‘Little Big Coil:’ A Skunkworks Program for >50 T Superconducting Magnets

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Superconducting coils based on REBCO (rare earth barium copper oxide) can generate magnetic fields above 50 T—*in theory.* In practice, REBCO contains manufacturing defects and property variations which produce emergent coil behavior and unexpected mechanical failures at lower fields.

Little Big Coils (LBCs) are ultra-compact REBCO magnets designed to probe for this emergent behavior. Each LBC is tested within the 31 T background field at the National High Magnetic Field Laboratory (NHMFL), which enables LBCs to access the regime of ultra-high electromagnetic stress (>800 MPa) using relatively little REBCO. This economical usage allows the entire coil to undergo comprehensive materials characterization at NHMFL’s Applied Superconductivity Center (ASC) and for REBCO from different manufacturers to be rapidly evaluated, thereby facilitating the correlation of different coil failure modes with the unique properties (critical current, irreversibility strain, yield stress, etc.) of different REBCO batches.

50 T magnets may finally be within striking distance. This past August 2025, LBC9 generated 48.7 T, blowing past its predecessor (LBC3, 45.5 T) and establishing a new world record field generated by a superconducting coil. We are presently upgrading the LBC design so that the next coil test may achieve 50 T. Our goal is to lay the groundwork for a new generation of ultra-high-field superconducting magnets for scientific user and societal applications (NMR, MRI, particle accelerators, fusion power plants, etc.).

Facilities and instrumentation used: 31 T Bitter Magnet (NHMFL - cell 7), a 15 T 2-inch bore Oxford magnet, in-house magnetization mapper, and other ASC devices/machines

Citation: **[1]** Hahn, S. at al, Nature, 570 (7762), 496+ (2019) 10.1038/s41586-019-1293-1; **[2]** Jan, J. et al, Scientific Reports, 14 (1), 31703 (2024) 10.1038/s41598-024-81902-0; **[3]** Bang, J. et al, Superconductor Science and Technology, 35 (9), 095009 (2022) 10.1088/1361-6668/ac8318; **[4]** Bang, J. et al, Superconductor Science and Technology, 37, 095011 (2024) 10.1088/1361-6668/ad6a9d; **[5]** Lee, J. et al, IEEE Transactions on Applied Superconductivity, 35 (5), 1-5 (2025) 10.1109/TASC.2024.3505115

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Figure 1. Little Big Coil 9, with Dr. Bang for scale, generated a world-record 48.7 T field in August 2025. His coil generated an extra 17.7 T on top of the 31 T MagLab Bitter Magnet to achieve the record.

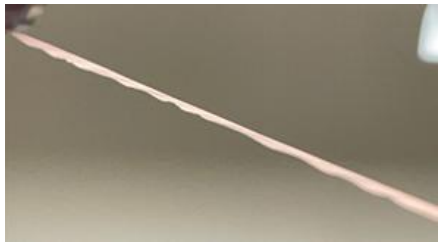

Figure 3. Post-mortem analysis of LBC tape reveals conductor waviness evidence of severe plastic overstress damage which can crack the REBCO and lead to local degradation. But still - the coil carried current!

Stress distribution in the windings

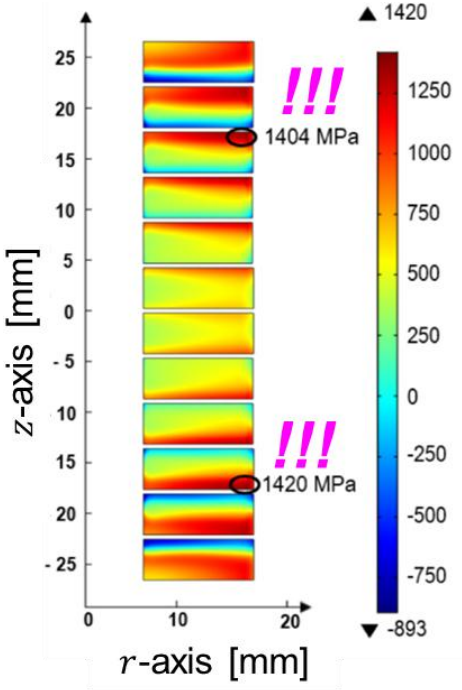

Figure 2. Extraordinarily high stress of more than 1 GPa yields the very strong superalloy substrate on which the superconducting REBCO layer is grown, cracking it and limiting the field.

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