Modular Cavity Status

Daniel Bowring

Lawrence Berkeley National Laboratory

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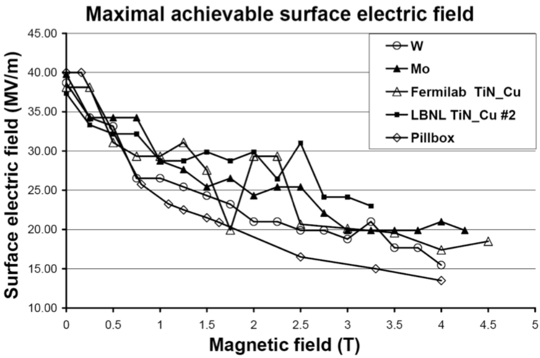
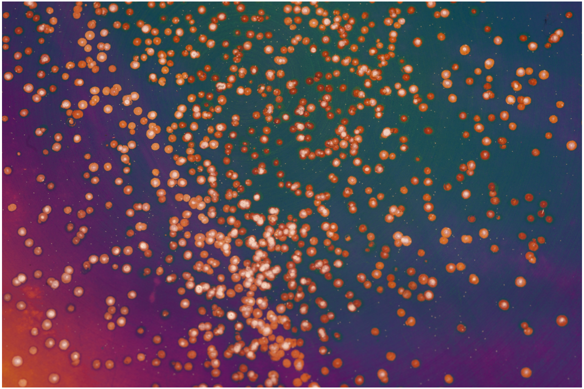
Maximum gradient decreases as applied *B*-field increases.



D. Huang *et al.*, *RF Studies at Fermilab MuCool Test Area.* Proc. PAC 2009, TU5PFP032, p. 888. Vancouver, Canada, 2009.

Reduction in gradient manifests as increased RF breakdown, cavity damage.



Damage from RF breakdown on the walls of an 805 MHz pillbox cavity. Surface is TiN-coated Cu. Damage spots are mm-scale.

RF breakdown in magnetic fields: Open Questions

- Does pulsed heating / cyclic fatigue play a role?
- Can we mitigate this problem via clever material choices?
- What role does the coupler play?
- Does measurement order (0 T vs. 3 T) play a role?

The modular cavity addresses these questions. This talk presents the design and fabrication status of the modular cavity.

Q: Who is building this cavity?

A: Lots of people.

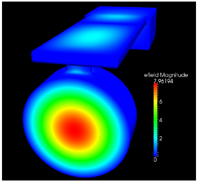
1. LBNL is responsible for the overall R&D effort.
2. FNAL (the MuCool folks) have contributed much to the design effort / integration with MTA systems.
3. SLAC is responsible for mechanical design, fabrication. They have also brought their `ACE3P` expertise to the design process.

$\sim$ 20 people at 4 institutions have contributed.

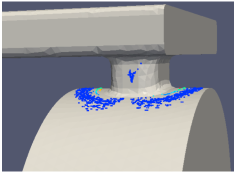
Design Goals

- Evaluate theories of RF breakdown in strong magnetic fields. (c.f. D. Stratakis *et al.*, *Effects of external magnetic fields on the operation of high-gradient accelerating structures.* Nucl. Inst. Meth. A, **620** (23) 2010.)
- Performance limited by *cavity*, not *coupler*. (Coupler design)
- Replace damage quickly, cheaply when damage occurs. (Modularity)
- Evaluate multiple materials, surface treatments. (Modularity)
- Use facilities at MTA. (Fit the whole package in the Lab G solenoid.)

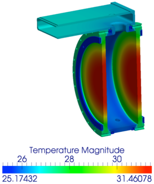
Simulation Effort



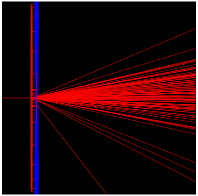
`Omega3P`



`Track3P`



`TEM3P`

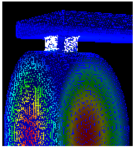


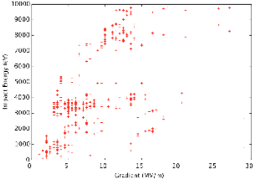
`G4beamline`

`ACE3P` and `G4beamline` indispensable during design phase.

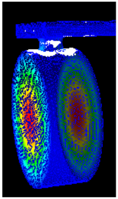
Multipacting simulation effort

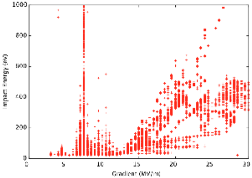
B=3T



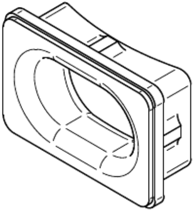


B=0T





Track3P multipacting simulations at 0, 3 T verify no resonant trajectories at problematic energies.



- Extensive design effort.
- Tight fab. tolerances to achieve Q, coupling specs.

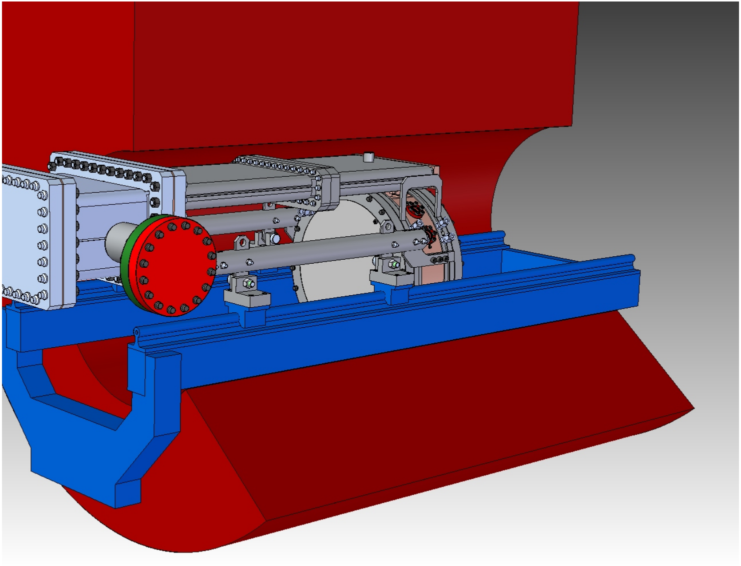
RF parameters

Mat.	Freq. (MHz)	Q_0	Q_{ext}	β	Neck width (mm)	Field Ratio*
Cu	805.012	25605	15854	1.62	65.25	5.36
Be	805.012	20499	15854	1.30	65.25	5.36

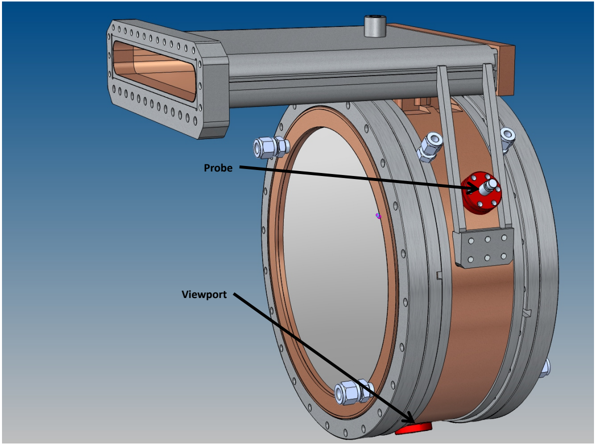
*Denotes the ratio of two fields: (1) the maximum surface electric field on the "beam axis"; (2) the maximum surface electric field elsewhere, i.e. on the coupling iris.

Cavity design is over-coupled in anticipation of clamping losses.

Mechanical Design: Overview

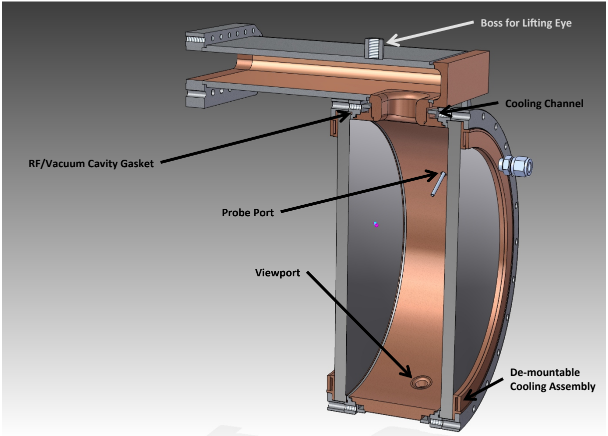


Mechanical Design (slide from David Martin)



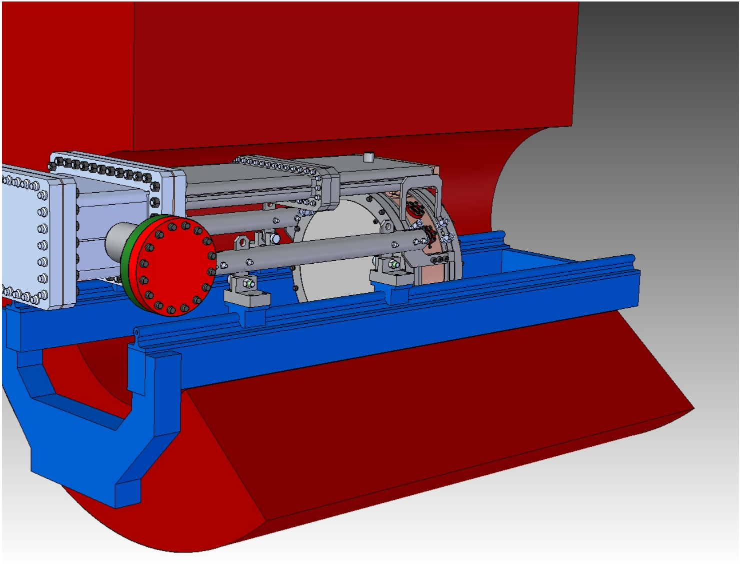
Cavity and Waveguide

Mechanical Design (slide from David Martin)



Cavity and Waveguide

Mechanical Design: Overview



Preliminary experimental program overview

1. Control runs on "regular" TiN-coated Cu end plates.
   - Does run order (0 vs. 3 T) matter?
   - Cu surface roughness comparable to that of Be end plates.
   - Quantify breakdown, damage behavior in this new cavity.
2. Assessment, workshop.
3. Study effects of chemical polishing on Cu performance.
4. Study effects of baking on Cu performance.
5. Run Be end plates.
6. Assessment.

A complete version of this document is available at `http://mice.iit.edu/mta/rf/modular/experimental_plan/experimental_plan.pdf`

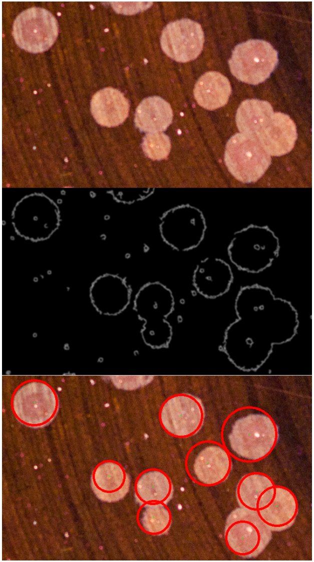
login = `modular`
passwd = `M0du1aR`
Comments, questions welcome.

What does a run look like?

- Commission at 0 T.
- Open, inspect cavity.
- Run at 0 T.
- Open, inspect cavity.
- Repeat process at 3 T.

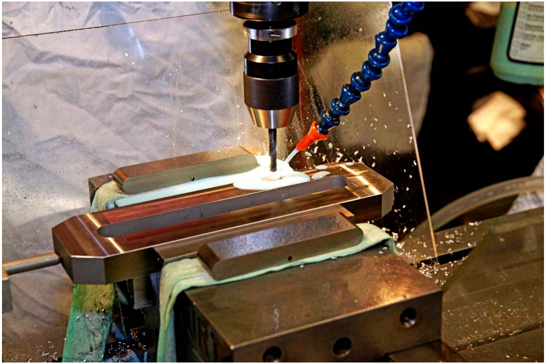
0 T, 3 T runs may be reversed, depending on the outcome of the control runs.

Automated damage inspection software will improve, speed up analysis.



- Input: digital photos at regular intervals during the experiment.
- Output: Locations, sizes, creation times of all breakdown damage spots.
- Developed using free, open source software → This will be straightforward for you to install and run on your machine.
- Relevant beyond the modular cavity.
- Development supported by Muons, Inc.

Fabrication is underway.



- We began cutting metal in February!
- Most work done in-house at SLAC.
- Regular, bi-monthly status meetings.

Fabrication Status as of February 28.

By Month Due	DESCRIPT	DATE_MS	Sum of QTY_ORDER	Sum of QTY_REC
2013				
Feb				
SK-SB-70126287-0	RECTANGULAR FLANGE BLANK	2/25/13	2	0
SK-SB-70126227-0	WR 975 O/P FLANGE BLANK	2/25/13	2	0
Mar				
PF-701-262-93-0	VIEWPORT INSERT	02/06/13	6	0
PF-701-262-83-0	OUTPUT BLOCK II	02/06/13	1	0
PF-701-262-84-0	COOLING CHANNEL LID	02/06/13	2	2
PF-701-262-79-0	COPPER PLATE	02/06/13	2	2
PF-701-262-90-0	END PLATE	02/06/13	1	1
PF-701-262-56-0	PIVOT MOUNT	S.B.V.	4	4
PF-701-262-69-0	WR 975 OUTPUT FLANGE	2/25/13	1	0
PF-701-262-97-0	SLOTTED PLATE	02/25/13	2	0
PF-701-262-63-0	TUBE	02/28/13	2	2
PF-701-262-64-0	6.00"OD ROT CF FLANGE MOD	02/22/13	2	2
PF-701-262-70-	STIFFENER	02/25/13	3	3
PF-701-262-16-0	PORT SPOOL	02/25/13	6	8
PF-701-262-62-0	TUBE, SUPPORT ARM	02/27/13	2	0
PF-701-262-58-0	MIDDLE PLATE	02/25/13	4	0
PF-701-262-59-0	END PLATE B	02/25/13	2	2
PF-701-262-61-0	END PLATE A	02/25/13	2	2
PF-701-262-95-0	MOUNT BLOCK	02/28/13	2	2
PF-701-262-96-0	GUSSET BAR	02/28/13	2	0
PF-701-262-98-0	8-32 BRAZE INSERT	02/28/13	12	0

Fabrication Photos

Looking forward

- Duplicate cavities.
- Build another cavity with gap length 15 cm.
- Dark current measurements using Be end plates.
- Button/anti-button tests.
- Exotic materials: Cu alloys, etc.