



BROOKHAVEN
NATIONAL LABORATORY

Investigating the limits of high-temperature superconductors for high radiation environments with the US-Japan HEP collaboration

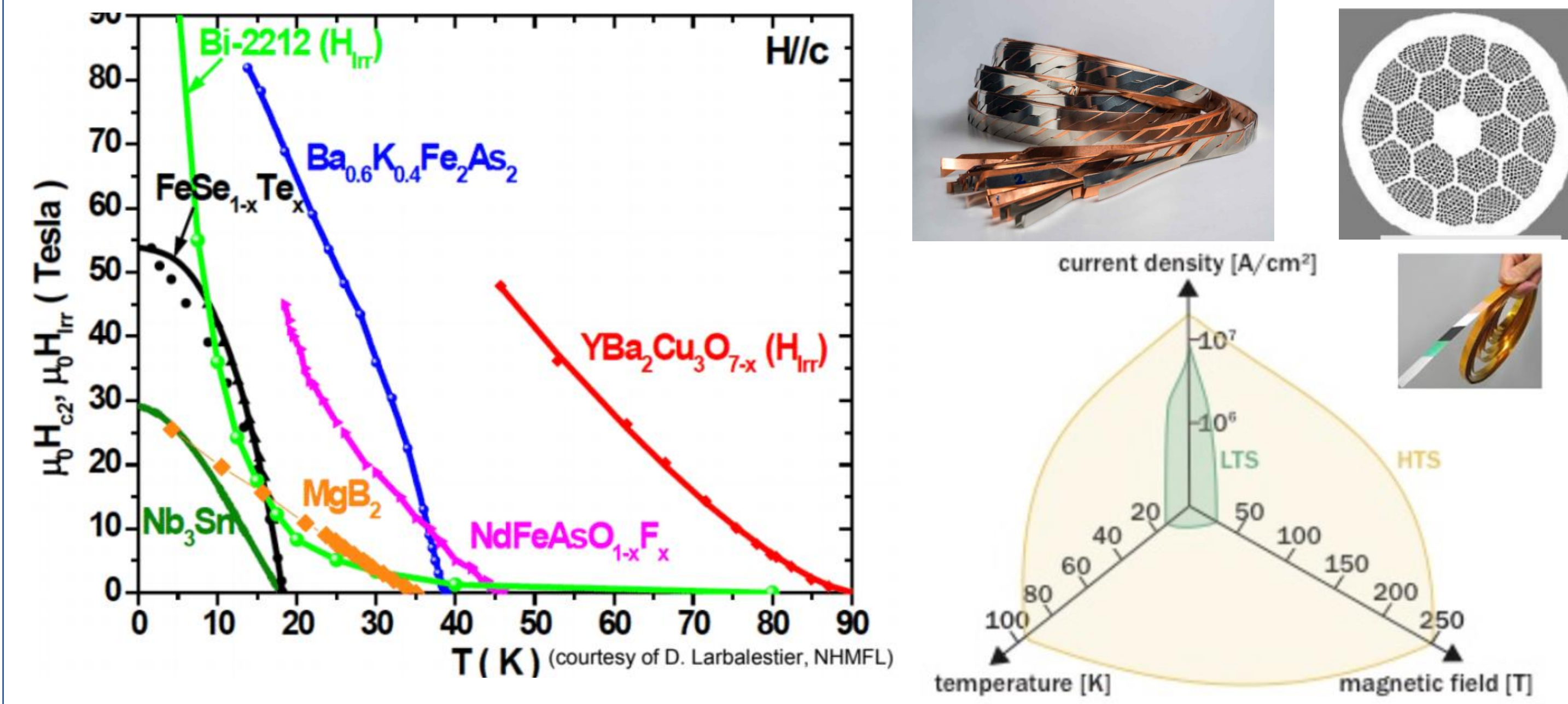
Christopher Reis^{1,4}, Laura Garcia Fajardo¹, Tengming Shen¹, Xiaorong Wang¹, Masami Iio², Toru Ogitsu², Yusuke Sogabe³, Xijie Luo³, Naoyuki Amemiya³, Ramesh Gupta⁵

1. Lawrence Berkeley National Lab, 2. KEK, 3. Kyoto University, 4. University of California, Berkeley, 5. Brookhaven National Lab



HTS Opens a New Application Space

High-Temperature Superconductors (HTS) have high critical fields and carry high electrical currents at a temperature range inaccessible to classical and Low-Temperature superconductors (LTS).



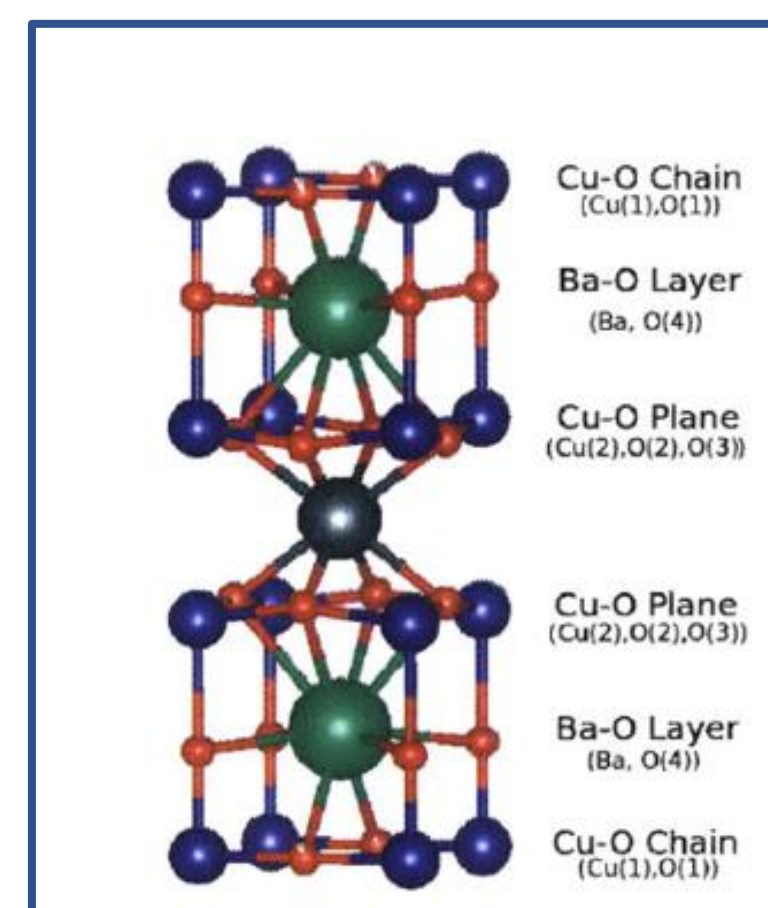
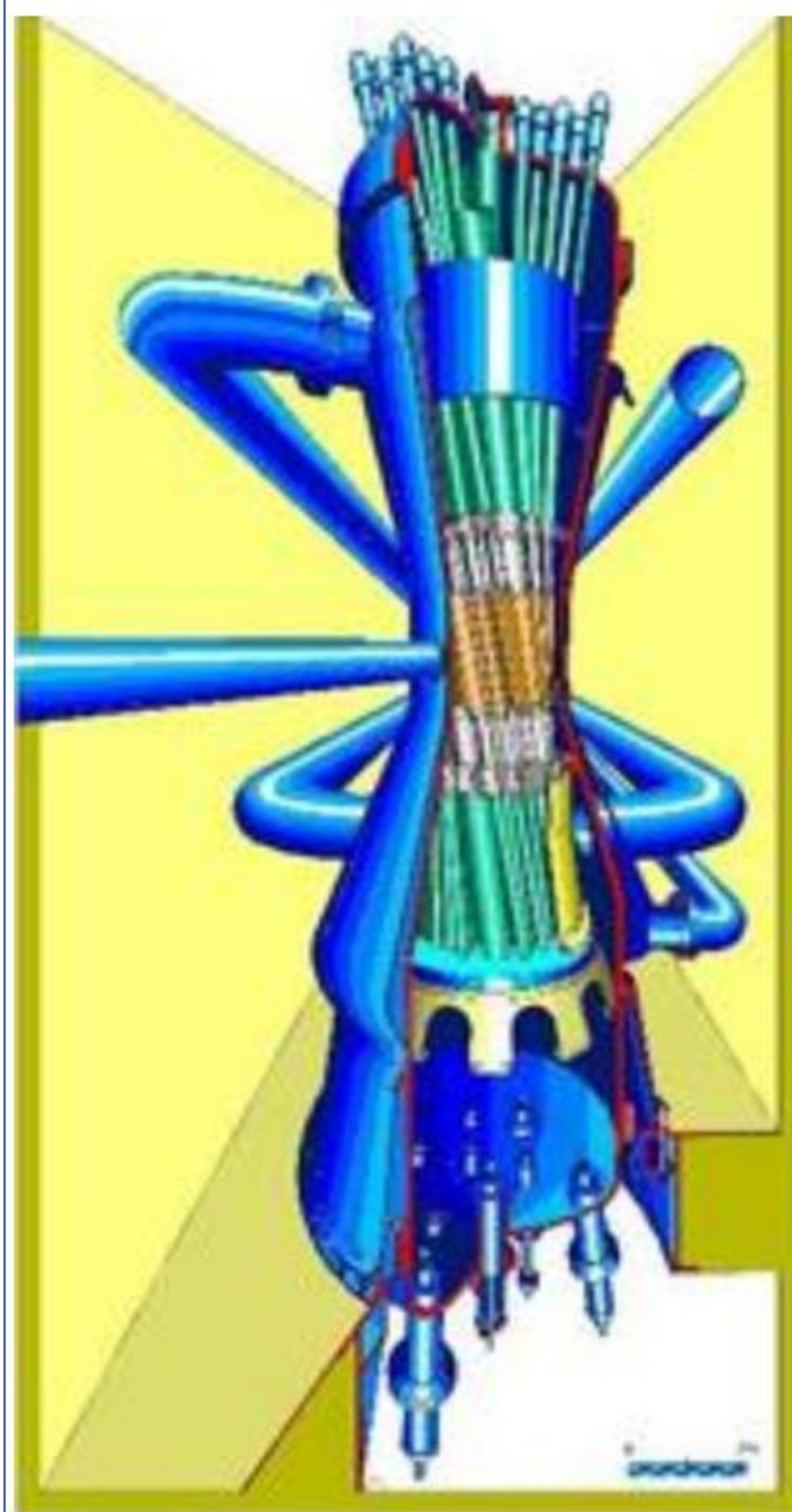
This makes them even better candidates for magnet materials

REBCO Performance Under Irradiation

For the high-radiation task, one of the main questions is how the performance of HTS like Rare Earth Barium Copper Oxide (REBCO) changes as a function of ambient fluence

We plan to irradiate at BR-2 and find:

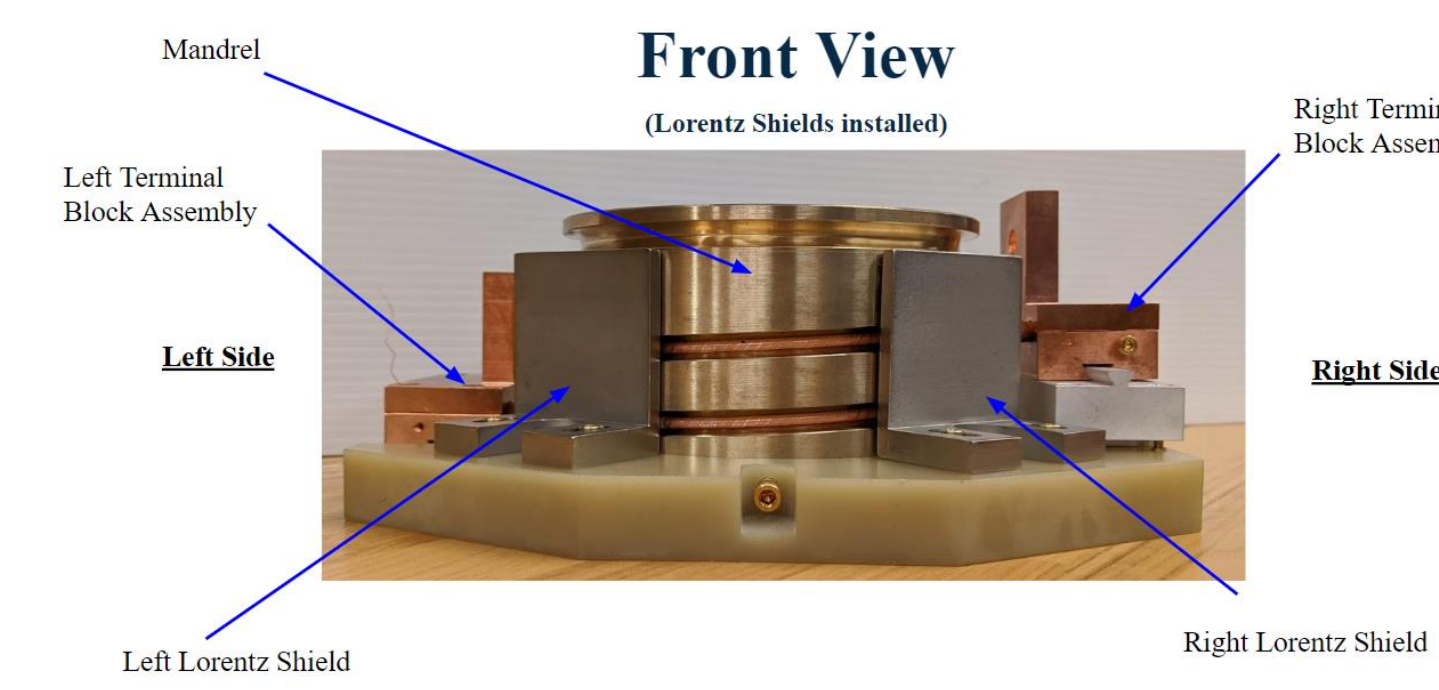
- Quantitative relationship between fluence/DPA and J_c/T_c
- Microstructural changes including void swell and Helium production using SEM, TEM, PALS, MOI etc.
- Annealing and Shielding possibilities
- Stretch goal: cryogenic irradiation



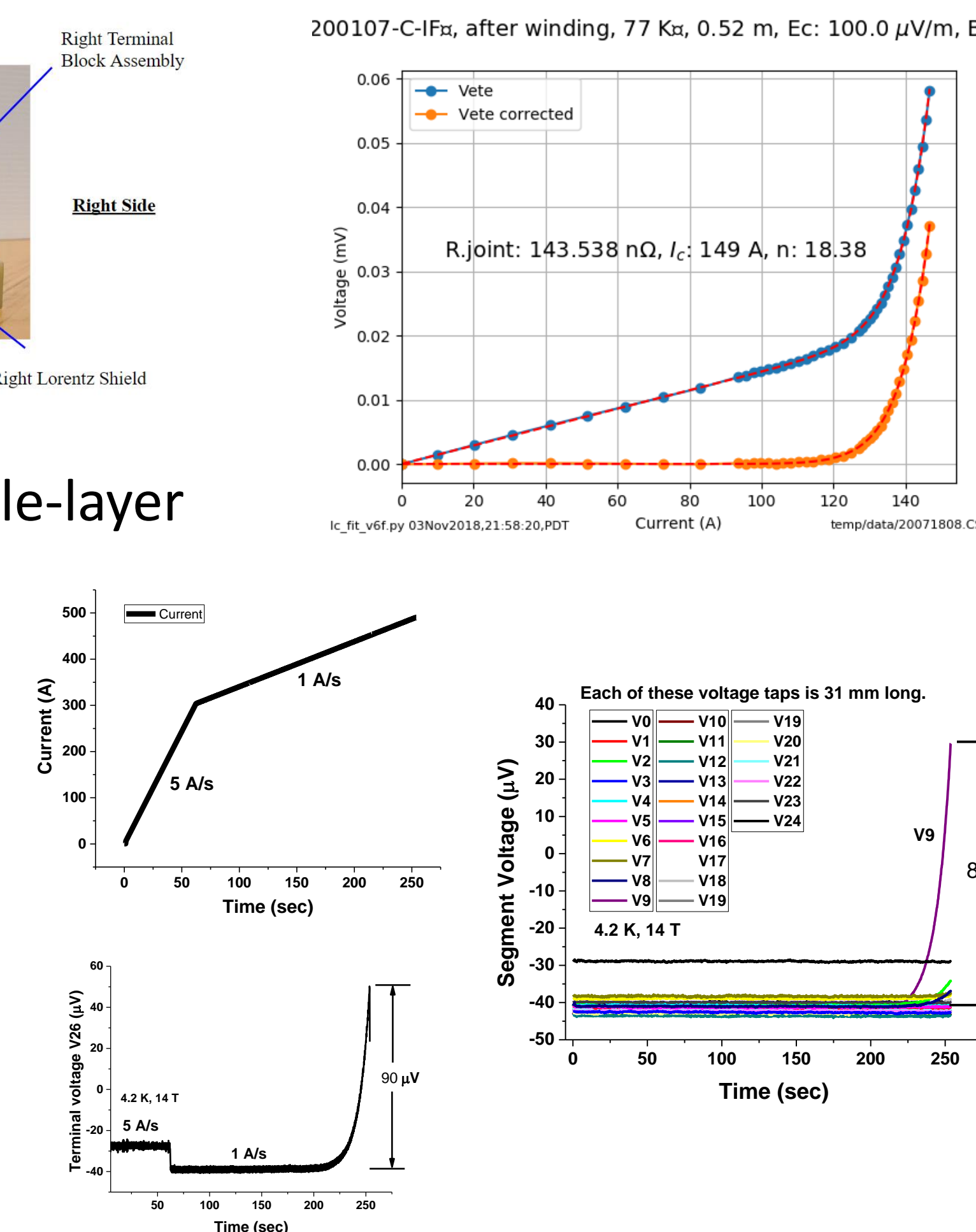
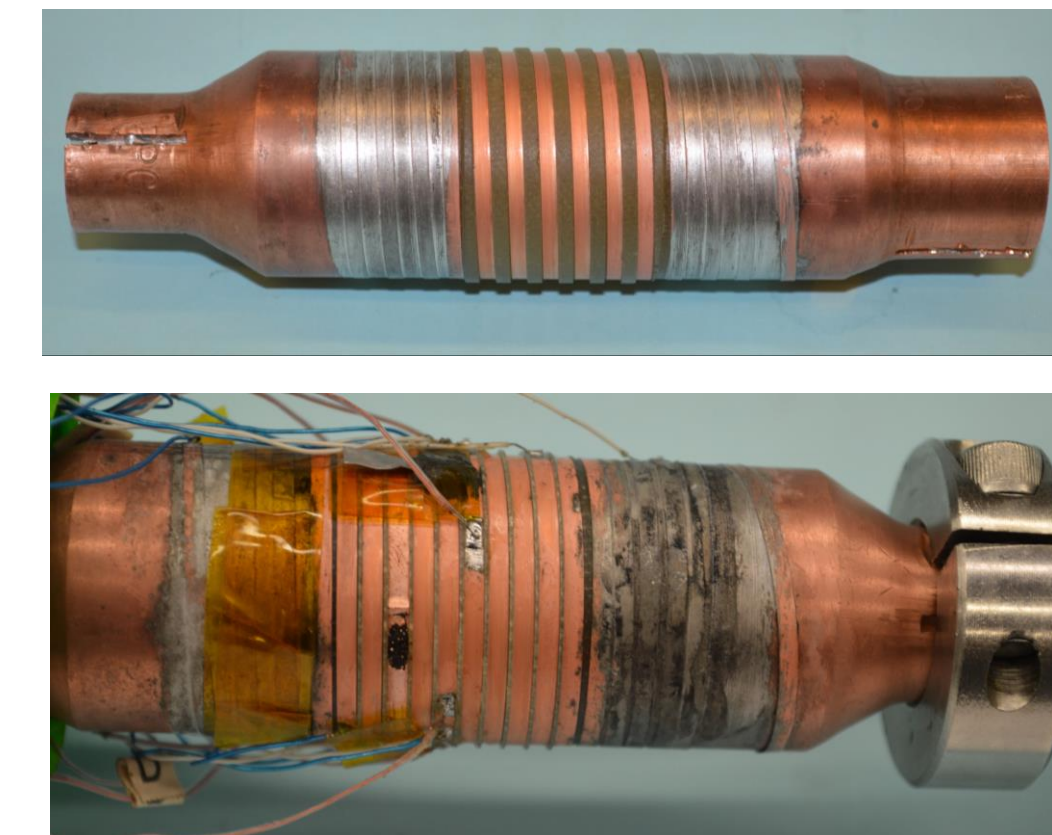
Quench Experiments and Modelling



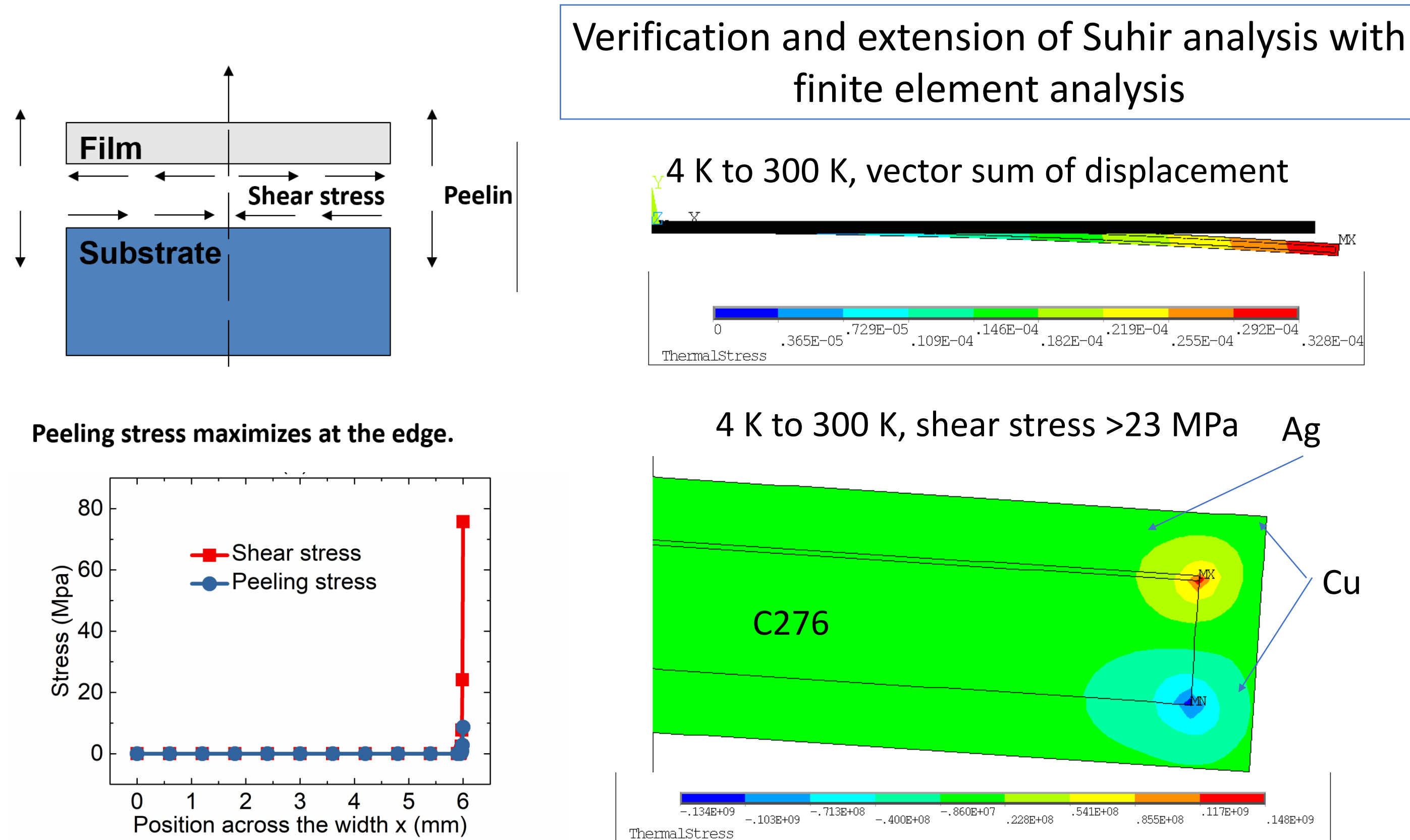
CORC wires fabricated by ACT and wound into a coil at LBNL for variable temperature conduction cooled experiment at Kyoto Uni.



Fast turnaround 2 m long single-layer barrel coil at LBNL



For the modeling task, the shear and peeling stresses during temperature rise due to a quench in the multilayered thin films as well as the nonuniform temperature rise are of interest.

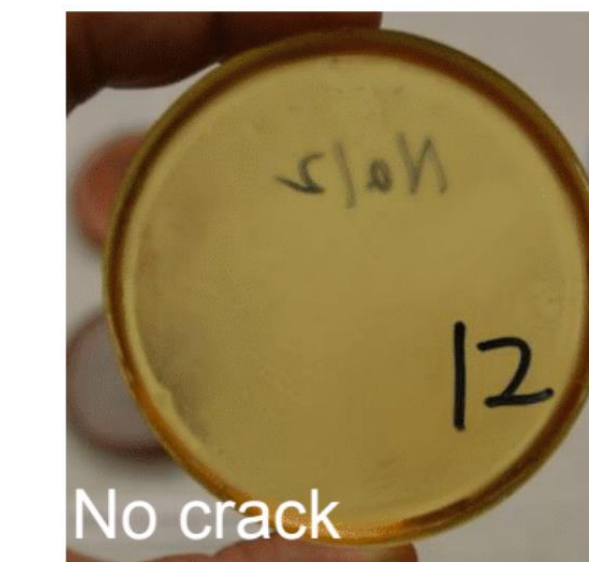


Novel epoxy resin and insulation

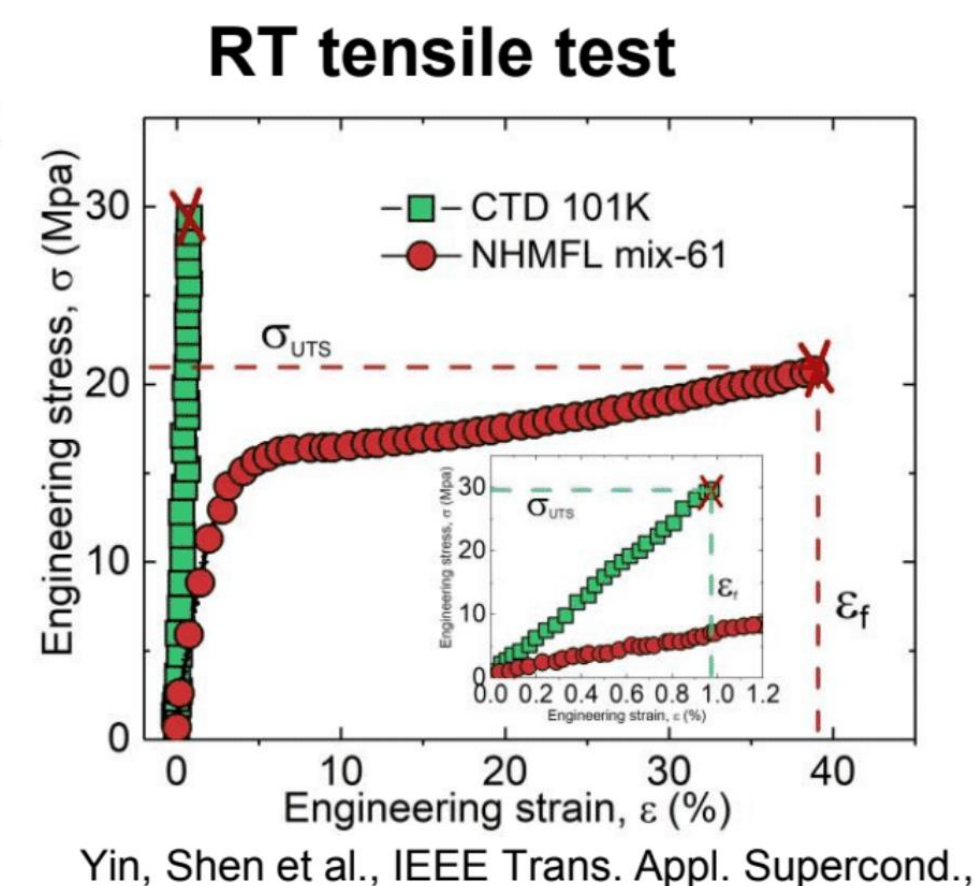
Investigating degradation of US insulating materials, both organic and inorganic, using Japan's gamma ray irradiation facility

CTD-101K, used by US LARP, after one thermal cycle to 77 K

NHMF-mix61, an amine-based epoxy after one thermal cycle to 77 K



Shijian Yin, Tengming Shen, LBNL



Yin, Shen et al., IEEE Trans. Appl. Supercond., 2019



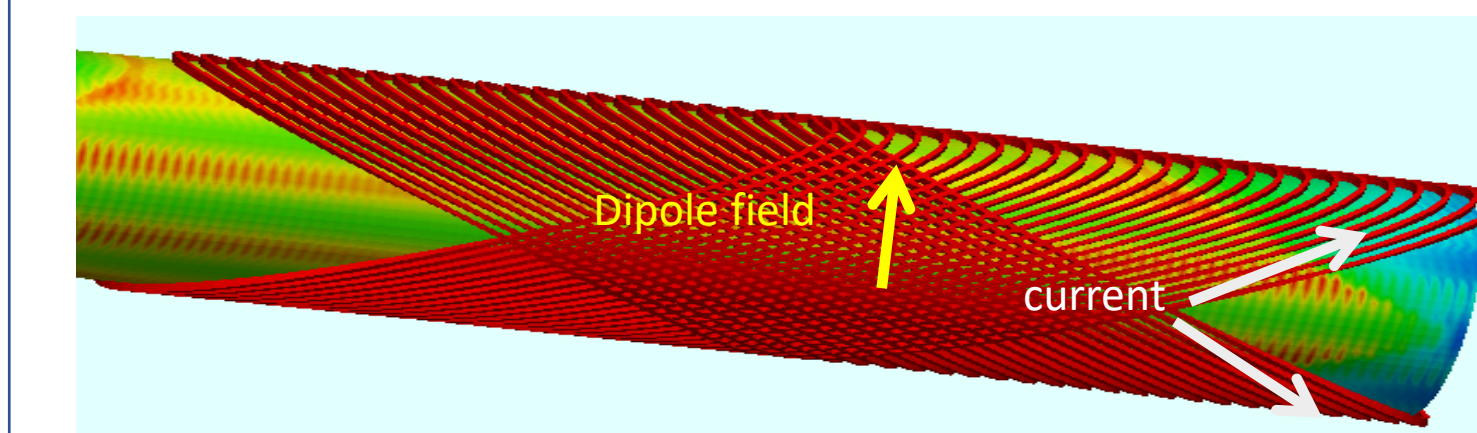
10 MGy and 20 MGy samples at QST.

- 100 MGy experimental time secured for 2019/2020, and samples prepared.



Field quality of REBCO cable dipole magnet

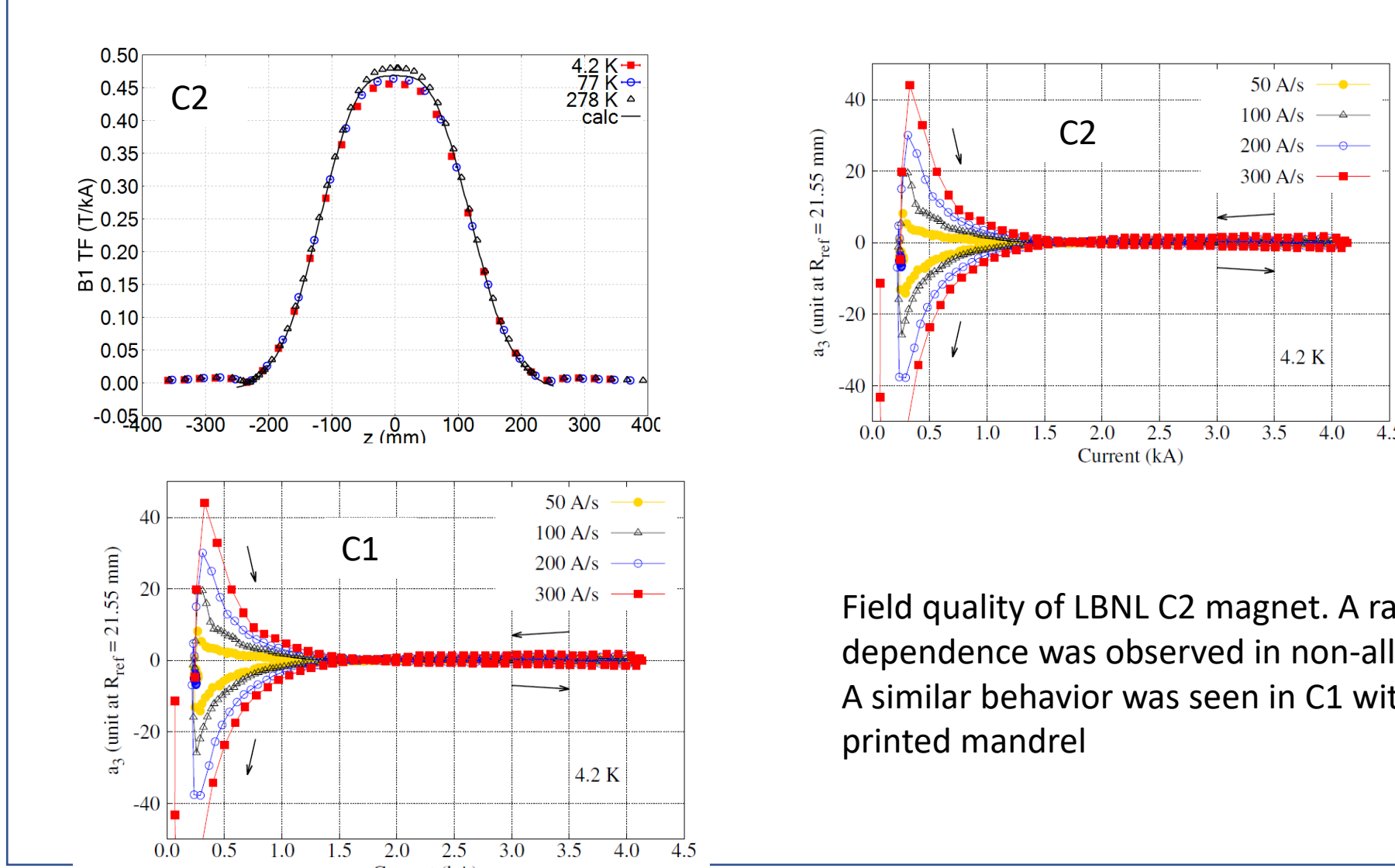
Canted cosine theta dipole magnet concept



REBCO CORC Canted cosine theta dipole magnet demo



REBCO CORC Canted cosine theta dipole magnet C2 field quality



Field quality of LBNL C2 magnet. A ramp-rate dependence was observed in non-allowed skew terms. A similar behavior was seen in C1 with the plastic printed mandrel

4-layer 65 mm Canted-Cosine-Theta dipole magnet made from REBCO CORC at LBNL achieved 3 T at 4 K and its field quality measured at LBNL and being modeled at Kyoto Uni.

Acknowledgements

The work at LBNL was supported by the Director, Office of Science of the US Department of Energy (DOE) under Contract no. DE-AC02-05CH11231

References

- D. X. Fischer, R. Prokopec, J. Emhofer and M. Elsterer, "The effect of fast neutron irradiation on the superconducting properties of REBCO coated conductors with and without artificial pinning centers," Superconducting Science and Technology, vol. 31 044006, 2018.
- E. Suhir, An Approximate Analysis of Stresses in Multilayered Elastic Thin Films, J. Applied Mechanics, 1988
- S. Yin et al., Degradation of REBCO coated conductors due to a combination of epoxy impregnation, thermal cycles, and quench: Characteristics and a method of alleviation, J. Appl. Phys., accepted, 2020

Contact

Christopher Reis
reisch@lbl.gov
(850)-597-0741

It's an exciting time for HTS magnet technologies with several crucial studies supported by US-Japan collaboration. We appreciate your continued support!

