Status of the 201-MHz Prototype Cavity

Derun Li

Center for Beam Physics

MUCOOL Friday Phone Conference

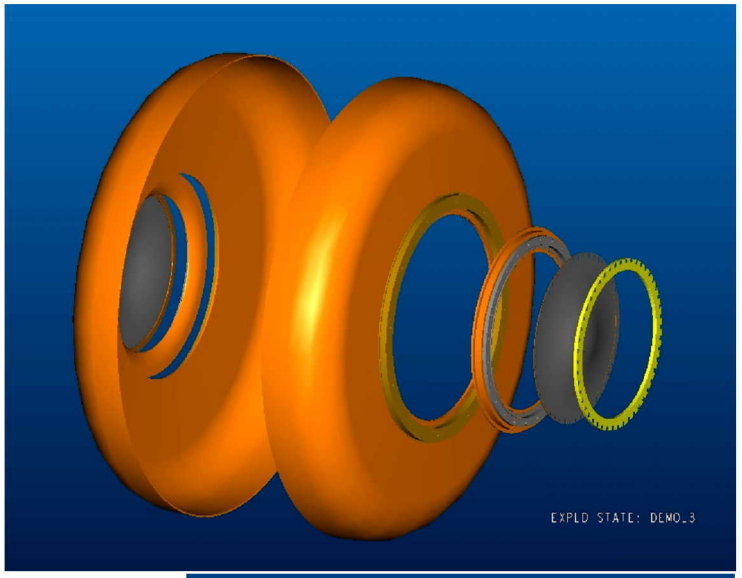
April 15, 2005

The Cavity + Background Info.

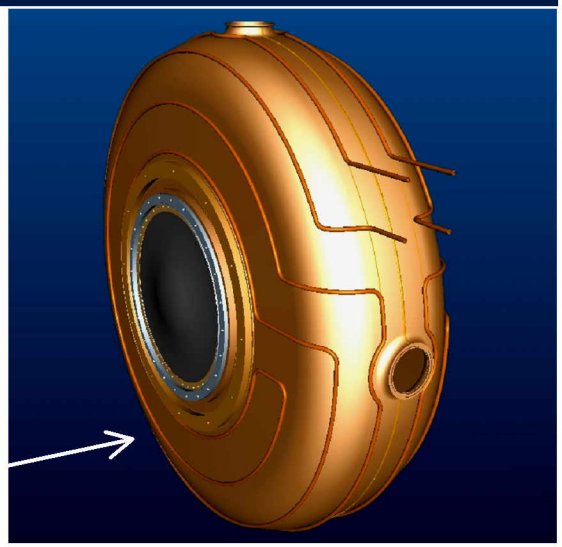
Goal: 201-MHz at ~ 16 MV/m in a few-Tesla magnetic field

Cavity and its sub-components

- Cavity body + water cooling lines
- Four ports and flanges
- RF loop couplers
- Cavity support structure
- Cavity tuners
- Ceramic RF windows (~ 4”)
- Curved Be windows
- Possible LN temperature operation



Cavity design concept



Layout of water cooling lines on cavity

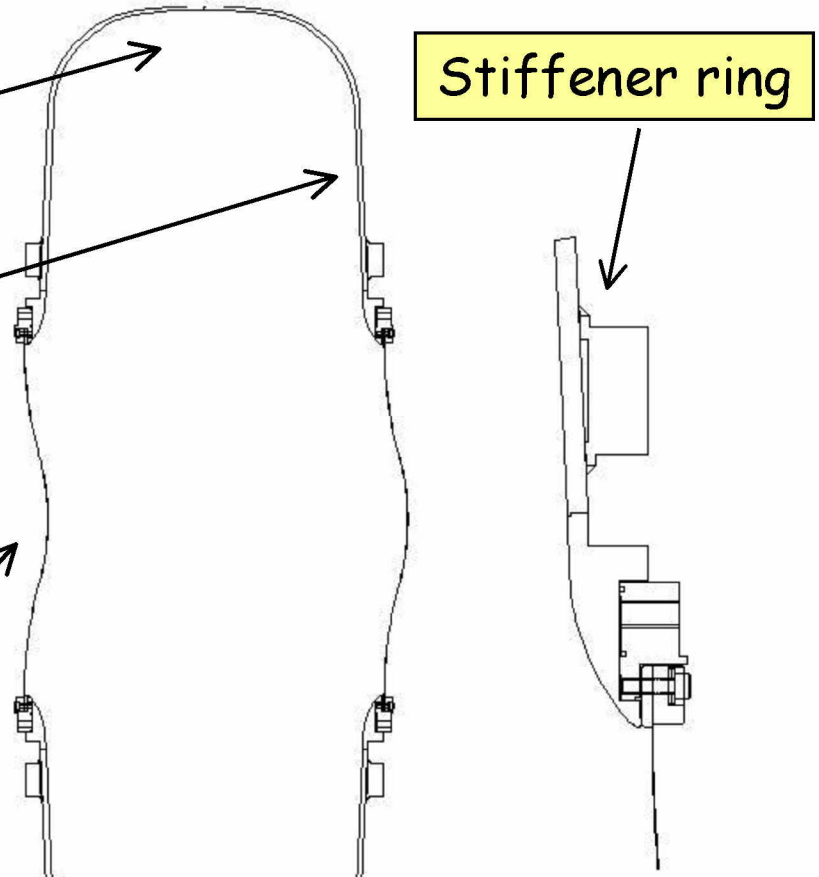
The Cavity Body Profile

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



- **Low peak surface field**
- **Easy fabrication**

The 201-MHz Cavity Parameters

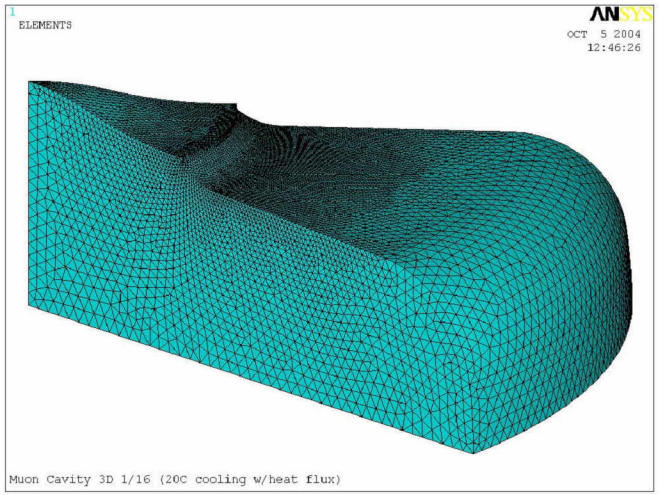
The cavity design parameters

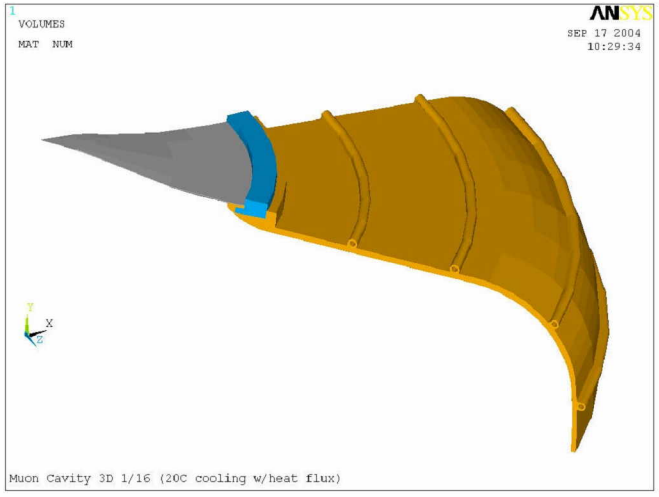
- Frequency: 201.25 MHz
- $\beta = 0.87$
- Shunt impedance (V_T^2/P): ~ 22 MΩ/m
- Quality factor (Q_0): ~ 53,000
- Curved Be window with radius and thickness: 21-cm and 0.38-mm

Nominal parameters for cooling channels in a neutrino factory

- Up to ~16 MV/m peak accelerating gradient
- Peak input RF power ~ 4.6 MW per cavity (assuming 85% of Q_0 and 3 times filling time)
- Average power dissipation per cavity ~ 8.4 kW
- Average power dissipation per Be window ~ 100 watts

Finite Element Analysis of the Cavity



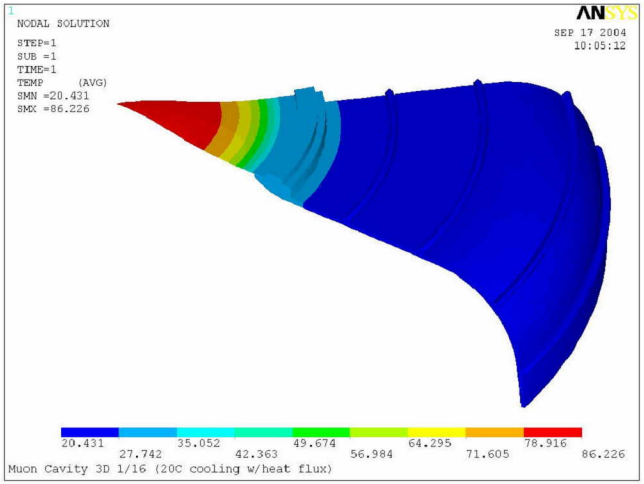


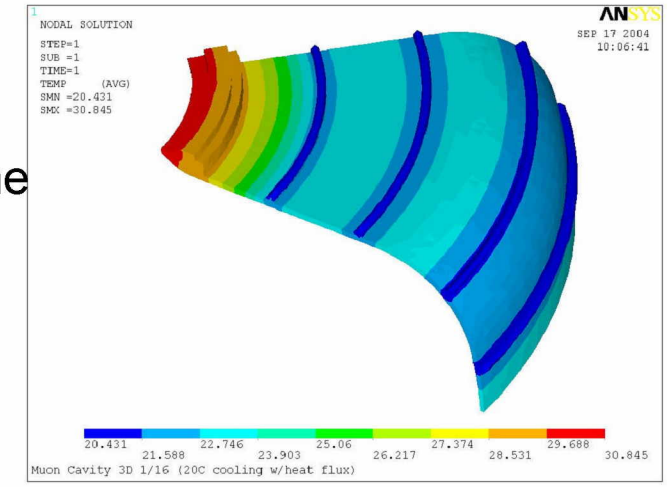
The thermal solution provides temperature distribution throughout the cavity and the beryllium window

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

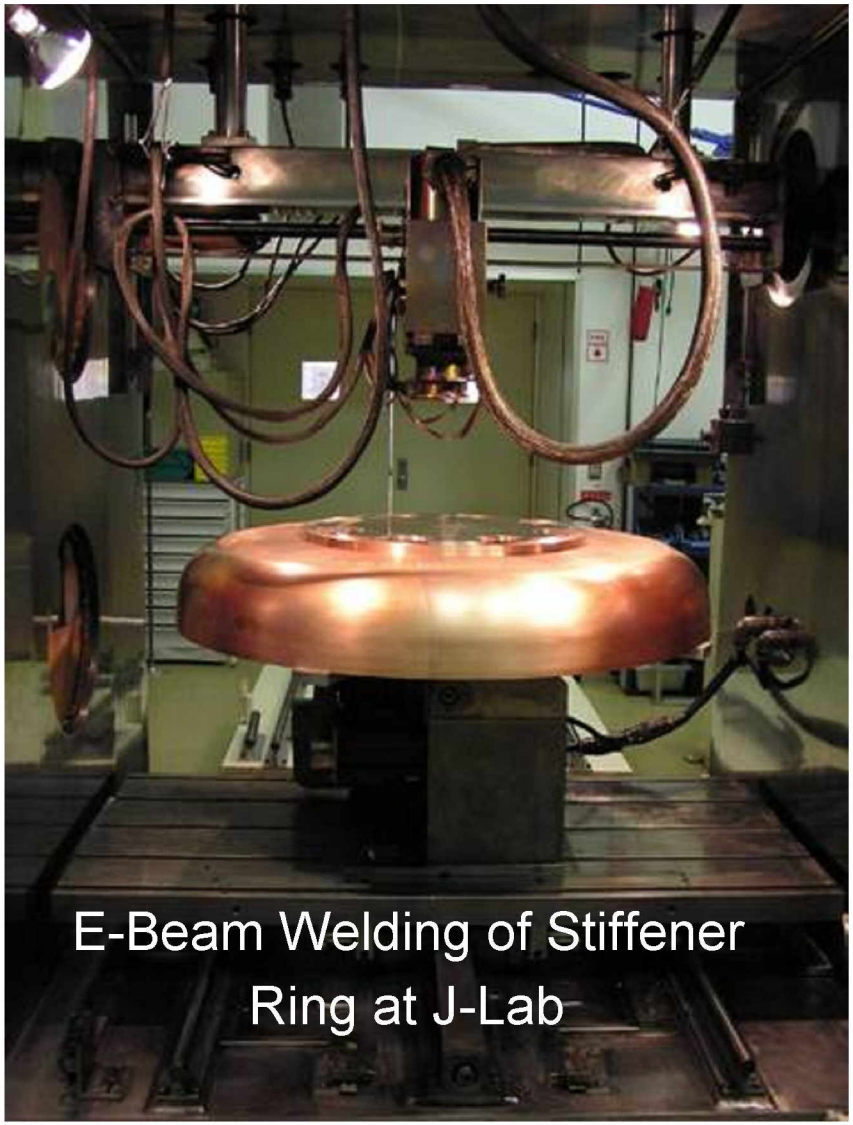
FEA helps to determine designs for:

→ Cooling tubes
→ Be window thickness





The Cavity Fabrication

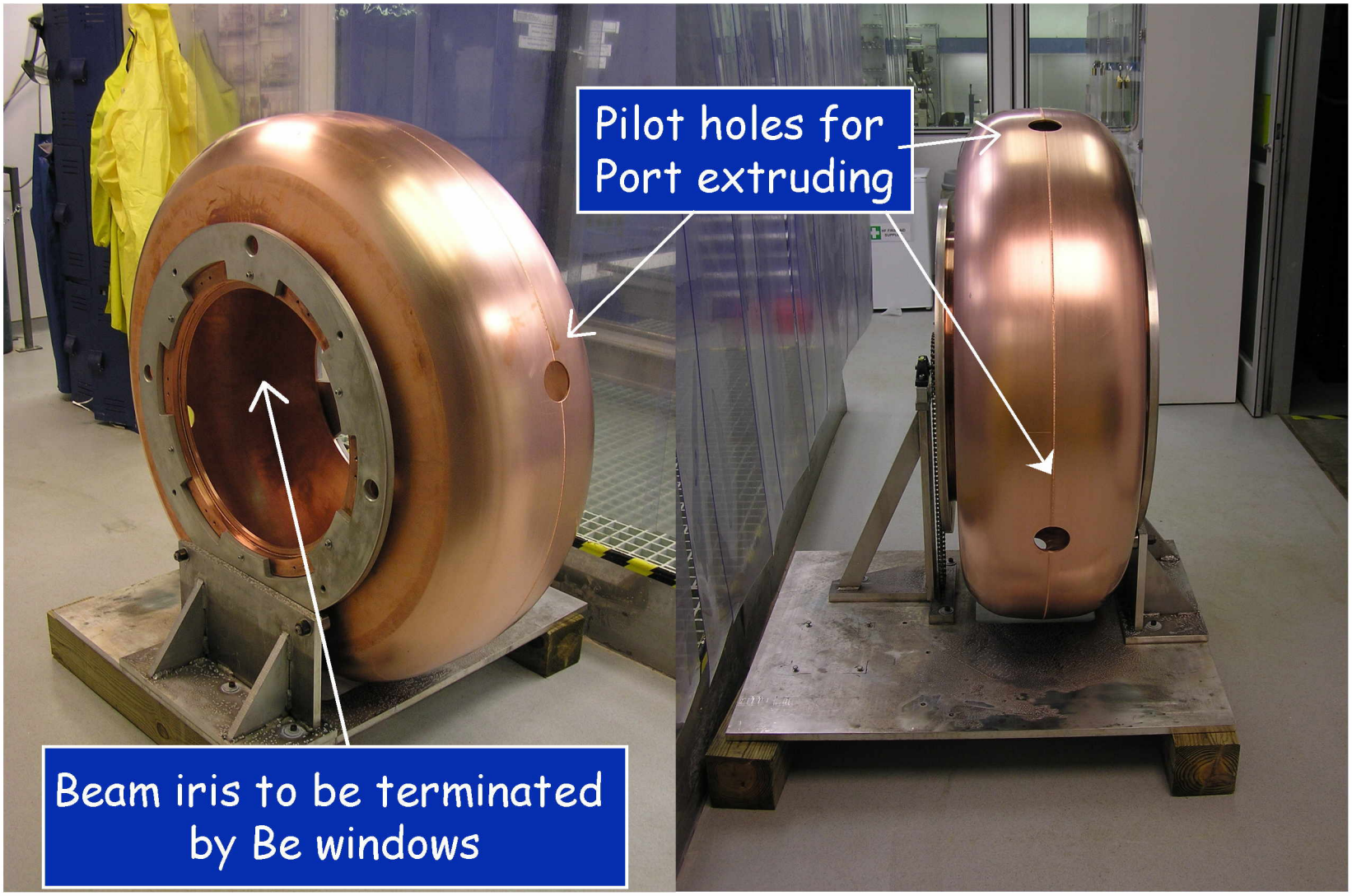


E-Beam Welding of Stiffener Ring at J-Lab

Finished equator welding

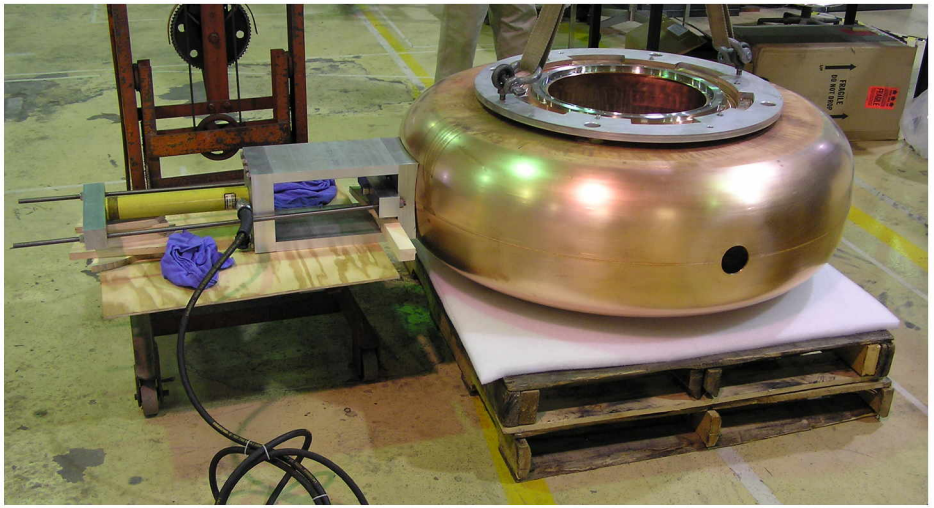
We have successfully developed extruding technique for port pulling over e-beam joints

Nose welding and Port extruding



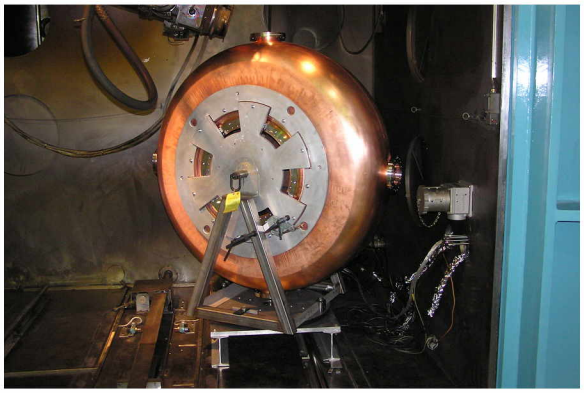
Port extruding and Flange Welding

Local annealing of ports

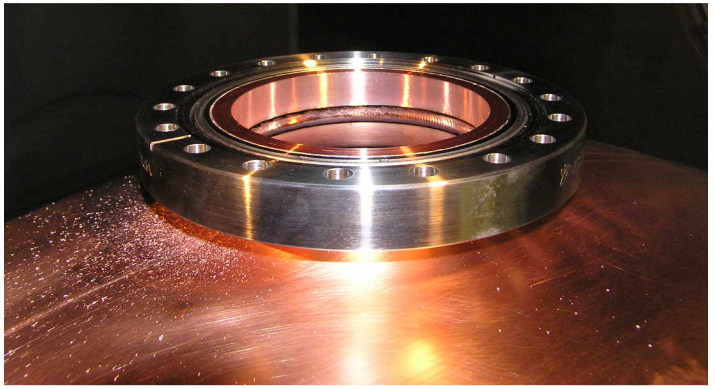


Cavity ports being extruded (pulled)

Extruded port

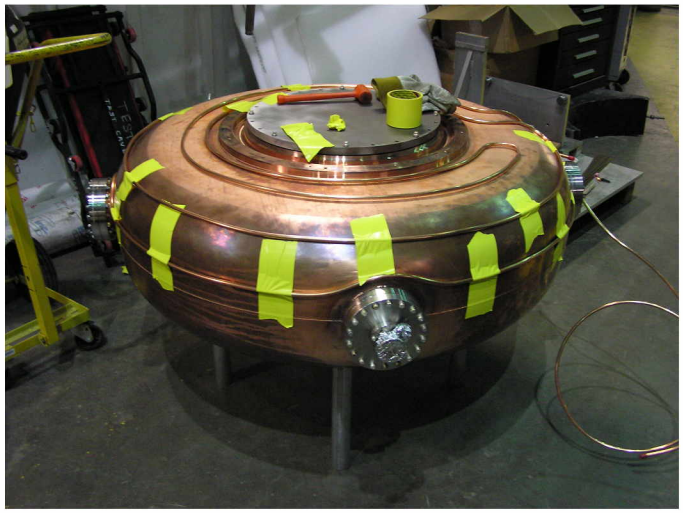


E-beam welding of the port flange



Finished cavity port

TIG Braze of Cooling Tubes

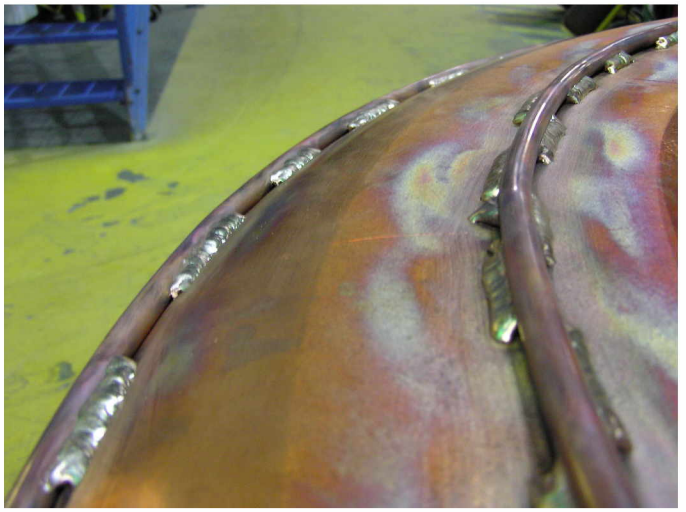


Requirement:

- Good thermal conduction
- No distortion on the cavity body
- Welding material
- Welding speed and temperature

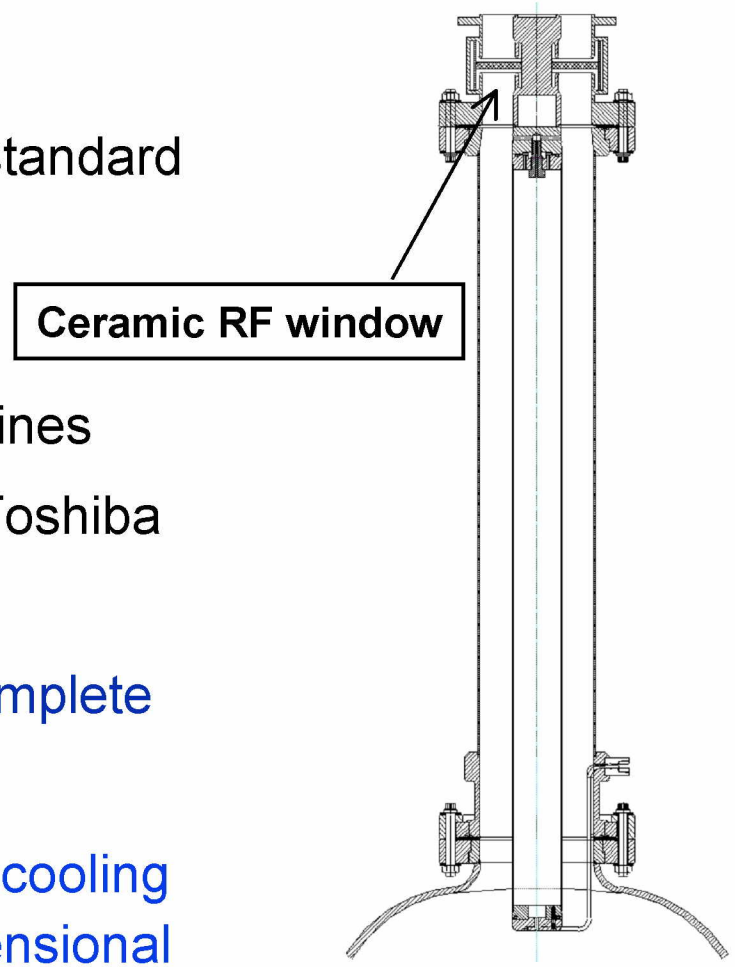
We have developed the technique and achieved the design goal

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



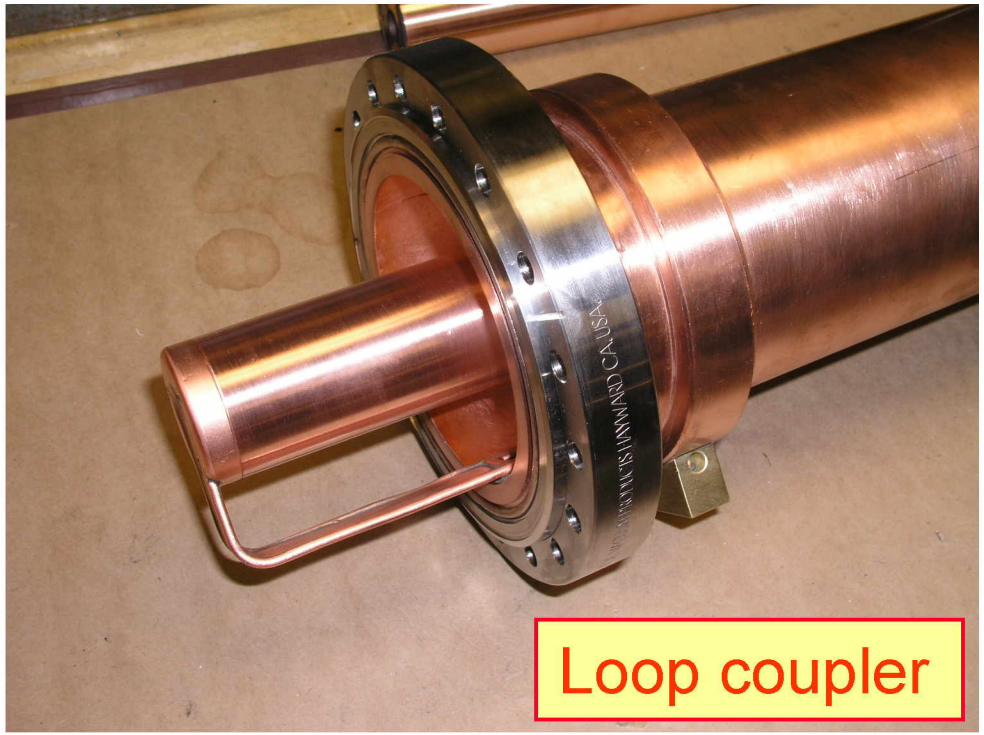
RF Coupler Design

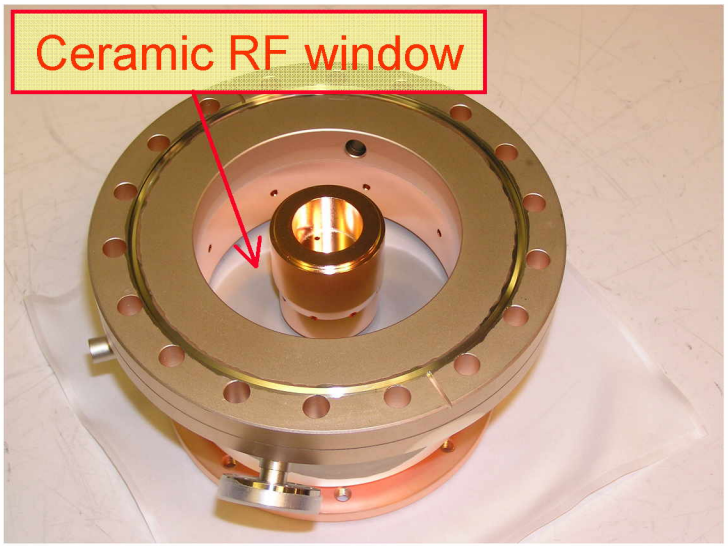
- Loop coupler at critical coupling
- Prototype coupling loop design uses standard off-the-shelf copper co-ax
- Parts were joined by torch brazing
- Coupling loop has integrated cooling lines
- ☺ Two SNS style RF windows mfg. by Toshiba received (no cost to us !)
- Two couplers with RF windows are complete and ready for high power
- Bellows connection required on MICE cooling channel (Study-II) for thermal and dimensional reasons

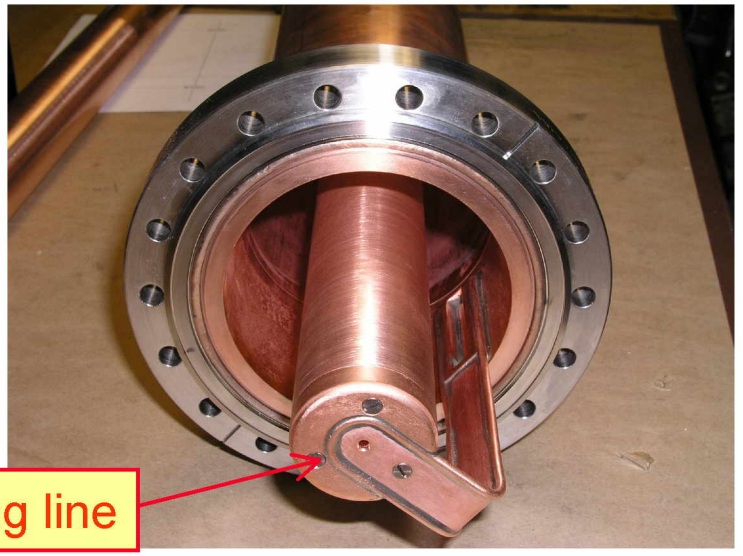


Loop Coupler Design

Fabrication of the Coupler







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

Curved Be Windows for 201 MHz Cavity

- Succeeded in two curved Be windows for the 805-MHz cavity
- Placed purchase order of three Be windows for 201-MHz cavity:

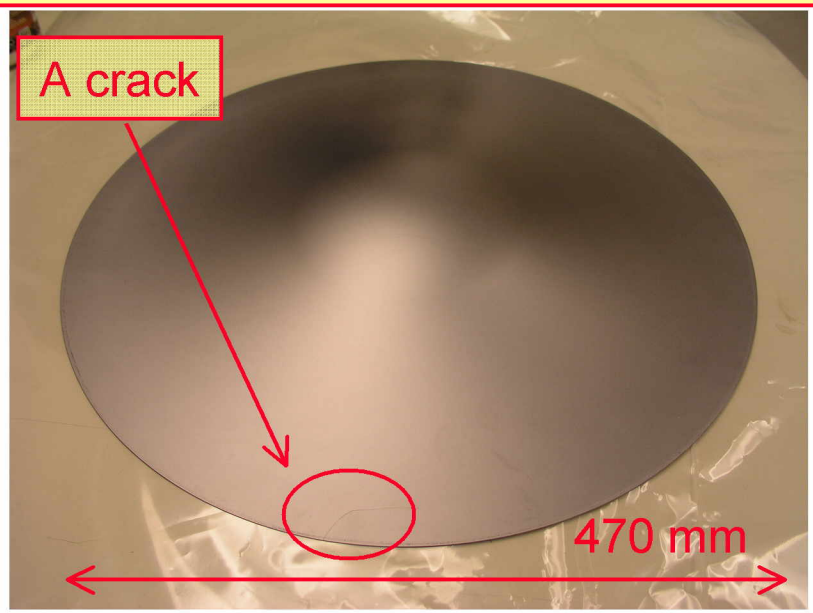
  0.38 mm thick, 420 mm diameter

  at Brush-Wellman (~100 watts per window with $\Delta T \sim 55$ degrees at nominal Study-II parameters)
- Window is formed by applying a die at elevated temperature
- Copper frame is brazed to Be window
- Be windows will be Ti-N coated

Brush-Wellman attempted twice so far:

- warping (1st one)
- cracking (2nd one) on edge, but still can be used
- Very confident for future ones

– Present a perfect conducting BC for RF.
– Min. scattering and mechanically strong



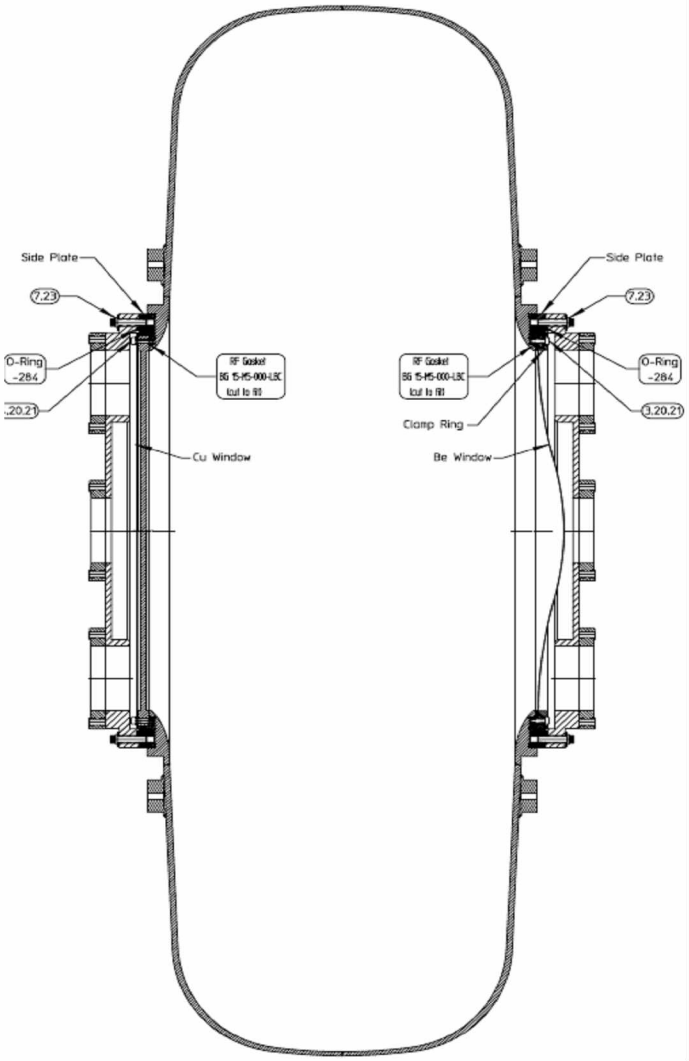
~ 470 mm diameter curved Be window for the 201 MHz cavity formed

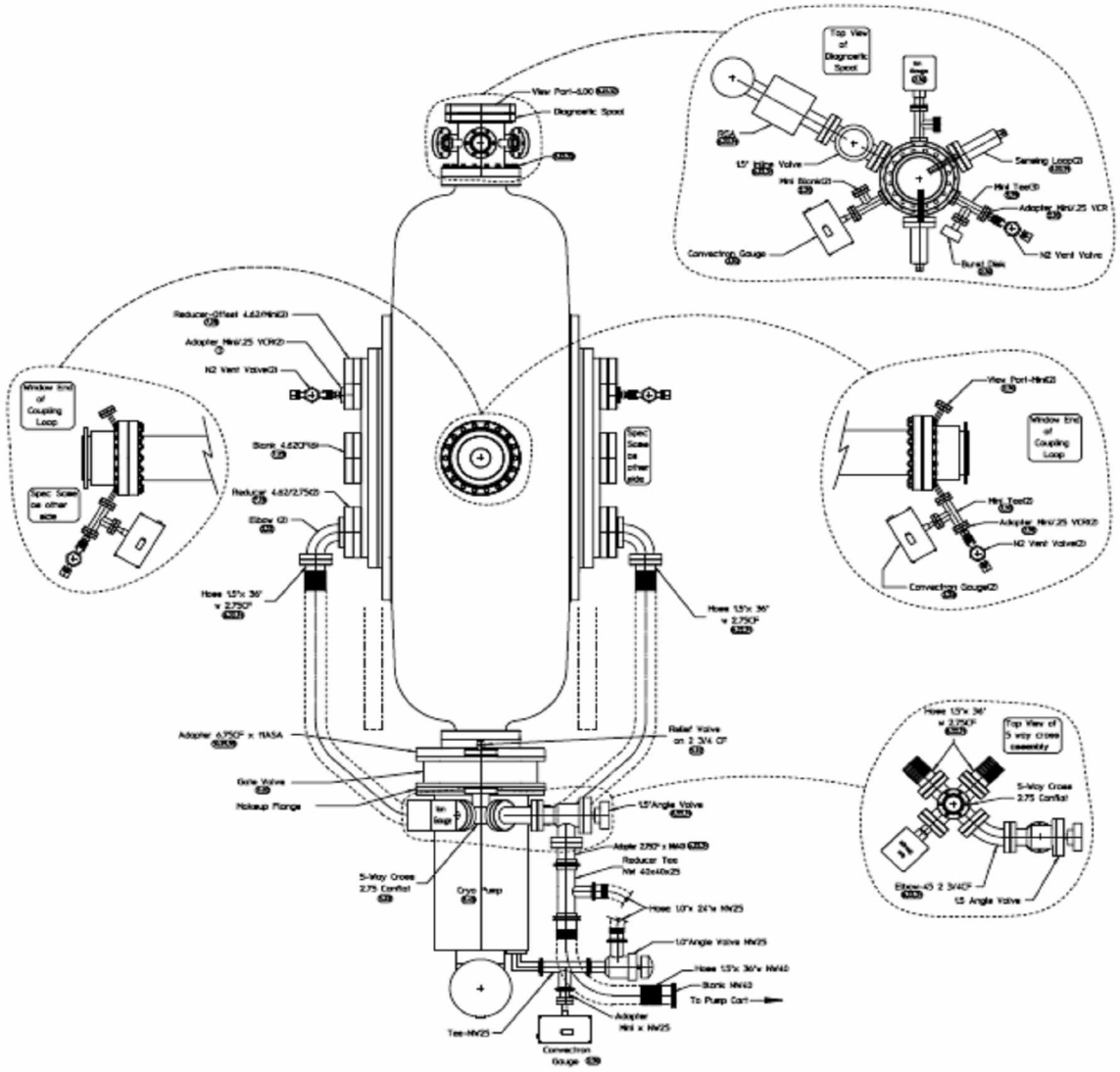
at Brush-Wellman.

This window has a crack on the edge, but still can be used (brazed under Cu frame).

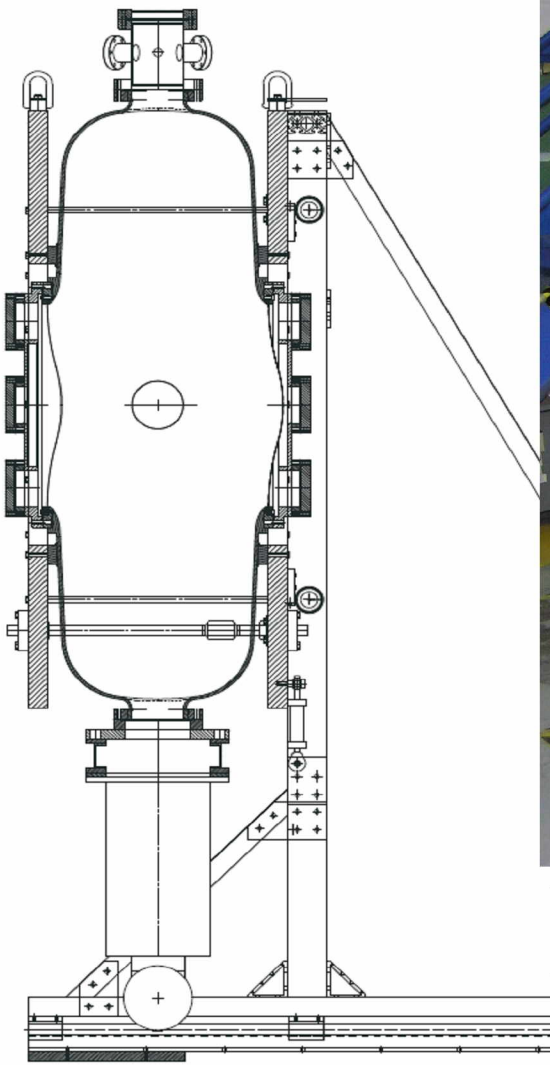
Curved Be Window with Cu Frame

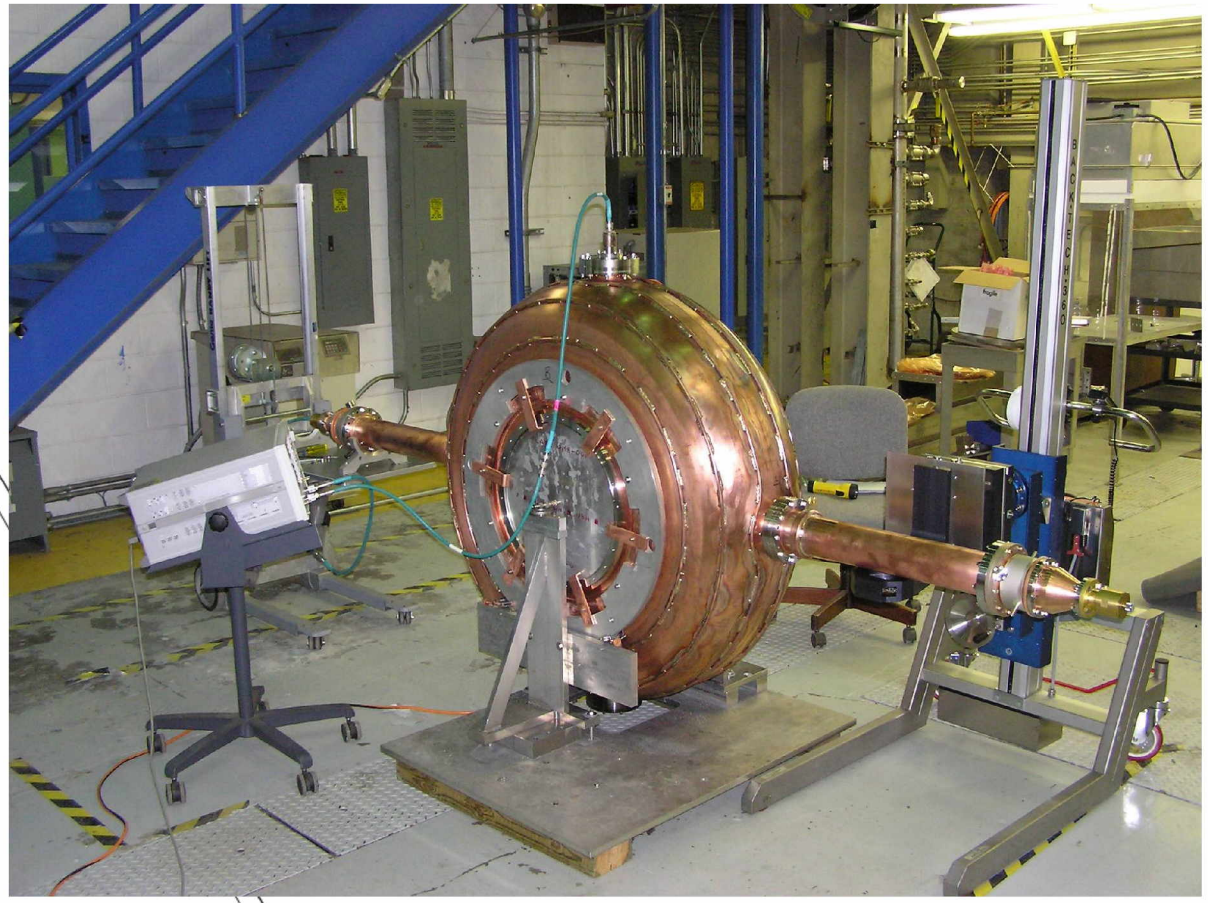
The cavity with all sub-components





The Cavity & Supporting Structure





Preliminary measurement: $f \sim 199.5$ MHz with β (max) ~ 5

Cavity Status and Plans

- RF couplers with ceramic RF windows are ready and will be high power conditioned at SNS in one to two weeks
- Curved Be windows are expected to arrive soon
- Assembly with RF couplers and low power measurements
- Cavity being cleaned now and will be EP in two weeks
- Support structure and tuners being assembled at J-Lab
- Expect to ship the cavity to MTA in early May-2005
- Detailed plans on high power test in progress