated with four tunable 201 MHz normal conducting RF cavities and a vacuum vessel
- The Coupling Coil design was developed by the Harbin Institute of Technology (HIT) in China (a MICE collaborator), in collaboration with LBNL
- A third Coupling Coil (first delivered) for MuCool will be sited in the MTA at Fermilab
- The 201 MHz cavity design is based on the prototype cavity developed by LBNL and J-Lab and has been operated in the MTA

# RFCC Module Overview

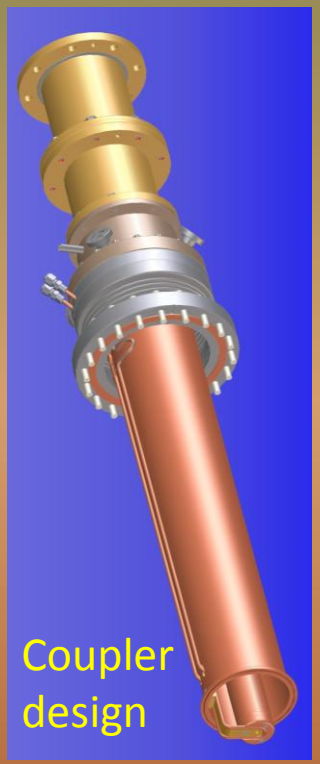


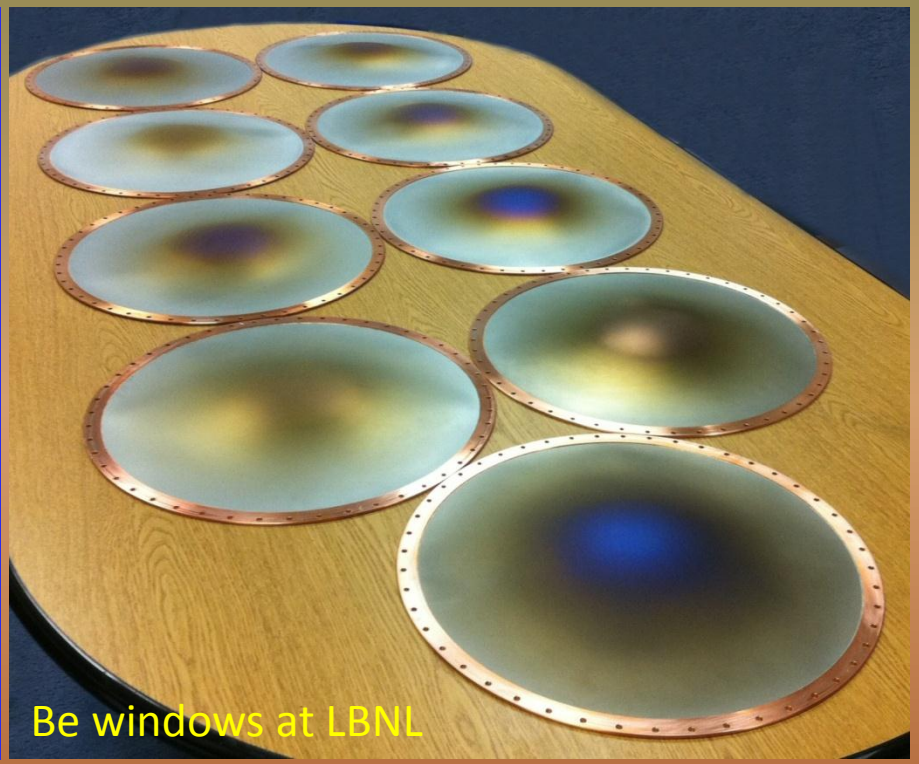
# Status of RF Cavities



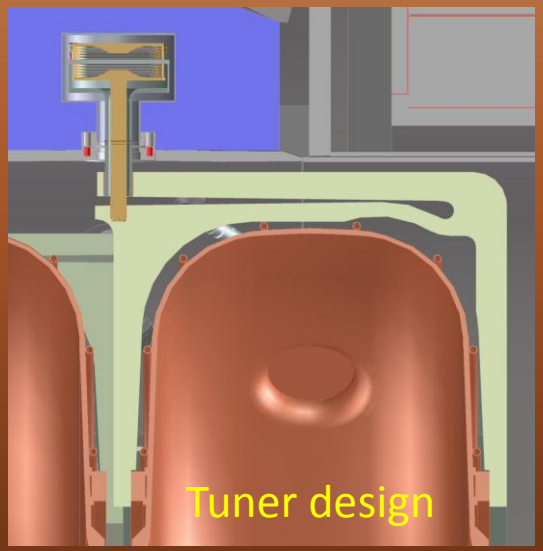
- Ten RF cavities (two spares) at LBNL now;
- All 11 beryllium windows received at LBNL;
- Ten ceramic RF windows;
- Six tuner flexures are being fabricated at Fermilab;
- Components for 6 actuators are being fabricated;
- RF loop coupler design has been updated to eliminate the gap between the outer coax and the RF loop;
- EP preparation in progress at LBNL:
  - Fabrication of fixturing complete;
  - ES &H approval for EP in progress at LBNL;
  - Preparation of the cavity surface: mechanical smoothing;
  - EP to start after the ES & H approval.
- Measurements of the remaining six cavities to start after EP;
- Each cavity will be tuned to a center frequency after EP.


EP setup at LBNL


Coupler design

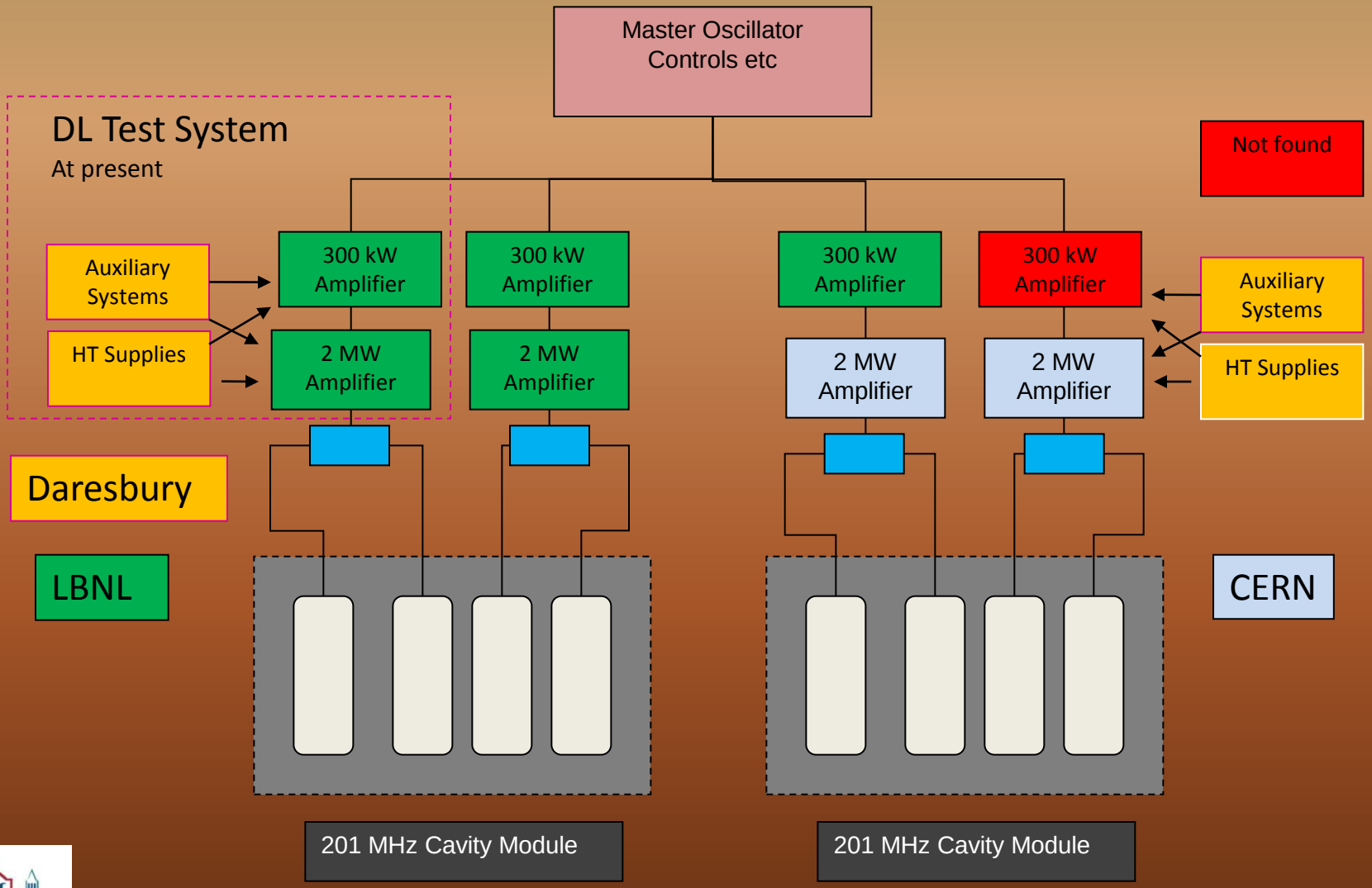

Be windows at LBNL


Tuner arms fabricated at FNAL


Tuner design


Wire EDM at FNAL

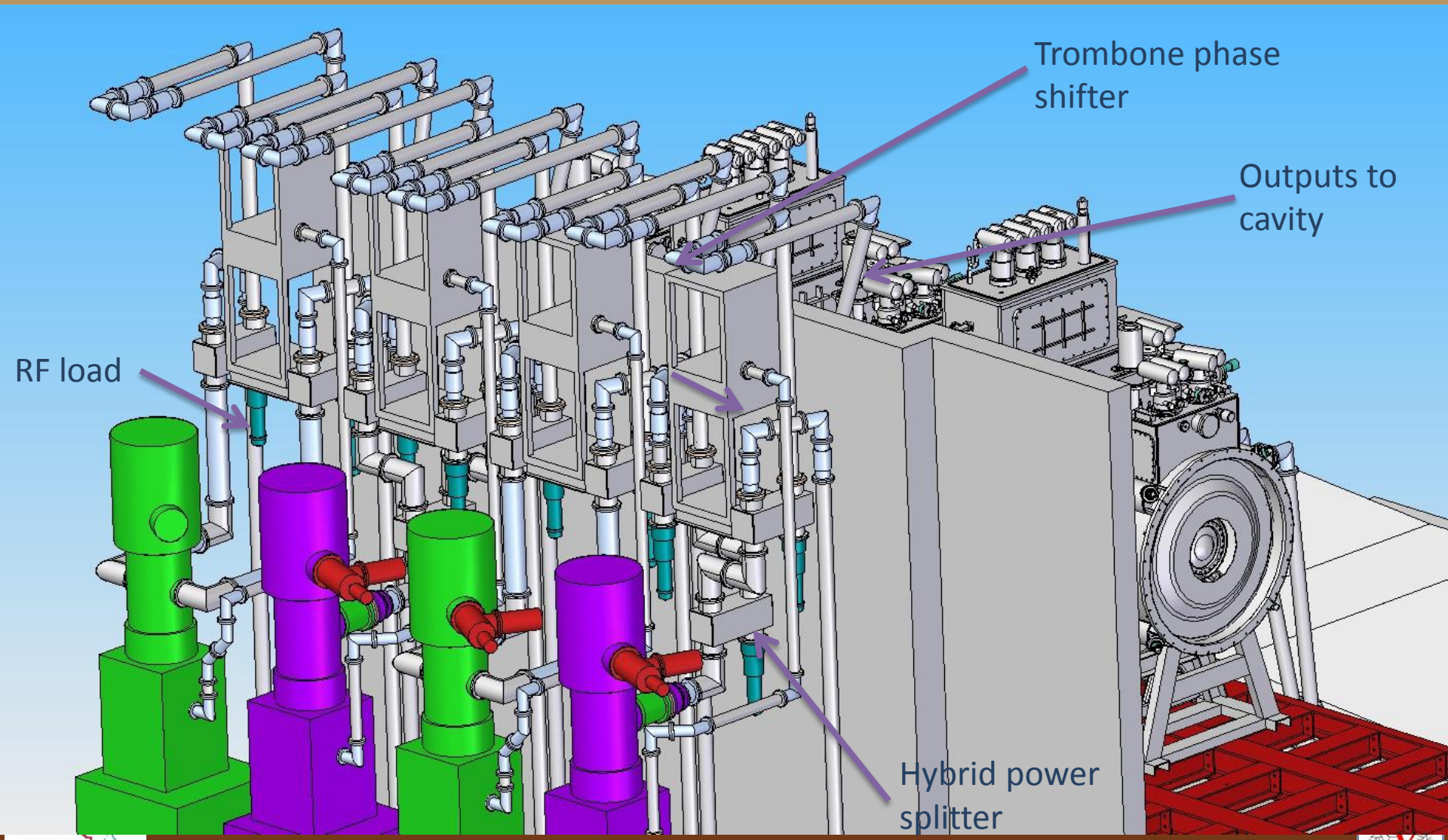
# RF Power System Components



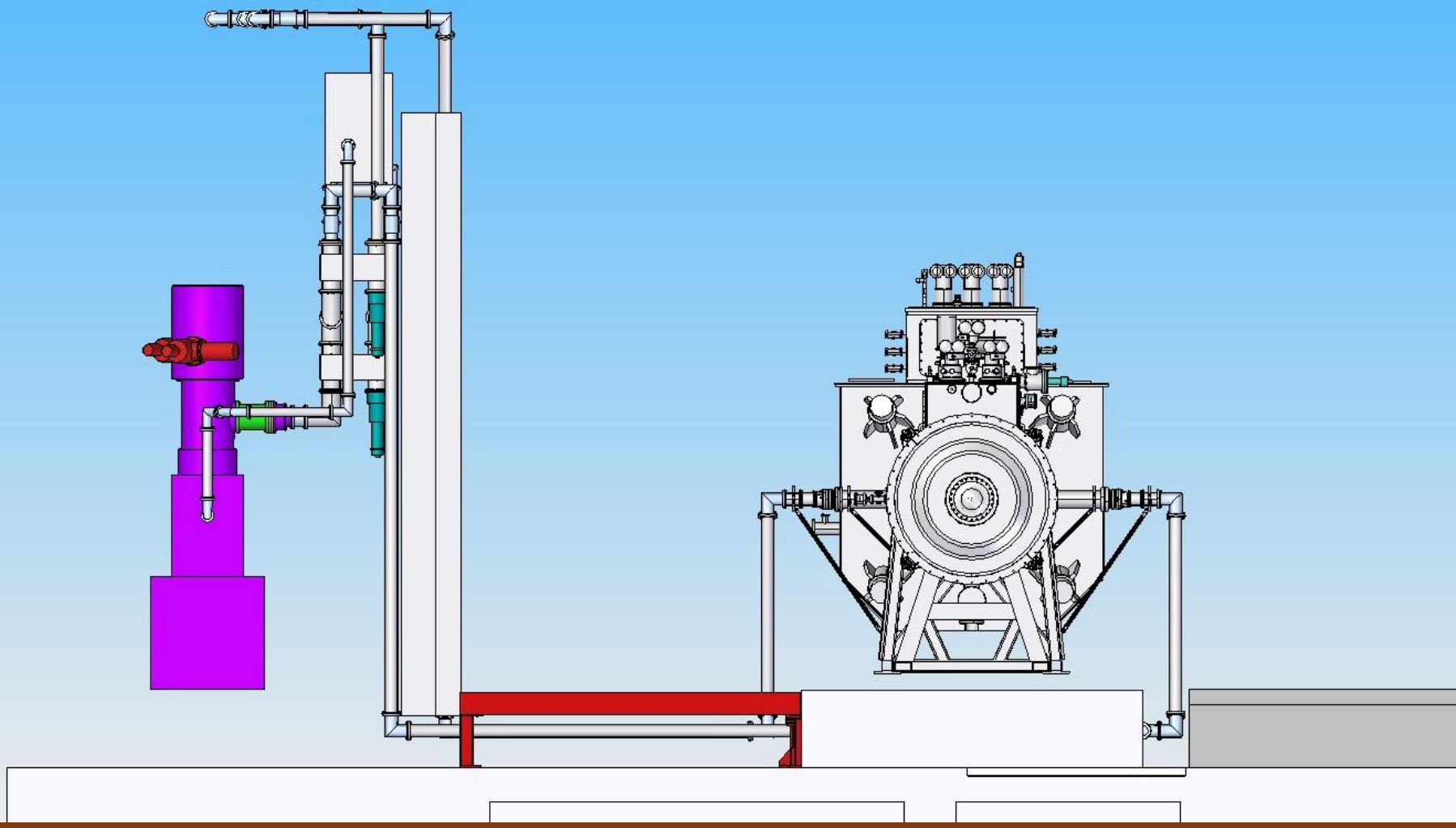
# RF Amplifier Status

- Refurbishment of LBNL and CERN RF components:
  - First medium power (250 kW) amplifier and power supply system tested 2008
  - Refurbishment and rebuild of first high power (2 MW) amplifier complete October 2009
  - Power supplies for first 2 MW amp operational
  - Two further 300 kW amplifiers awaiting repair
  - Two refurbished 2 MW CERN amplifiers partly tested, awaiting assembly and high power test
- Need to build 3 more sets of power supplies
- One more 300kW amplifier to buy/acquire

# RF Power Distribution



# RF Power Distribution

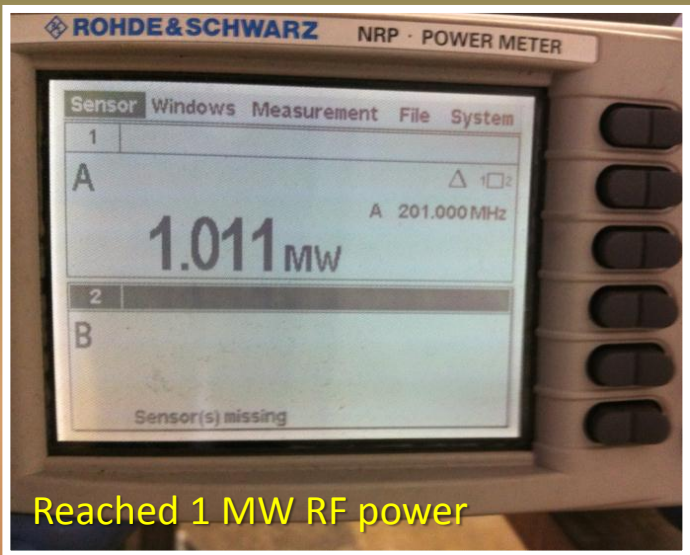


# Current Status/Plan of RF Power Sys.

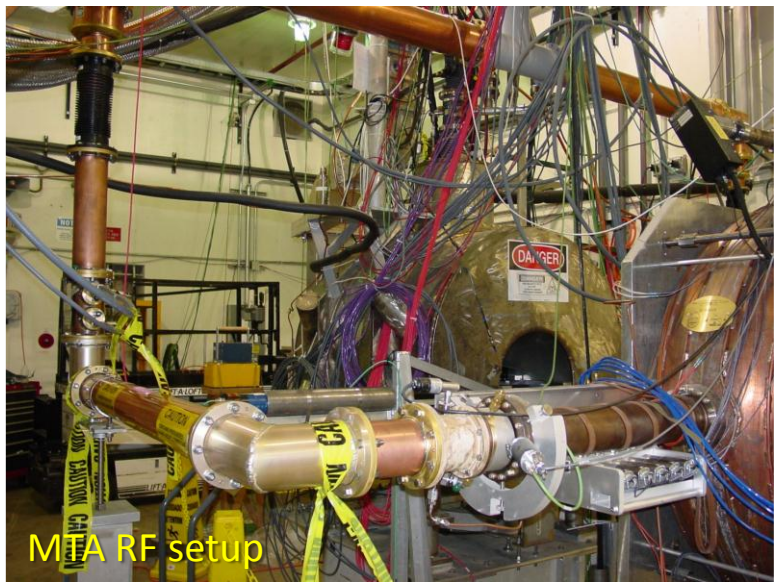
- Amplifier test system tested to 1 MW with power supplies;
- Coax system designed to phase match RF into each cavity, all coax lines are the same length and have the same number of elbows;
- Hybrids will be used to split RF power and give good isolation, reject load can be small as balanced reflected; power will be directed back to triode, this should not present an issue;
- Cavity phasing can be done using a combination of LLRF and limited range high power phase shifters;
- Nitrogen gas pressure will be used to extend the peak voltage stand off of the coax guides.

4616 Medium Power Amplifier


High Power Amplifier



Reached 1 MW RF power


MTA RF setup

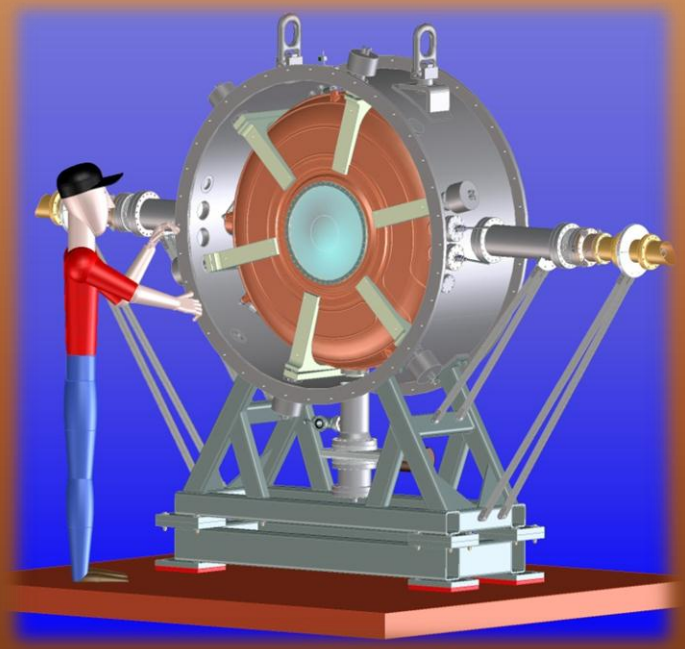

Andrew Moss working at Daresbury Laboratory

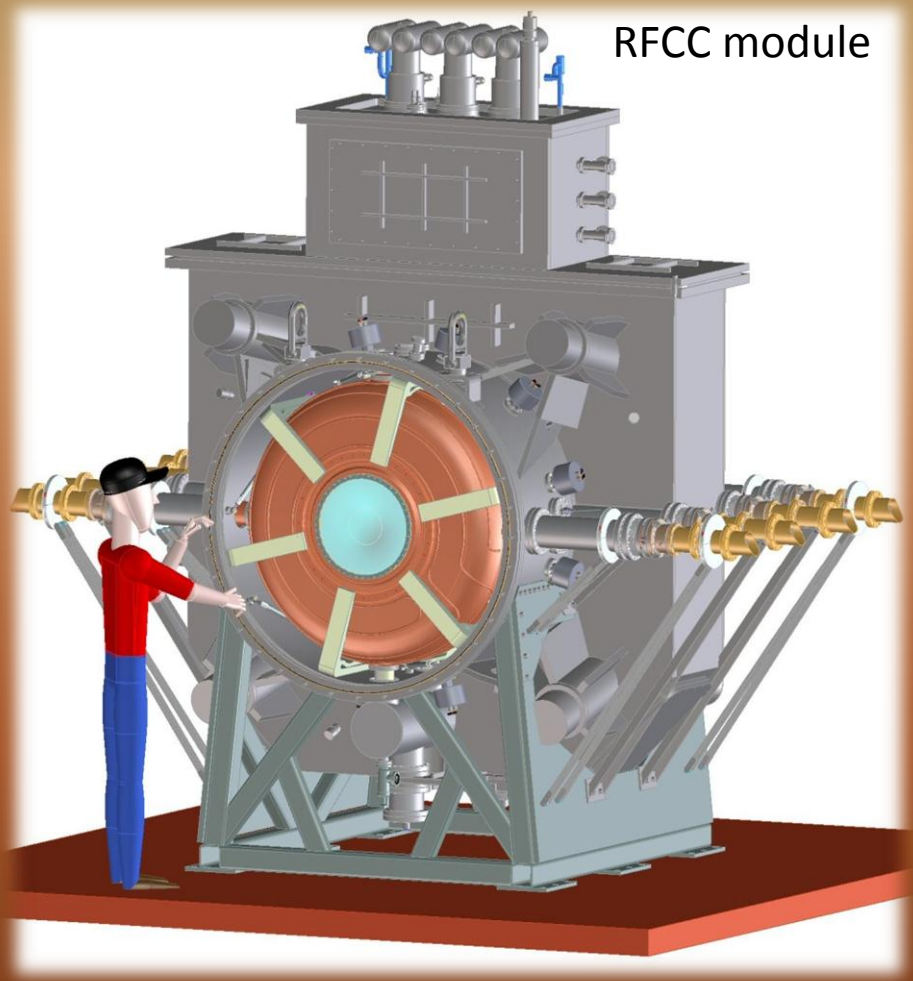
# Presentations on RF at CM32

- Thursday afternoon, February 9, 2012
  - RF Cavities
    - Derun Li (LBNL)
  - RF Power
    - Andrew Moss (Daresbury Laboratory)
  - RF Control and Monitoring
    - Chris White (STFC Daresbury Laboratory)
  - RF US Program
    - Yagmur Torun (Illinois Institute of Technology)
  - RF review report and RF Specification
    - Andrew Moss (Daresbury Laboratory)

# Single Cavity Vacuum Vessel

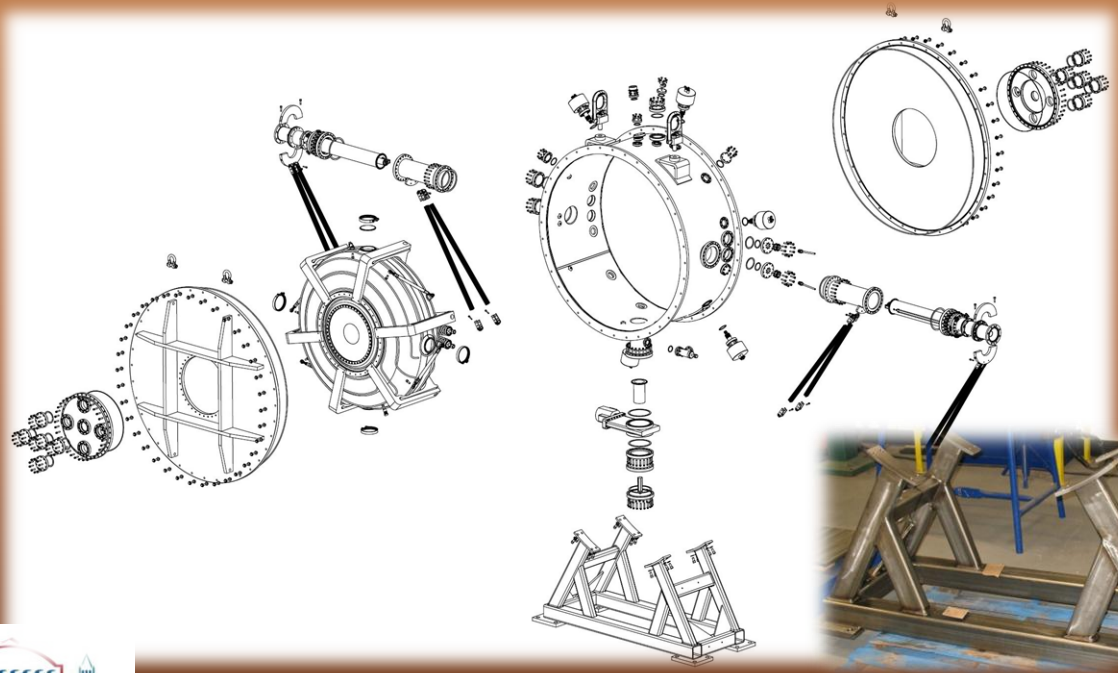
- The design kept as much as possible of the same dimensions and features of the RFCC module
- One vessel to accommodate two types of MICE cavities (left and right)
- Possible for future LN operation



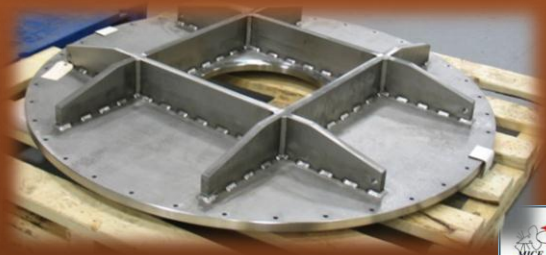


# Single Cavity Vacuum Vessel Status

- Design was completed in mid-2011 at LBNL
- Fabrication is complete at Keller Technology in Buffalo New York
- The vessel should arrive Fermilab this week







# Testing of the Single Cavity Vessel

- Check engineering and mechanical design
  - Fully define the fabrication process
  - Incorporate any design changes into the RFCC vacuum vessel design
- Test of the RF tuning system with 6 tuners and actuators on a cavity and verify the frequency tuning range
- Obtain hands-on experience on assembly and procedures
- Cavity installation
  - Develop fixturing for inserting the cavities into the vacuum vessel
  - Beryllium windows
  - RF couplers and connections
  - Water cooling pipe connections

# Testing of the Single Cavity Vessel

  - Vacuum port and connections
  - Tuners and actuator circuit
  - Mounting and alignment of the tuners onto the cavity is critical to alignment of the cavity in the vacuum vessel
  - Alignment of actuator (through the vacuum vessel wall) to the tuner is important
- Aligning cavity with hexapod support struts
  - Test developed MathCAD alignment software program
- Vacuum vessel support and handling
- Verify operation of the getter vacuum system
- RF processing MICE cavities
- RF power system and future LN operation

# Summary and Tasks

- Progress in MICE RF hardware development ;
- RF design review held in December 2011 (to be reported by A. Moss);
- Progress of the LLRF control (A. Moss);
- *Specification/Interface between RF power system and RFCC modules;*
- *Plan/development for diagnostics and controls, in particular with detector/analysis group:*
  - *Communications/meetings started recently at LBNL, but need a real plan*
- *Testing plan of using the single cavity vessel at the MTA, Fermilab*
  - *Waiting for cavity EP at LBNL, fabrication of other accessory components;*
  - *Assembly and integration;*
  - *MICE cavity tuning and control;*
  - *Experimental study of high magnetic field at RF coupler region;*
  - *Welcome RF testing proposals from MICE collaborators.*