A Beryllium Wall Cavity Design

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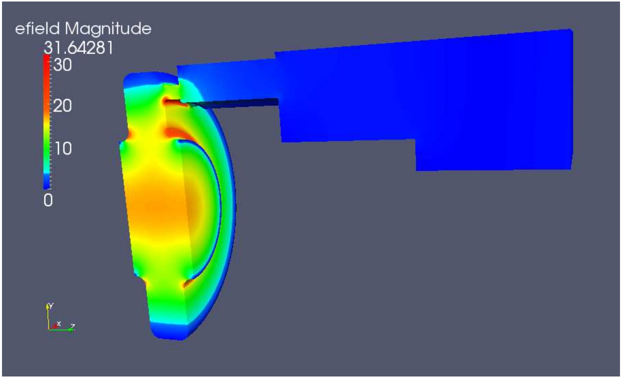
A timeline of Be wall cavity development:

- The 805 MHz pillbox cavity is problematic.
- A replacement pillbox cavity was designed by SLAC.
- Concurrently, a cavity with Be walls was proposed.
- This cavity has been designed twice.
    1. Near complete design for longitudinally-coupled cavity.
    2. During the design of the longitudinally-coupled cavity, Al Moretti suggested a radially-coupled cavity. So we did that one too. RF design exists, with engineering design soon to follow.

Currently: The pillbox cavity is problematic.



Problems with this cavity: breakdown at low (∼16 MV/m) gradients; extensive damage; **difficulty holding vacuum**.

"Damage" means lots of small craters, plus contamination.

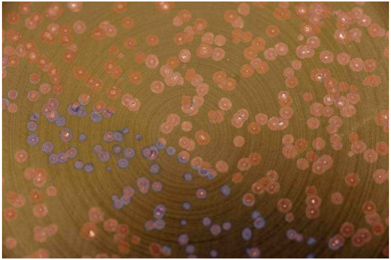


Figure: Damage on a Cu window coated with TiN. Note the blue streak, possibly from chemical contamination.

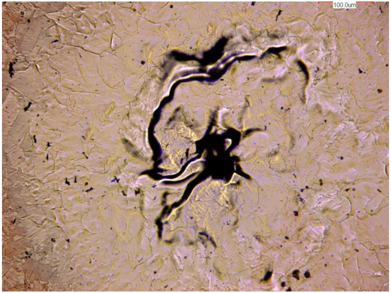


Figure: Laser confocal microscopy image of a single "crater".

Solution: Two cavities planned.

1. Replacement 805 MHz pillbox cavity
   - Some hope for "clean" measurements.
   - Improved statistics from N=2.
2. **Beryllium wall cavity**
   - Radiation length in Be $\rightarrow$ less damage expected from R. Palmer's breakdown model.
   - Modular design allows $N >> 1$.
   - Many experiments possible: material evaluation, window/button tests, accumulation of statistics for Cu cavities. (More on this later.)

An embarrassment of riches: There are currently two Be wall cavity designs.

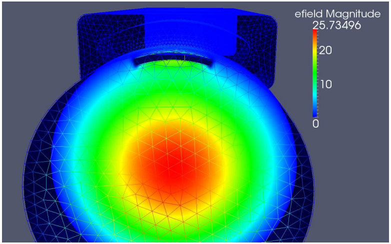


Figure: Longitudinally-coupled design. Similar to existing design, uses all existing hardware.

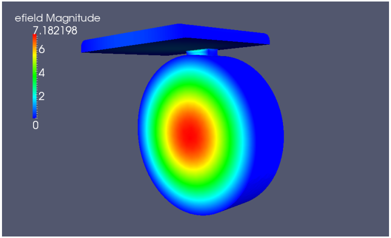
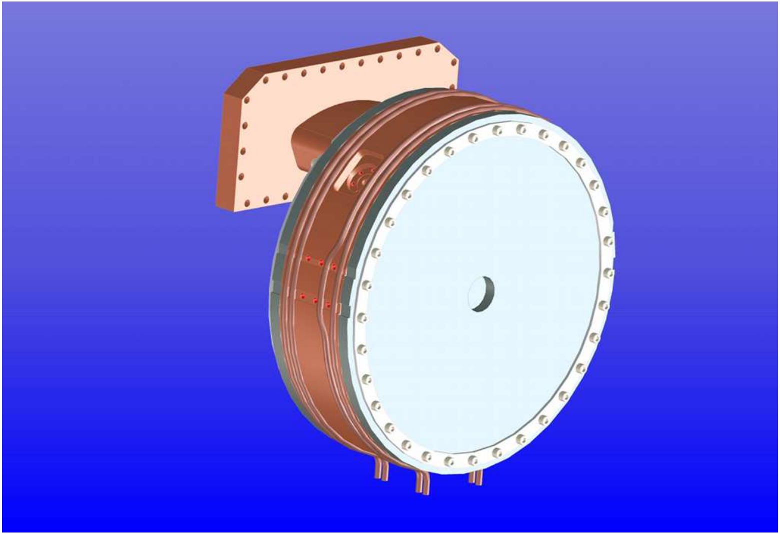
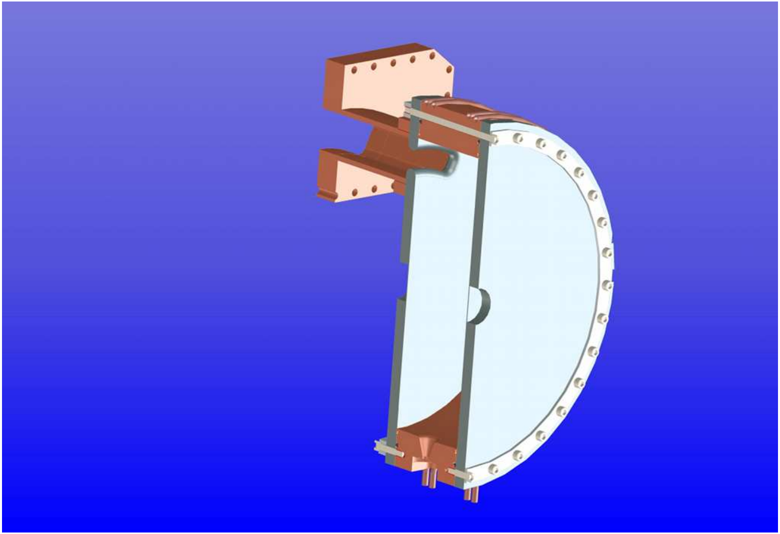


Figure: Radially-coupled design may be more resistant to breakdown, is certainly more relevant to an actual cooling channel.

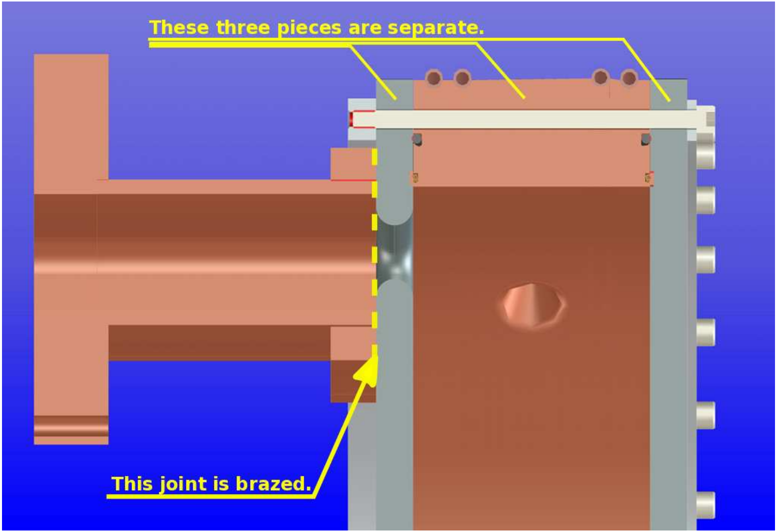
We have preliminary engineering drawings for the cavity we *aren't* building.



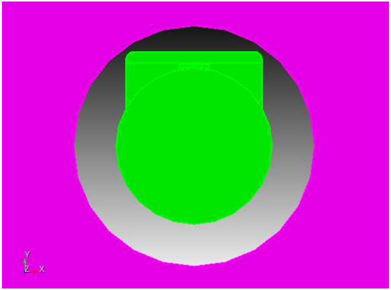
We have preliminary engineering drawings for the cavity we probably *aren't* building.

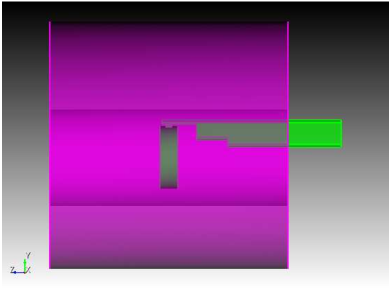


We have preliminary engineering drawings for the cavity we *aren't* building.

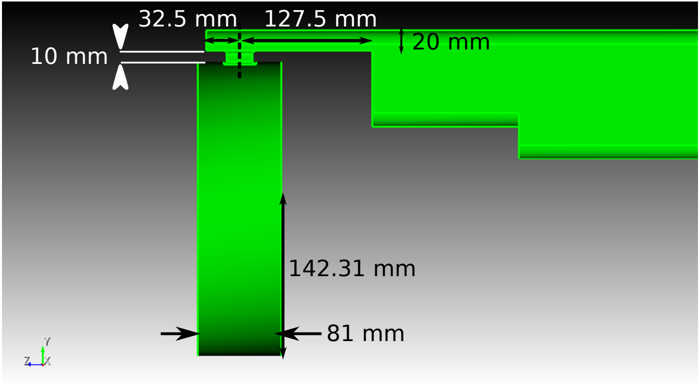


The radially-coupled design *does* fit in the magnet.





Some dimensions



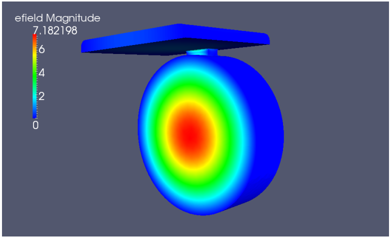
The coupler port is 53×25 mm with 3 mm blended edges.

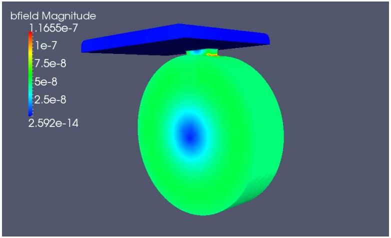
Design comparison

	z-coupled	ρ-coupled
Frequency (MHz)	805.0	805.0
Inner radius (mm)	142.06	142.31
Q_0	16600	17191
coupling β	1.13	1.30
field ratio $E_{\mathrm{axis}}/E_{\mathrm{coupler}}$	1.5	4.4

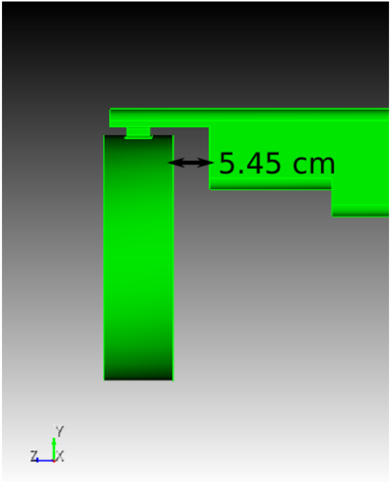
This table compares the two designs with Be walls.
Convergence study $\rightarrow$ frequency errors are < 1 kHz.
Replacing Be with Cu end-plates: $Q_0 \rightarrow 21938$ so $\beta \rightarrow 1.7$.
(This can be tweaked.)

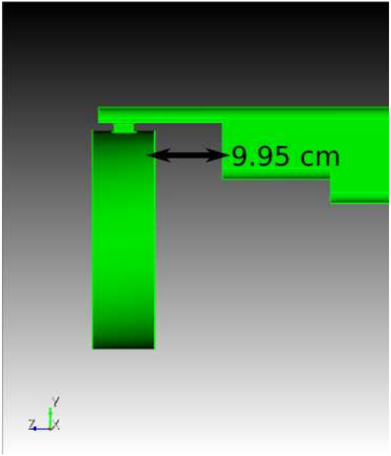
Omega3P eigenmode simulations





Several equivalent coupler lengths give us some breathing room in the lab.





Both these geometries give a field ratio of ~ 4.4.

Many experiments possible with the radially-coupled Be wall cavity.

1. Evaluate R. Palmer's breakdown theory.
2. Modular design allows us to cheaply, "quickly" accumulate breakdown statistics.
3. With slightly modified end-plates, further button, window tests possible.
4. Material studies, SEY film coating evaluations.
5. Tilt cavity, study effect of non-orthogonal fields (c.f. J. Norem).
6. Breakdown mechanism studies using thin Be windows, faraday cup, anti-buttons.
7. And many more!

We have a clear path to a complete engineering design.

1. Multipacting analysis (`ACE3P`→`Track3P`)
2. Stress analysis (`ANSYS`)
3. Benchmark design with other codes (`ANSYS`,`CST`)
4. Structural design issues (seals, braze joints, etc.)
5. Instrumentation design
6. Design review
7. Procurement, fabrication