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201 MHz Prototype Cavity Status for MUCOOL

Derun Li

Center for Beam Physics
Lawrence Berkeley National Laboratory

Muon Collaboration at UC, Riverside, CA
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Collaborators

J. Staples, S. Virostek, M. Zisman

Lawrence Berkeley National Laboratory, USA

R. Rimmer, L. Philips, G. Wu

Thomas Jefferson Laboratory, USA

W. Lau, S. Yang

Dept. of Physics, Oxford University, UK

D. Summers, M. Reep

Mississippi University, Oxford, MS, USA

The 201 MHz Cavity

201 MHz cavity is one of the key components of a muon cooling channel

- High accelerating gradient ~ 16 MV/m peak (1.07 Kilpatrick);
- Thin low-Z Be foils (windows) to terminate RF fields
  - Enhance on-axis accelerating field — higher shunt impedance
  - Lower ratio of accelerating field versus peak surface field
  - Mechanical stability of the windows under RF heating power
- Operation under strong magnetic fields (a few Tesla)
  - Conditioning with and without the magnetic fields
  - Multipactoring, dark currents
  - Cavity/Window surface damage
- Explore engineering challenges for a cost effective cavity design, fabrication and integration

The Cavity Design Update

Cavity profile design with the consideration of

- Low ratio of acceleration field versus peak surface field
- Numerical simulations with MAFIA, URMEL, SUPERFISH and **ANSYS** (RF, thermal and mechanical) codes
- Simple (easier) fabrication without losing the performance
- De-mountable window design allow for other windows and grids
  - Baseline window design: pre-curved thin Be windows

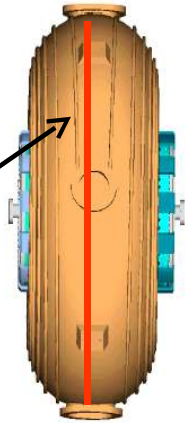
Accessories

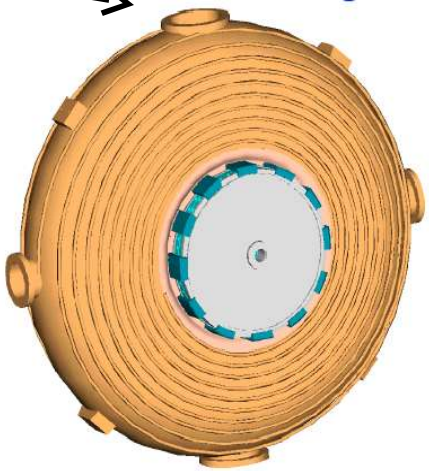
- Four larger ports for two loop couplers, vacuum
- Two smaller ports for probes
- Mechanical tuners similar to the ones used in SCRF cavities

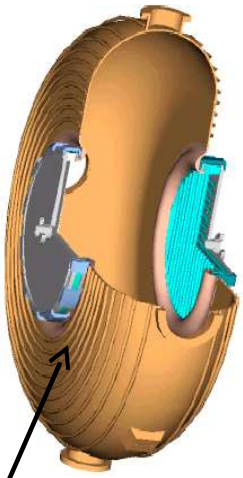
201 MHz Cavity Concept

Extruding ports

Spinning of half shells and e-beam welding

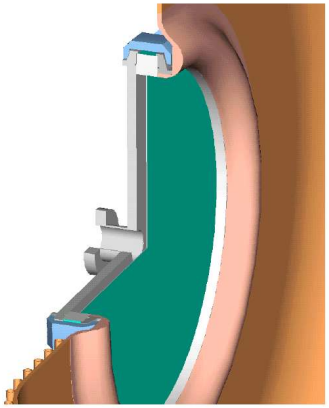


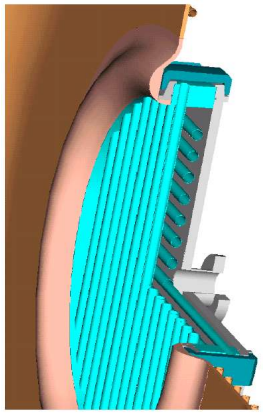




201.25 MHz cavity conceptual design

Water cooling channels





Cavity design accommodates different windows

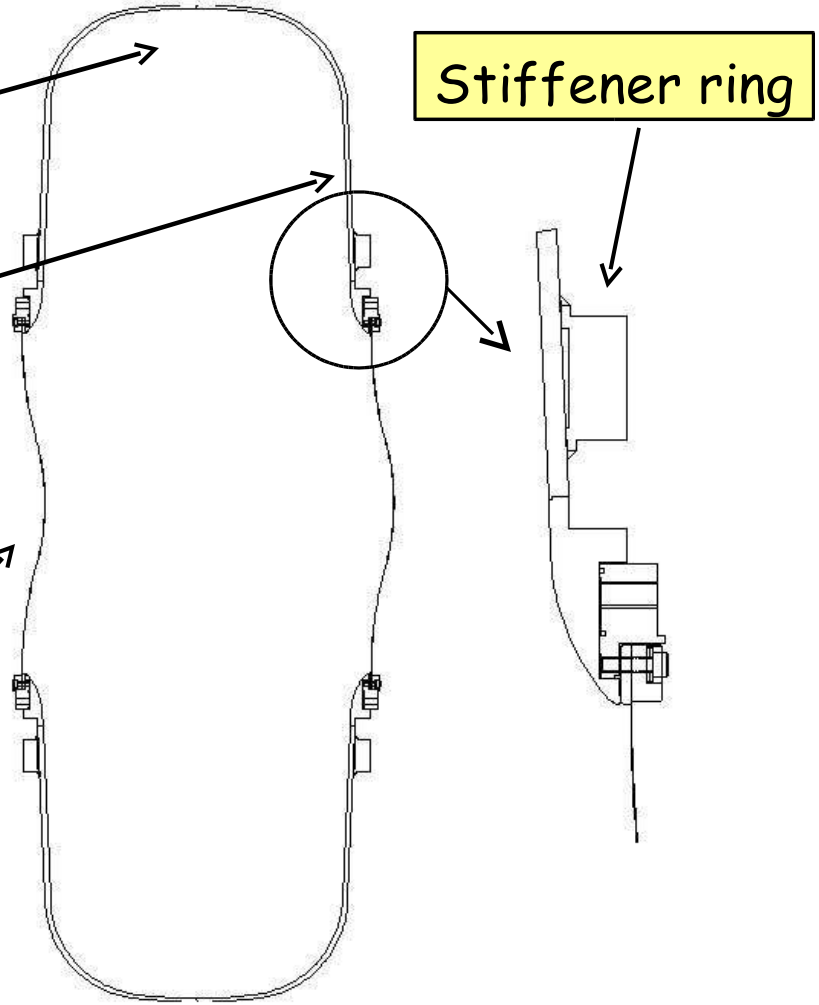
The Cavity Body Profile

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

2° tilt angle

6-mm Cu sheet allows for uses of spinning technique and mechanical tuners

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



The Cavity Parameters

The cavity design parameters

- Frequency: 201.25 MHz
- β = 0.87
- Shunt impedance (V_T^2/P): ~ 22 MΩ/m
- Quality factor (Q_0): ~ 53,000
- 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

Cavity fabrication techniques

- Cavity body:
  - ✓ Spinning of half-shells (spun four of them) from 6-mm thick Cu sheets using bakelite mold at ACME, a company in Minnesota
  - ✓ Chemical and mechanical cleaning (JLab)
  - – Electro-polishing (JLab)
- ✓ E-beam welding to join stiffener rings and half shells (JLab)
- ✓ Stiffener rings, nose-cone pieces and some support structures (Univ. of Mississippi) for e-beam welding
- ✓ Support fixturing for the equator welding (LBNL)
- Pulling (extruding) ports on the equator of the cavity body (baseline plan: cut ports, and jointed by e-beam welding)
  - RF loop couplers
  - Vacuum ports
  - Probes and view ports

Spinning @ ACME

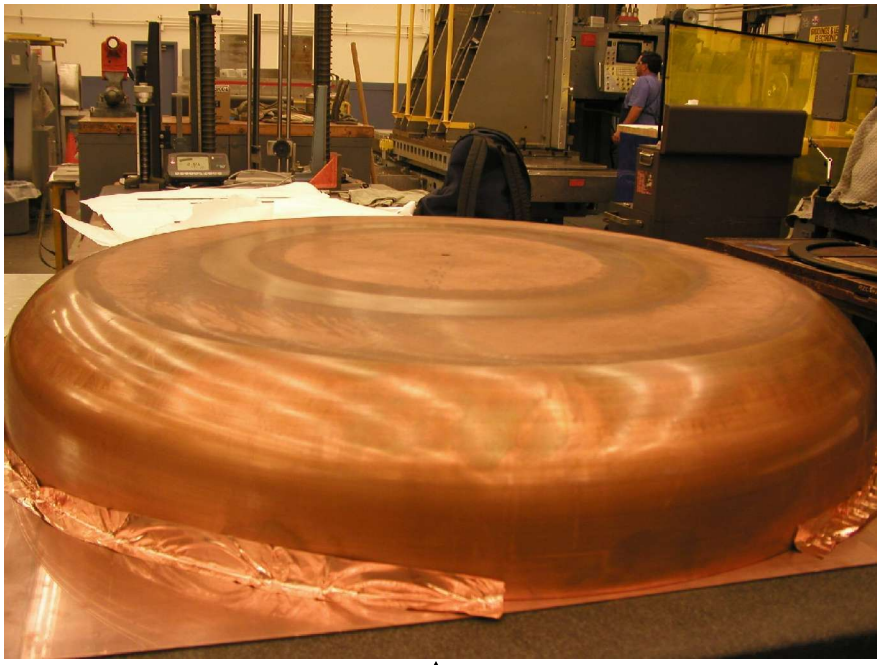
An example of using spinning technique !

Spinning a bowl

Spinning tools

A Spun Half Shell @ ACME

RF and CMM Measurements

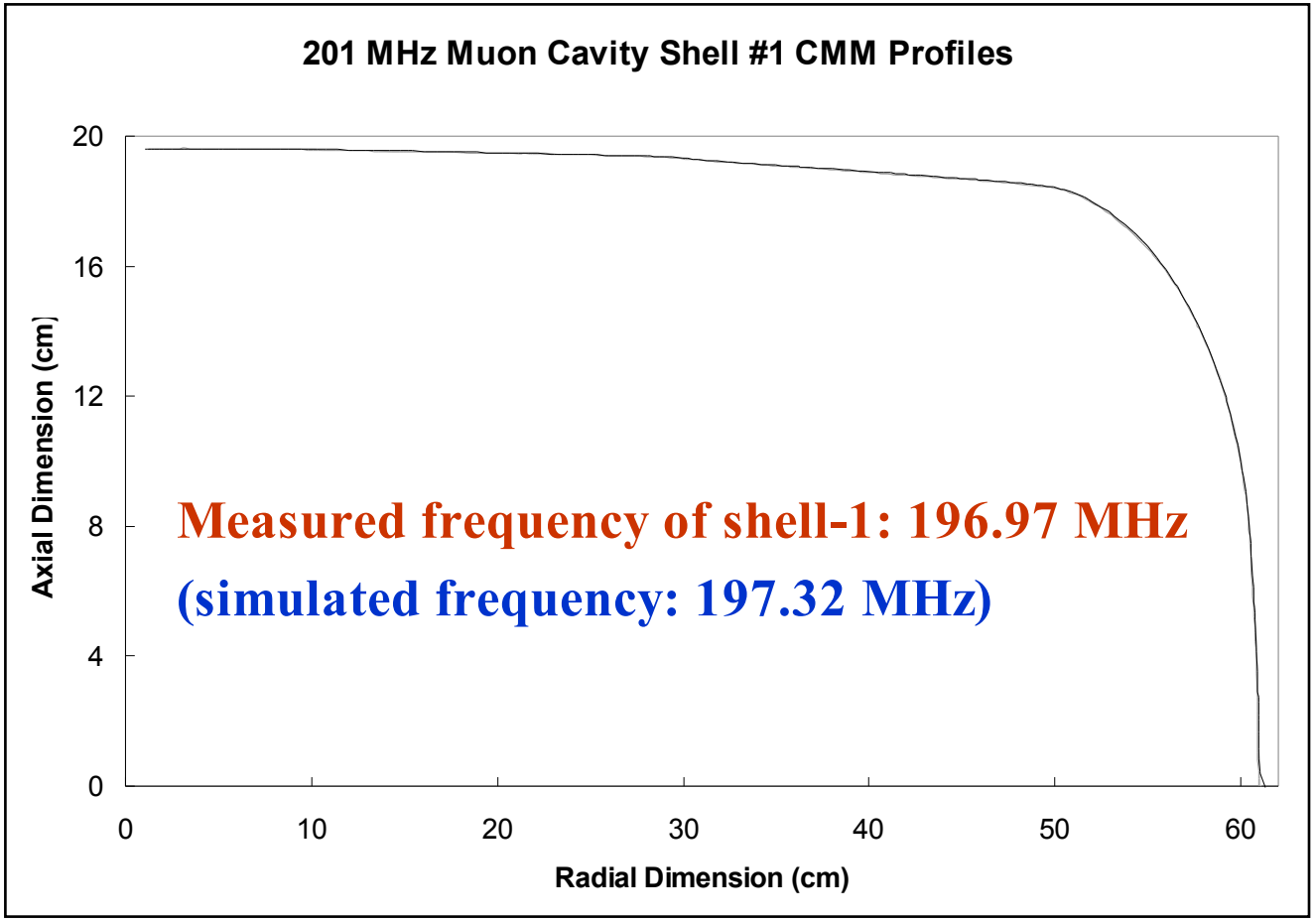


CMM setup and scans at 0, 45 and 90 degrees, respectively

Frequency and Q measurements of half shells; Cu tape for better RF contacts

CMM Profiles

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



Measurement & Simulation Results

Calculated Half Shell Frequencies [MHz]

- Calculated Shell Frequencies as Spun (based on CMM data)

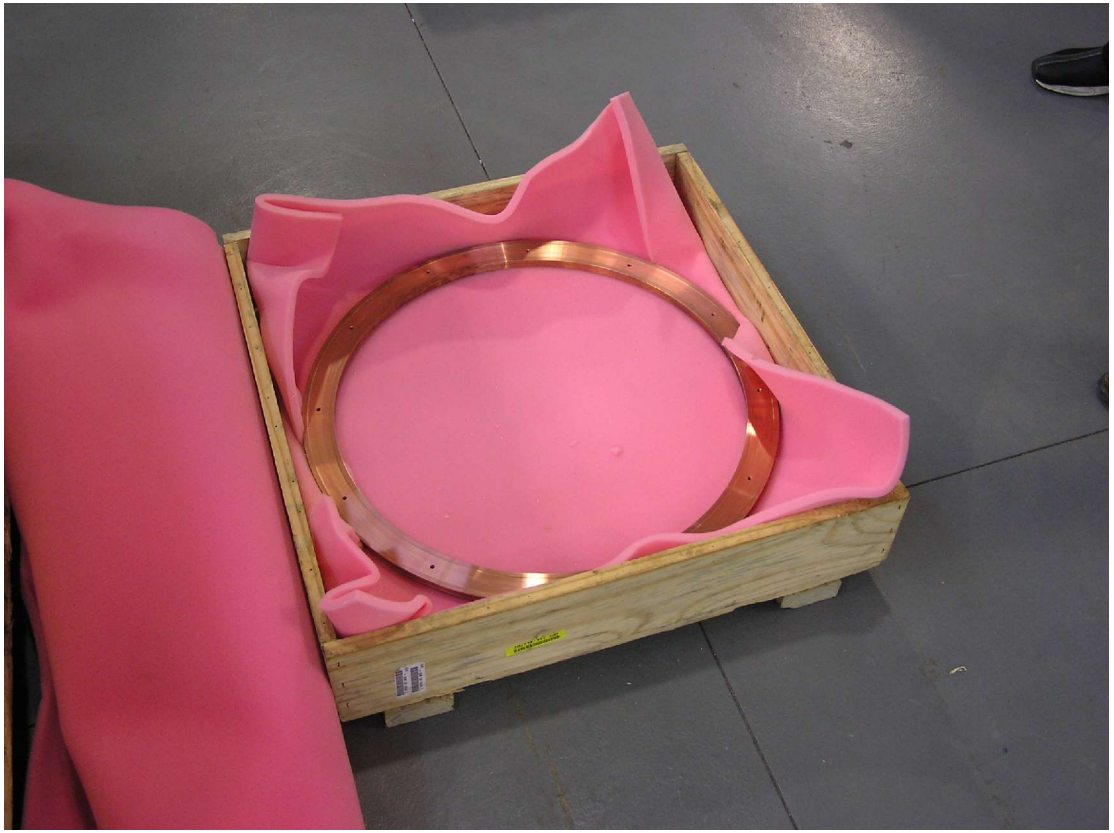
Shell #	0	45	90	Average
1	197.24	197.45	197.26	197.32
2	197.76	197.82	197.80	197.79
3	197.81	197.97	197.86	197.88
4	197.07	197.21	197.38	197.22

- Calculated Shell frequencies with nose and flat window

Shell #	0	45	90	Average
1	201.55	201.76	201.58	201.63
3	201.96	202.05	201.84	201.95

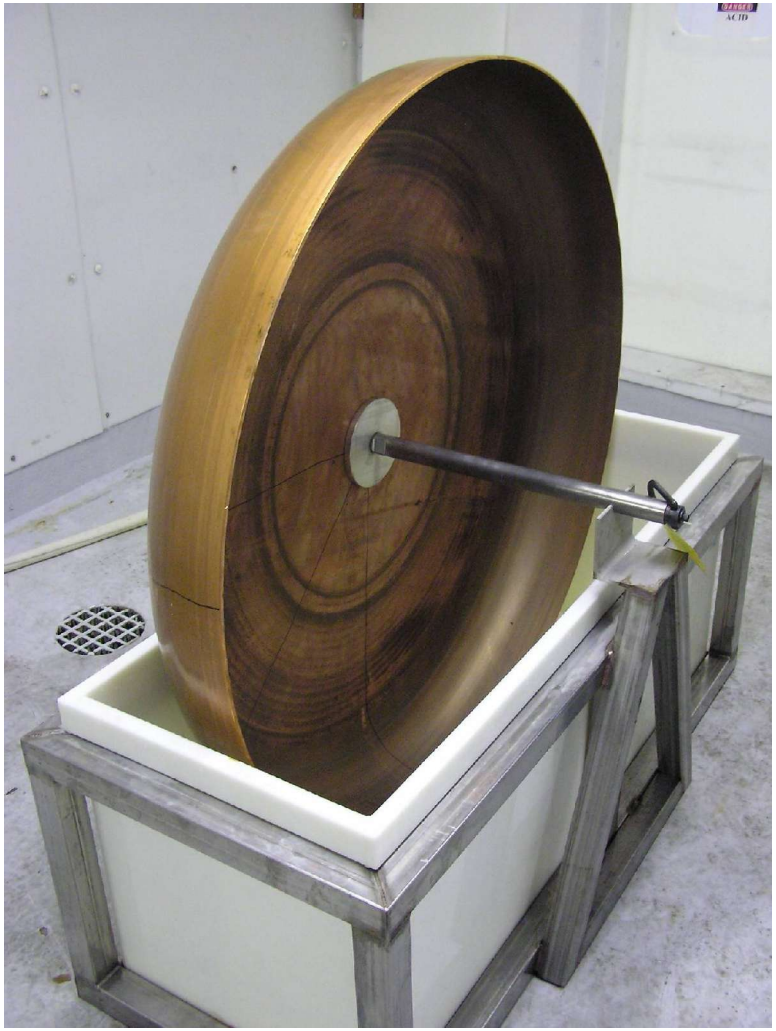
Frequencies of nominal with flat/curved windows: 201.36/201.17 MHz

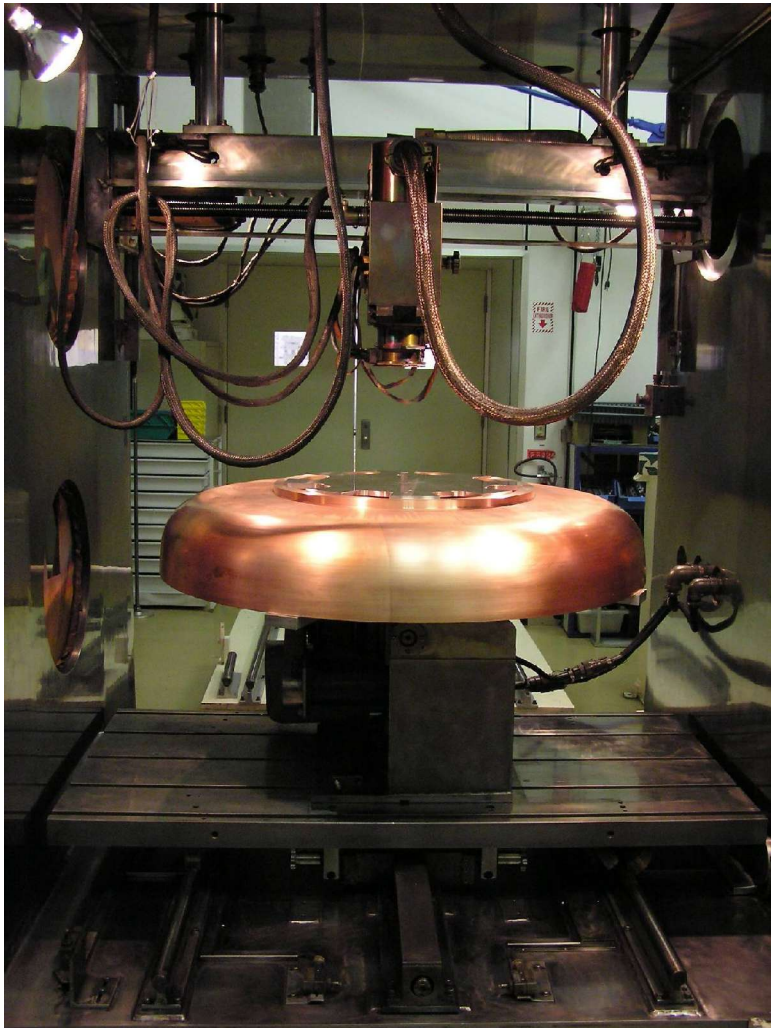
Stiffener Rings



Two stiffener rings were fabricated at Mississippi University and shipped to JLab for e-beam welding

E-Beam Welding Preparation

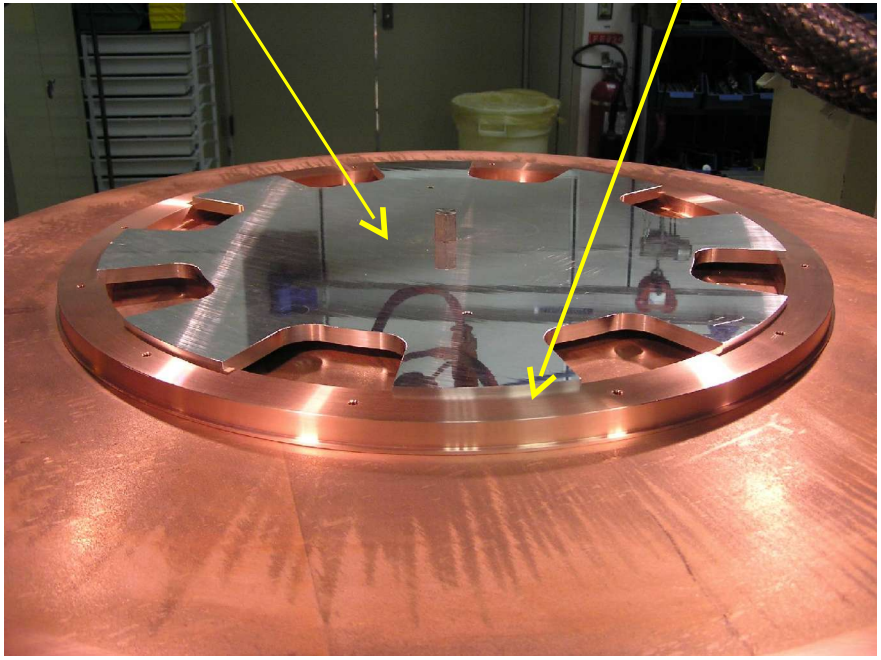




E-Beam Welding of the S. Ring

"Spider" holder

Stiffener ring



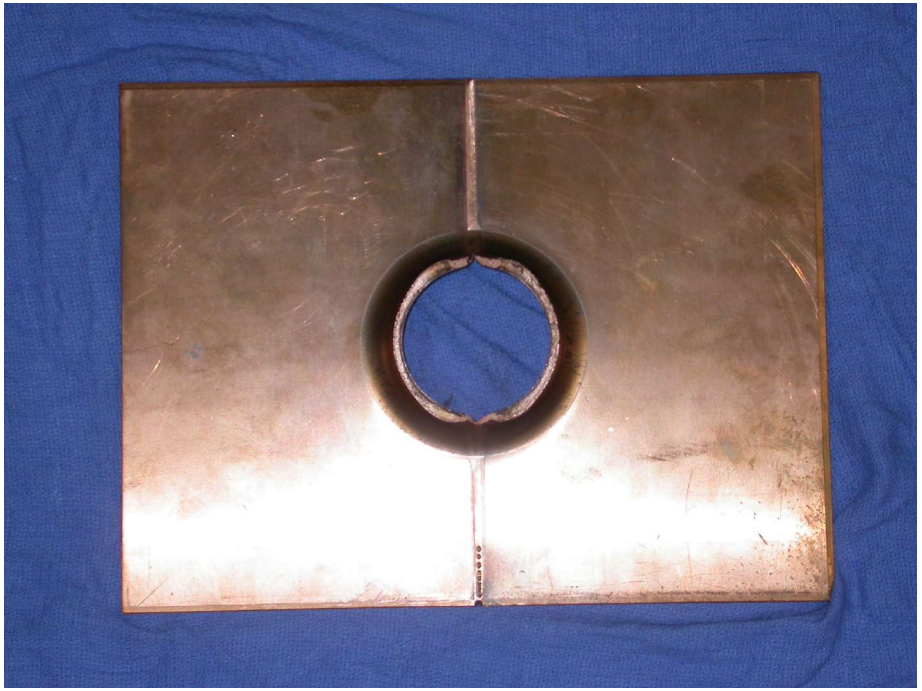
Skip e-beam welding first to hold the stiffener ring in place, then finish the complete welding

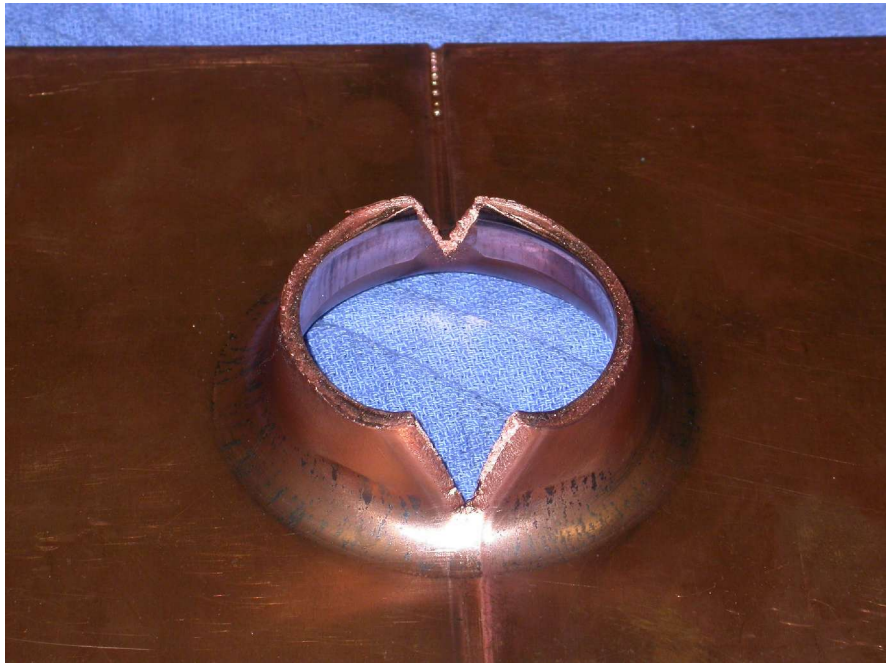
After E-Beam Welding

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

Extruding tests at JLab

Extruding tests on a flat Cu plate
Going through e-beam joint

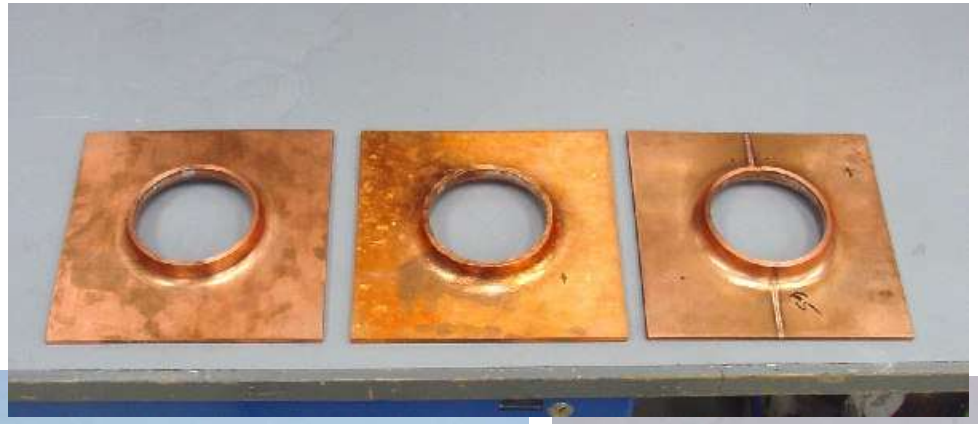


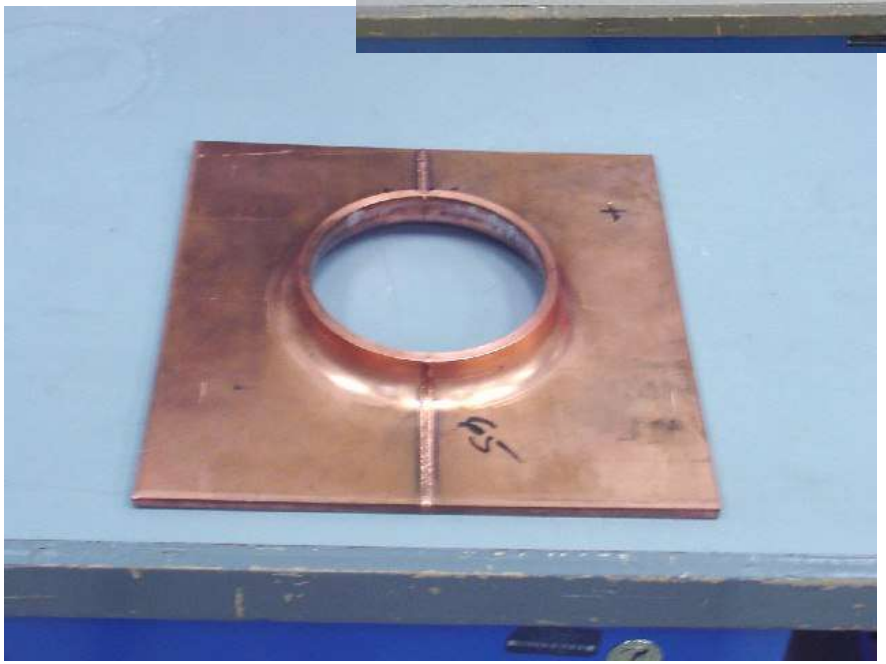


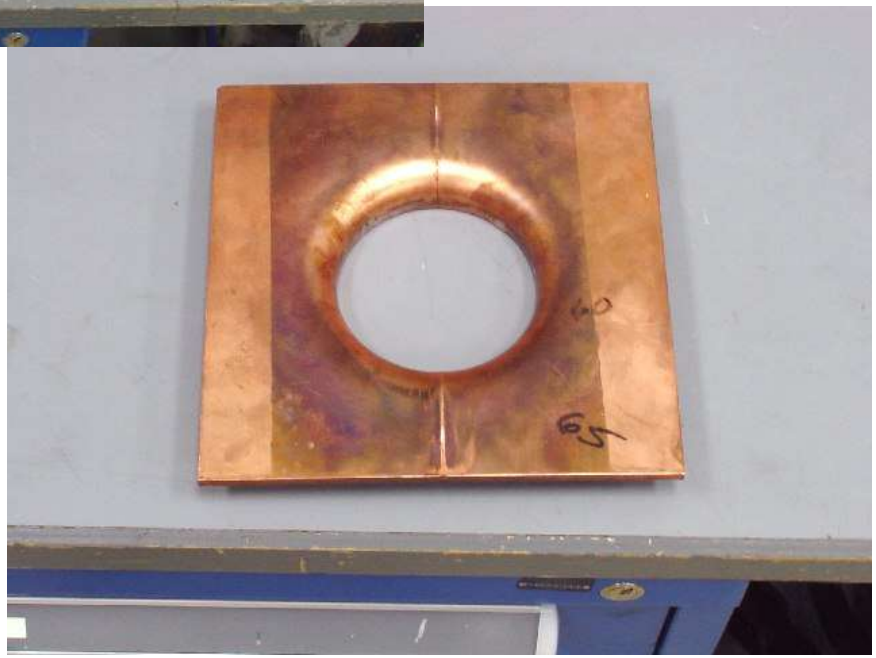
A successful test recently!

Possible improvement:
Anneal around the extruding area or combination between pilot hole dimensions and lid heights, …

Recent Extruding Tests







201 MHz cavity status

- ✓ Four half shells have been formed by spinning
- ✓ Cu stiffener rings were e-beam welded to two half shells
- ✓ The shells are being mechanically cleaned at JLab
- ✓ Shells are ready for machining prior to e –beam welding of equator joint
- ✓ Equator weld fixturing has been fabricated at LBNL
- ✓ Cavity nose piece rings (Univ. of Mississippi) have been brazed at LBNL
- ✓ Conceptual design of RF loop coupler
- ❑ E-beam welding of equator joint
- ❑ Extruding four ports
- ❑ Chemical cleaning and electro-polishing of the cavity
- ❑ Pre-curved Be windows
- ❑ The cavity should be ready for test in MTA at Fermilab this fall

Ernest Orlando Lawrence
Berkeley National Laboratory

Cavity windows: Domed

Collaboration with Oxford University

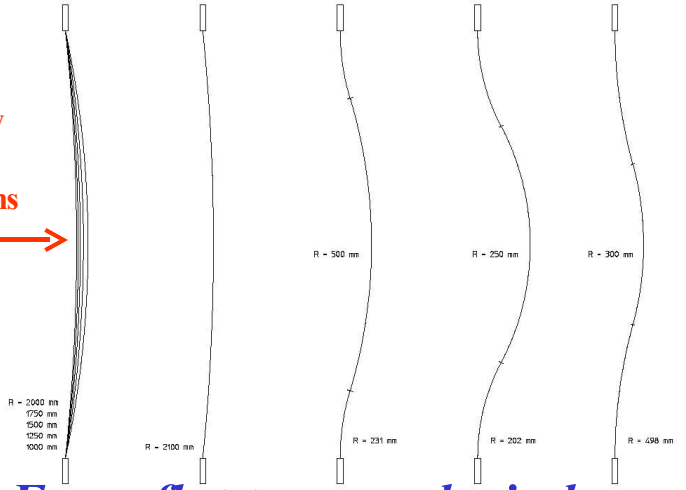
Dr. W. Lau will talk on the curved window designs and FEA modeling tomorrow

January 30th 2004

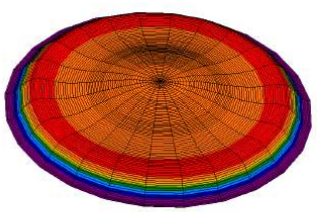
A brief review: Be window R&D

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

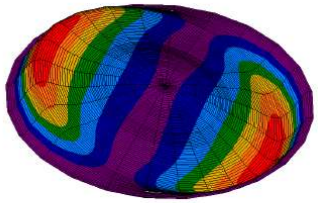
Window profile evolutions



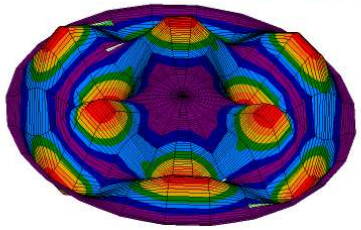
From flat to curved windows



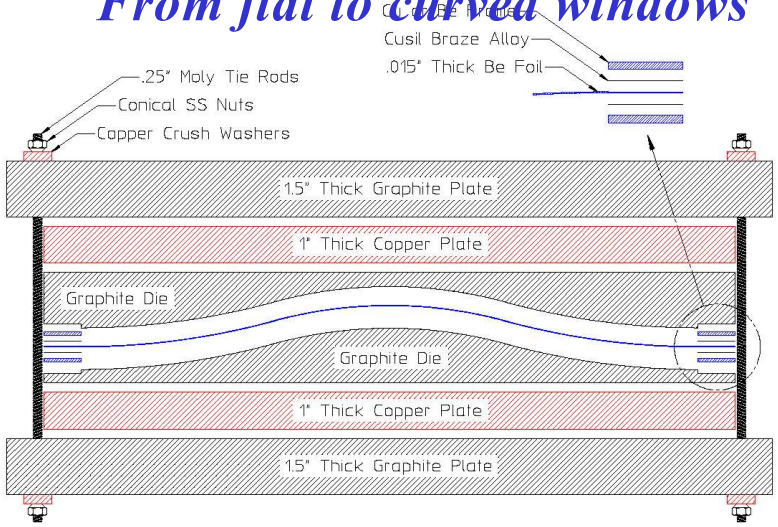
1st natural frequency: 530 Hz.



2nd natural frequency: 673 Hz



A pre-curved Be window: 0.25 mm thick and 21 cm in radius (by Oxford Univ.)



Curved Window Prototype

Pre-curved windows

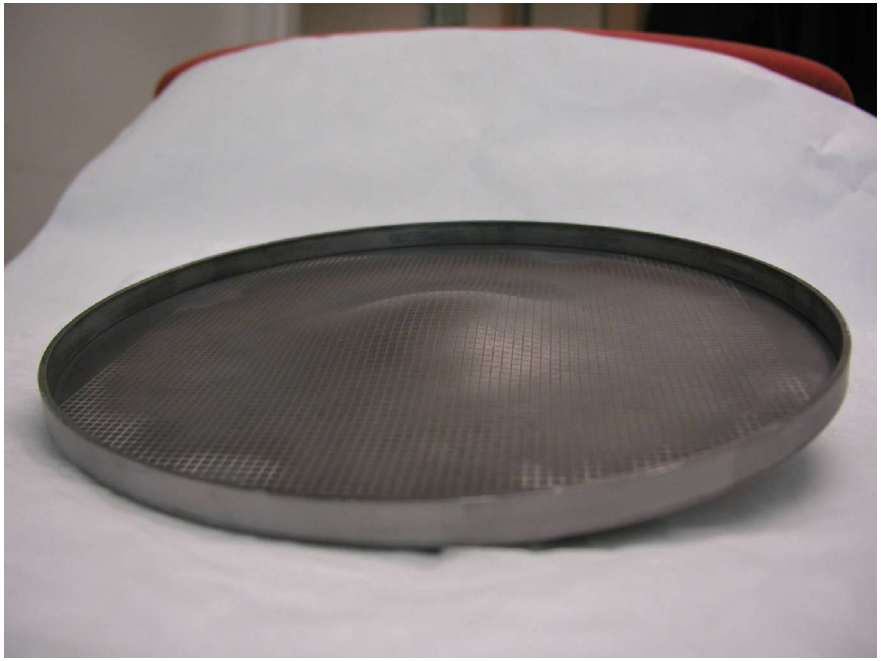
- Pre-form the windows at room or high temperatures using graphite or Al die (setup for 16-cm diameter windows for 805 MHz cavity)

Setup for Window formation

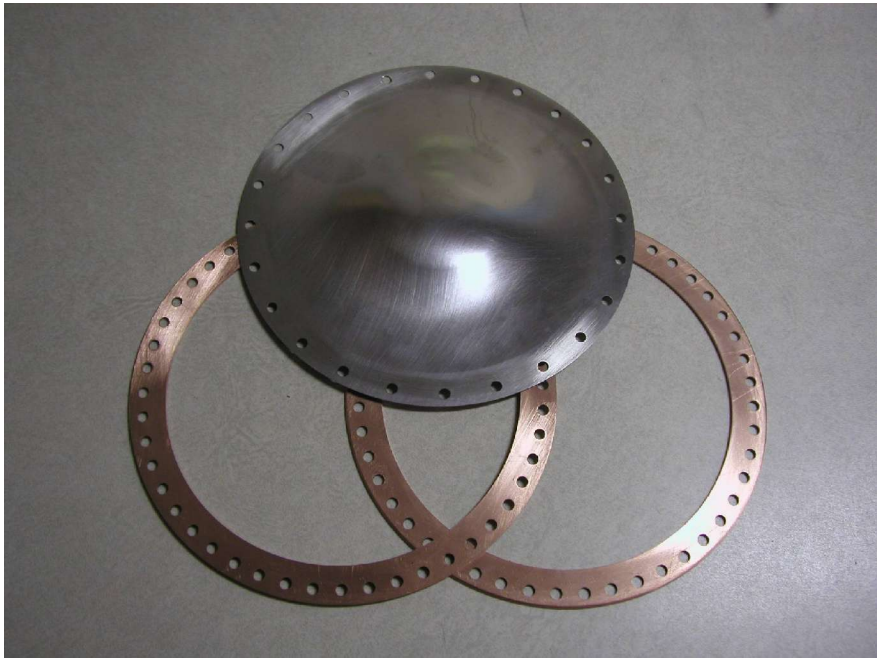
- The graphite die in Al fixture (room or high temperatures)
- 10 S.S sheets (10 mils) and 3 Be foils (10 mils) have been ordered for the pre-form tests
- Halogen lamp heating tests may be conducted at the 805 MHz low power test cavity to benchmark the FEA models

Curved S.S. windows

Tests in forming 0.254-mm S.S. windows for 805 MHz cavity



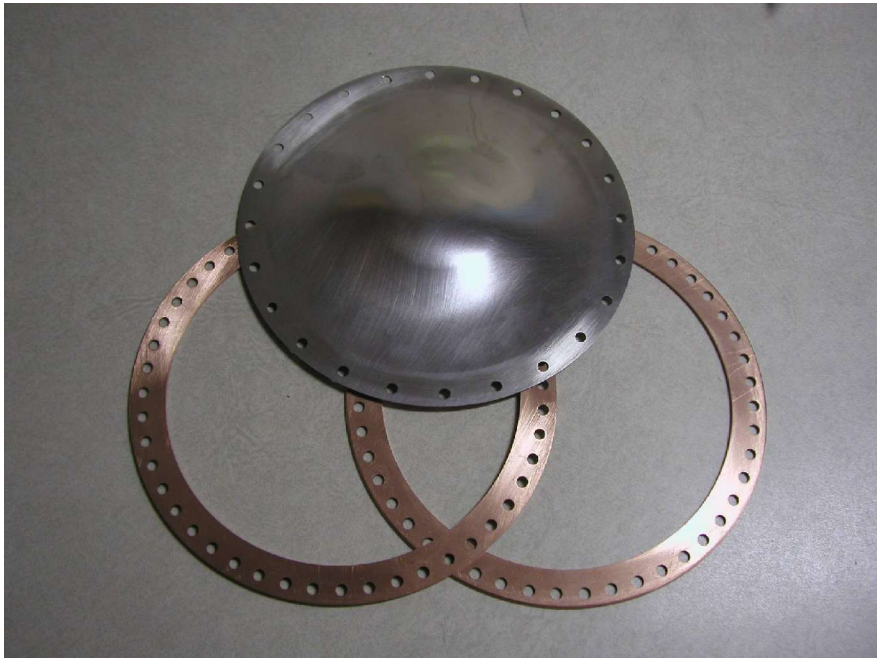
Pre-formed at room temperature and final profile at high temperature



Pre-formed at room temperature by holding foil edge, braze to Cu frame

Curved S.S. windows (cont'd)

Succeeded in the S.S. window with Cu frame for 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

Curved Be Window

Failed in forming Be window at room temperature

We believe the curved Be windows can be formed at high temperature (not at LBNL). It can be formed and brazed at Brush-Wellman Company. Purchase order has been placed and the windows will be ready soon.

Summary

The 201 MHz cavity design and fabrication go smoothly

- ✓ Spun shells ready for machining after e-beam welding
- ✓ Nose pieces, stiffener rings and fixture were made
- ✓ Support structures for the equator welding

Engineering design (details) is continuing

- ❑ Ports (succeeded in extruding test)
- ❑ Couplers (done with conceptual design)
- ❑ Tuners

Significant progress on curved window design and fabrication

- Succeeded in making S.S. curved windows
- Failed in forming a curved Be window at room temperature
- Curved Be windows for 805 MHz (by Brush-Wellman) will be ready in a week (purchase order has been placed)

The cavity will be ready this fall !