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201 MHz and 805 MHz Cavity Developments in MUCOOL

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Muon Collaboration

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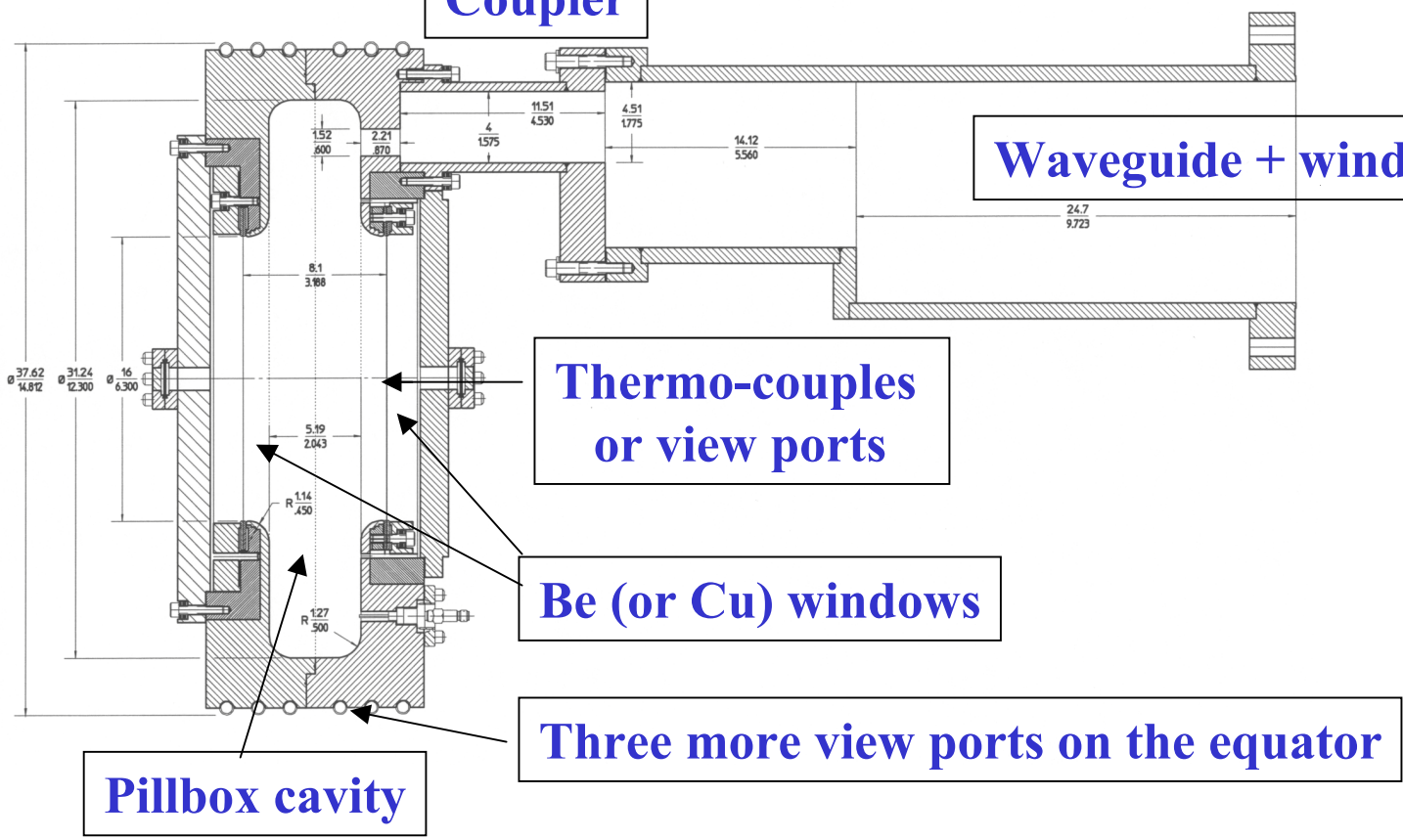
Introduction & Review

- Development of 805 MHz Pillbox cavity
  - High shunt impedance and high acceleration gradient at order of 30 MV/m $\rightarrow Z_0$ = 38 MΩ/m
  - Allow for testing of Be windows with different thickness, coatings and as well as other windows
  - Study RF cavity operation issues under the influence of strong magnetic fields in solenoid and gradient modes
- The cavity: design and status
  - The 805 MHz pillbox cavity design should allow for testing of different windows Ø demountable windows to cover the beam irises (five Be windows, four Cu windows: two of them with Ti coatings on one side)

Cavity Design & status

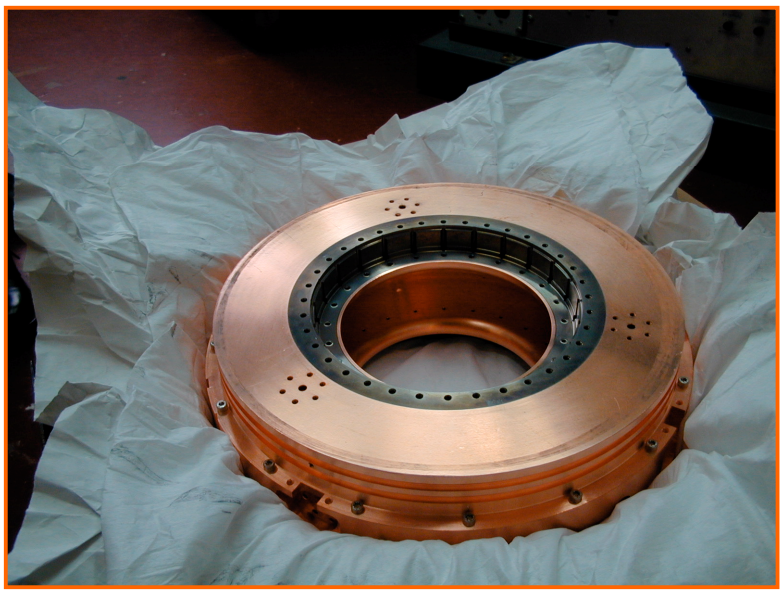


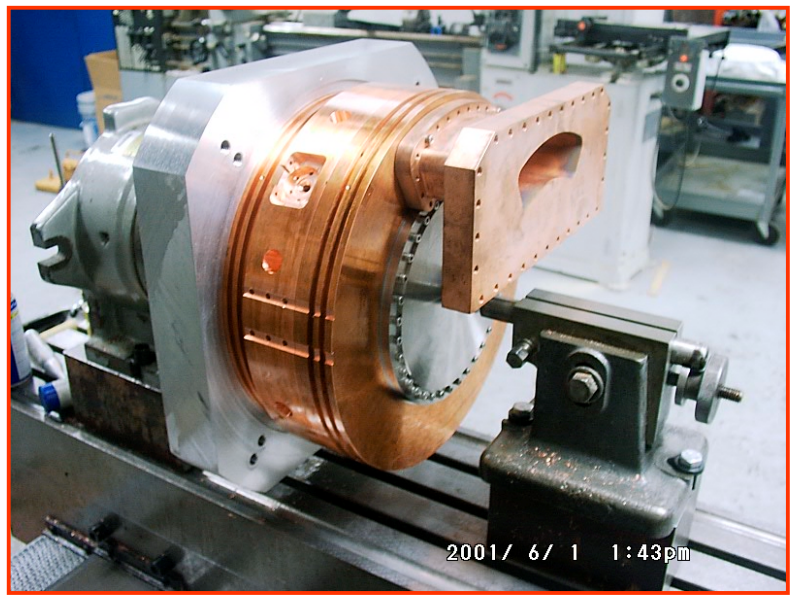
Cavity Design Parameters

- Frequency: 805 MHz
- Shunt Impedance:
  - 38 MW/m (Z_0); 32 MW/m (ZT^2); {$Z = V_{\{0,T\}}^2/P$}
- Quality factor: Q_0 = 18,800
- Coupling Constant:
  - b_c = 1.0 at critical coupling;
  - <E> = 30 MV/m requires ~ 2 MW peak power and 350 watts average power, 52 watts on windows (Cu, 66 watts for Be) at duty factor of 1.8×10^{-4} (12 [FNAL=19] us pulse length and 15 Hz repetition rate).

Manufacturing of the cavity

The cavity was fabricated at University of Mississippi, brazed at Alpha Braze Comp.





Cavity tuning (1)

- The cavity was ready for final tuning for the frequency and coupling in June, 2001.

  (June 24-27, 2001 in University of Mississippi)

  - Before tuning: f = 803.198 MHz, b_c = 0.12
  - After tuning: f = 805.486 MHz, Q_{ext} = 12,800
  - After final brazing:

    Measurements done in November 14, 2001 at LBNL before shipping to Lab G at Fermilab:

$f = 804.946$ MHz, $b_c = 1.3$, $Q_0 = 15,000$

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Cavity Tuning (2)

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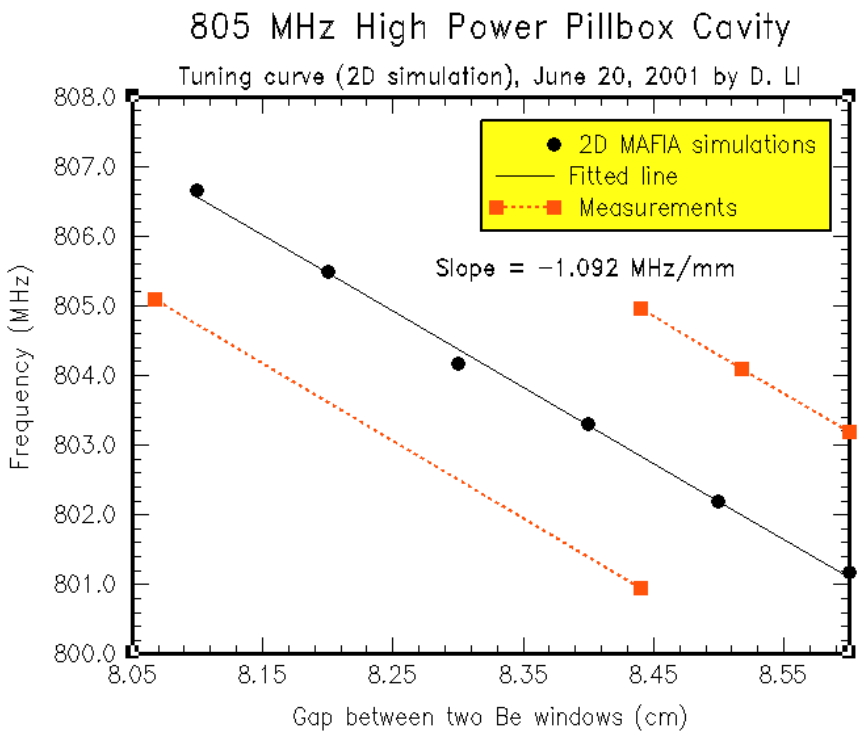
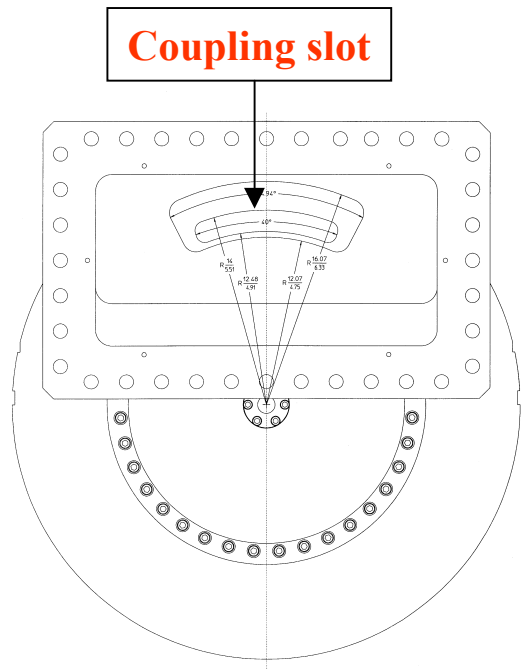
Cavity halves, coupler and Cu windows

Michael and Daniel assembling the cavity

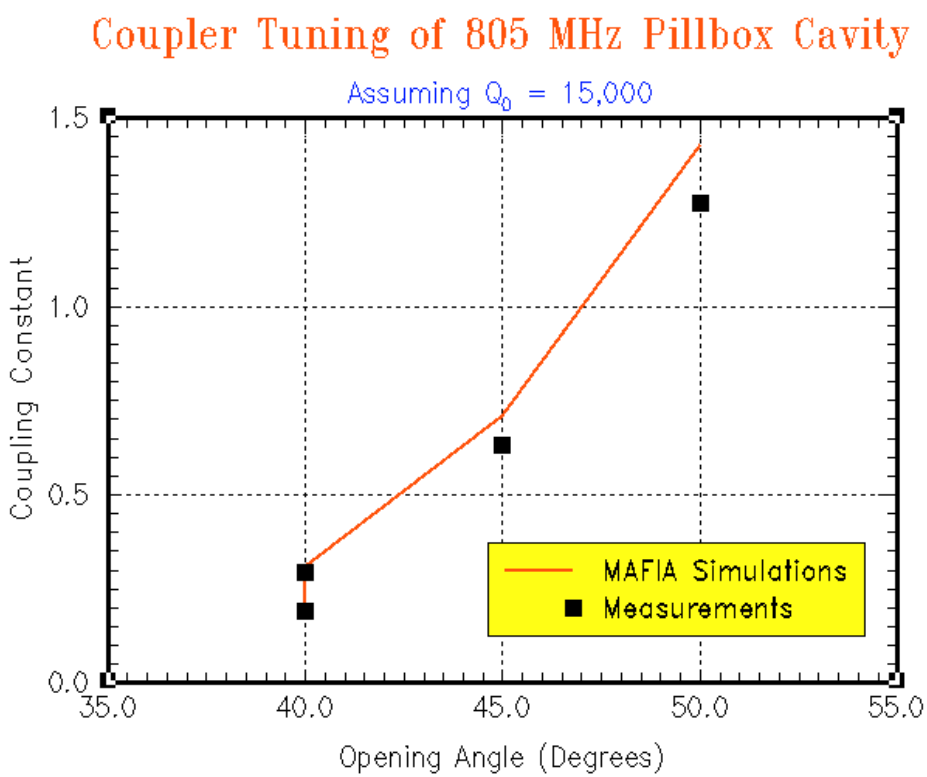
Cavity Tuning (3)

- Frequency tuning (shortening the gap)
- Coupler tuning (widening coupling slot and shortening the





Coupler Tuning



- The couple slot angle was widened from 40^0 to 50^0 (two cuts) in order to get close to critical coupling.
- Measurements of the coupling agree well with time domain MAFIA simulations

Milestones

- The cavity was fabricated at Univ. of Mississippi
- Final machine tuning was done in June 24-27, 2001 at University of Mississippi
- Leak tight and last measurement in November 14, 2001 (air) at LBNL before shipping:

  $f = 804.946$ MHz, $b_c = 1.3$, $Q_0 = 15{,}000$
- Low power measurement Lab G, Fermilab in March 12th 2002 (under vacuum):

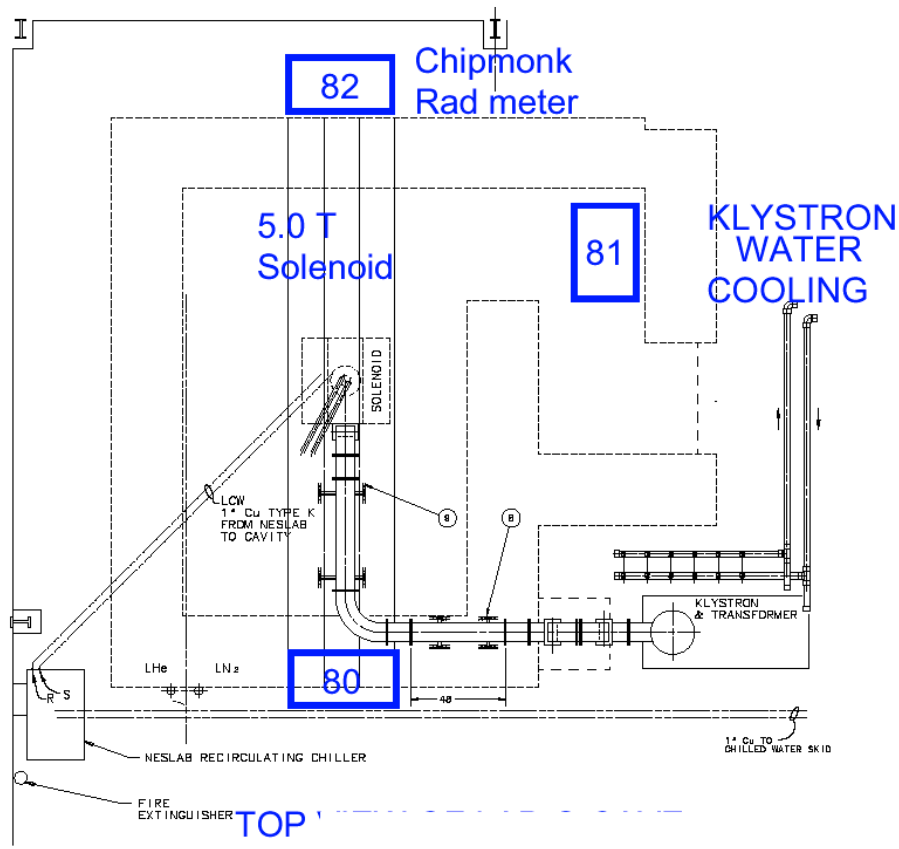
  $f = 805.135$ MHz, $b_c = 1.08$, $Q_0 = 15{,}080$
- Started RF conditioning in March 14th 2002

Diagnostics (1)

- Three view ports on the equator of the cavity
- Three RF probes (adjusted to about -52 dB gain from the standard waveguide port) available for E & M field measurement
- An optic bore-scope can be used to inspect the windows and inner surface of the cavity (need lighting and TV/VCR for viewing and recording)
- Maximum six thermo-couples can be attached to monitor temperature distribution on windows
- Two compartments behind the cavity can be used to measure window deflection by frequency shift

Diagnostics (2)

- Equipment available at Lab G:
  x-ray, dark current
  + spectrum, forward
  + reflected RF power
  and arc detector
- Lab G layout Ø



Test Results at Lab G

- 33 MV/m with little sparking: 1 out of 25,000 pulses in April 22, 2002
- went through multipacting zones
- reached about 29 MV/m in twenty days (2.2 MW peak power inside the cavity)
- sparking at gradient of 30 MV/m and up (need to find the reasons, Cu windows to be inspected)
- RF power was measured by forward power probe and RF probe inside the cavity→ agree within 10 %
- Future test plan has been developed

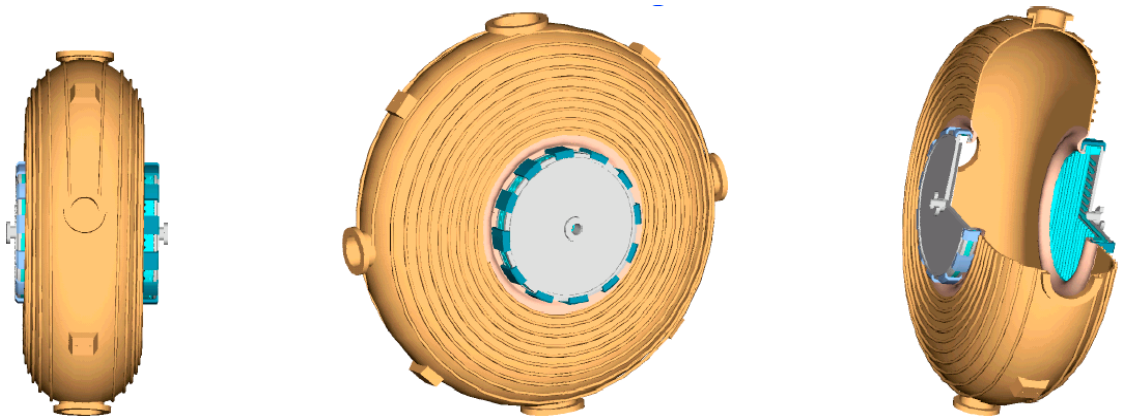
Test Plan (1)

- A new thin Cu window is being made at LBNL
- An alternative end plate by U. of Mississippi
  - better x-ray measurements
  - better dark current measurements
- Through inspection of current Cu windows
- Careful and complete log and documentation
- Installation of the new Cu window and the end-plate
- RF conditioning up to 20 - 24 MV/m

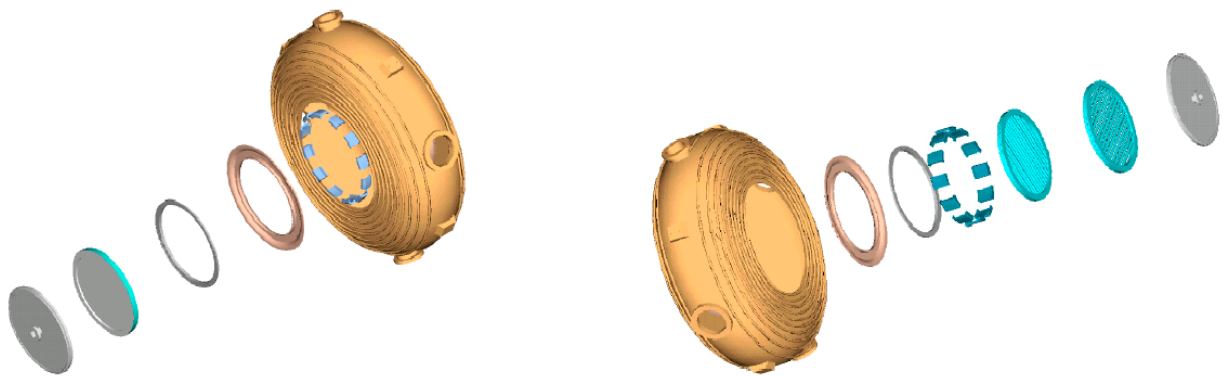
Test Plan (2)

- RF conditioning with magnet fields
- Replace two Cu windows with Be windows with TiN coatings
- RF conditioning with/without magnetic fields

201 MHz cavity design

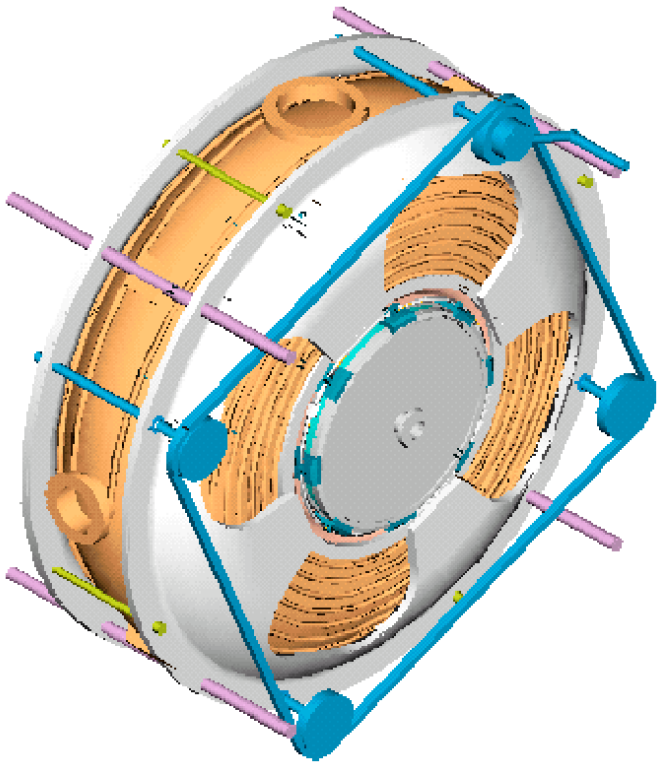


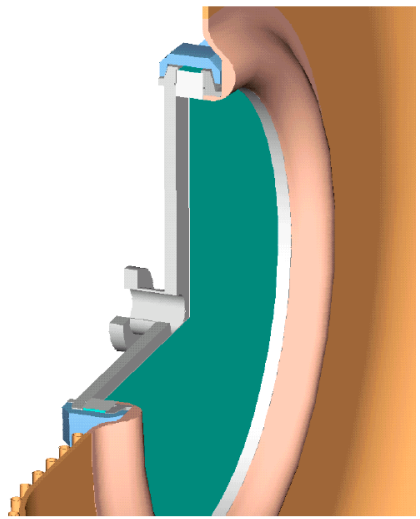
201.25 MHz cavity conceptual design

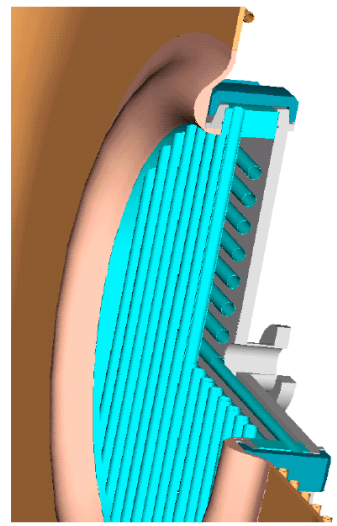


Exploded views showing foil and grid mounting hardware

201 MHz Cavity: windows



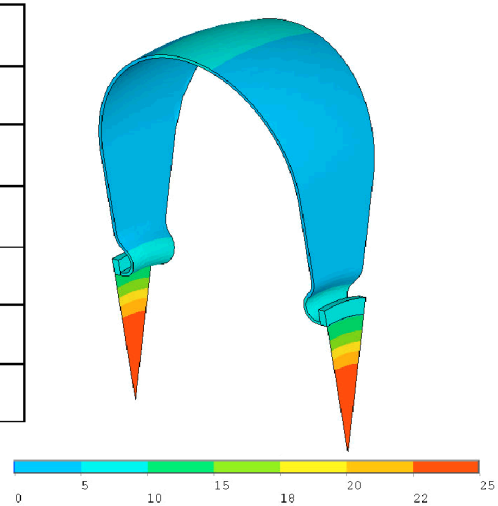




Preliminary cavity design with water cooling channels and tuning mechanism. The cavity design accommodates either Be windows or a grid design.

201 MHz Cavity Parameters

V_{eff} (on crest)	5.76 MV
Length	0.430 m (T=0.827)
$E_o$equivalent	16.2 MV/m
E_{pk} on surface	26.5 MV/m
Peak power per cavity*	4.18 MW
Forward power (3τ filling)	4.63 MW
Average power (0.2% duty factor)	8.36 kW



* assumes 85% of the theoretical Q_0

Cavity radius	61.0 cm
Cavity length	43.0 cm
RT^2 [MΩ/m]	18.5
Q_0	54,000

Thermal analysis by ANSYS code assuming 10 kW total rf heating power with water cooling for 21 cm radius and ~ 1.15 mm thickness Be window.

Summary

- 34 MV/m has been achieved for the 805 MHz pillbox cavity
- The high power tests will continue at Lab G of Fermilab as planned
- Surface damage and rf breakdown issues will be studied carefully
- Grid design is currently under investigation
- 201 MHz cavity for MUCOOL is nearly completed and ready for prototype