Normal Conducting RF Cavity R&D for Neutrino Factory or Muon Collider

Fermi National Accelerator Laboratory

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Acknowledgements

Work presented here was conducted in collaboration with colleagues at LBNL and many collaborators in NFMCC

Fermi National Accelerator Laboratory

Argonne National Laboratory

Thomas Jefferson National Laboratory Facility

Illinois Institute of Technology

University of Mississippi

Oxford University, UK

Cockcorft Institute, UK

Outline

- **Introduction**
  - Muon Ionization Cooling
  - International Muon Ionization Cooling Experiment (MICE)
- **Experimental study program**
  - 805 MHz cavity design
  - Fabrication
  - Coupler design
  - Achievable accelerating gradient under a few Tesla magnetic fields
  - Button tests with different materials and coatings
- **Thin beryllium windows for RF cavity**
  - Pre-stressed flat windows, grids
  - Curved Be windows
- **201 MHz Cavity Program**
  - Cavity design
  - Fabrication techniques
    - Spinning
    - Extruding
    - E-beam welding
    - Cleaning and electro-polishing (EP)
  - Loop coupler and conditioning
  - High power tests the cavity at MTA, FNAL
- **Some of the US MICE responsibilities**
- **Summary**

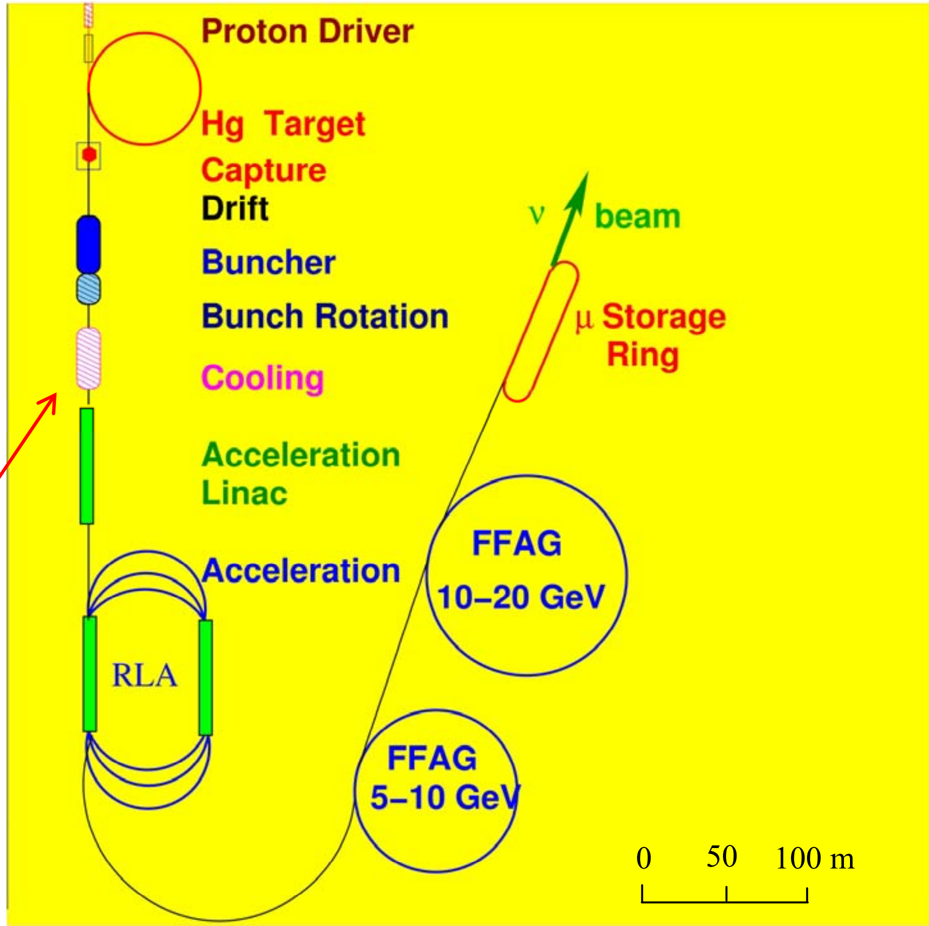
Introduction

- R&D program under auspices of the U.S. Neutrino Factory and Muon Collider Collaboration (NFMCC)
- Three leading national laboratories (BNL, FNAL, LBNL) + JLab and university research groups
  - Production, acceleration and storage of intense muon beams (hardware and software)
    - Technology and engineering solutions
    - Accelerator physics of intense muon beams
- Support from DOE, NSF, ~~Illinois State~~ and U.S.-Japan collaboration
- R&D progress enhanced significantly by corresponding programs in Europe and Japan
- Long term goals
  - Continue evaluating physics opportunities afforded by intense muon beams from Neutrino Factory through a Muon Collider
- Near term goals
  - Muon cooling R&D (software and hardware)
  - International Muon Ionization Cooling Experiment (MICE)
  - Cost effective Neutrino Factory Design

Neutrino Factory Ingredients

Neutrino Factory comprises

- **Proton Driver**
  - primary beam on production target
- **Target, Capture, and Decay**
  - Create π ; decay into μ
- **Bunching and Phase Rotation**
  - Conditioning: reduce ΔE of bunch
- **Cooling**
  - Reduce transverse emittance
  - *MICE*
- **Acceleration**
  - 130 MeV ~ 20–50 GeV
- **Storage Ring**
  - Store for ~ 500 turns; long straight

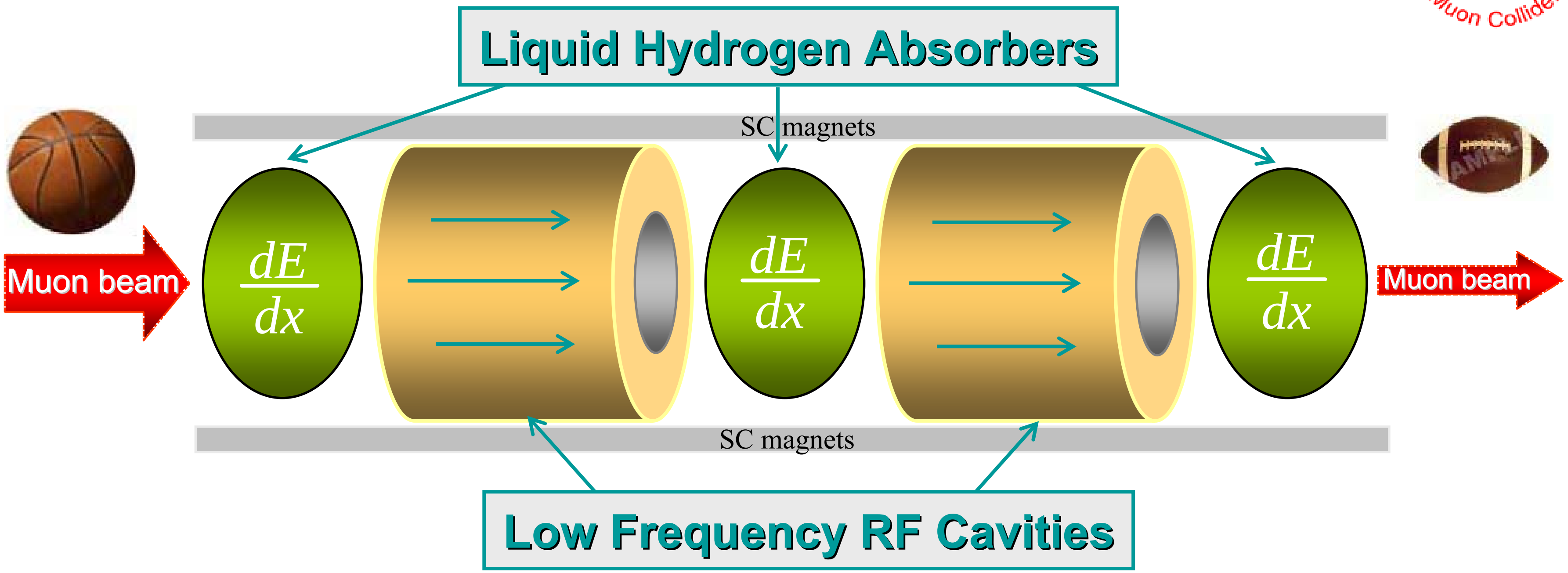


Challenging, but no show stoppers!

Cooling R&D Programs

- Cooling
  - Components R&D: NC RF cavities, absorbers and solenoids
  - Normal conducting RF cavity studies:
    - Experimental studies at 805 MHz using a pillbox cavity
      - Window tests
      - Button tests
    - Be windows R&D
      - Thermal and mechanical stabilities at high accelerating gradients
      - Scattering and limits
    - Tests are being conducting now at MTA (MUCOOL Test Area), FNAL
    - 201 MHz cavity design, fabrication and tests
  - Absorbers (ICAR, Japan-US funding)
    - Absorbers, windows and safety issues
    - Design and FEA simulations of absorber windows
    - Absorber tests at MTA, FNAL
  - SC solenoids (magnets)
  - International MICE experiment

Muon Ionization Cooling



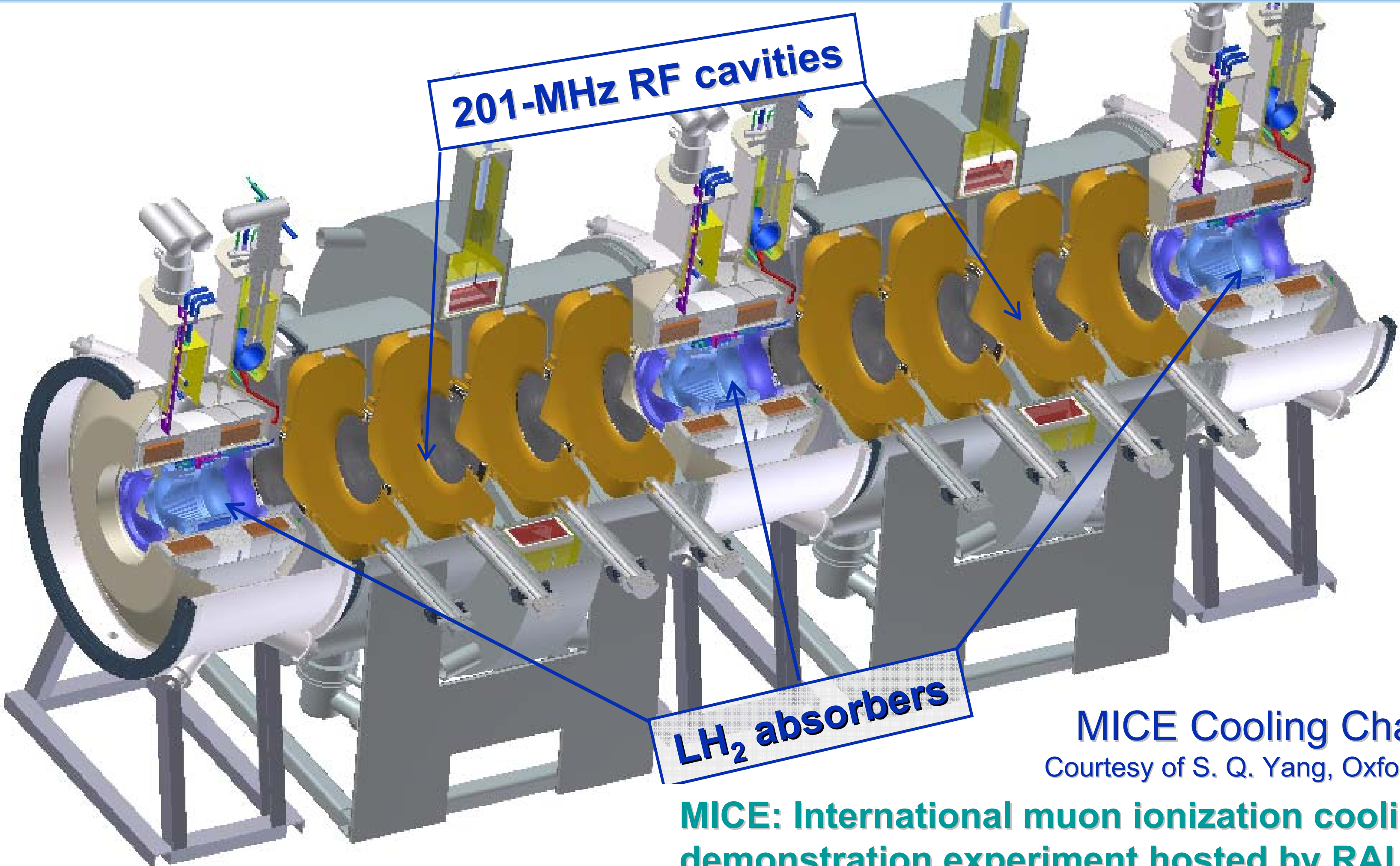
– High gradient RF cavities to compensate for lost longitudinal energy
– Strong magnetic field to confine muon beams
– Energy loss in LH_2 absorbers

Goal:

– Development of NC 201-MHz cavity operating at ~ 16 MV/m in a few-Tesla solenoidal *B* field (~ 30 MV/m at 805-MHz)

MICE: Ionization Cooling Channel

Single particle measurements: 10% cooling of ~ 200 MeV/c muons requires ~ 20 MV of RF
Measurement precision can be as good as $\Delta(\varepsilon_{out}/\varepsilon_{in}) = 10^{-3}$; Never been done before!



MICE Cooling Channel
Courtesy of S. Q. Yang, Oxford Univ.

MICE: International muon ionization cooling demonstration experiment hosted by RAL, UK

Demand for High Gradient RF

Technical challenges

- Muon beam is unstable, and has short decay time (~ 2 μs at rest)
- Muon beam is created with very LARGE 6-D phase space
  - Muon beam manipulation must be done quickly including cooling

→ Normal conducting RF cavity with highest possible accelerating gradient

- Requirements of RF cavity for muon beams
  - Goal: high cavity shunt impedance, high gradient and high field
    - Gradient at 201 MHz: ~ 16 MV/m {Kilpatrick criterion: 15 MV/m}
    - Gradient at 805 MHz: ~ 30 MV/m {Kilpatrick criterion: 26 MV/m}
  - RF cavity design approach for muon cooling
    - RF cavity with closed beam iris (iris terminated by Be window)
      - Higher shunt impedance
      - Independent phase control, higher transit factor
      - Lower peak surface field
      - Reduced RF power requirement

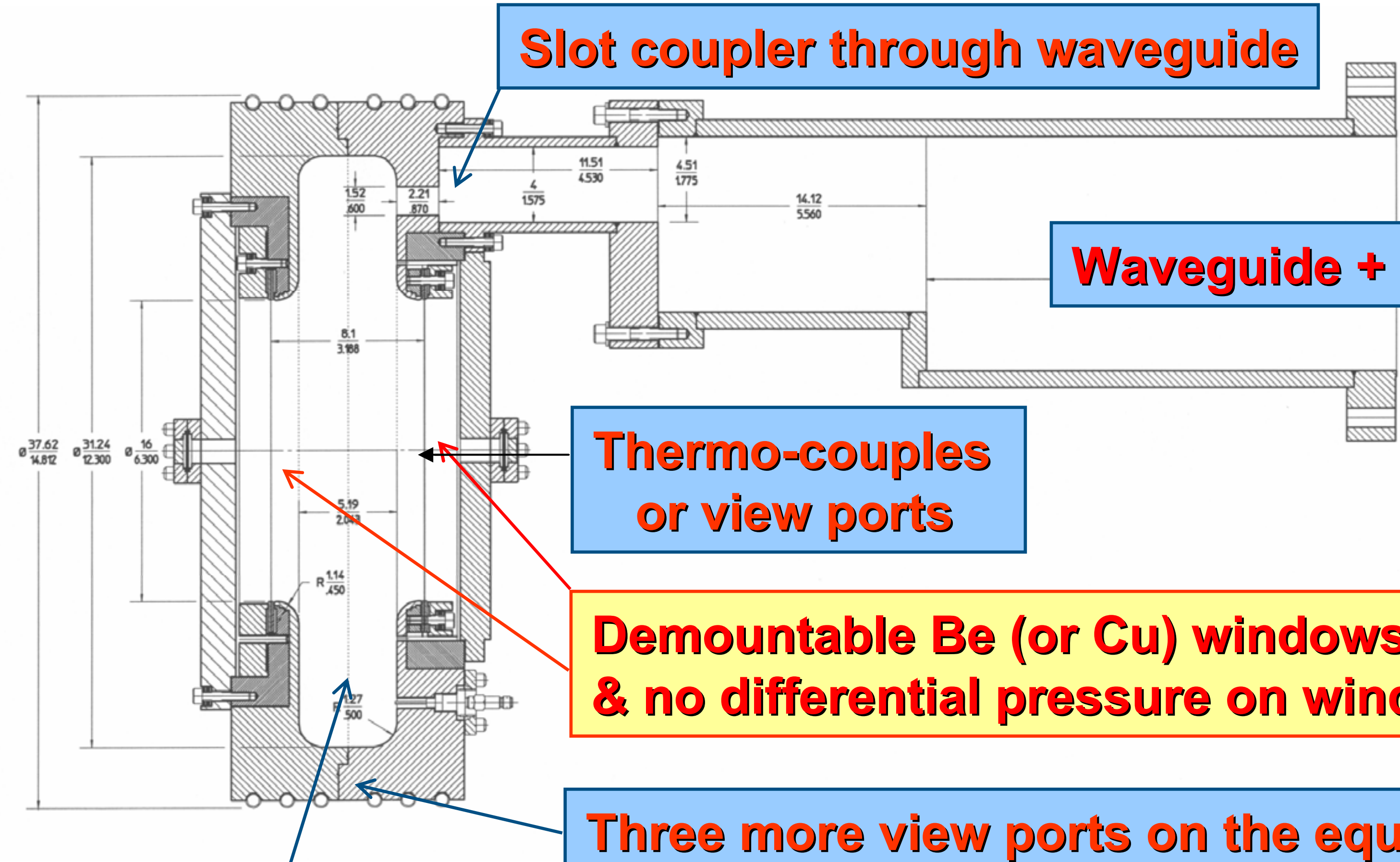
Experimental Studies at 805 MHz

The 805-MHz “round” pillbox cavity design, fabrication and tests

Experimental Programs at 805-MHz

- **Development of the 805 MHz Pillbox cavity**
  - Design and fabrication
  - High shunt impedance and high accelerating gradient at the order of ~ 30+ MV/m in strong magnetic field environment
  - Allowing for testing of Be windows with different thickness, coatings, and other windows as well
    - Copper windows, Be windows, Grids and curved Be windows
  - Study RF cavity operation and conditioning under the influence of strong external magnetic fields (a few Tesla) at both the solenoid and gradient modes
- **Be windows R&D**
  - Mechanical stabilities and thermal stress under RF heating
  - Prototype and FEA modeling
  - Evolutions of Be window designs

Cavity Design and Sub-Components



Slot coupler through waveguide

Waveguide + window

Thermo-couples or view ports

Demountable Be (or Cu) windows & no differential pressure on windows

Three more view ports on the equator

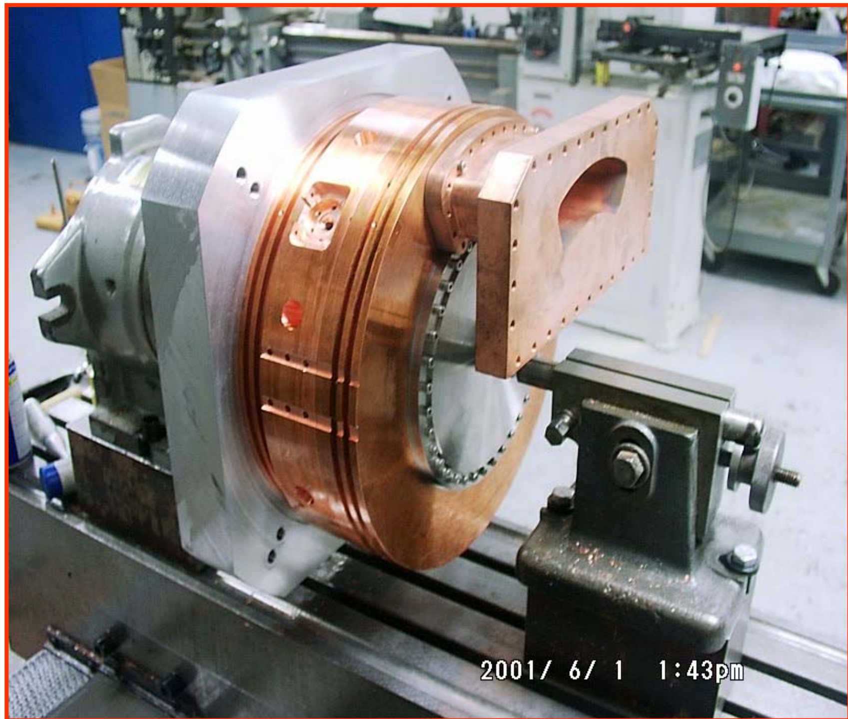
Pillbox cavity

Cavity Design Parameters

- **Frequency: 805 MHz**
- **Shunt Impedance:**
  - **38 MΩ/m (Z_0); 32 MΩ/m (ZT^2); {definition used: $Z = V^2/P$}**
- **Quality factor: Q_0 = 18,800**
- **Coupling Constant:**
  - **Critical coupling at $\beta_c = 1.0$**
  - **Accelerating gradient of 30 MV/m requires 2 MW peak power**
  - **350 watts average on cavity body, 52 watts on two Copper windows (66 watts if Be windows) at a duty factor of 1.8×10^{-4} (12 μs pulse length and 15 Hz repetition rate: US NF Study-II parameters)**
- **Up to 12 MW peak power available at MTA**
- **Tests have been running since 2002**

Fabrication of the cavity

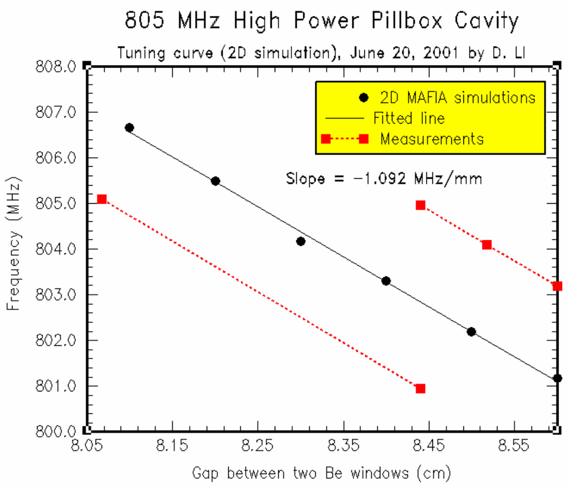
The cavity was designed and engineered at LBNL, parts were fabricated at University of Mississippi, and brazed at Alpha Braze Company in Fremont, CA



Cavity and coupler tuning

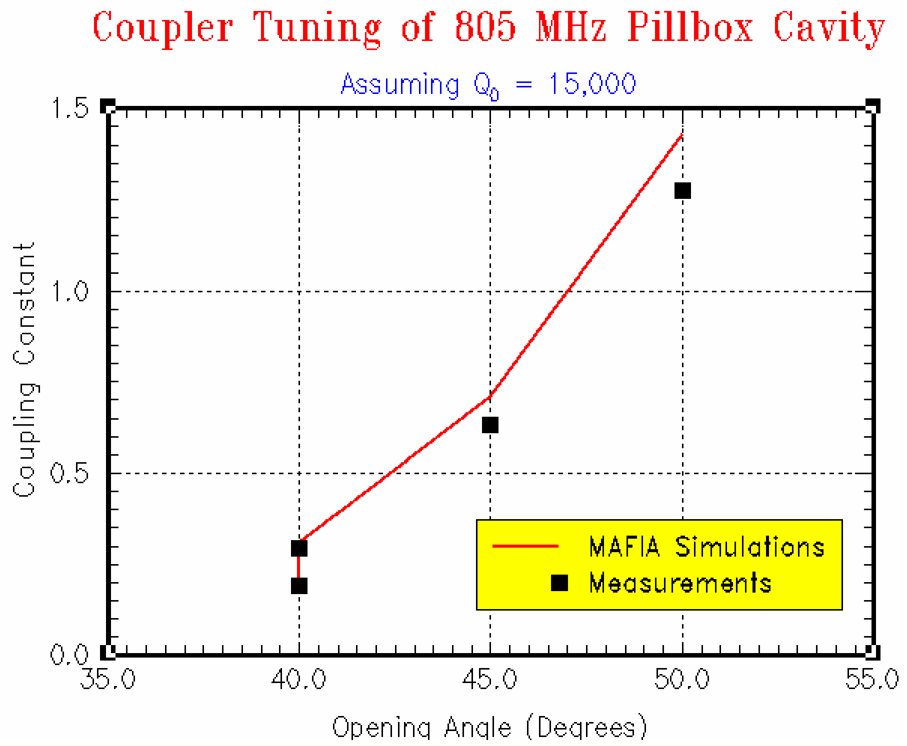
- **The cavity final tuning for frequency and coupling at University of Mississippi**
  - Before tuning: f = 803.198 MHz, β_c = 0.12
  - After tuning: f = 805.486 MHz, Q_{ext} = 12,800
  - Shipped to Alpha Braze, California for final brazing
  - Measurements after final brazing prior to shipping to FNAL:

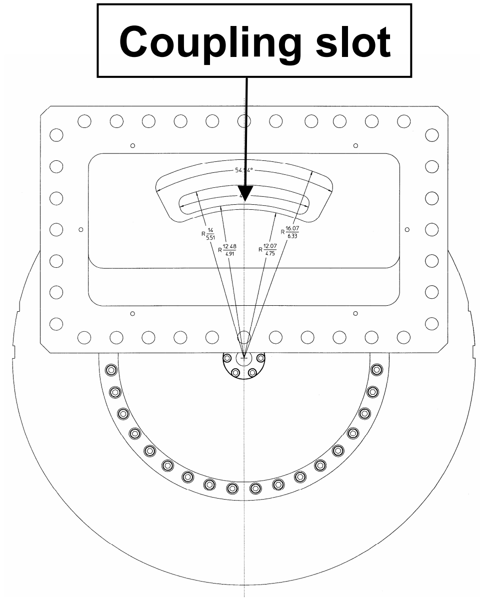
f = 804.946 MHz, β_c = 1.3, Q_0 = 15, 000 measured at LBNL



Cavity Tuning (Continued)

- Frequency tuning by shortening the cavity gap
- Coupler tuning by widening coupling slot or shortening the length of the transition waveguide
  - Good agreements between simulations and measurements
  - Simulation technique has been applied to other cavity designs

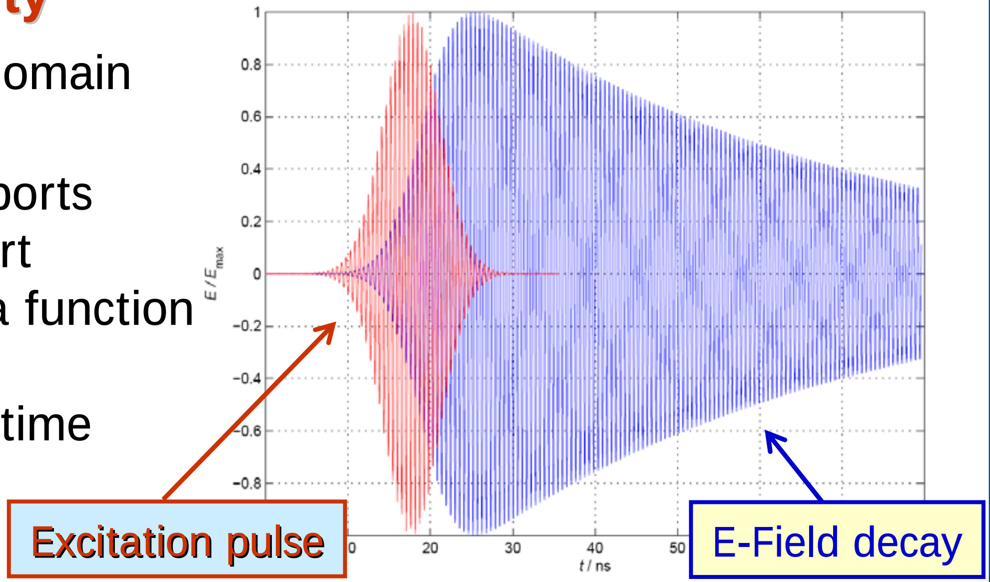




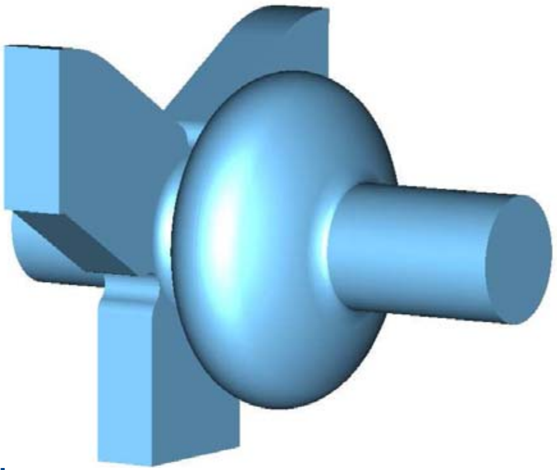
External *Q* calculations by MAFIA/MWS

Simulation accuracy improved using CST MWS, an example of the J-Lab HOM damped cold test cavity

- Same concept, using MWS in time domain instead of the MAFIA code
- Waveguide boundary conditions at ports
- Excite cavity from one RF (HOM) port
- Record the field (energy) decay as a function of time inside the cavity
- External *Q* is calculated from decay time



MWS model of the J-Lab Cavity



$$\rho(s) = \frac{Q}{\sqrt{2\pi}\sigma_s} e^{\frac{(s-s_0)^2}{2\sigma_s^2}}, \left[\frac{\mathrm{C}}{\mathrm{m}}\right],$$

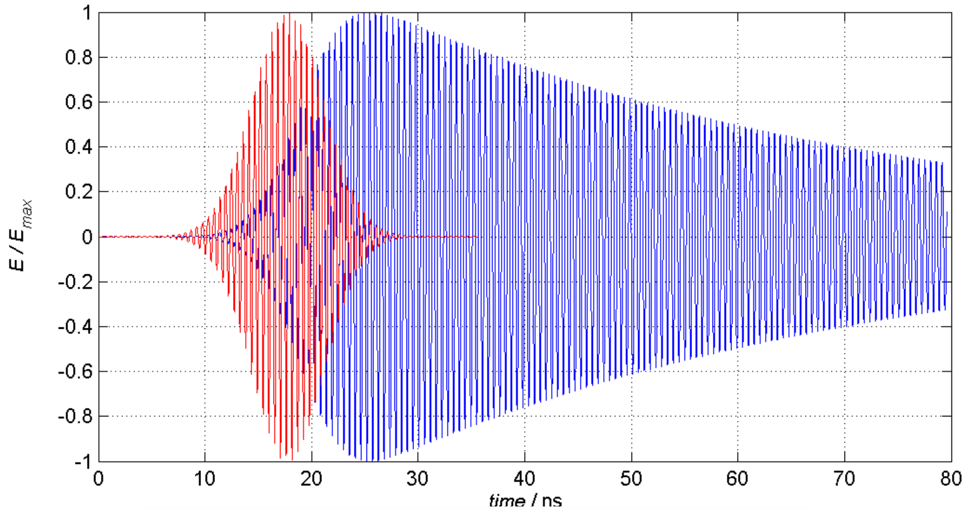
$$i(t) = \frac{Qc}{\sqrt{2\pi}\sigma_s} e^{\frac{(t-t_0)}{2(\sigma_s/c)^2}}, [\mathrm{A}],$$

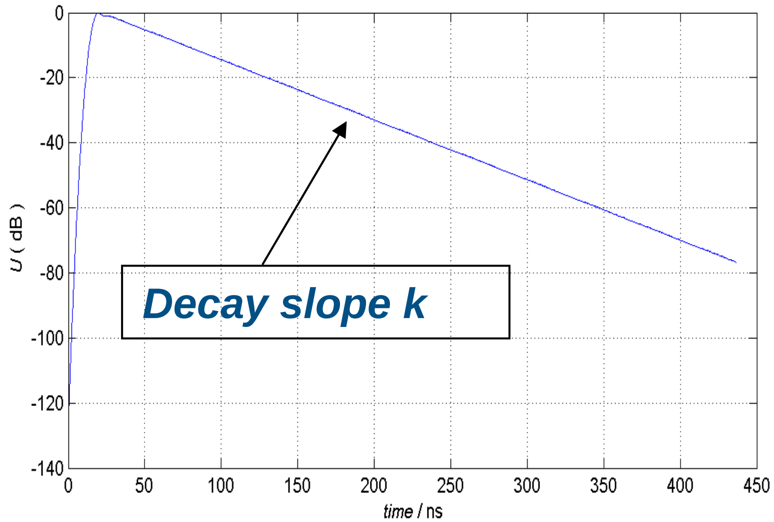
$$i(\omega) = Q e^{\frac{\omega^2}{2(c/\sigma_s)^2}}, [\mathrm{C}].$$

MS Calculated		Measured	
f/GHz	Q_{load}	f/GHz	Q_{load}
1.84727	276	1.848006	317
1.84764	264	1.848252	227
2.03046	719	2.029628	996
2.03055	746	2.030226	667
2.43190	2750	2.426183	2878

CST MWS External *Q* Calculations

- **Energy in the cavity decays with time due to coupling to outside world or losses in cavity**
- **Time decay constant varies with the coupling strength or losses**





$$U(t) = U_0 \exp\left(-\frac{\omega t}{Q_{load}}\right)$$

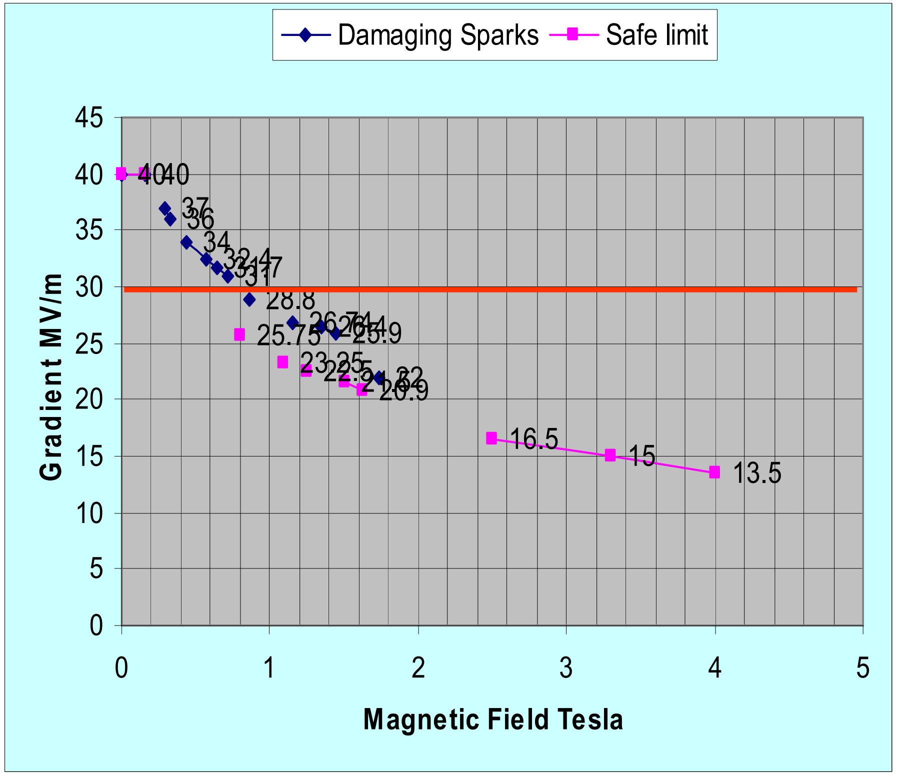
$$Q_{load} = -\frac{10\lg e \cdot \omega}{k}$$

- **Simulation agrees very well with measurements**
- **Application for coupler and HOM damping designs**

Experimental Study Results

We have conducted experimental studies at 805 MHz for nearly four years at Lab G and MTA, FNAL, respectively

- Open 5-cell cavity reached 25 MV/m gradient (54 MV/m surface field)
- Large dark current associated with surface and Cu window damage
- Pillbox cavity test exceeded its design gradient of 30 MV/m without magnetic field and reached up to 40 MV/m
- Thin Be windows with TiN-coated surface have been tested as a function of magnetic fields up to 4 Tesla
  - No surface damage was found on the **Be windows**
  - Little multipacting was observed; safe accelerating gradient limit strongly depends on the external magnetic field



Curtsey of A. Moretti, J. Norem, Z. Qian, Y. Torun and other MUCOOL collaborators in NFMCC

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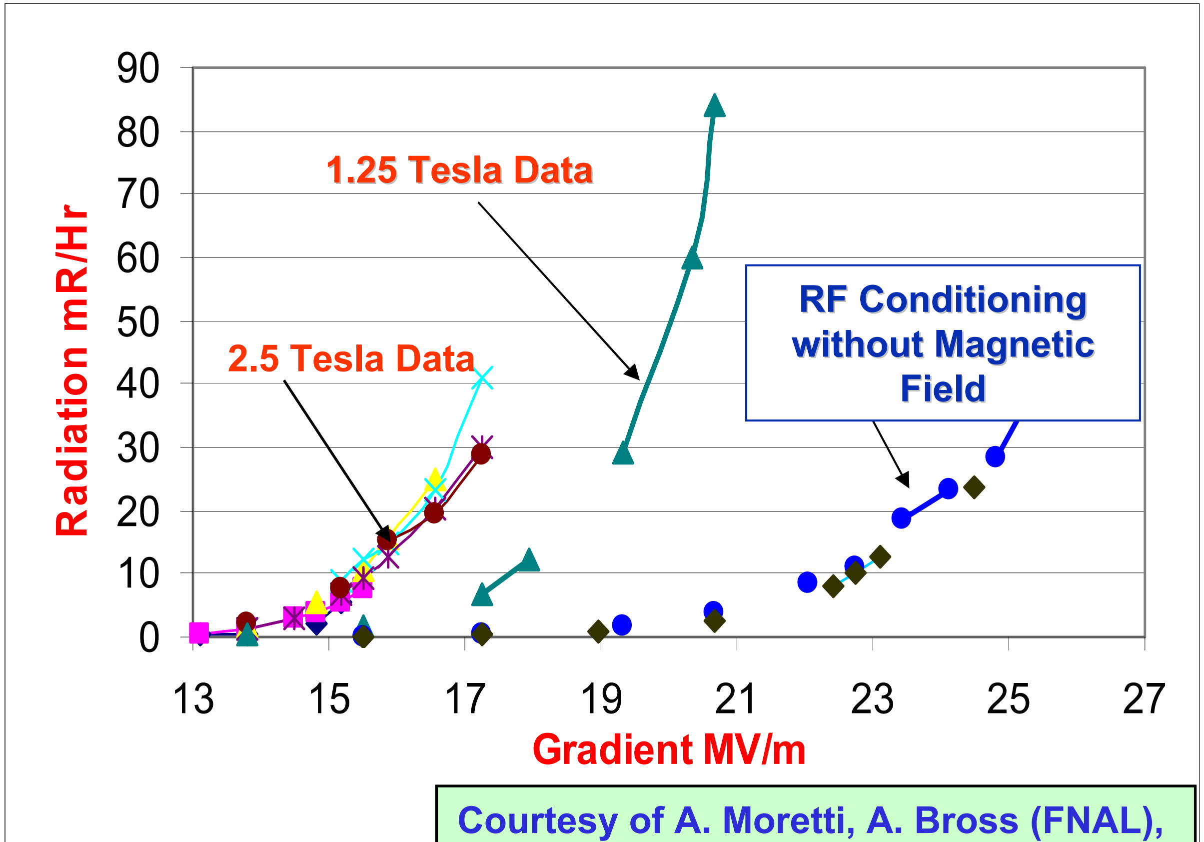
More RF Studies with Magnetic Fields

Latest accelerating gradient limit data at 2.5-T and 1.25-T using the 805-MHz pillbox cavity with curved Be windows with Ti-N coatings



Courtesy of A. Moretti, A. Bross (FNAL), J. Norem (ANL), Y. Torun, D. Huang (IIT)

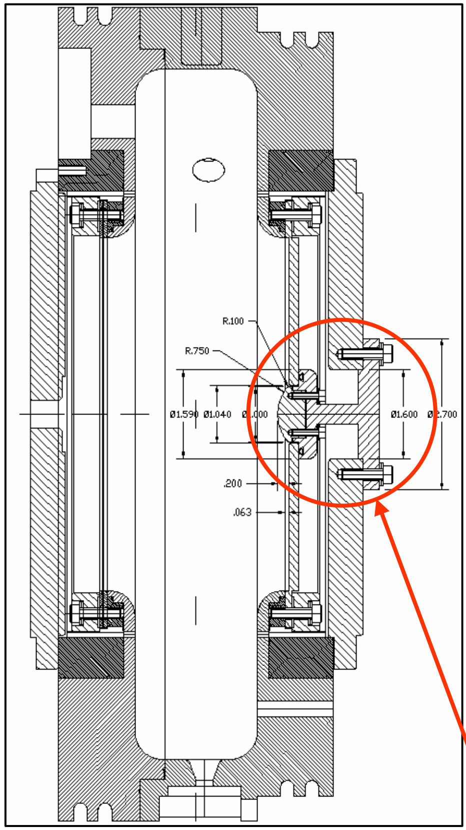
- **Generic R&D for RF breakdown study to understand the RF gradient limit in strong magnetic fields**
- **Confirmed previous experimental results**
- **How to scale the RF gradient limit with magnetic fields to 201-MHz cavity**
- **Minimizing radiation and dark current is important to MICE where detectors are sitting close to 201-MHz RF cavities**

We have not achieved our goal yet, R&D continues!

Years of World-Class Science 1931-2006

Button and Window Study Using the 805 MHz Pillbox Cavity

Neutrino Factory Muon Collider



- Curved Be windows
- Button study

— Modified cavity design to house the buttons

—Parts are ready

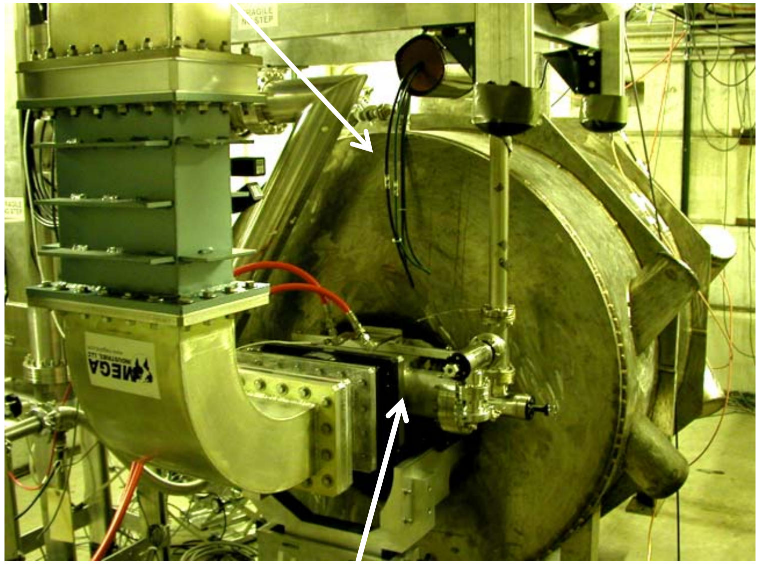
— Ratio of peak surface field (on the button) versus accelerating field on-axis ≈ 1.7 with ~ 0.5 MHz shift

— Many button materials and coatings
  - Cu, SS, NB, Mo, …

Demountable button

SC Solenoid

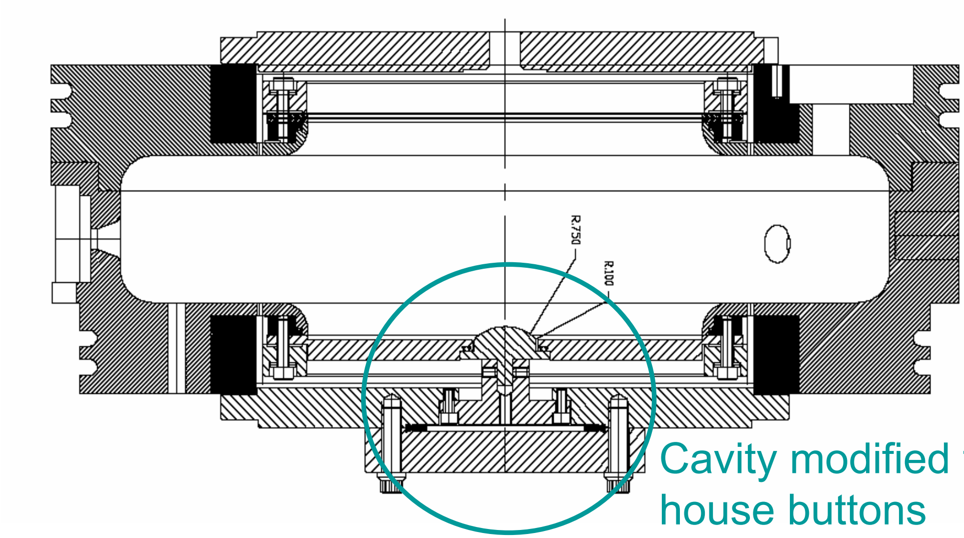
Up to 12 MW peak power



805 MHz pillbox cavity inside the SC solenoid

Berkeley Lab 75 Years of World-Class Science 1931-2006

Test Plans of 805 MHz Cavity*



Cavity modified to house buttons

Goal: Looking for materials and coatings can withstand high peak surface fields in strong magnetic fields

- **Button tests at MTA, FNAL**
  - ✓ **Button holder for quick replacement of buttons**
  - ✓ **Special window and flange**
  - → **Buttons are ready for high power tests**

*** In collaboration with Fermilab, J-Lab, ANL, IIT and University of Mississippi**

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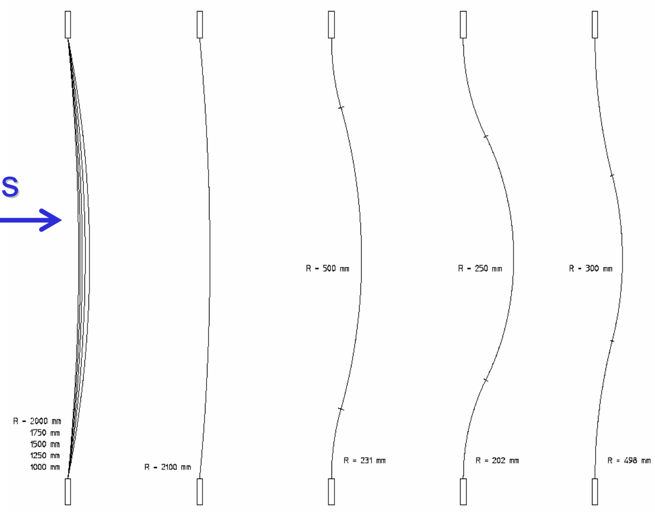
RF Cavity Iris Terminations

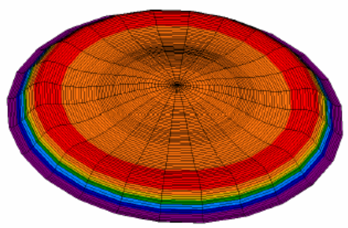
Thin Be Windows R&D

Be Windows R&D

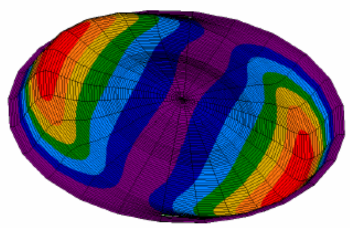
- **Ideal windows to terminate irises**
  - Transparent to muon beams
  - Perfect electric boundary to RF field
  - <u>No detuning to cavity frequency</u>
- **Engineering solutions**
  - Pre-stressed flat Be windows
  - **Pre-curved Be windows**
  - Grids

Window profile evolutions



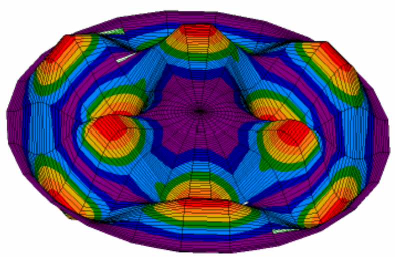


1^{st} natural frequency: 530 Hz.

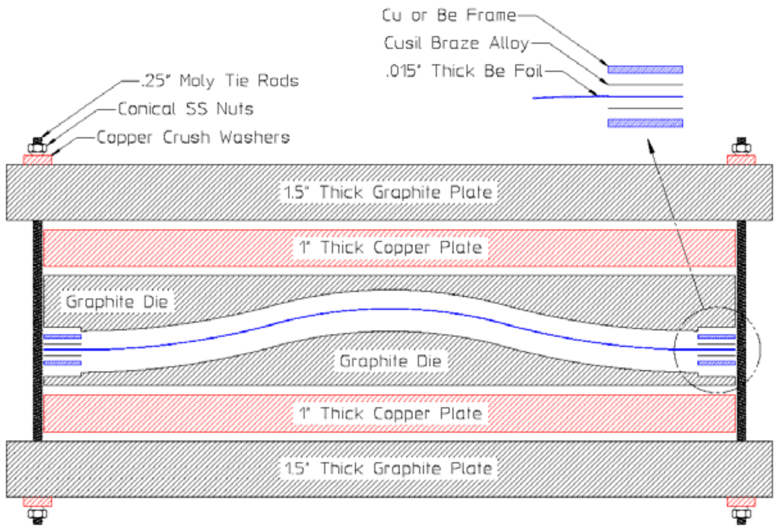


2^{nd} natural frequency: 673 Hz

A pre-curved Be window: 0.25-mm thick and 42-cm in diameter



FEA simulations to study mechanical vibration modes



In collaboration with Oxford University, UK

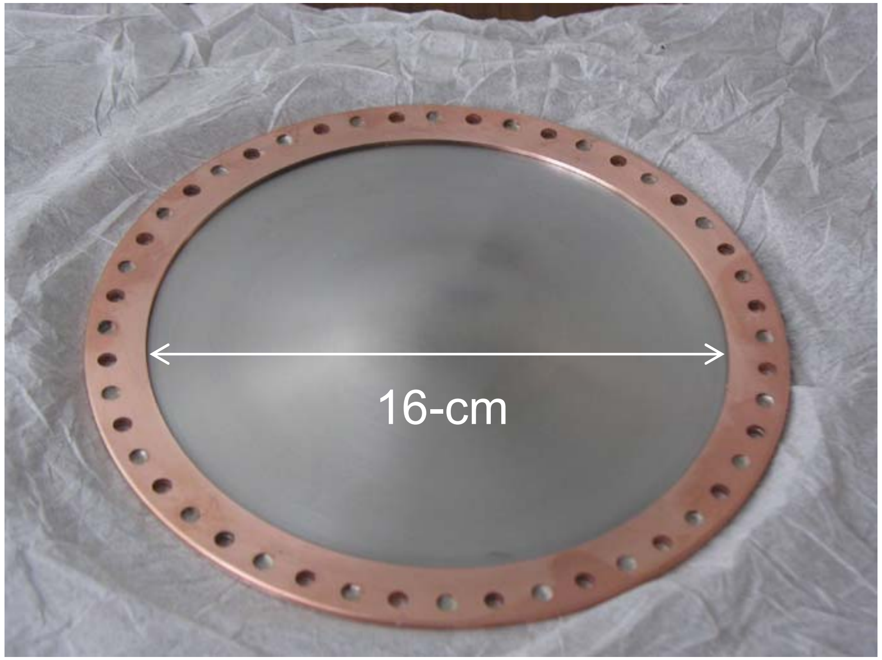
Setup for Window Formation

- The graphite die in Al fixture (room or high temperatures)
- 10 S.S sheets (10 mils) and 3 Be foils (10 mils) have been ordered for the pre-form tests
- Halogen lamp heating tests conducted at the 805 MHz low power test cavity to benchmark the FEA models

Curved S.S. Windows

Successful in fabrication of the S.S. window with Cu frame for the 805 MHz cavity

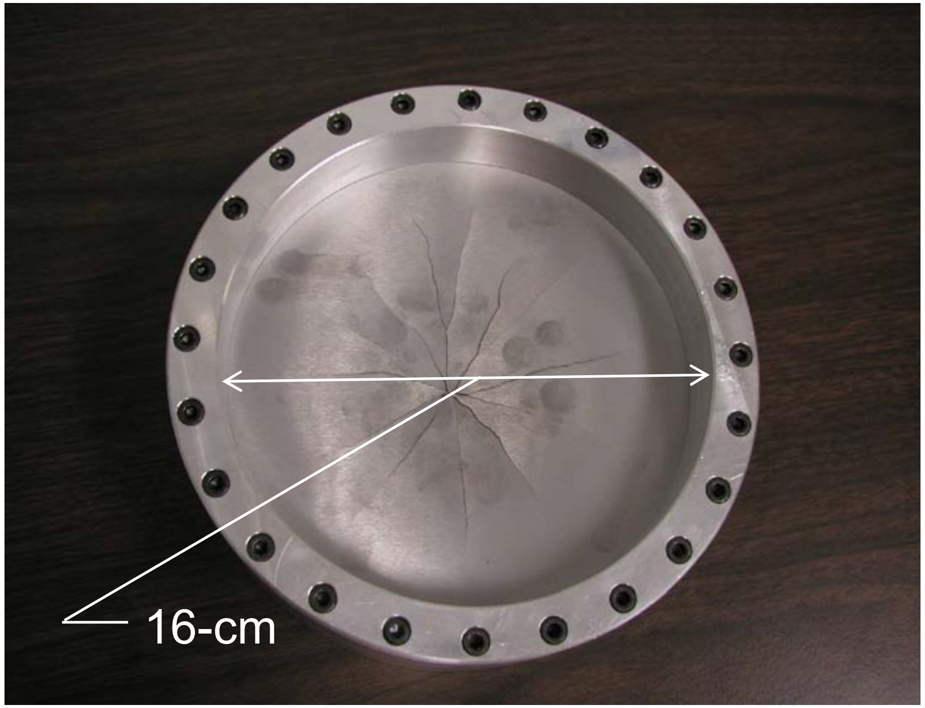
Pre-formed at room temperature by holding foil edge then braze the Cu frame



A finished curved S.S. window with brazed Cu frame

The First Curved Be Window

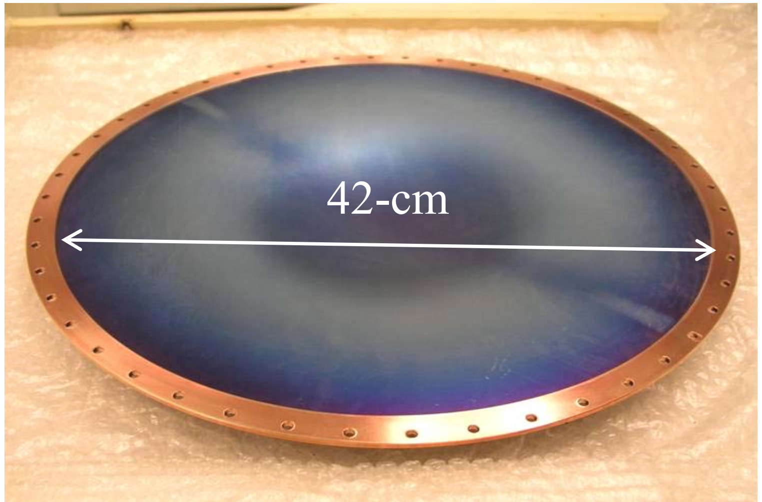
Initially failed in forming Be window at room temperature

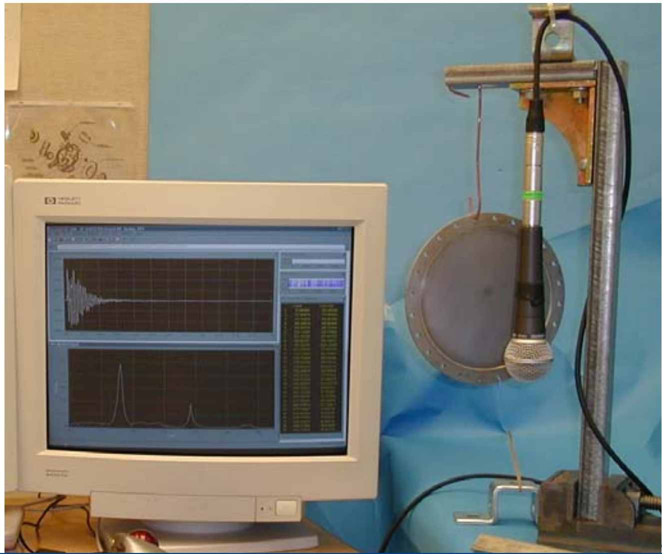


Demonstrated subsequently that the curved Be windows can be formed at higher temperature at Brushwellman Company *without significant cost increases*. Now we have successfully made three (805 MHz cavity) and two (for 201 MHz) curved Be windows.

Successful Curved Be Windows

- Five curved Be windows: three for 805-MHz and two for 201-MHz
  - 42-cm diameter and 0.38-mm thick for 201-MHz cavity
  - "Good" braze (between annular frames and foil)
  - Achieved ~ 95 % of the designed profile
  - Thin Ti-N coatings
- Windows to be installed pointing to the same direction in the cavity to minimize frequency shifts
- Ready for HP tests





Measurement setup for window's mechanical vibration modes

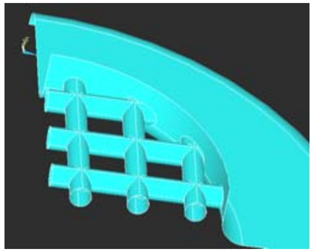
Alternative: Tube-Grid Study

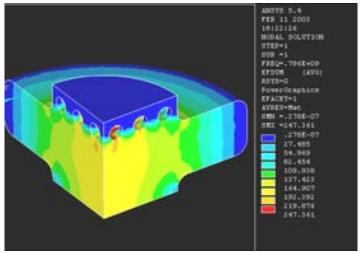
ANSYS study of tube grid design and prototype for 805 MHz pillbox cavity

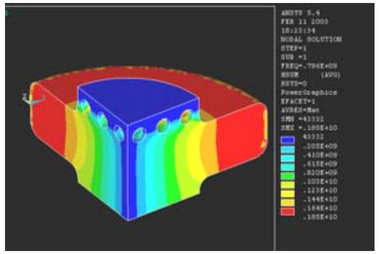
(Ph.D thesis at IIT)

- Simulation and fabrication
- Field enhancement between 1.4 & 3.6
- RF Heating on tubes

Grid Model | **Electric Field** | **Magnetic Field**



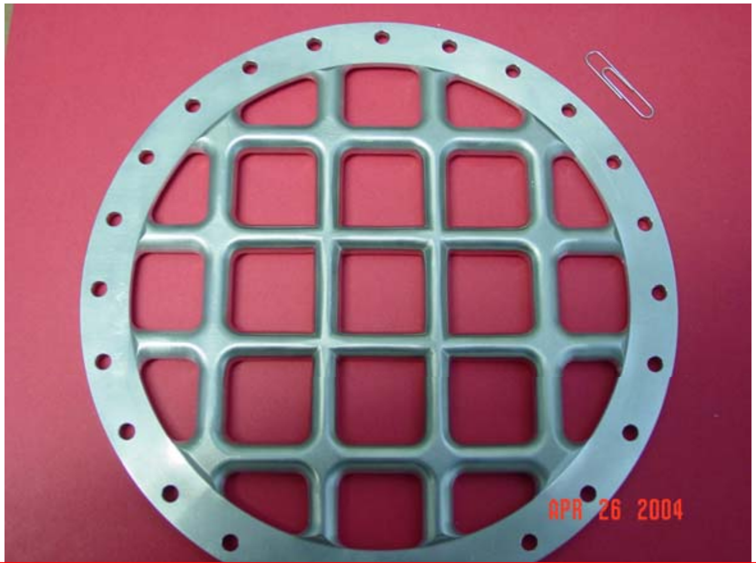




Maximum Surface Field Enhancement

Grid \ Tube DIA (cm)	0.50	1.00	1.25	1.50
4x4-Connected	3.60			
4x4 -Waffle	2.30	1.80		
6x6 -Waffle		1.64	1.40	1.39
6x6 Middle-Concentrated/Waffle		1.40		

First prototype of solid Al grid



Never been tested experimentally!

201 MHz RF Cavity R & D

Cavity design, fabrication and preliminary high power tests at MTA

201 MHz RF Cavity R&D

Goal: building and operating a real piece of muon cooling hardware to explore engineering, fabrication and operational challenges

- Prototype cavity for MUCOOL/MICE (baseline design)
  - RF Design
  - Couplers incorporated with ceramic RF windows
  - Engineering: explore techniques for fabrications
  - Fabrication: cavity body, ports, tuners, etc.
  - Large, pre-curved and thin 42-cm diameter Be windows
- Commissioning and operation
  - RF Conditioning and background (for MICE only)
  - High gradients (~ 16 MV/m) and high RF power
  - With the thin Be windows
  - With external magnetic fields

The Cavity Body Profile

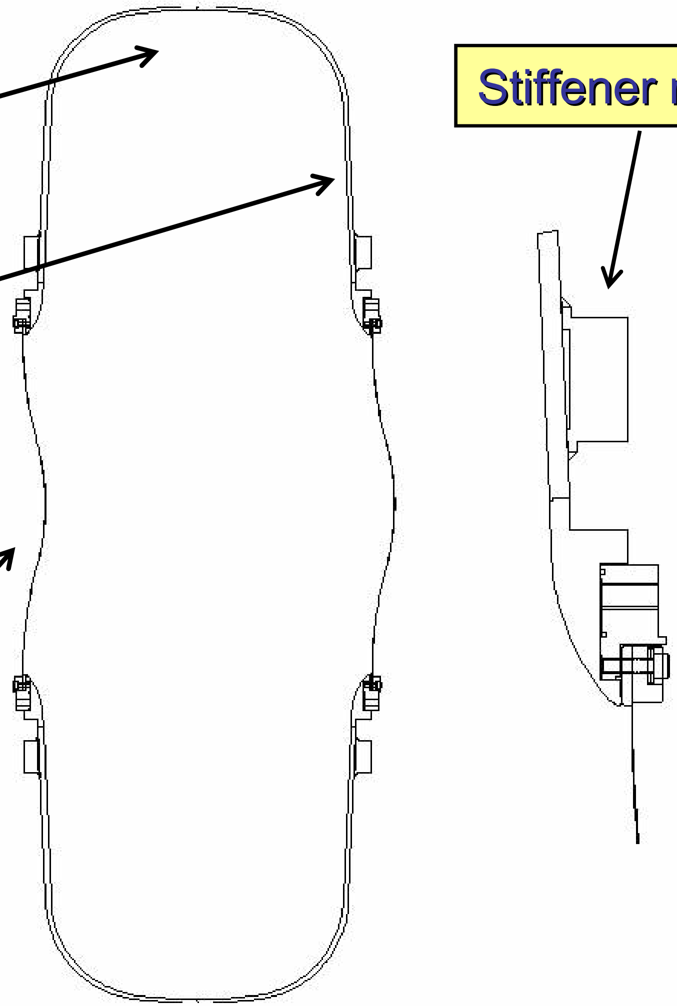
Spherical section at the equator to ease addition of ports (± ~ 6^o)
Elliptical-like (two circles) nose to reduce peak surface field

2^o tilt angle

6-mm Cu sheet allows for uses of spinning technique and mechanical tuners similar to SCRF ones

De-mountable Pre-curved Be windows to terminate RF fields at the iris

Stiffener ring

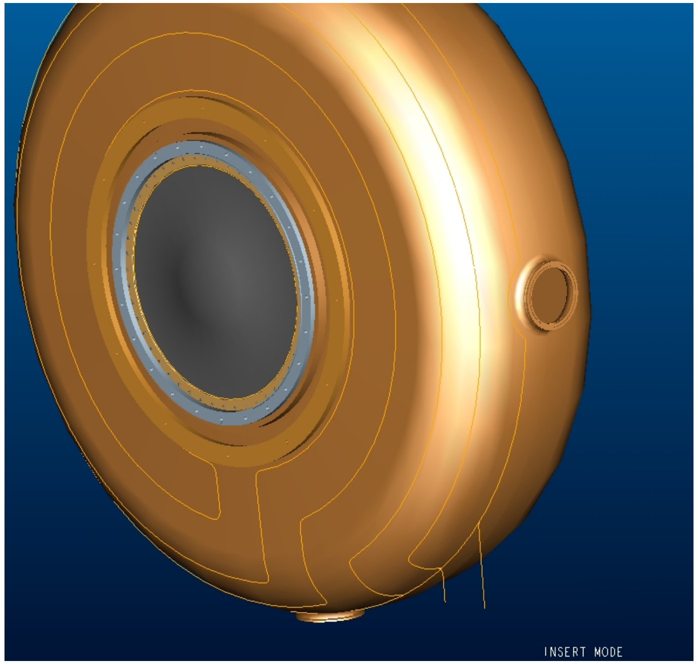


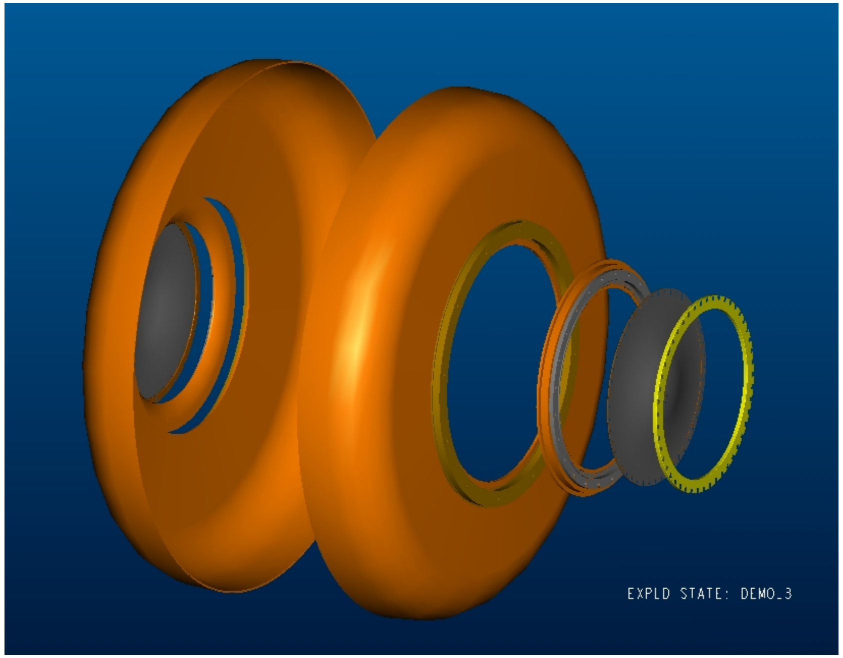
Cavity Design Parameters

- **The cavity design parameters**
  - Frequency: 201.25 MHz
  - $\beta = 0.87$
  - Shunt impedance (definition used: VT^2/P): ~ 22 MΩ/m
  - Quality factor (Q_0): ~ 53,500
  - Be window radius and thickness: 21-cm and 0.38-mm
- **Nominal parameters for cooling channels in a muon collider or a neutrino factory**
  - ~ 16 MV/m peak accelerating field
  - Peak input RF power ~ **4.6 MW** per cavity (85% of Q_0, 3τ filling)
  - Average power dissipation per cavity ~ **8.4 kW**
  - Average power dissipation per Be window

    ~ **100 watts**

201 MHz NC Cavity Concept





Spinning of half shells using thin copper sheets and e-beam welding to join the shells

Cavity design uses pre-curved Be windows, but also accommodates different windows

Shells Spun at ACME Company

An example of using spinning technique !

Spinning a bowl

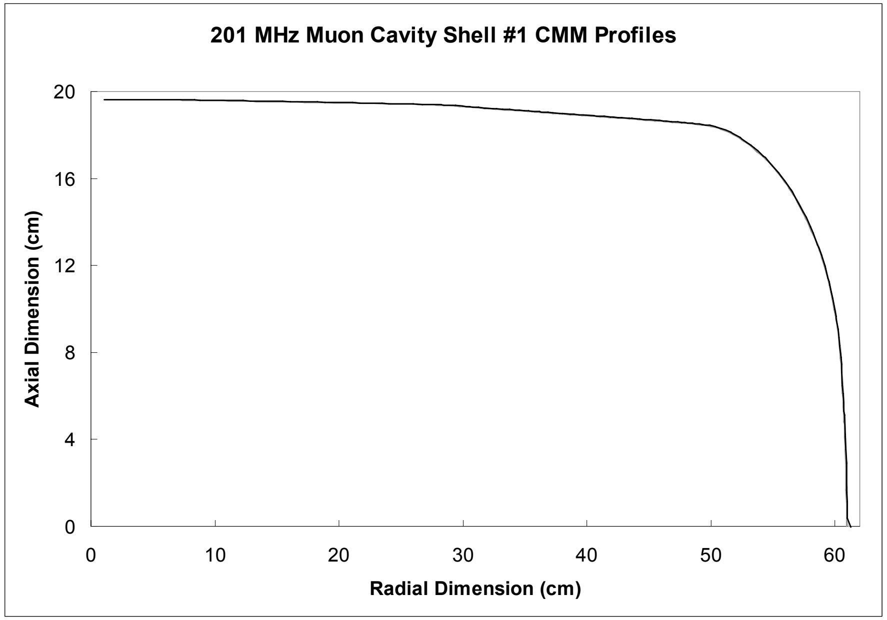
Spinning tools

Shell Measurements at LBNL

- CMM scans to measure the spun profiles of shells
- Frequency and Q measurements
- Copper tapes for better RF contacts

Measured frequency of shell-1: 196.97 MHz

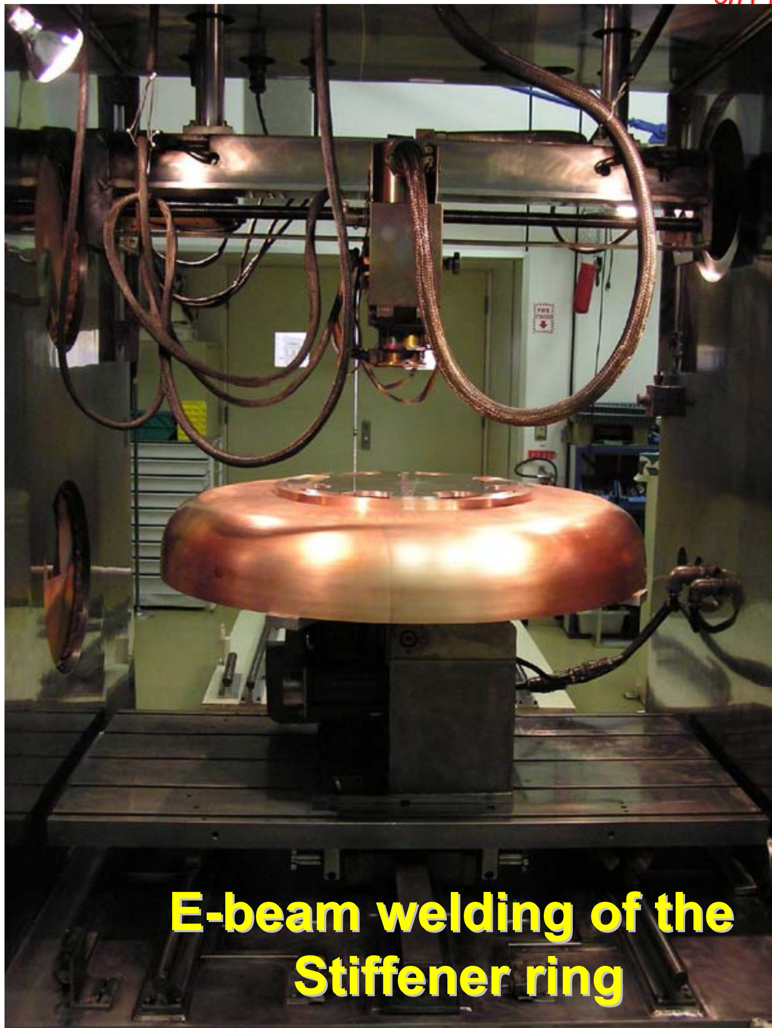
(simulated frequency: 197.32 MHz)



Profile measurements:

3 CMM scans per half shell conducted at 0^o, 45^o, 90^o, respectively

E-beam Welding at J-Lab



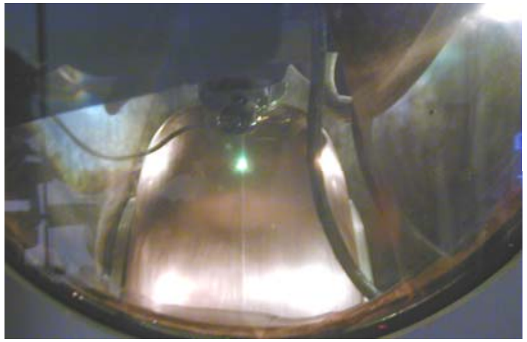
Mechanical Cleaning

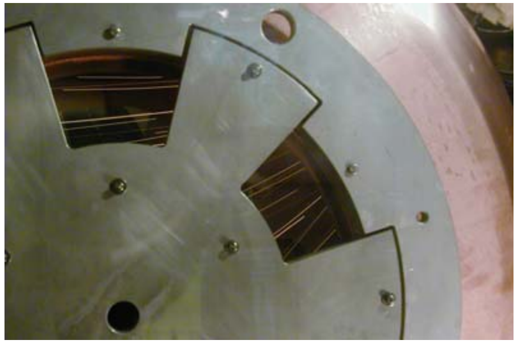
Neutrino Factory
Muon Collider

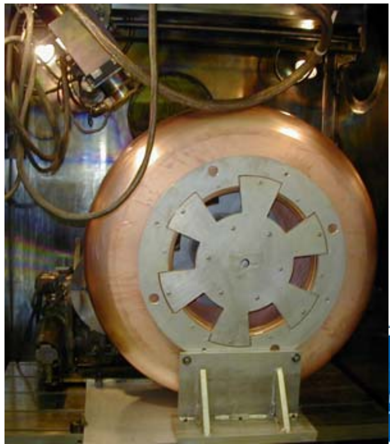
Mechanical cleaning of the cavity inner surface right after e-beam welding of the stiffener ring (above)

Cavity Equator Welding

- Cavity and fixture system is mounted and assembled on a plate and placed on the welder sliding table
- External structural weld is near full penetration and is achieved in three offset passes
- A final cosmetic/vacuum weld is performed on the inside of the joint with the cavity mounted on a horizontal rotary table

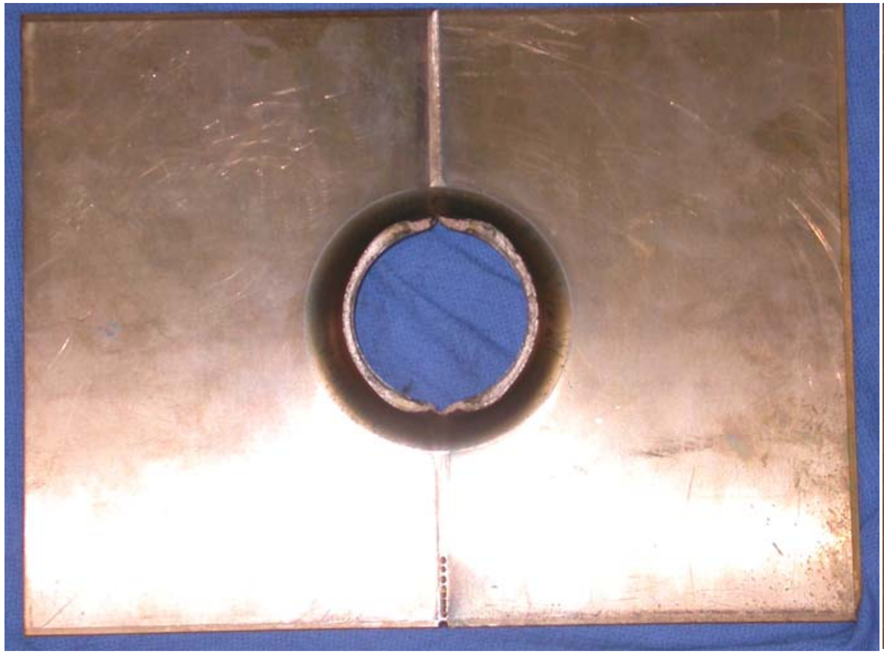


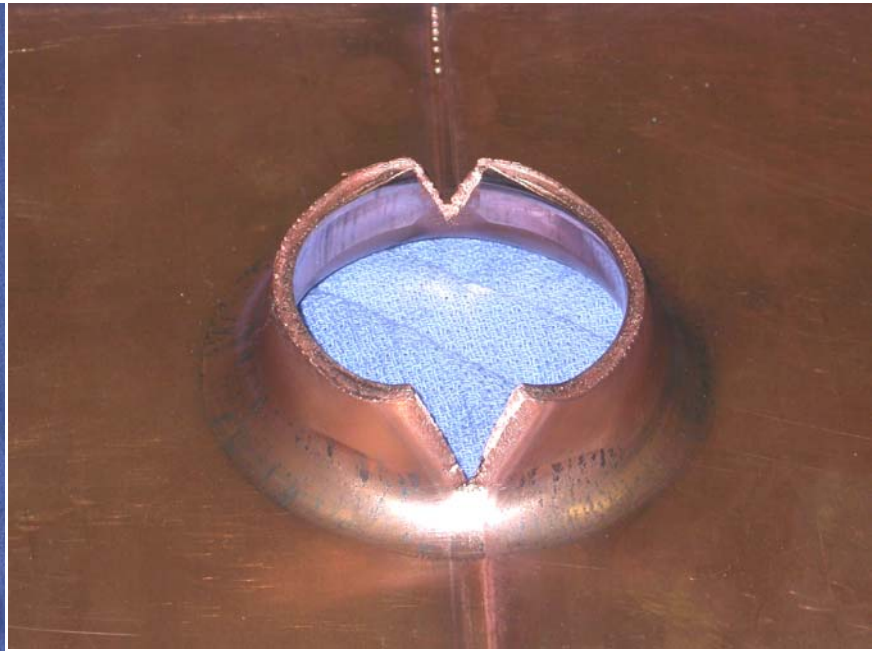




RF Port Extruding Tests at J-Lab

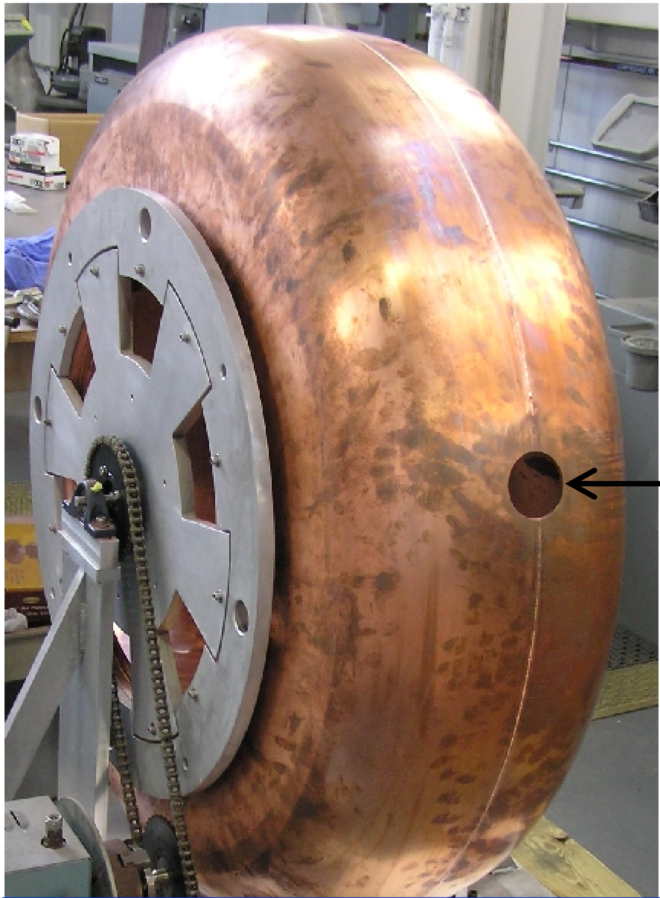
Extruding RF ports through e-beam joints: tests on flat copper plates going through e-beam joints





Possible improvement: Anneal around the extruding area → local heating + with combination between pilot hole dimensions and lid heights, …

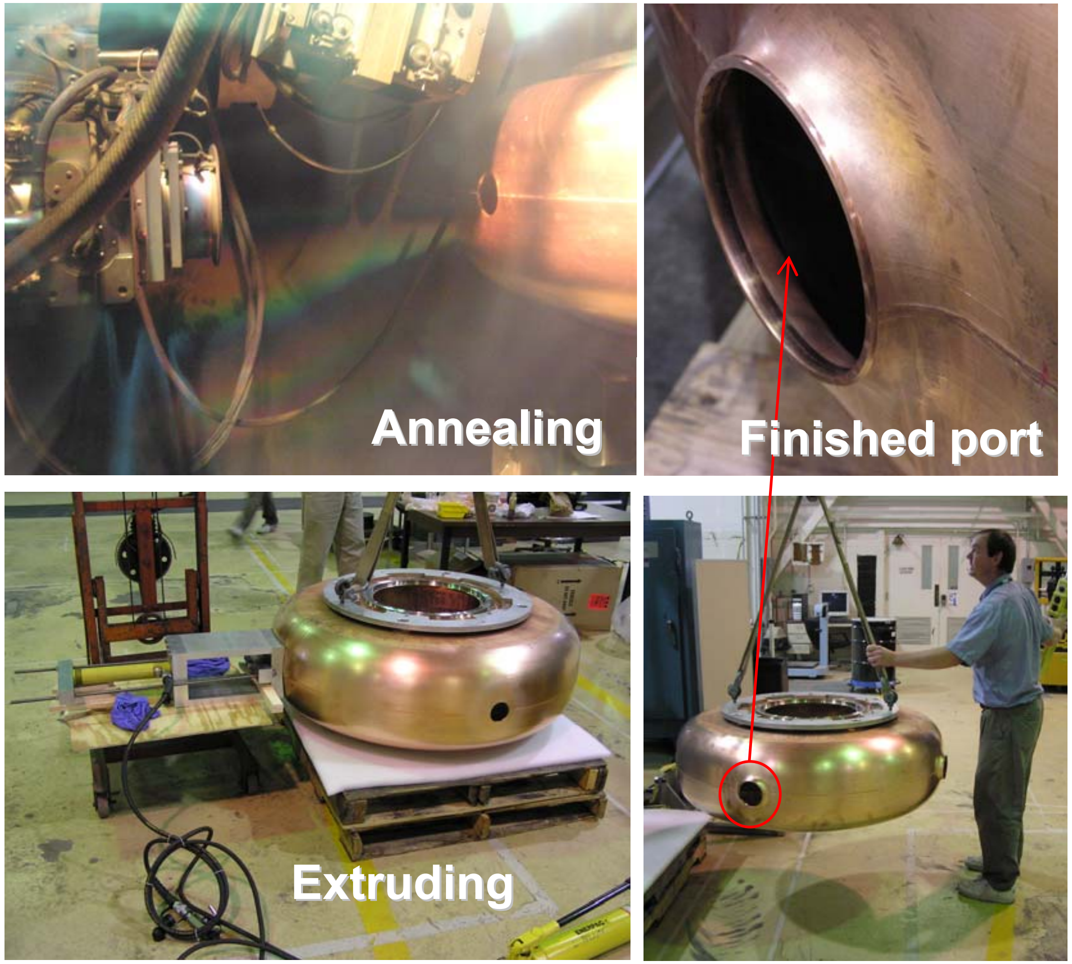
More on RF Ports Extruding



Port extruding

We have successfully developed techniques to extrude ports across e-beam welded joints.

Cavity Port Forming



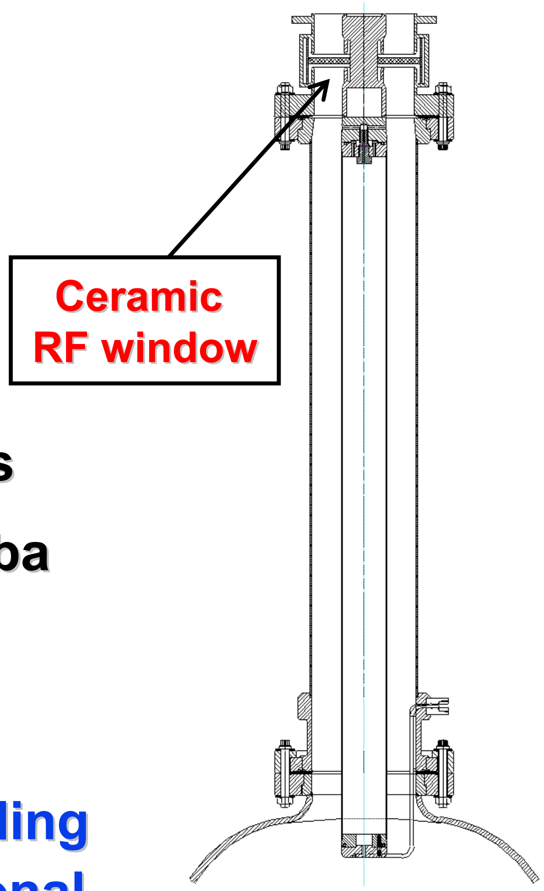
- Local annealing is achieved by repeatedly passing a diffuse e-beam around port
- Softening of copper must be local to preserve cavity overall strength
- Port pulling tool is used in a horizontal orientation
- A weld prep is machined into the port lip using a numerically controlled mill

RF Coupler Design

- ☐ Loop coupler at critical coupling
- ☐ Prototype coupling loop design uses standard

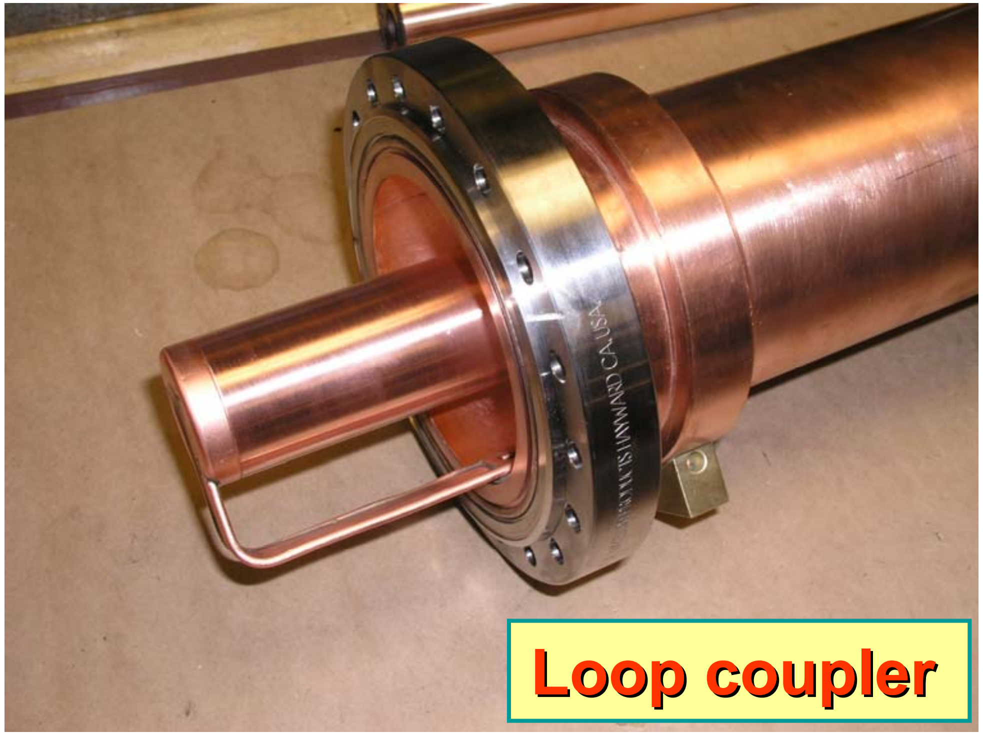
  off-the-shelf copper co-ax
- ☐ Parts were joined by torch brazing
- ☐ Coupling loop has integrated cooling lines
- ☺ Two SNS style RF windows mfg. by Toshiba

  received (no cost to us !)
- ■ Two couplers with RF windows
- ■ Bellows connection required on MICE cooling channel (Study-II) for thermal and dimensional reasons

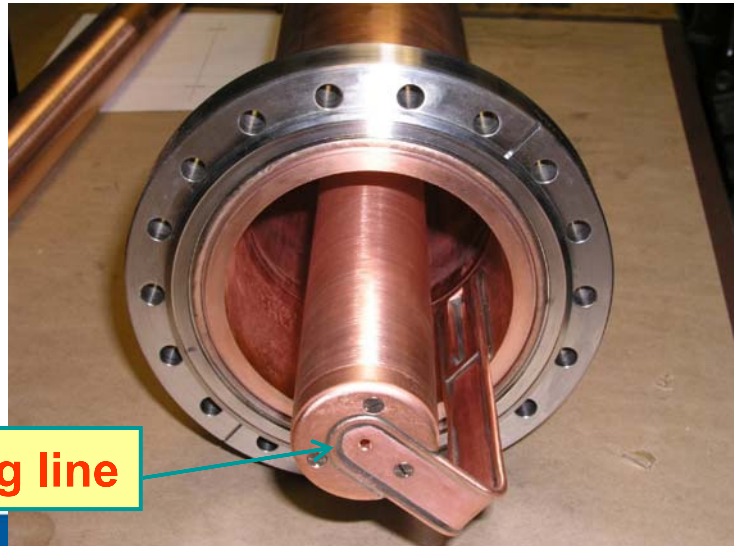


Loop Coupler Design

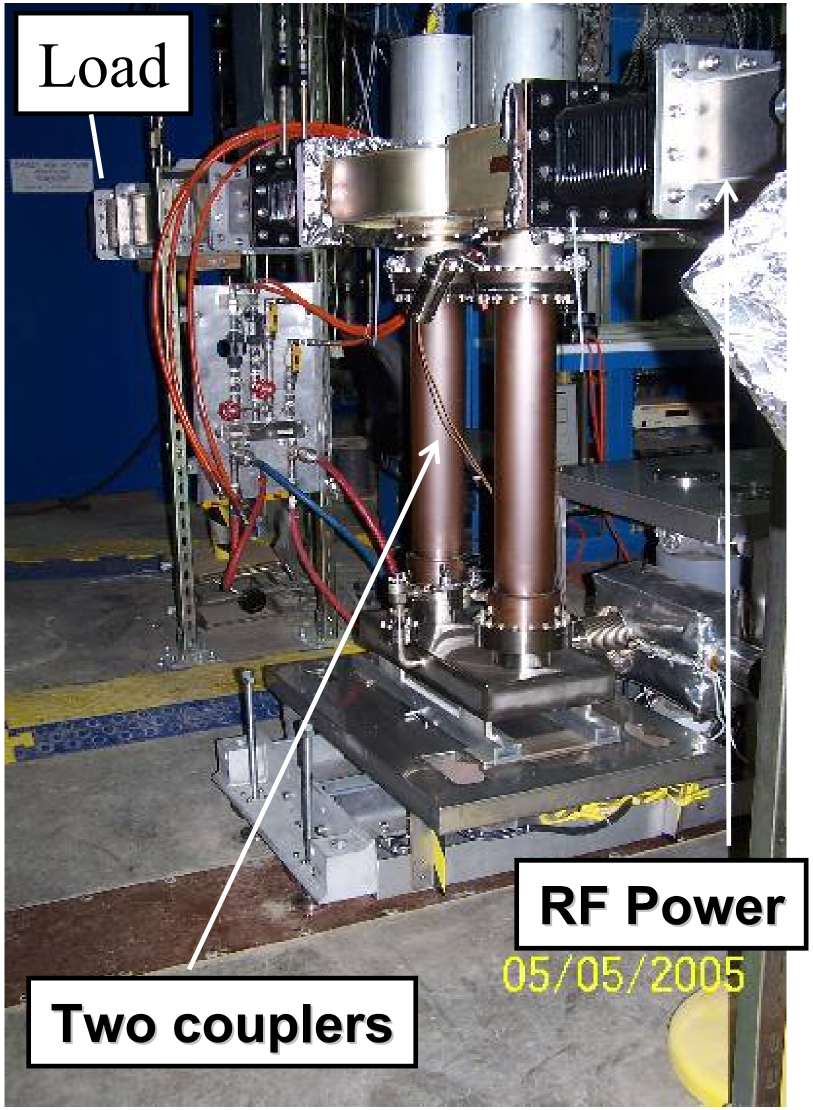
Fabrication of the Coupler



- The coupling can be adjusted by rotating the loop
- Water cooling line goes around the loop



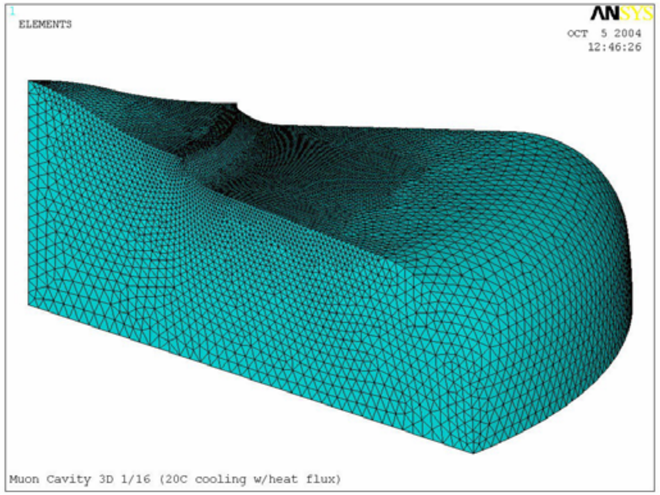
RF Coupler Conditioning

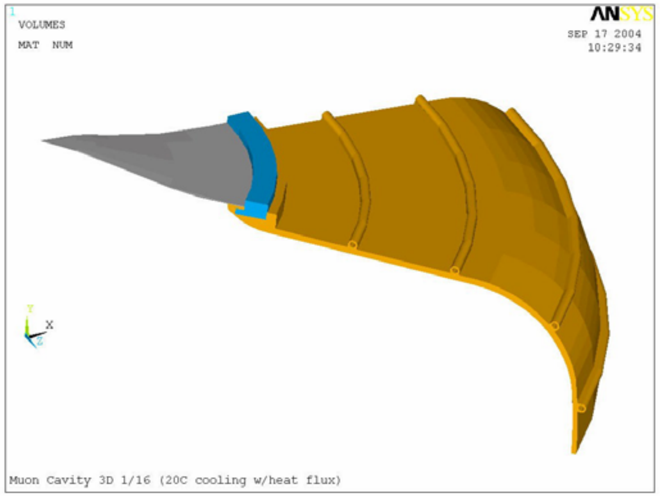


Two loop couplers

- Conditioning started during at SNS, ORNL
- Good vacuum ~ low 10^{-8} T
- Achieved **600 kW** in TW mode (matched load)
- Achieved **10 kW average power** (~ 9 kW for nominal NF parameters)
- Achieved **2.4 MW peak power** in SW mode (at variable short positions)
- Ceramic windows work perfectly within two weeks of the conditioning

Finite Element Analysis



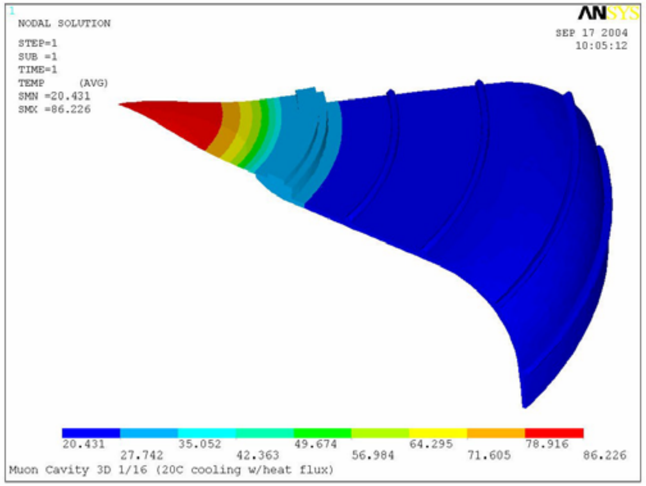


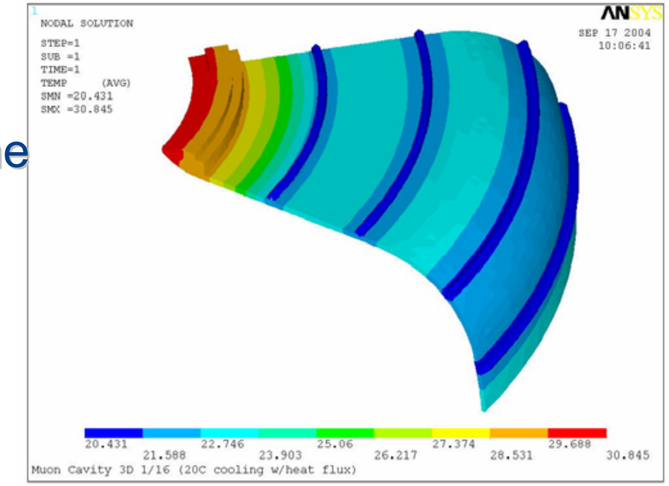
The thermal solution provides temperature distribution throughout the cavity and the beryllium window

The peak temperature occurs at the center of the beryllium window (86 ºC)

FEA helps to determine designs for:

→ Layout of water cooling tubes
→ Be window thickness





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TIG Braze of Cooling Tubes

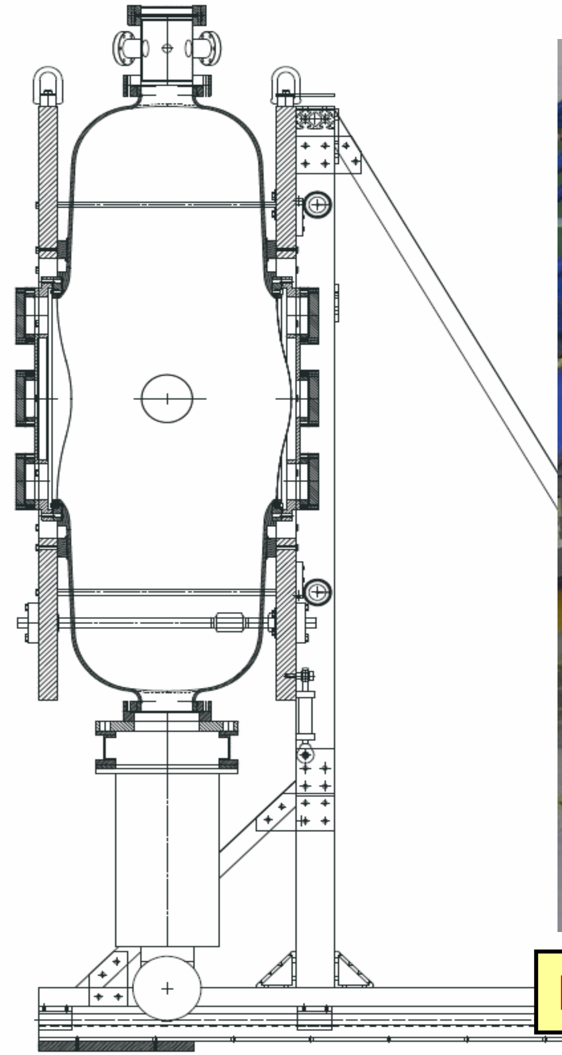
Requirement:

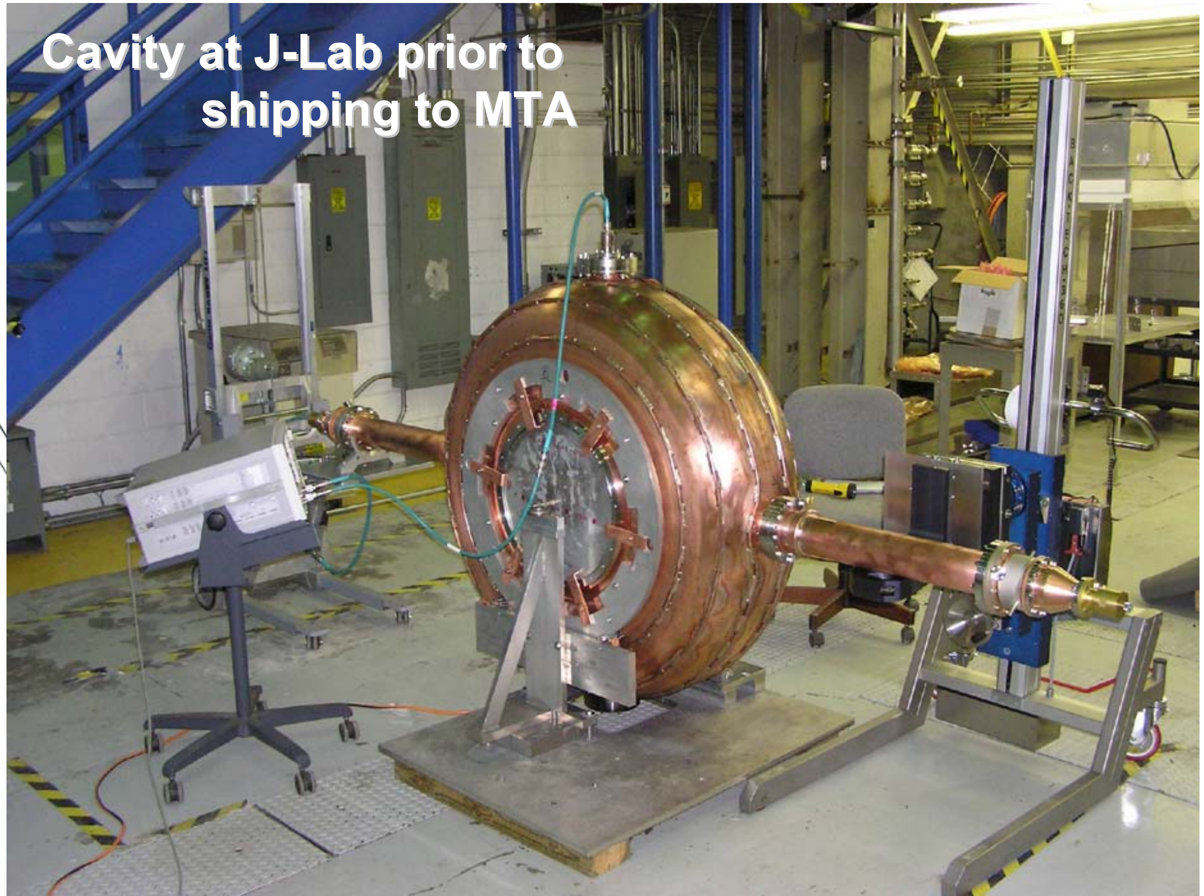
- Good thermal conduction
- Minimum distortion on the cavity body
- Welding material
- Welding speed and temperature

We have developed the technique and achieved the design goal

Silicon-Bronze with helium gas torch + argon gas flowing in the cooling tubes

Cavity & Supporting Structure

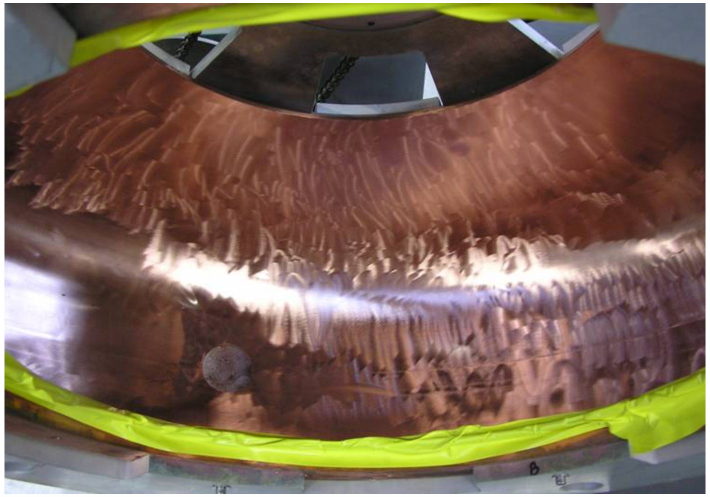




First measurement: f ~ 199.5 MHz with β_c (max) ~ 5

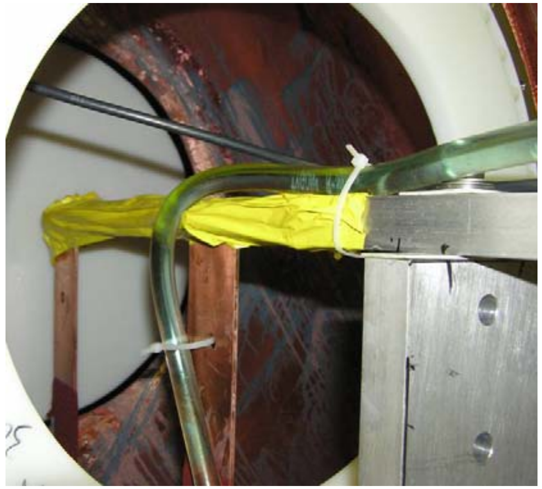
Final Interior Buffing

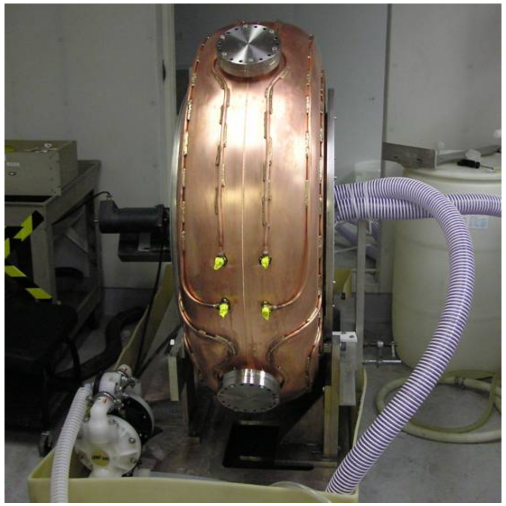
- Final interior buffing of cavity is performed to ensure the surfaces are ready for EP
- Less buffing needed near equator
- An automated process of buffing was developed using a rotary buffing wheel and a cavity rotation fixture
- Some local hand work required to clean up some areas
- A series of pads with graduated coarseness
- Goal was scratch depth shallow enough for EP removal



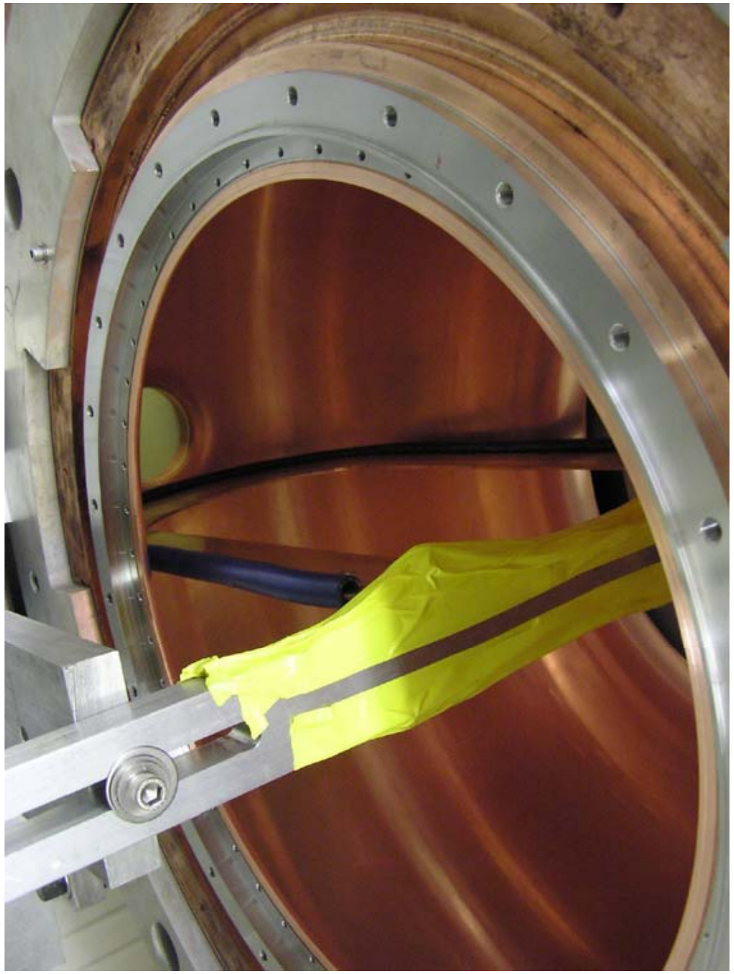
Interior Surface Electropolish

- After buffing, cavity underwent a chemical cleaning process
- Test bars with various degrees of buffing were run through an electropolish process
- Cavity was rotated with a U-shaped electrode fixed in place
- Initial polish failed due to depletion of the solution, and rebuffing was required
- 2nd EP successfully removed scratches in high field regions
- Final process is a high pressure water rinse of cavity surface





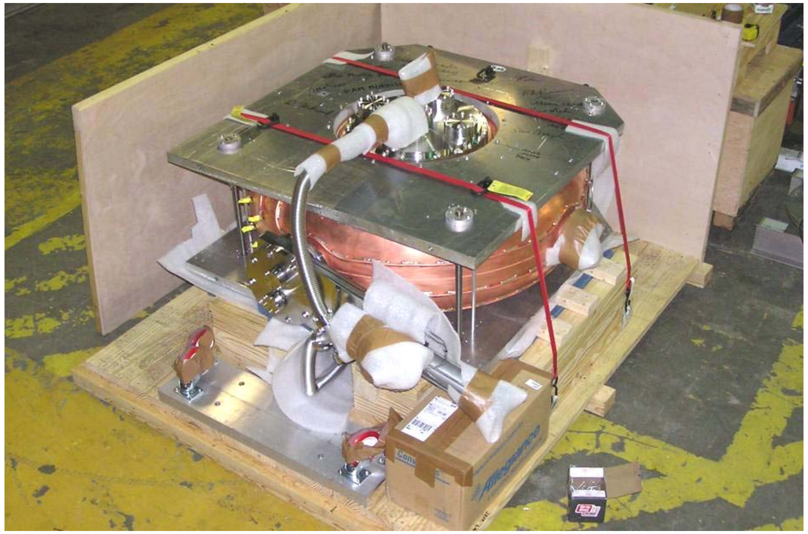
Electro-polishing (EP) Setup



EP setup and the U-shape electrode for EP at J-Lab

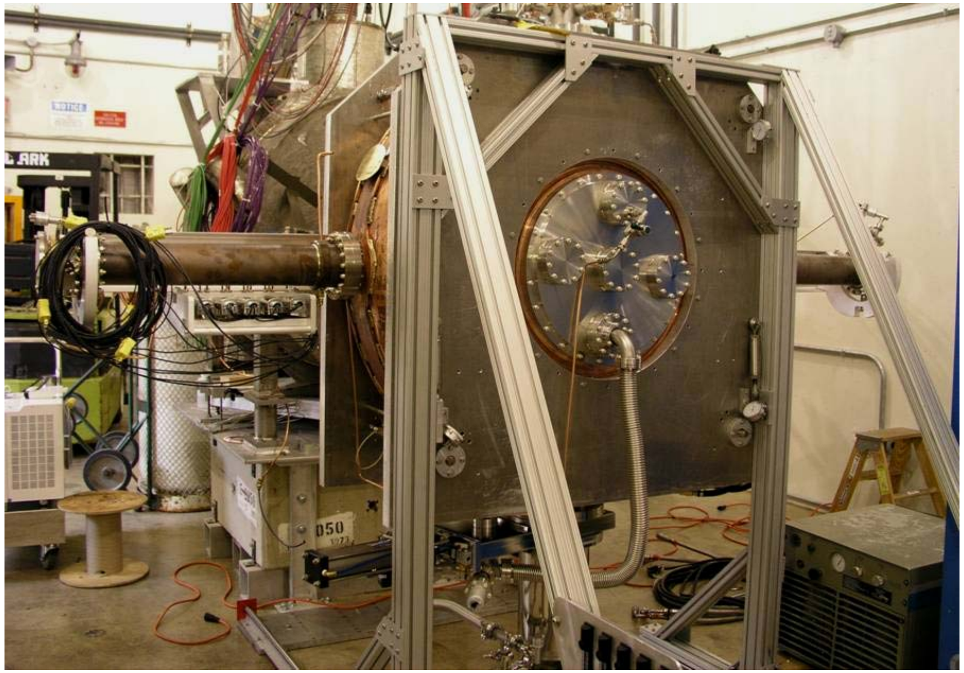
Shipment to the MTA at FNAL

- **System assembly included: tuner plates, port blank-offs, diagnostic spool, window cover plates, gate valve and window pump-out tubes**
- **Final leak check conducted prior to shipping**
- **Cavity was back-filled with nitrogen in its assembled state and packaged in a custom made crate for shipping to the MTA**



Final Assembly & Measurement at MTA

- Cavity assembly was mounted on the support and couplers were installed in a portable clean room
- Dummy copper windows (flat) are used initially
- Couplers were set and frequency was measured
- Bakeout system hardware was installed
- System is leak tight



The cavity in a portable clean room at MTA

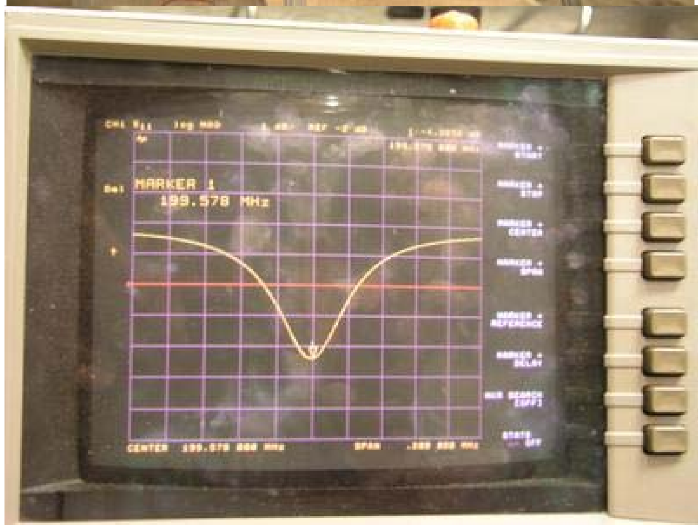
Low Power Measurements

f = 199.578 MHz

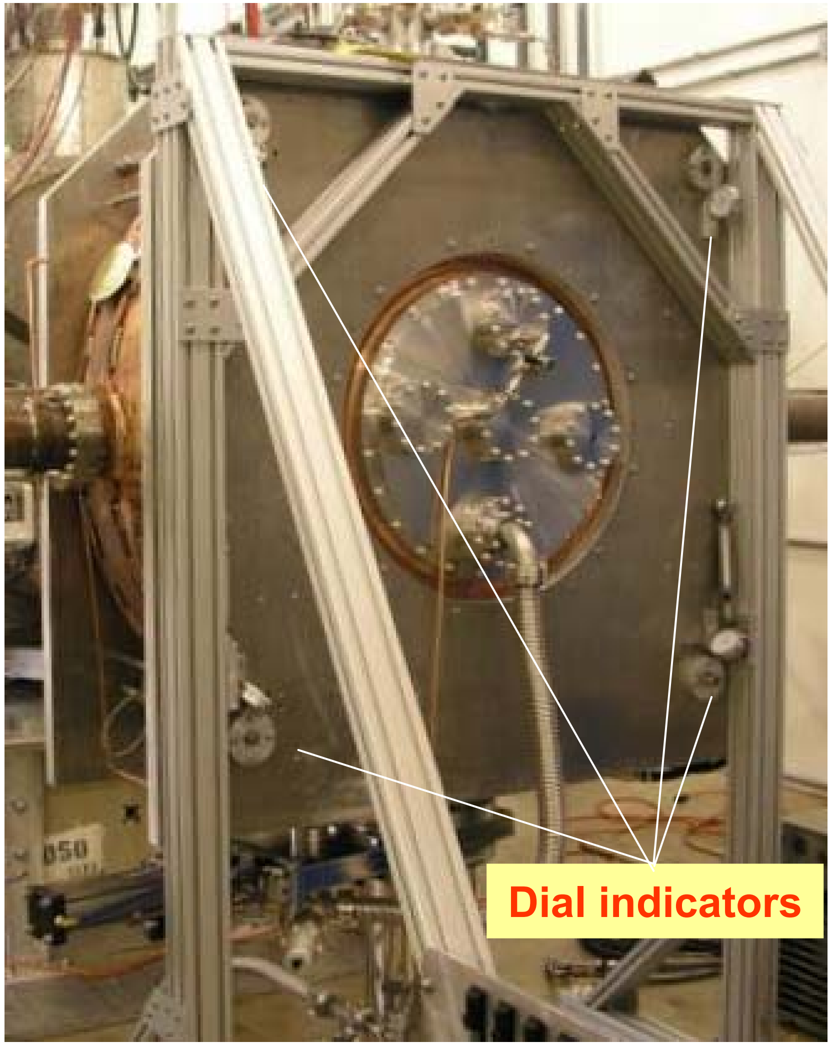
Q_0 = 49,000 ~ 51,000 (better than 90% of the design value)

Two couplers

- Balanced
- Coupling adjustments

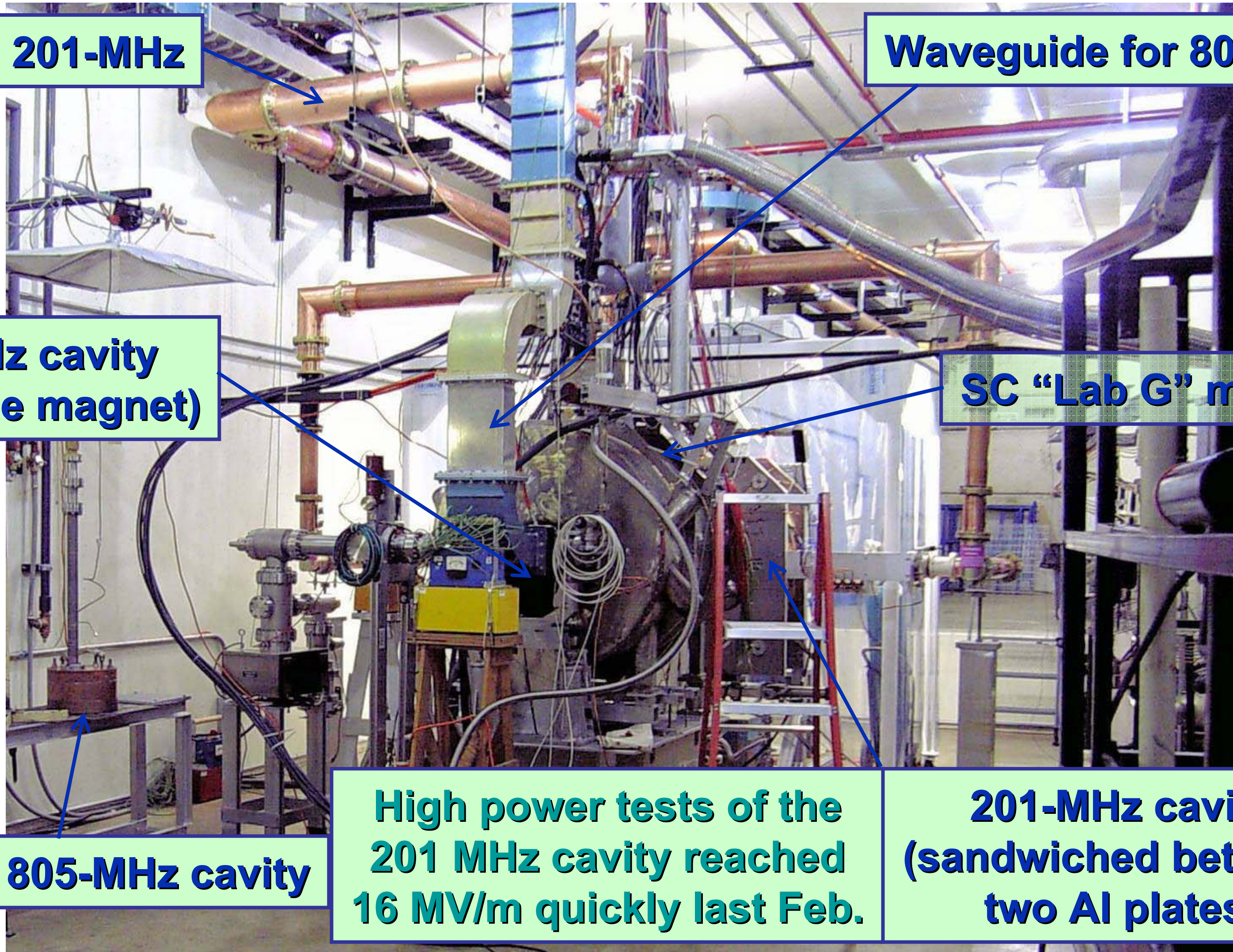


Tuner Measurements



- Mechanical tuning plates at four locations
- Dial indicators to measure displacement between Al plates
- Tuning measurement in air
  - Equivalent to MICE cavity under vacuum
- Adjusted up to 2-mm with 8 steps of 0.25-mm each
- Measured tuner sensitivity
  - ~ 78 kHz/mm
- Calculated tuner sensitivity
  - 115 kHz/mm
  - Disagreements are due to deflection of the Al plates

High Power Tests at MTA, FNAL



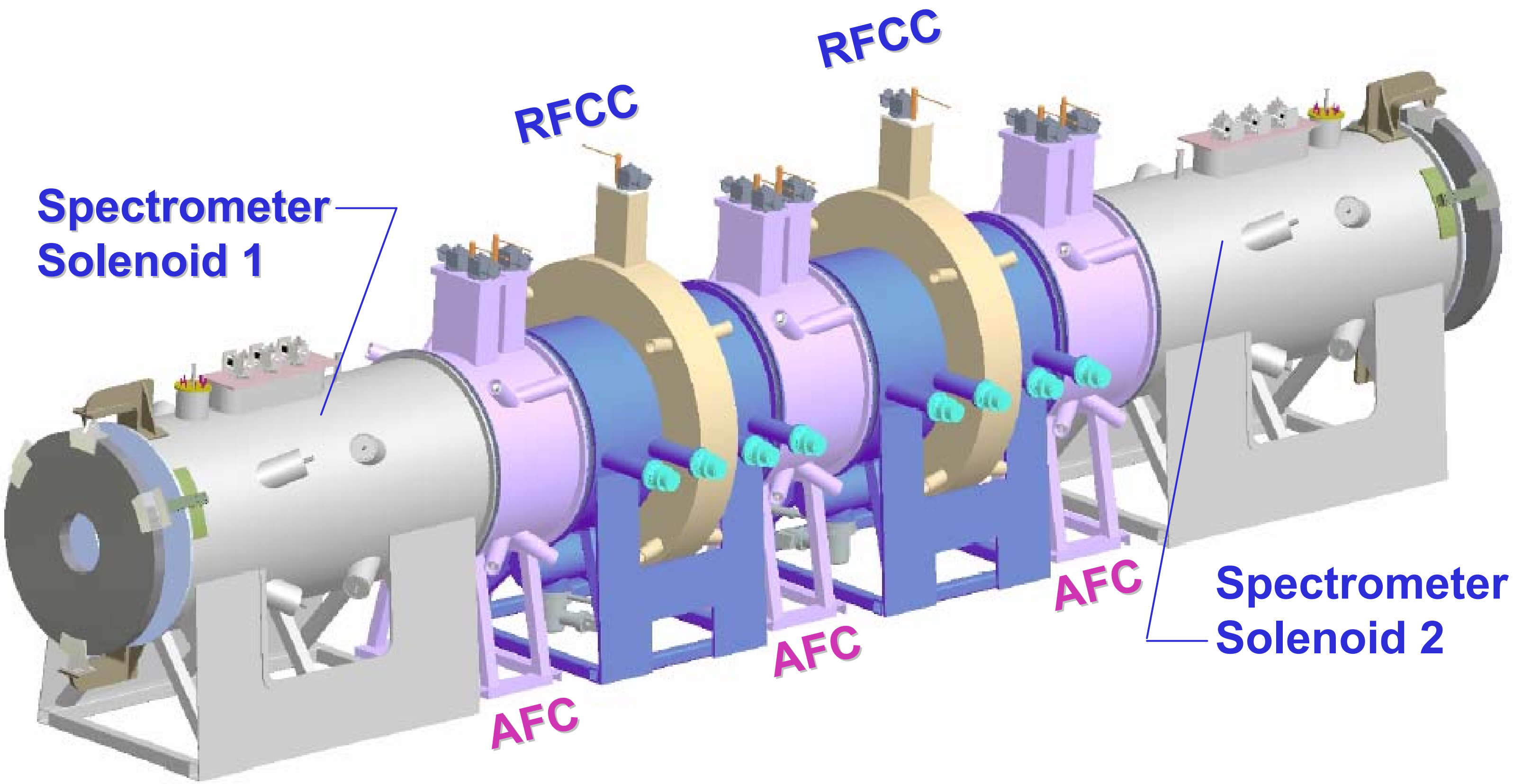
High power tests of the 201 MHz cavity reached 16 MV/m quickly last Feb.

High Power Test Results

- **Conditioning started late Feb. 2006 with**
  - Flat copper windows (plates) with Ti-N coatings
  - RF diagnostics
  - Good vacuum ~ high 10^{-9} Torr
- **Without external magnetic field, the cavity conditioned very quietly and quickly to reach ~ 16 MV/m, limited by available RF power of 4.2 MW, could not go higher**
- **Curved Be windows will be installed for future tests**
- **More careful RF conditioning and mutipactroing studies are being conducted now: with "magnetic fields" ~ 250-G on-axis nearest window (2.5 T in solenoid), reached to 16 MV/m again (March 10, 2007)**
- **Multipactoring simulation effort launched in collaboration with Cockcroft Institute in UK**

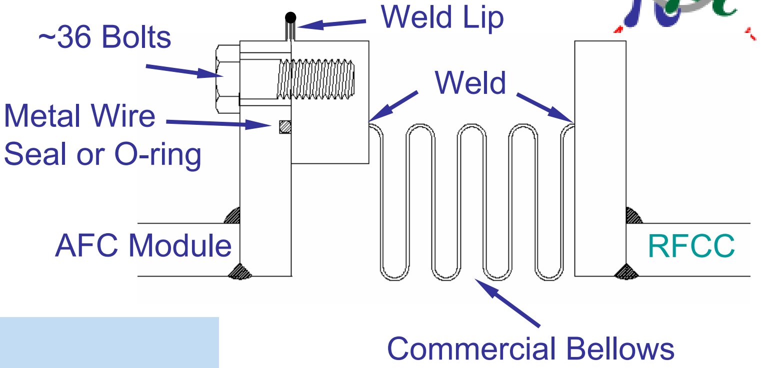
US Responsibility for MICE

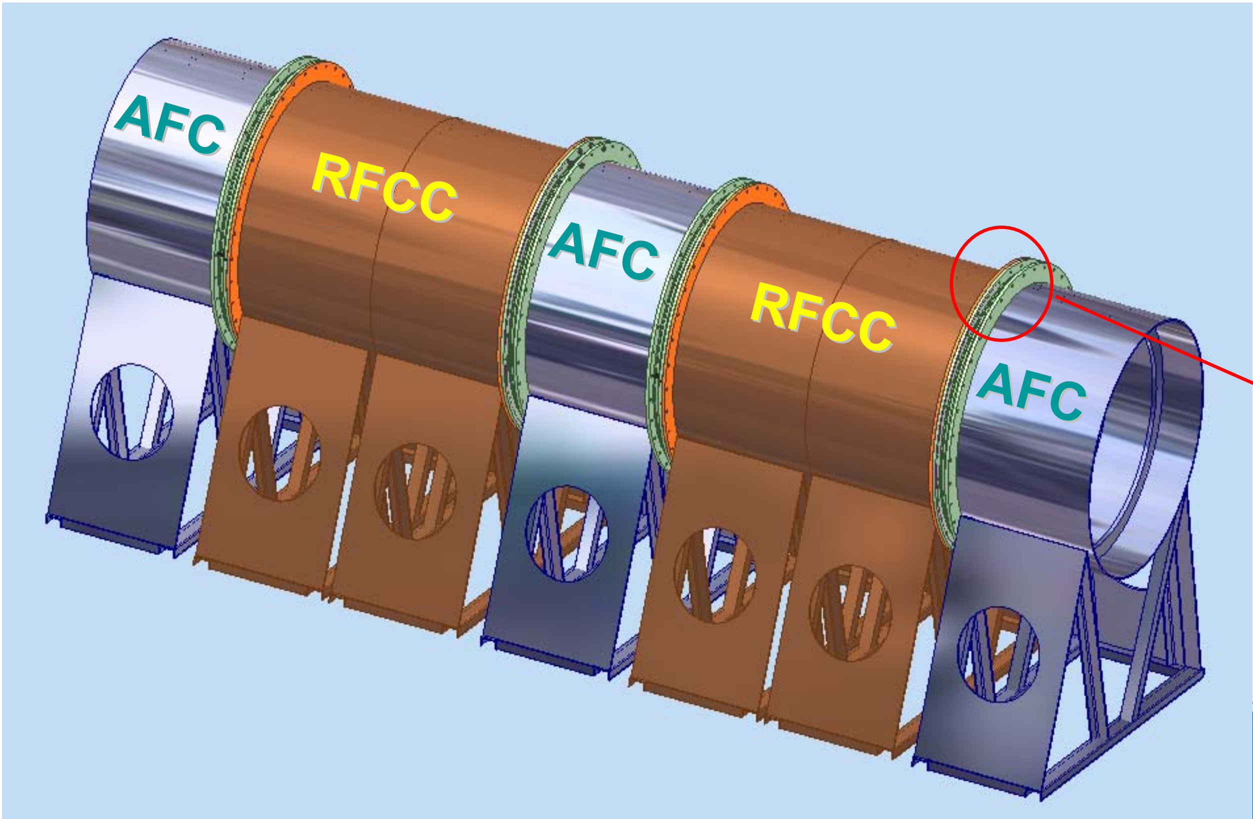
Management and planning; Spectrometer solenoid, detectors, absorbers, RFCC and the Cooling Channel integration

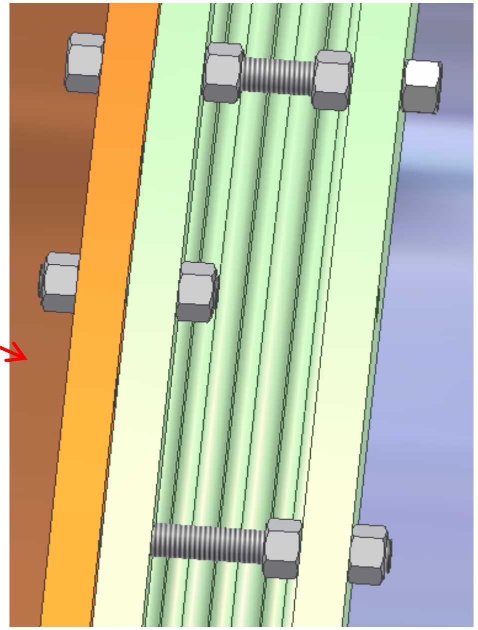


Integration of MICE Cooling Channel

- RFCC module design
- Integration of MICE Cooling channel
  - Options for vacuum seal
  - Options for module joints







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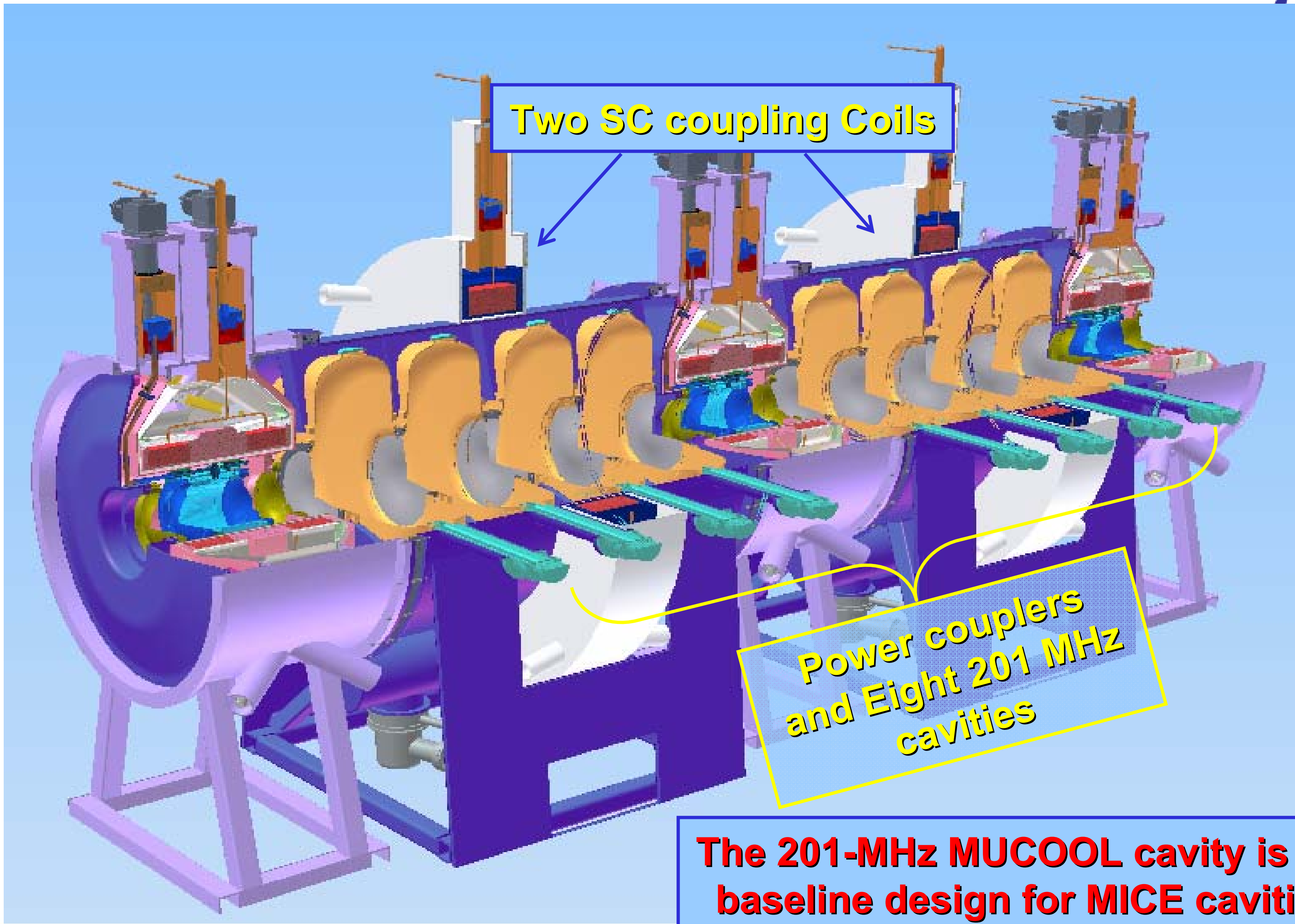
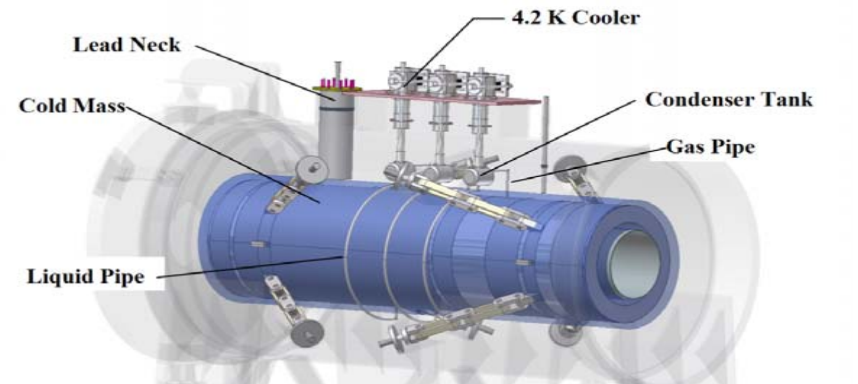
MICE RFCC Module



The 201-MHz MUCOOL cavity is the baseline design for MICE cavities

MICE Spectrometer Solenoid



Spectrometer solenoid contract awarded to B. Wang Company, Livermore, CA
Two solenoids to be delivered by Oct. 2007

1st Coil winding form

Coil Winding Apparatus

Photo taken March 2, 2007

Summary

- **NFMCC has continued to make good technical progress in R&D for intense muon beam accelerator**
- **R&D Programs**
  - RF cavity R&D
  - Be window R&D
  - SC magnets and system integration for MICE
- **Experimental studies at 805 MHz using the pillbox cavity are being conducting now at MTA**
  - Button tests
- **The 201 MHz test cavity tests continue at MTA**
  - **Reached 16 MV/m quickly without magnetic field**
  - More careful conditioning and multipactoring studies
- **Continue to develop and test hardware for μCOOL and MICE**