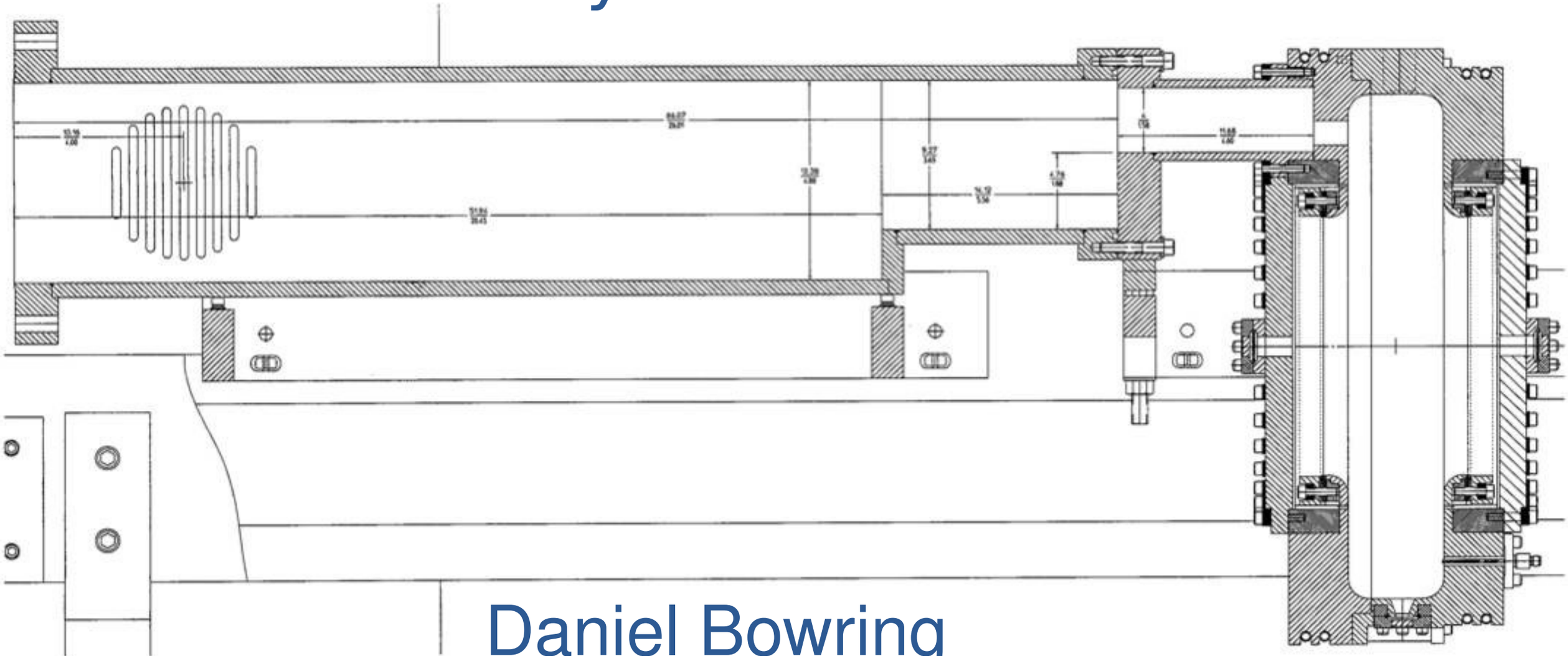
U.S. DEPARTMENT OF ENERGY

UNIVERSITY OF CALIFORNIA

BERKELEY LAB

Lawrence Berkeley National Laboratory

A Plan to Refurbish the 805 MHz Pillbox Cavity



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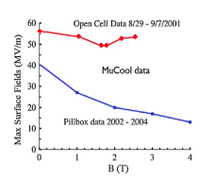
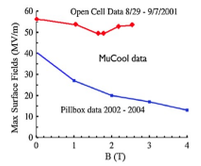


Talk Objective

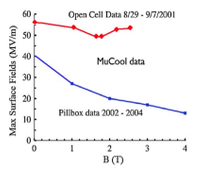
- Inform MAP community of recent developments.
- Encourage healthy debate about next steps in pillbox program.

Overview

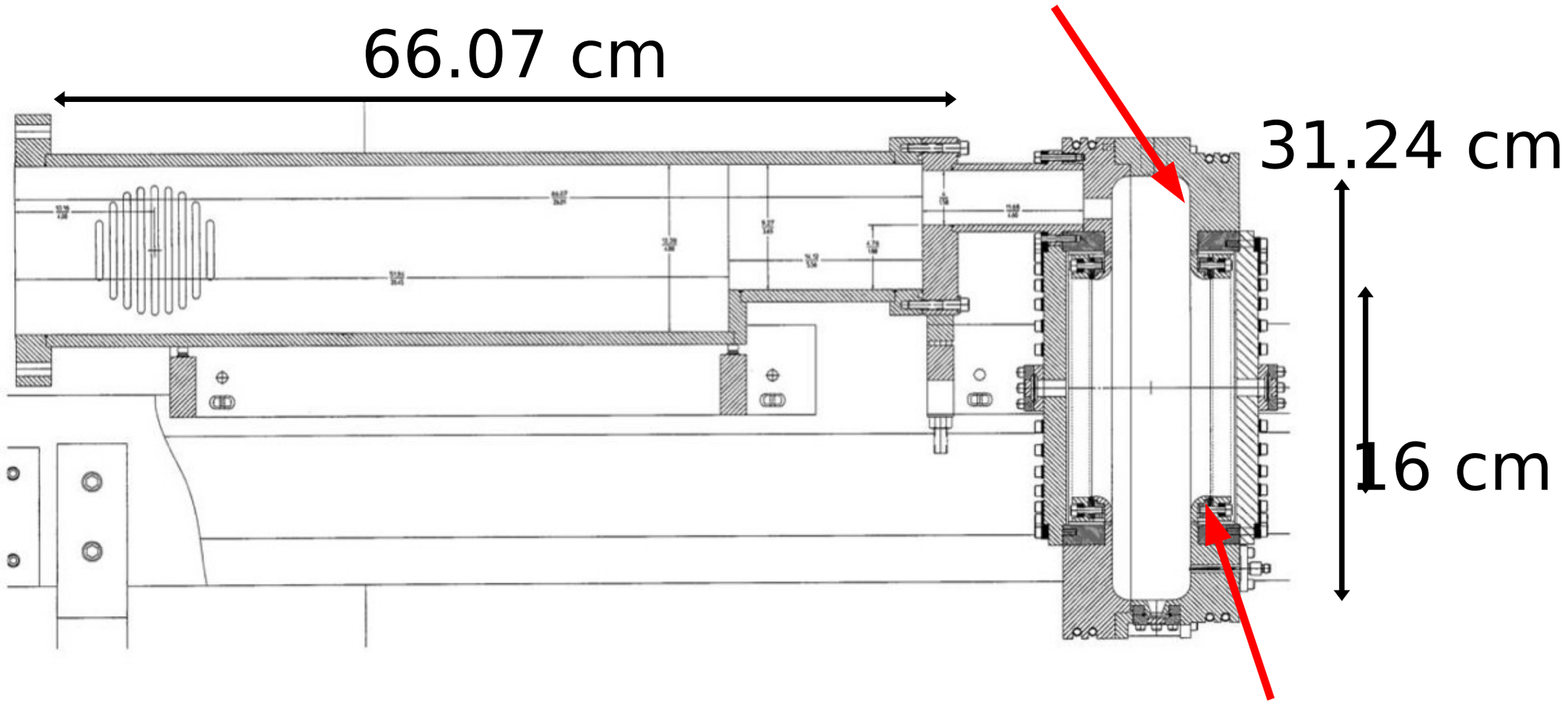
- Background and current status
- Arguments in favor of refurbishment
- The current debate
- A plan for refurbishment



Background & Current Status



805 MHz Pillbox Cavity

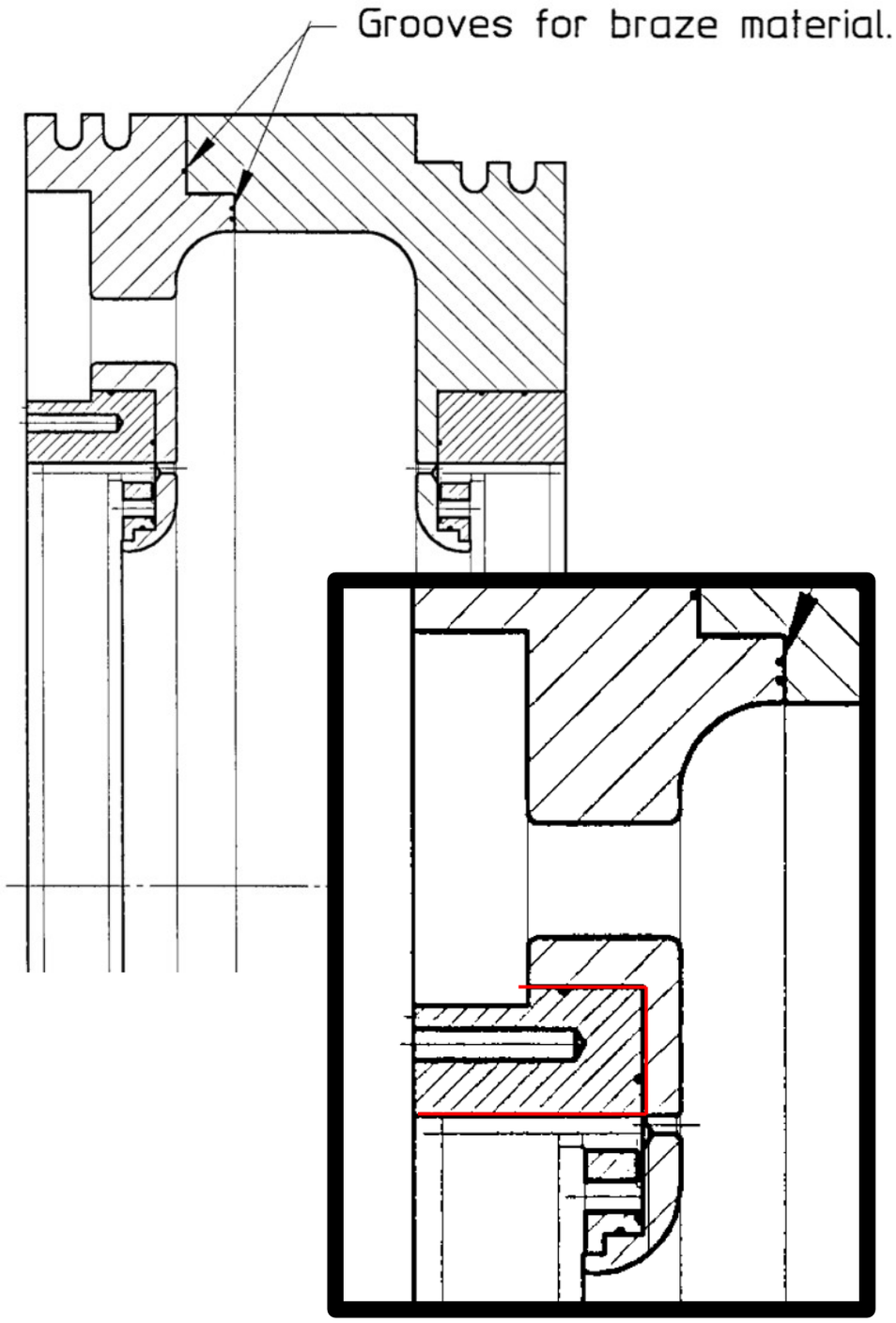


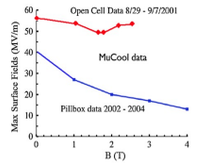
Synopsis

- The cavity is obviously damaged and probably contaminated (dirty).
- SLAC & LBNL are working to design & fabricate a new pillbox cavity.
  - –Informed by experience with current cavity.
  - –Money exists, is in place.
  - –Coupler optimization, FE simulation underway.
- In the meantime,
  - –What *specifically* is wrong with the old cavity?
  - –What can be done to improve it?

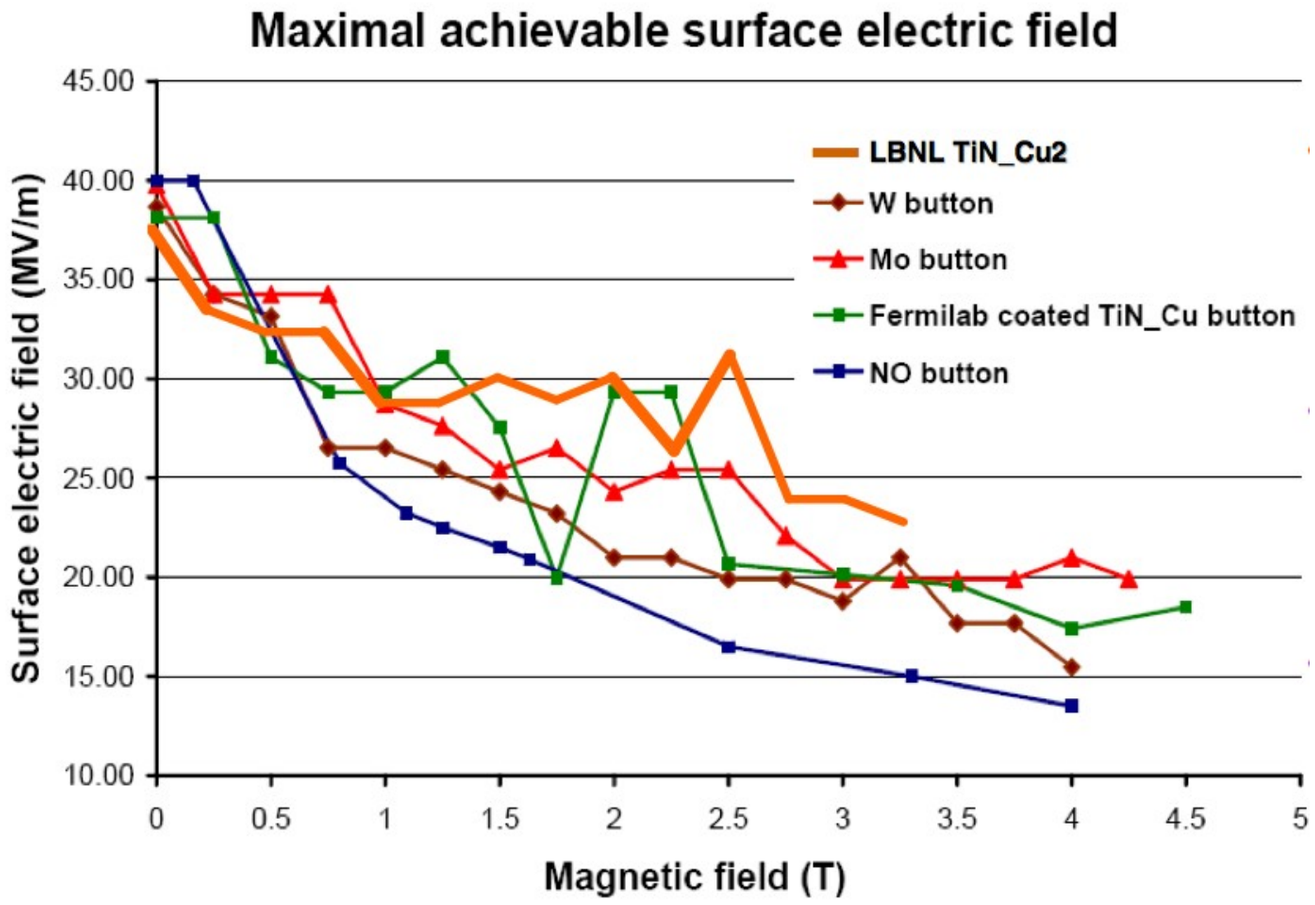
Braze problems

- Leaks after machining into original braze joint.
- Difficult to achieve vacuum (ideally ~10^{-8} Torr).
- Has complicated plans for surface treatment.



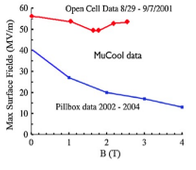


Button Tests



Plot from D. Huang's MUTAC Review Talk LBNL, April 2008

http://www.cap.bnl.gov/mumu/conf/MUTAC-080408/talks/09AM/DHuang1-080408.pdf

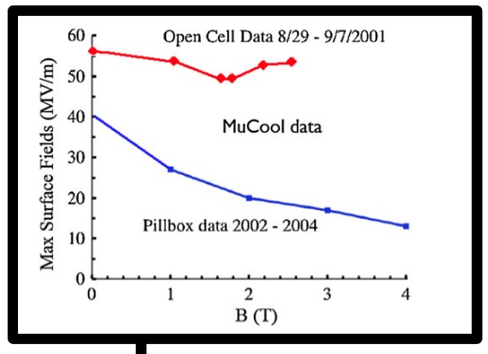


Pillbox Timeline

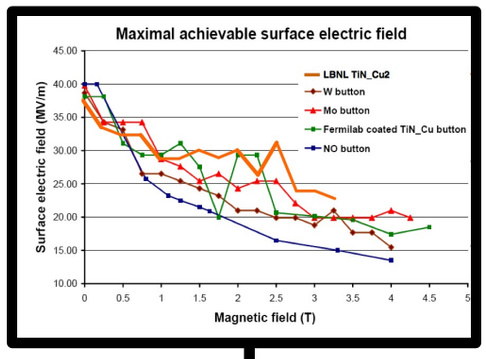
Design & fabrication

2000

Cavity damaged via mis-calibration.



2002



2005

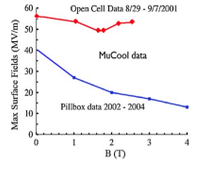
2007-8

JLab refurb. effort

2009

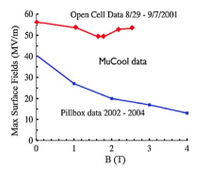
Gradient does not improve, damage returns.

2010-11



Current Status

- Cavity did not perform – even with B=0 – after refurbishment.
- You've already seen some of the erratic breakdown data.
- **Significant damage.**
- Possibility now of **contamination**.
- New button tests in the pipeline w/ greater field enhancement.



What do I mean by “damage”?

Damage

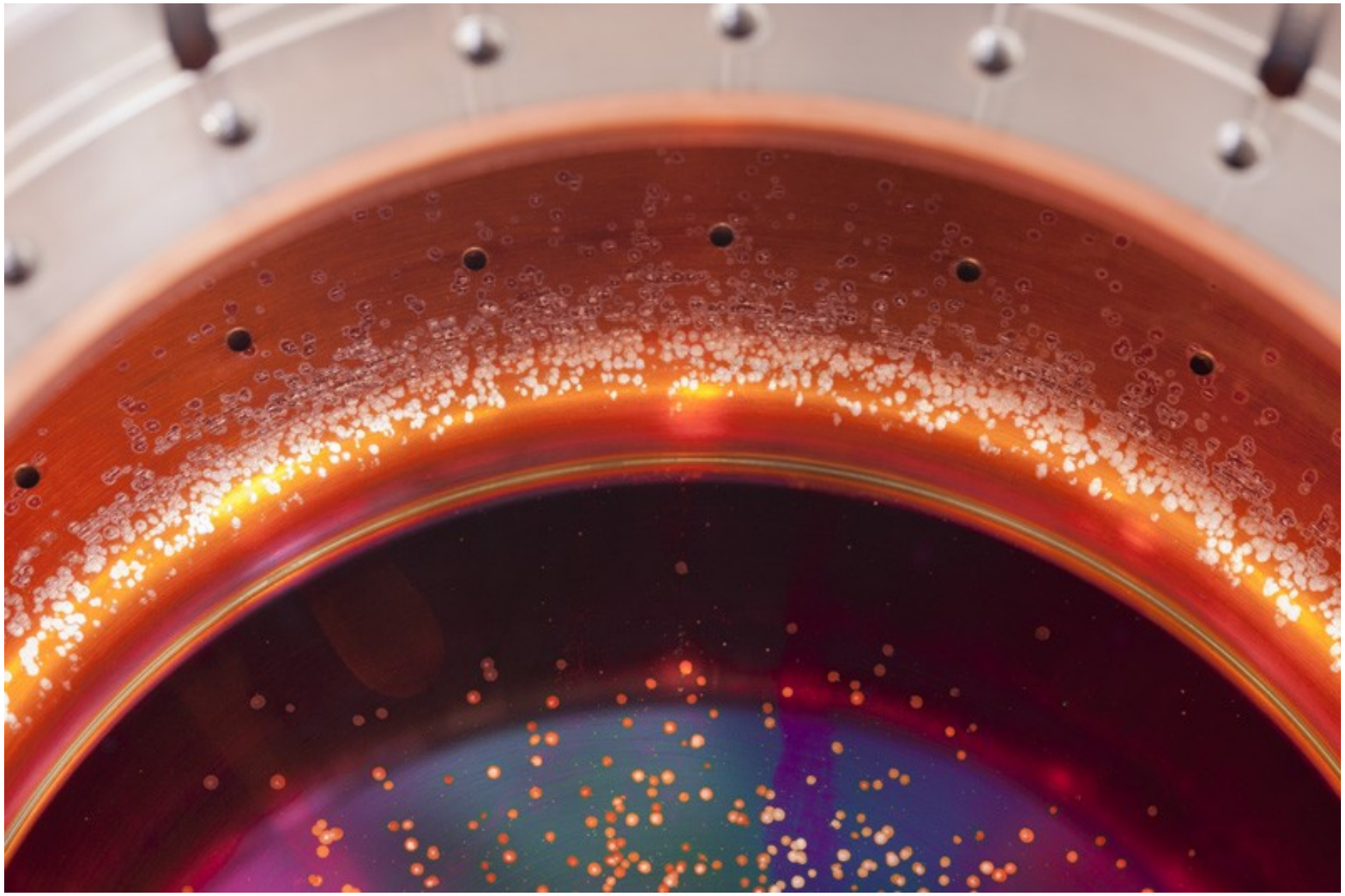
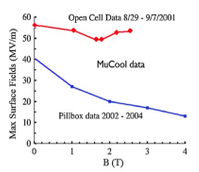
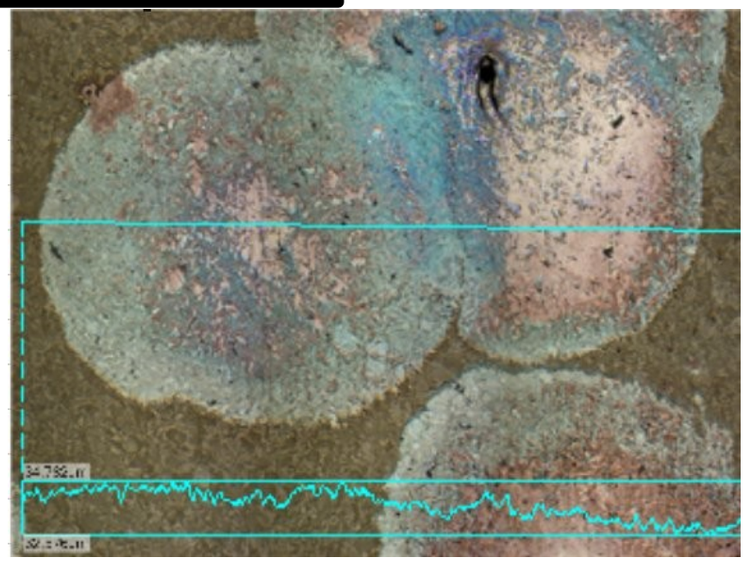


Photo Credit: Reidar Hahn, Fermilab Visual Media Services

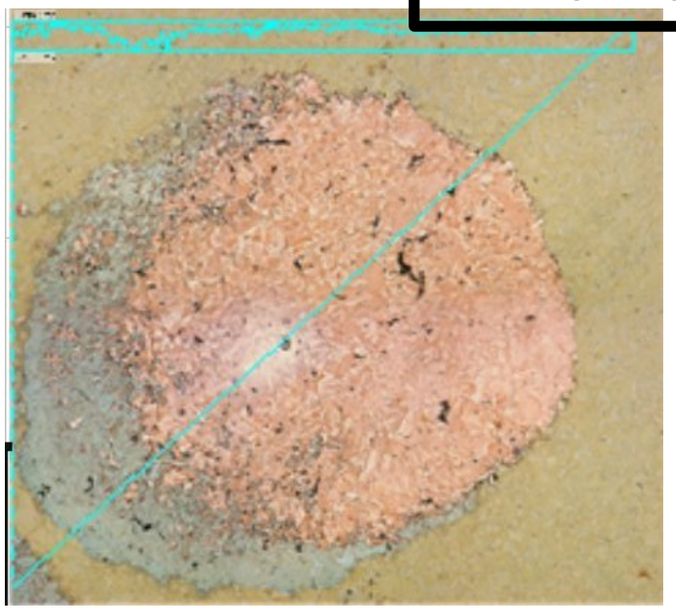


Damage Closeups: Crater roughness

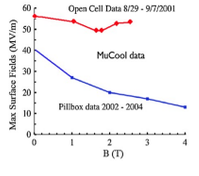
1.90 mm scan
Δh=0.804 um



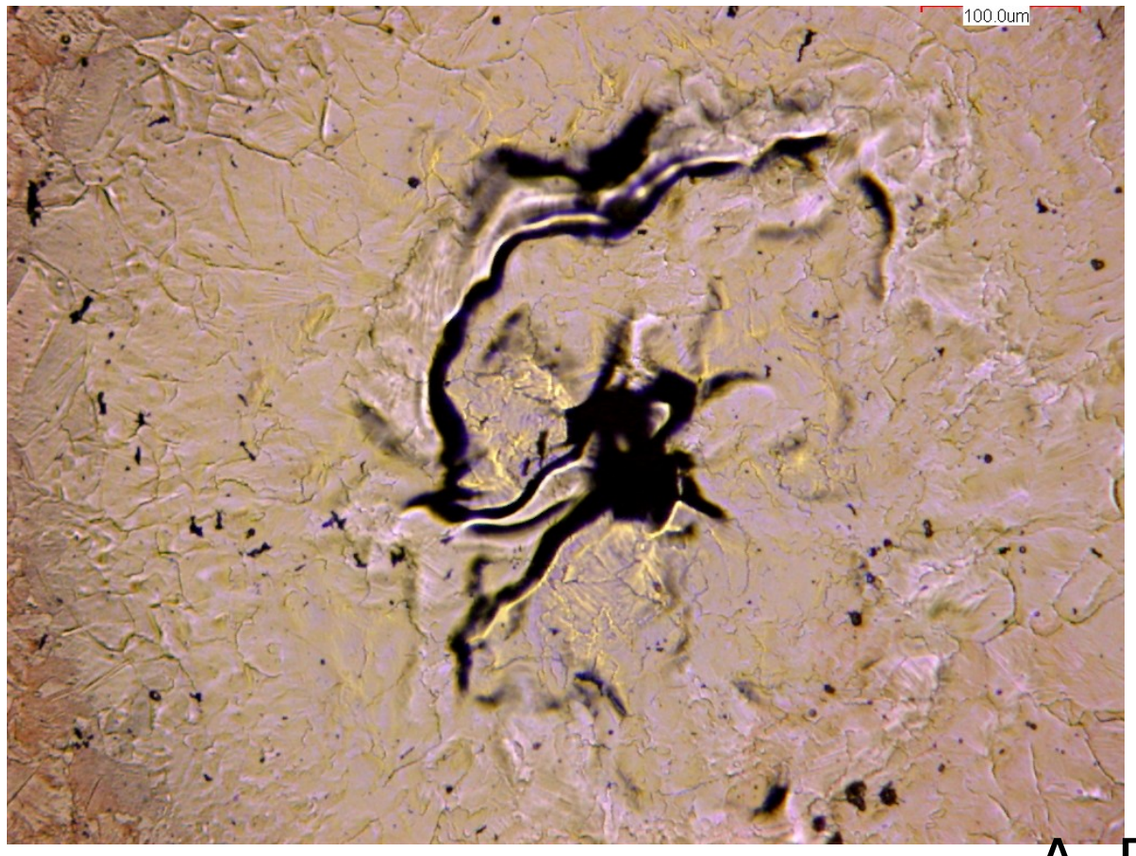
1.83 mm scan
Δh=0.208 um

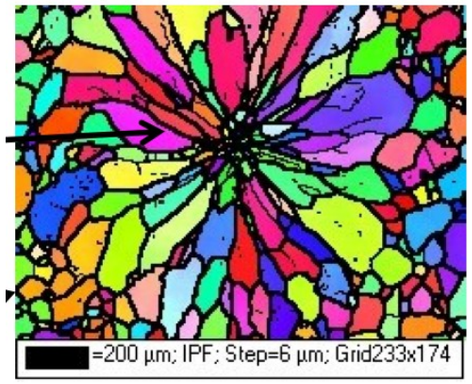


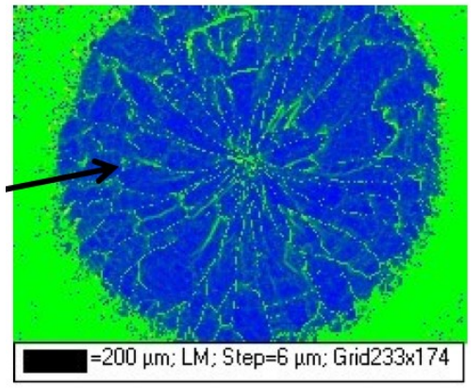
Laser confocal microscopy (LCM) from A. Romanenko, A. Dyzuba @ FNAL. Nonuniform craters with no clear center peaks. This suggests low-energy crater events with partial melting. EBSD would help here.



Damage Closeups



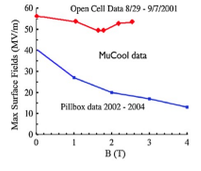




A. Dyzuba & E. Toropov, ALCPG11.
EBSD studies of laser remelting spots.
I want images like these for our craters.

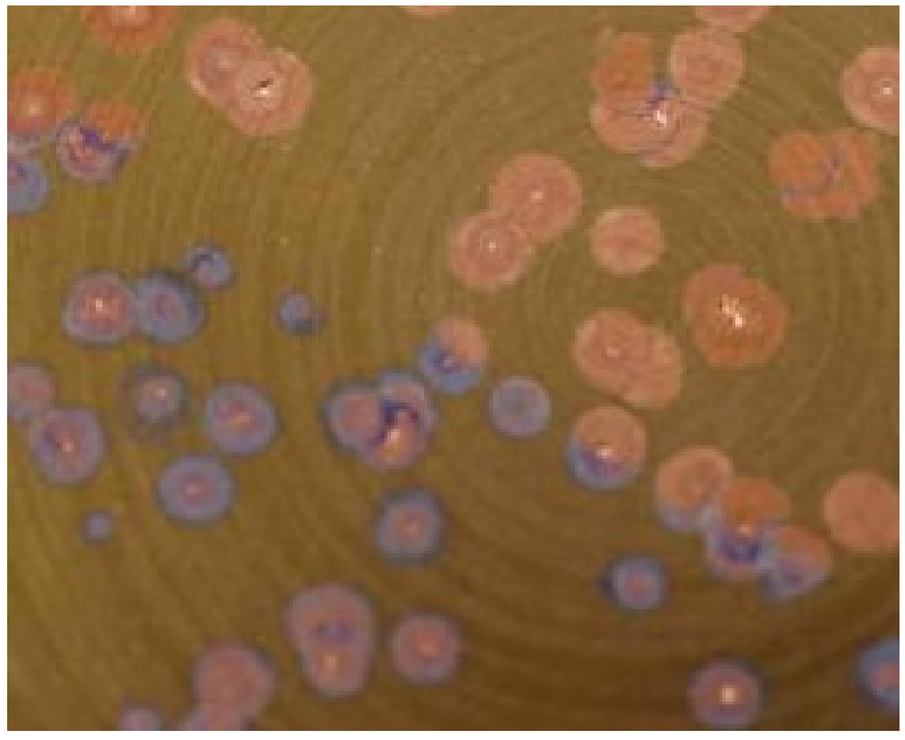
Crater closeup (LCM)

Center peak formation may give info. on damage process.



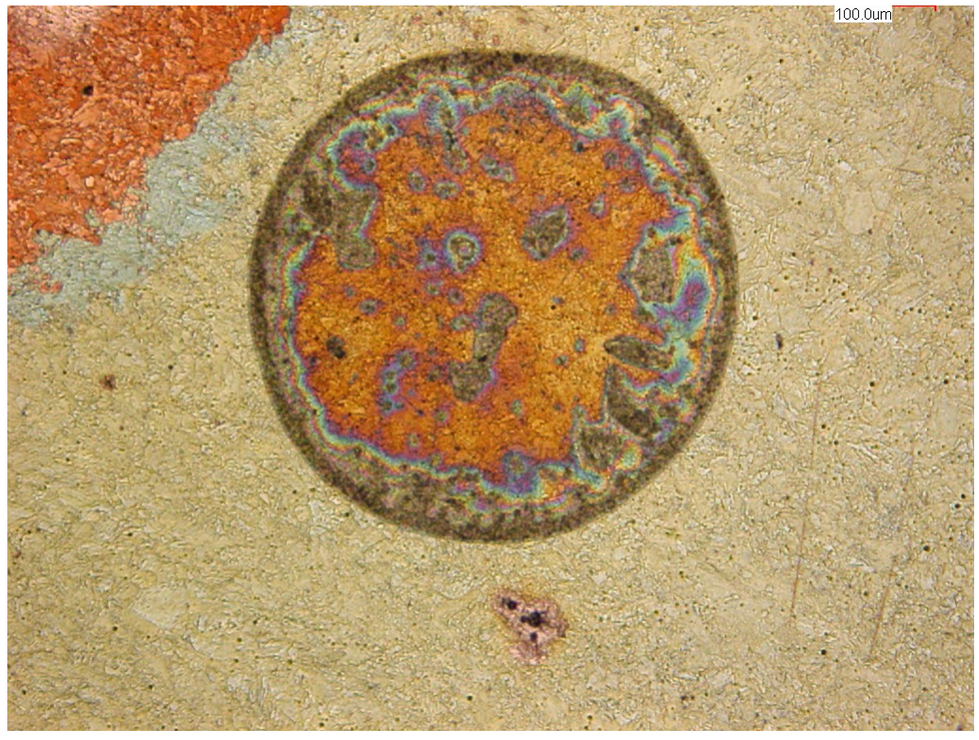
Contamination

Macro Photograph

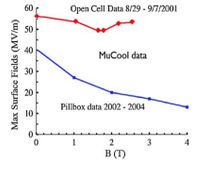


Bi-colored damage spots imply chemical flow across window.

Laser Confocal Microscopy

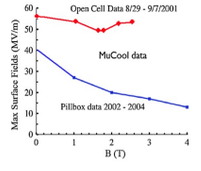


Rainbow pattern: oxide or nitride contamination?



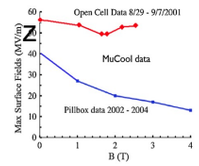
Contamination

- Small samples have been cut from the downstream Cu/TiN window.
- Surface science tools can determine local elemental concentration: EDS + SIMS
- NB: “Scotch-brite” may have embedded dielectric particulate in cavity surface. Further contamination source?



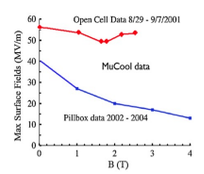
Damage/contamination analysis

- Ongoing
- Elemental composition + crystallographic data should tell us a great deal about the damage process.
- Craters suggestive of a low-energy process (c.f. laser remelting work done by A. Romanenko and A. Dyzuba @ ICB)

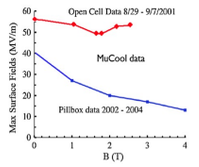


The Current Debate

- Is refurbishment worthwhile?
- Should it be done now or later? This is a harder question, in light of upcoming button tests.
- Now: Things we learn during refurb. can inform fabrication of new cavity.
- Later: Button tests aren't delayed, plus we might break the cavity.



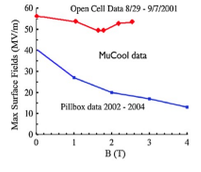
A Plan For Refurbishment



Plan Overview

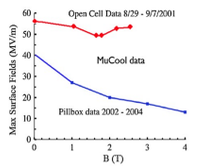
GOAL: A quantifiably clean cavity, prepared using best practices, that sets a clear performance benchmark.

- Mechanical polish to remove craters
- Chemical etch
- Heat treatment
- None of these steps are optional!



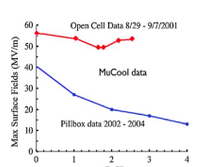
Mechanical Polish

- Hand polishing is the simplest option. **Good-looking** results @ JLAB.
  - But aside from ultrasonic bath & water rinse, no further treatment.
    - OFHC copper is very soft, particulate easily embedded.
- Required to remove damage, but **cannot** be the only step.
- Not site-specific.



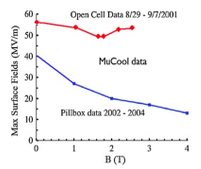
Chemical Polish

- SLAC: Basically no material removal. Mild “detergent” rinse.
- FNAL: Chemical etch w/ “Copper Bright”. Some material removal.
- ANL, LBNL: Electropolishing. HF solution, aggressive material removal.
- **Our choice depends on what we learn from surface analysis.**



Baking

- SLAC: 10+ day bake at 650°C
- Geared towards hydrogen removal (from their brazing ovens).
- Required after chemical treatments.
- Cavity was previously baked. Not clear that this, by itself, would have much effect on embedded particulate.

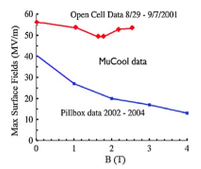


How Long?

- 1 month for surface analysis results
- ~ 2 weeks for mechanical polishing
- Chemical polishing time unclear.
- 10 days to bake.
- *At least* 1-2 months for delays, transportation.

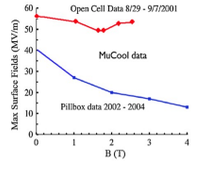
+

~ 3-4 months total



Open Questions

- When to refurbish?
- Which chemical treatment is most appropriate?
- Since the cavity is damaged and possibly contaminated, what can we learn from further tests without refurbishing?



Current MTA Schedule

- HPRF tests will end soon
- Cavity swap
- 805 MHz button tests to begin in late August

Acknowledgements

- For measurements and lab assistance: Alex Romanenko and Alex Dzyuba (FNAL)
- For helpful discussions and advice: Lance Cooley, Charlie Cooper, and Alan Rowe (FNAL)
- Chris Adolphsen, Andy Haase, Zenghai Li (SLAC)
- Jim Norem (ANL)