Results from a multi-metallic conduction-cooled SRF single-cell cavity

Tesla Technology Collaboration Meeting

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CERN

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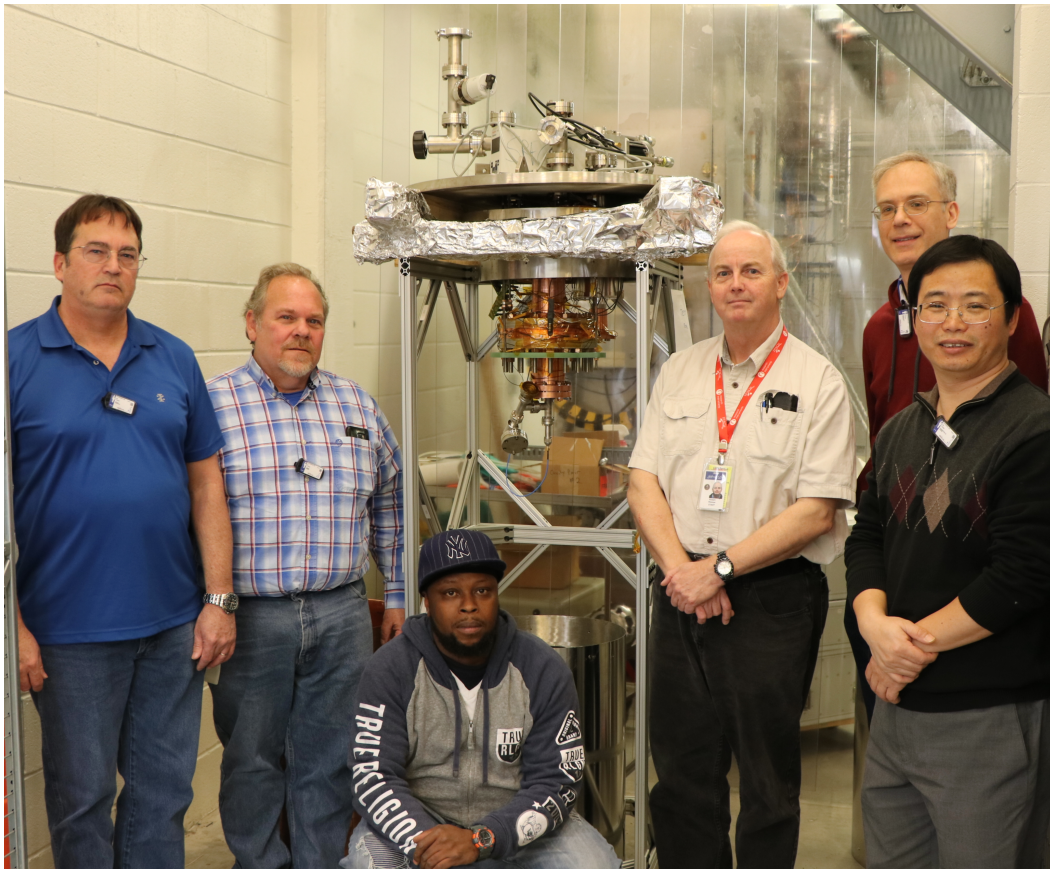
R. Rimmer

Tuesday, February 4, 2020



Left to right: **K. Harding, J. Henry, D. Tucker, R. Rimmer, G. Ciovati** and **G. Cheng**. Not shown: **U. Pudasaini**

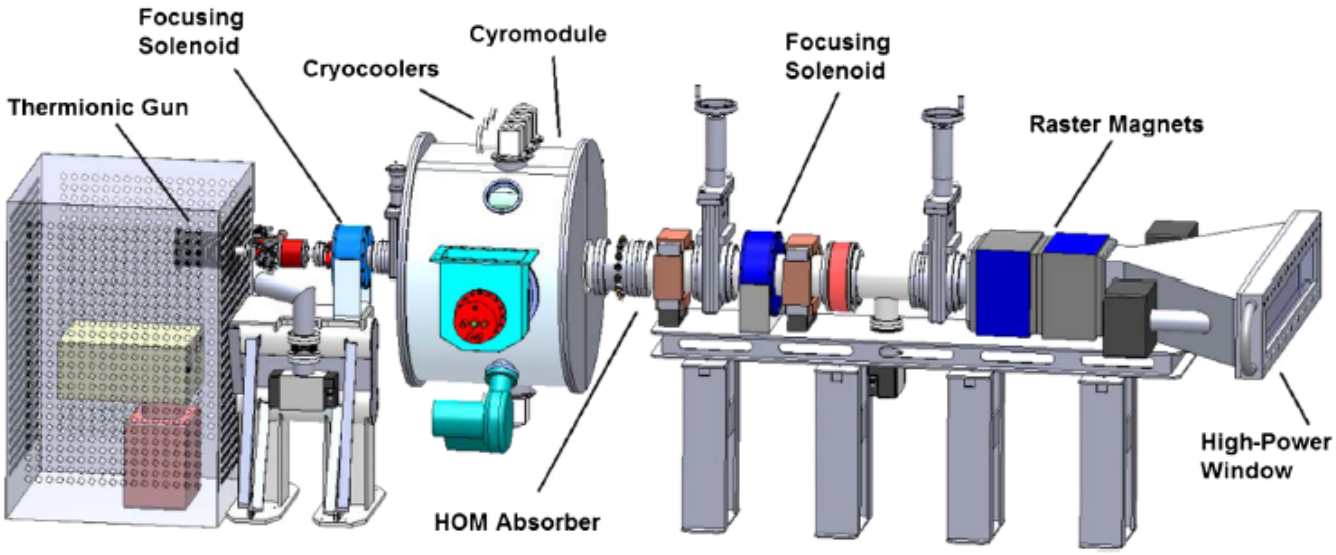
Jefferson Lab

U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

Objective

- Demonstrate operation of a single-cell SRF cavity by conduction cooling using a commercial cryocooler
  - Use Nb_3Sn thin film to achieve lower R_s than Nb at T > 4 K
  - Deposit thick Cu outer shell for good thermal conduction
  - Minimize number of joints between the 4 K stage of cryocooler and the cavity



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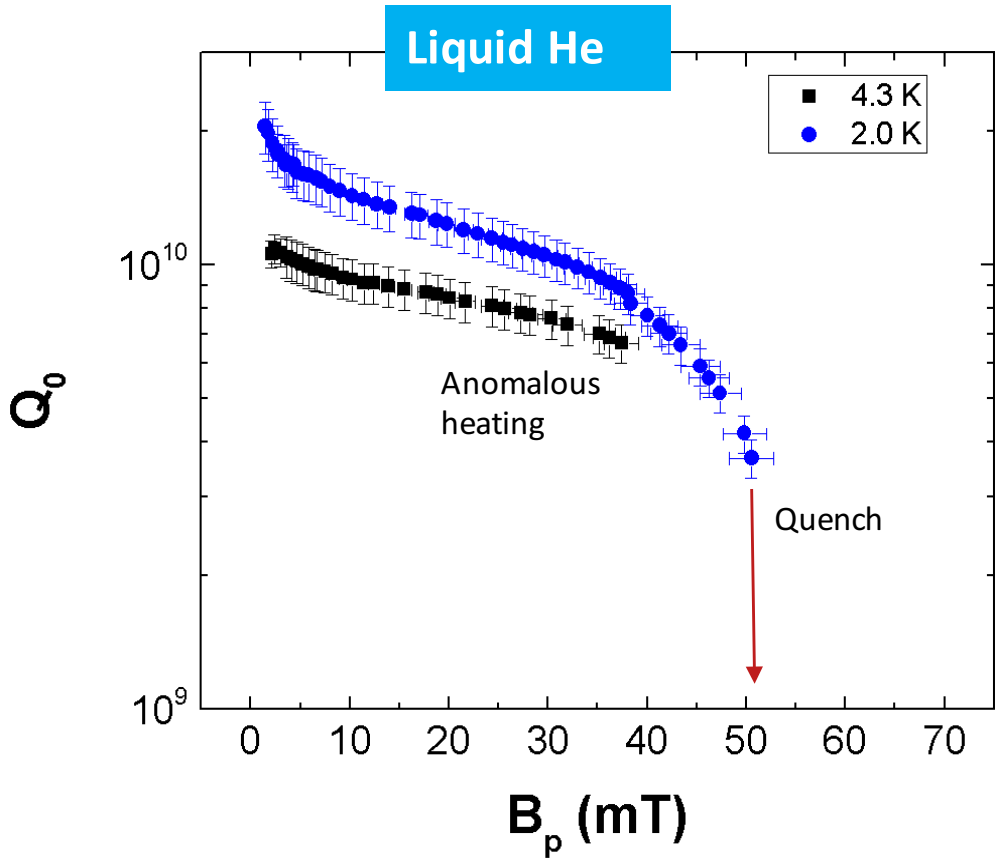
Nb_3Sn coating

- Nb_3Sn thin film grown by vapor diffusion at 1200 °C on ~2.9 mm thick bulk Nb (large grain) 1.495 GHz single cell cavity
- Synergy with Nb_3Sn development program at JLab

Courtesy of G. Eremeev



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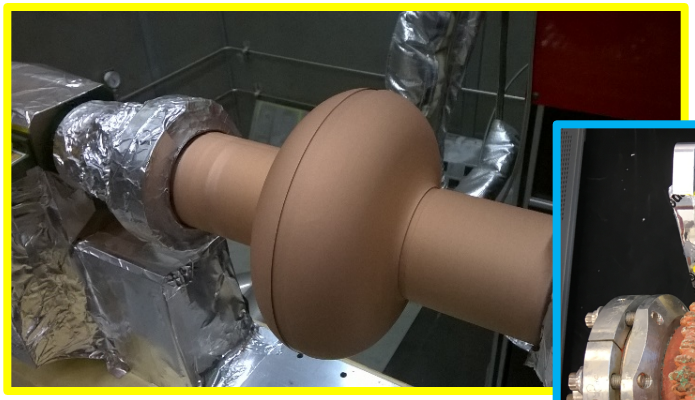
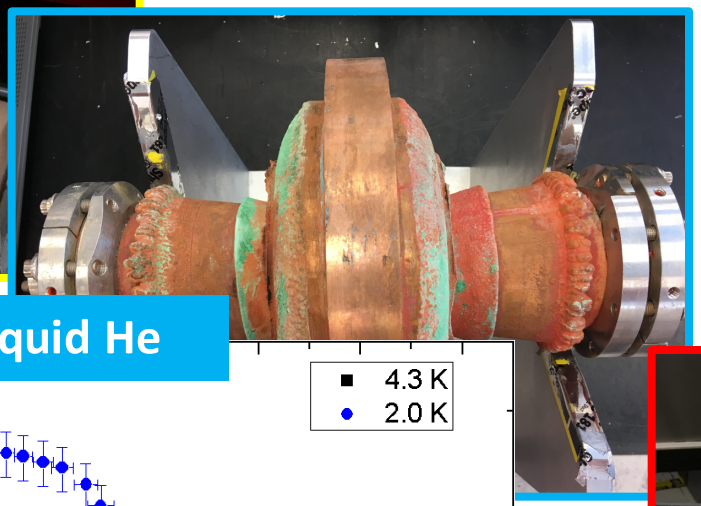
Cu outer coating (1)

- Thermal analysis with ANSYS indicated ≥5 mm thick Cu outer layer to allow reaching ~37 mT with conduction cooling
- Deposit seed layer (~76 μm thick) of Cu on Nb outer surface by cold-spray at CTC, Johnstown, PA
- Deposit ≥5 mm thick oxygen-free Cu on seed layer by electroplating at AJ Tuck Co., Brookfield, CT. A 10" diameter, ½" thick ring was also grown at the equator by electroplating.

- Thermal conductivity measurement on Nb/Cu samples showed ~1000 W/(m K) at 4.3 K

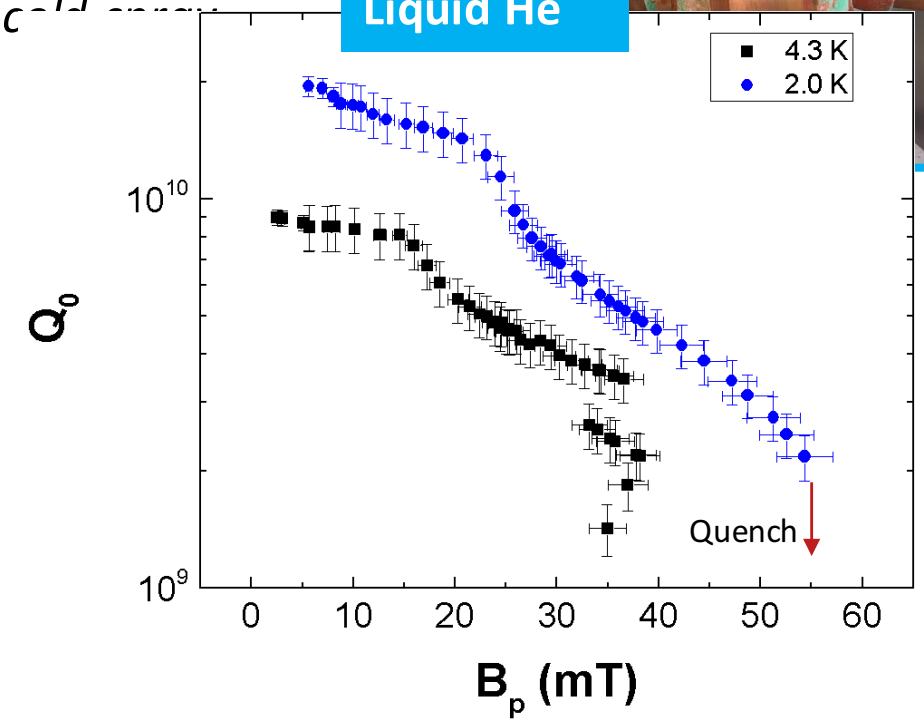
Cu outer coating (2)

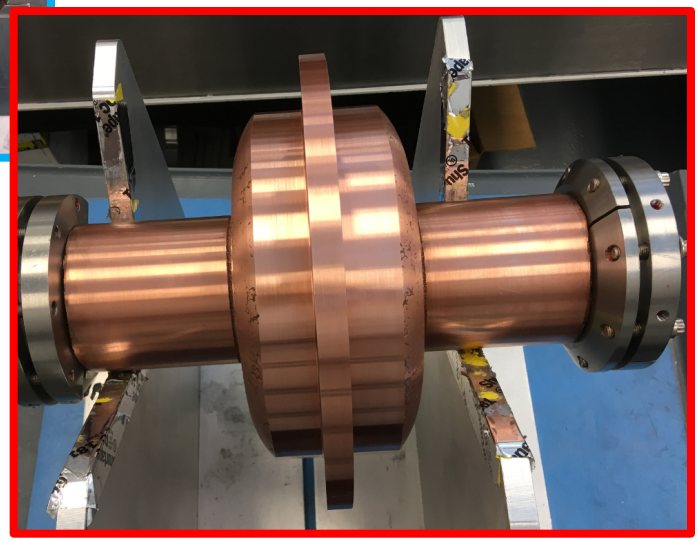




After c[illegible]

Liquid He





After machining

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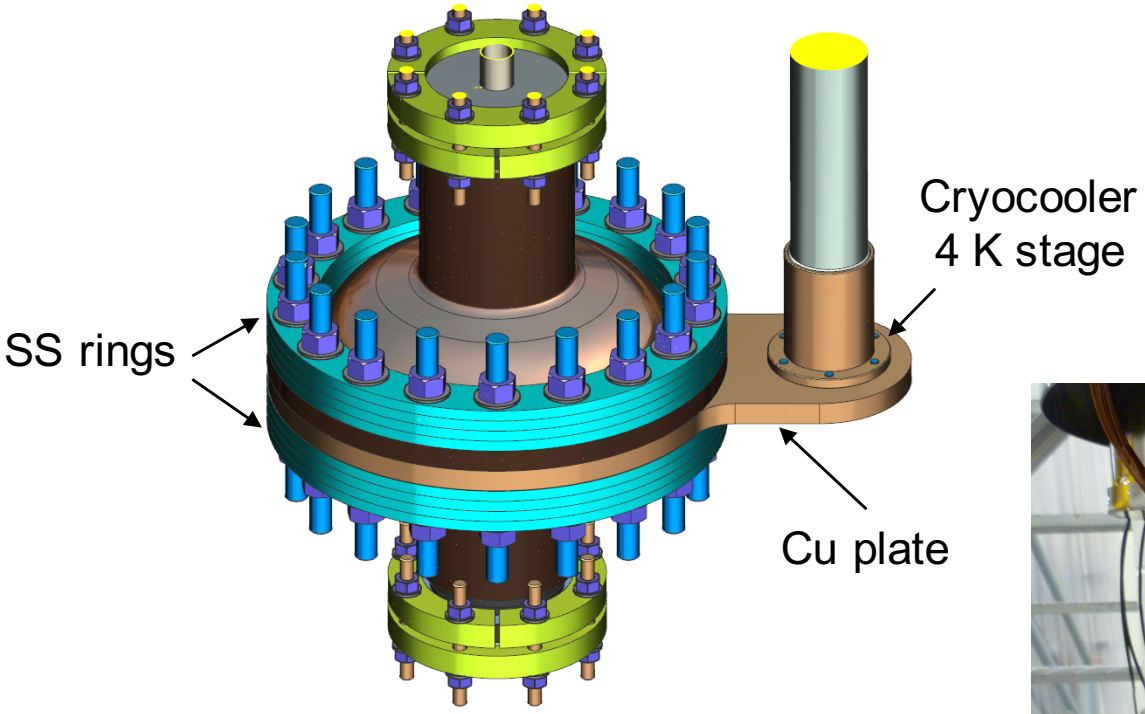
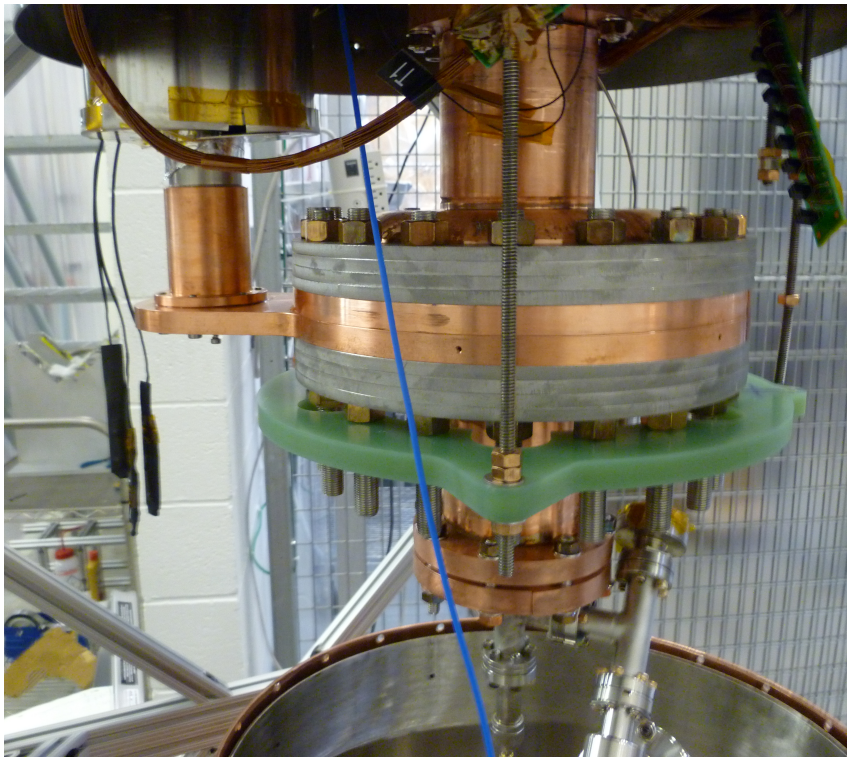
Cryocooler connection





Cryocooler: Gifford-McMahon type, Sumitomo RDE-418D4, cooling power: 2 W at 4 K

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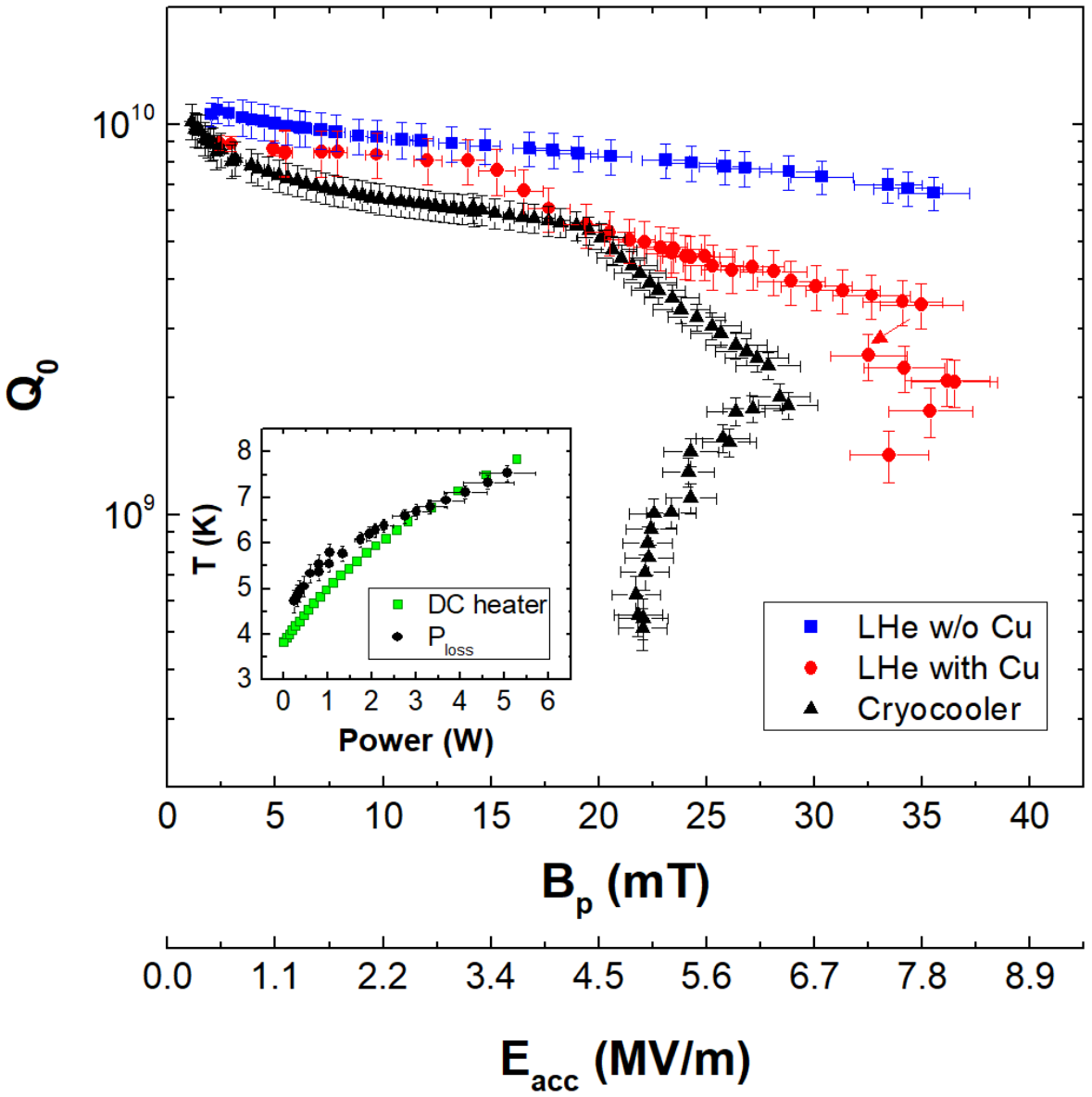
RF test results

- Cavity temperature after cooldown: ~3.8 K
- T-gradient at 18 K: ~0.09 K/cm
- Max residual B at 18 K: ~14 mG
- Amplitude of microphonics: 13.8 Hz pk-to-pk



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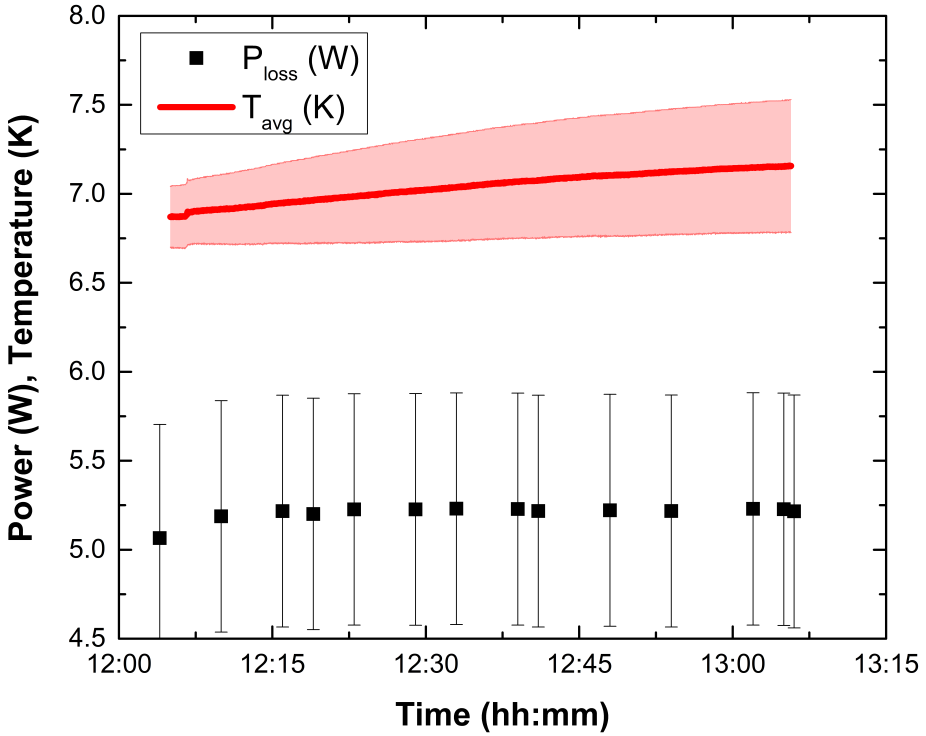
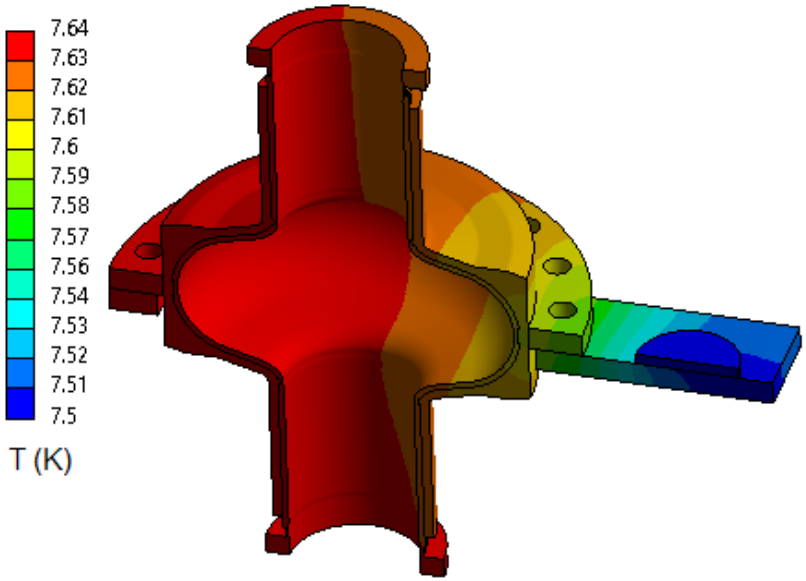
RF test results

- The cavity was thermally stable during a 1 h operation at P_{diss} = 5 W even with anomalous losses (Q_0 ~ 5e8 at 22 mT)





- Cu layer allows remarkable thermal stability

Conclusions

- We developed for the first time a multi-metallic Cu/Nb/Nb_3Sn single-cell cavity
- We were able to demonstrate operation of the cavity up to B_p ~ 29 mT (E_{acc} ~ 6.5 MV/m), limited by defects in the Nb_3Sn film
- The cavity exhibited remarkable thermal stability even with 5 W of power dissipation
- The amplitude of microphonics was well within what has been measured in standard cavities in cryomodules

- **These results are a stepping stone towards developing SRF industrial accelerators**

Acknowledgments

- B. Golesich at CTC, A. Tuck at AJ Tuck Co.
- JLab cavity production group and machine shop
- E. Daly, G. Eremeev and T. Powers at JLab
- I. Parajuli at ODU
- M. Dale at Sumitomo Cryogenics of America