SuperPower Inc.

2G HTS High Field Magnet Demonstration

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MAGNET LAB
NATIONAL HIGH MAGNETIC FIELD LABORATORY
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Providing HTS Solutions for a New Dimension in Power – TODAY!

Acknowledgements

SuperPower, Inc.

- Jason Duval, Venkat Selvamanickam, Yi-Yuan Xie
- …and the rest of the SuperPower Team
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National High Magnetic Field Laboratory / FSU

- Zhijun Chen, David Larbalestier, Denis Markiewicz, Ed Miller, Patrick Noyes, Ken Pickard, Ulf Trociewitz, and Huub Weijers
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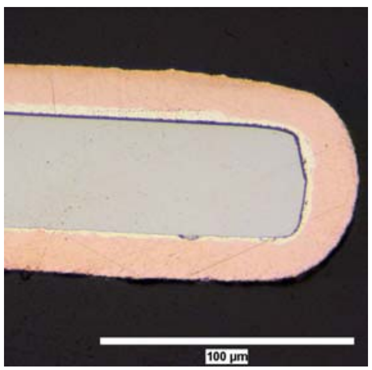
SuperPower's 2G wire utilizes high strength substrates coupled with high throughput processing

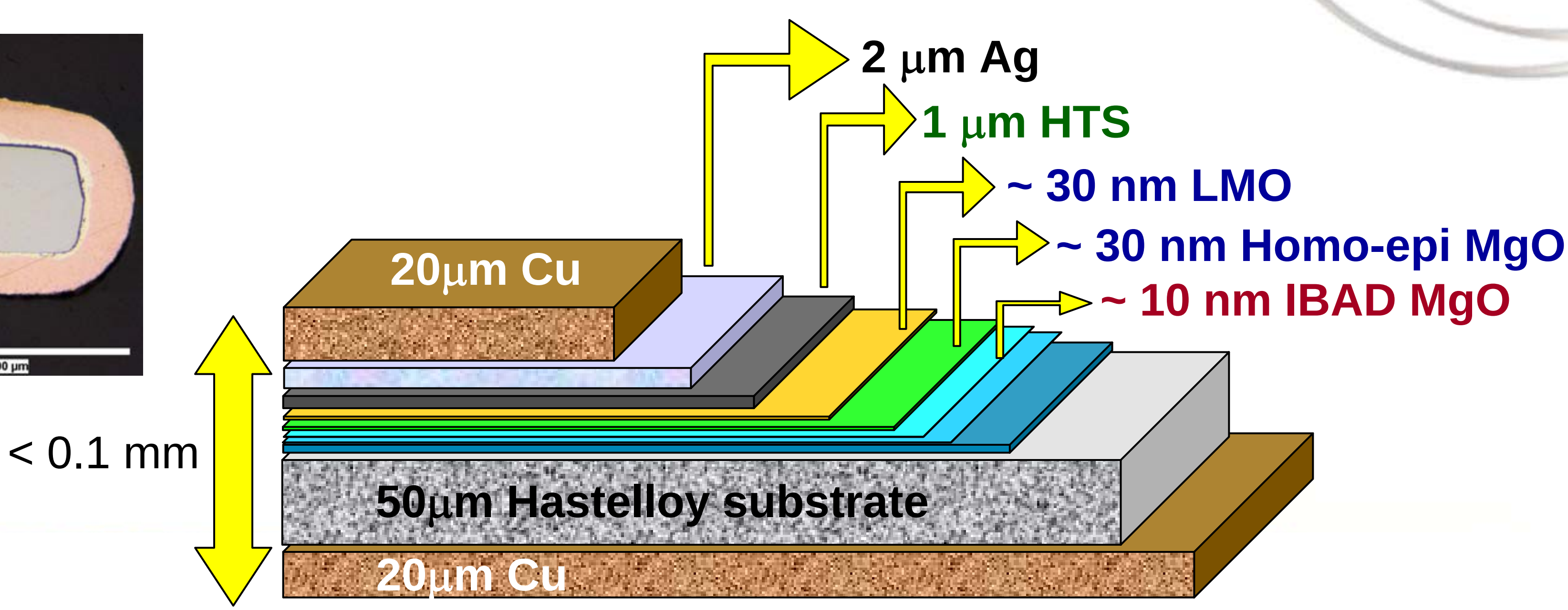
SuperPower's 2G HTS wire is based on high throughput IBAD MgO and MOCVD processes.

Use of IBAD as buffer template provides us choice of any substrate.

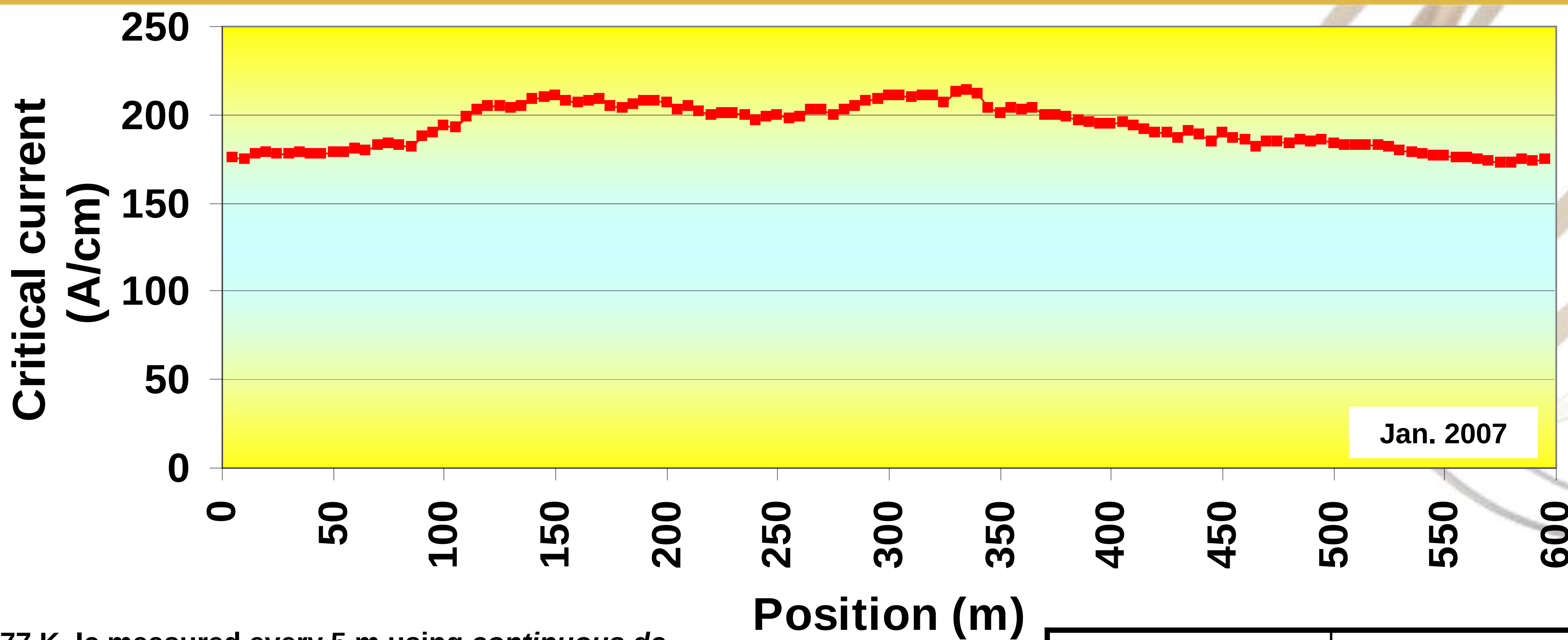
- Advantages of IBAD are high strength, low ac loss (non-magnetic, high resistivity substrates) and high engineering current density (ultra-thin substrates)

High throughput is critical for low cost 2G wire and to minimize capital investment.





Long length processing of 2G wire demonstrated



77 K, Ic measured every 5 m using *continuous dc currents over entire tape width of 12 mm (not slit)*

Minimum Ic = 173 A/cm over 595 m

Ic × Length = 102,935 A-m

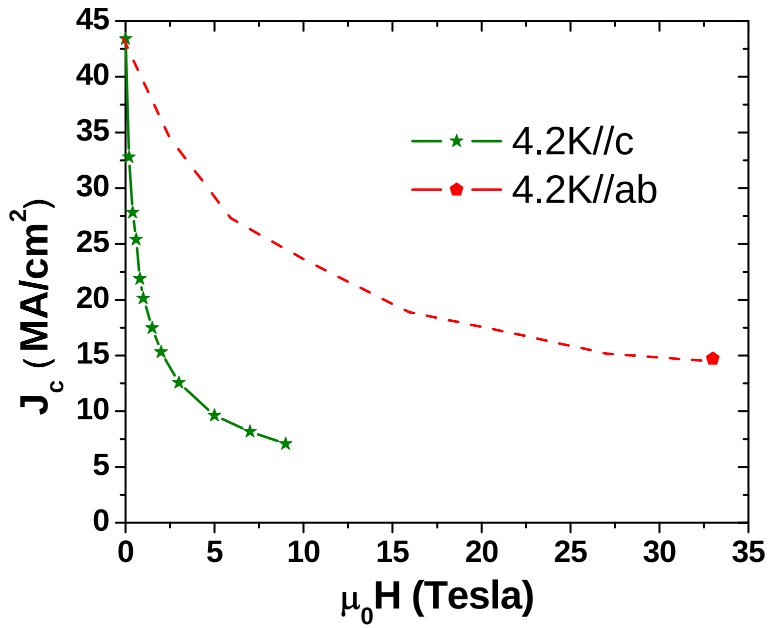
Uniformity over 595 m = 6.4%

Process (single pass)	Speed of 4 mm tape (m/h)
IBAD MgO	360
Homo-epi MgO	213
LMO	360
MOCVD	135

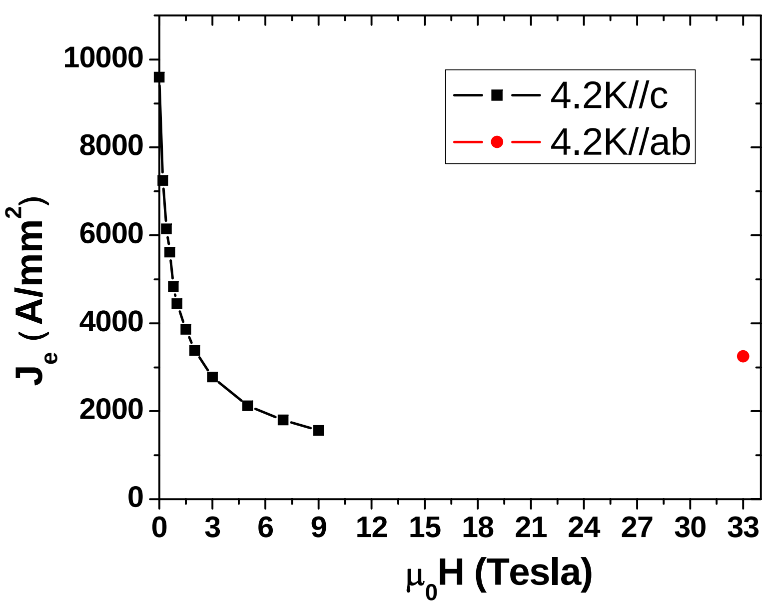
Critical current properties of the 2G wire make it ideal for lower temperature, high field applications

Data (solid figures) taken on bridge sample.

Dashed red line is hypothetical curve.



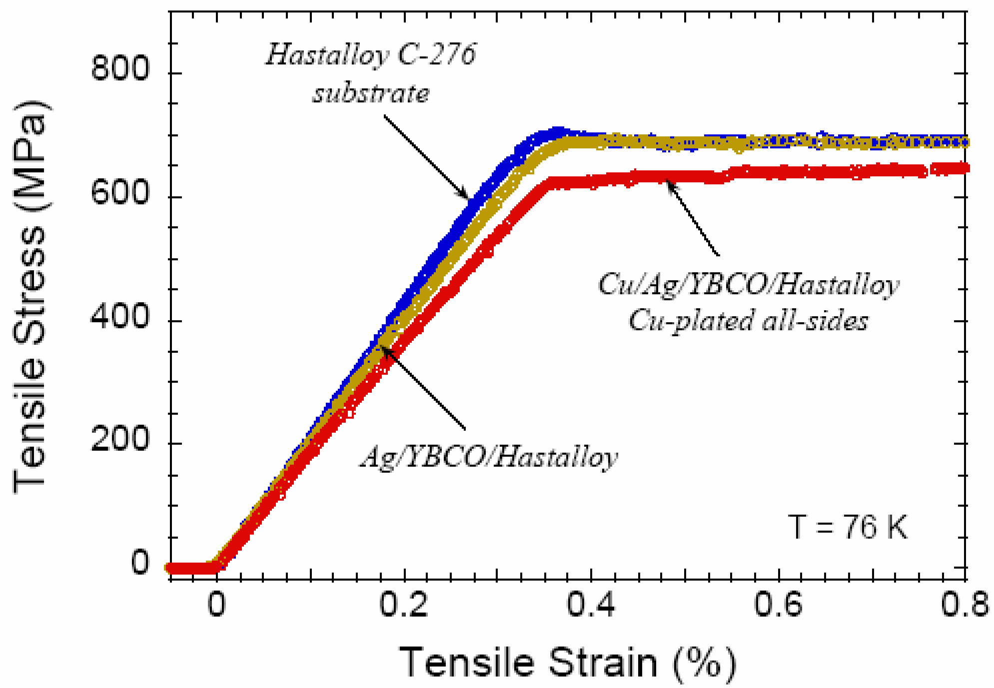
Superconductor critical current density



Conductor critical current density thickness ~ 95 μm

Data by Z. Chen at NHMFL / FSU (2007)

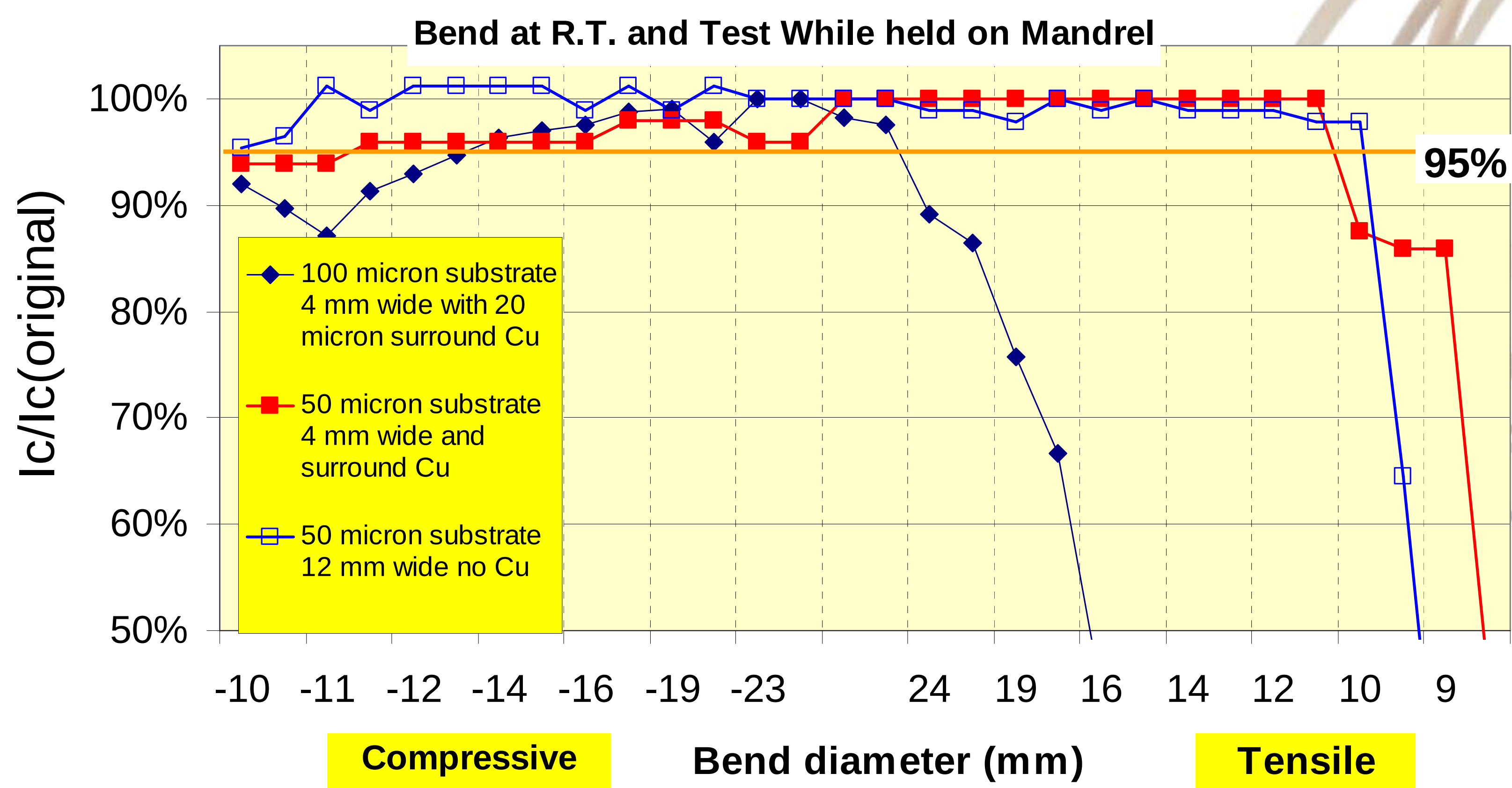
Mechanical properties of 2G wire are ideal for high stress applications



Stress-strain traces for SuperPower 2G YBCO at 76K. Included are a trace of the base substrate material, Hastelloy C276 which dominates the conductor mechanical properties. Note the impact of copper stabilizer which slightly lowers the overall composite strength.

Measurements conducted at NIST by Ekin et al (2004)

50 micron substrate tape shows superior bend strain characteristics



Maximum Bend Strain = +/- t / D ~ 95 μm / 11000 μm = 0.86 % (~ 0.45 % on the YBCO)

High field insert coil construction

Conductor:

Dimensions: 4 mm wide x
95 microns thick

Substrate: 50 micron Hastelloy

HTS: ~ 1 micron YBCO

Stabilizer: ~ 2 micron Ag on YBCO

~ 20 microns of surround copper stabilizer per side

Tape Ic 72 – 82 A, 77 K, sf

Coil Winding

Double Pancake Construction

Dry Wound (no epoxy)

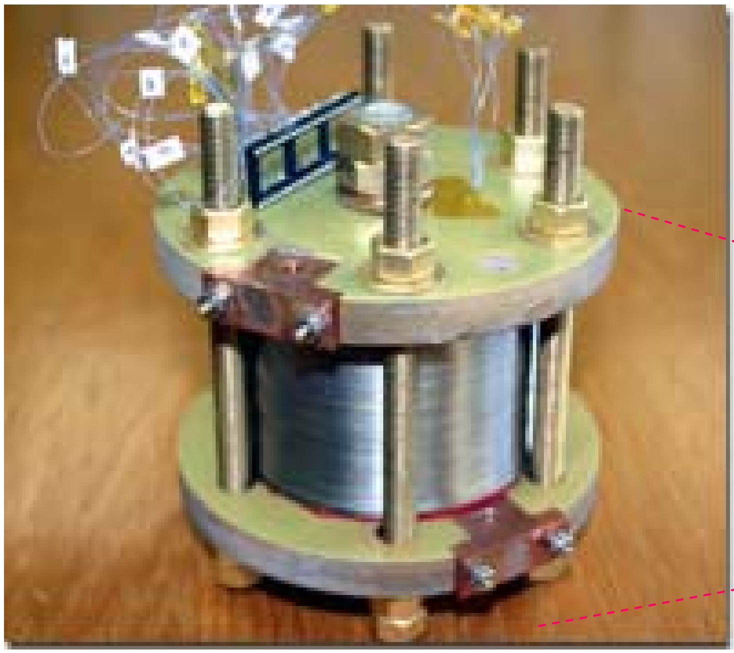
Kapton polyimide insulation (co-wound)

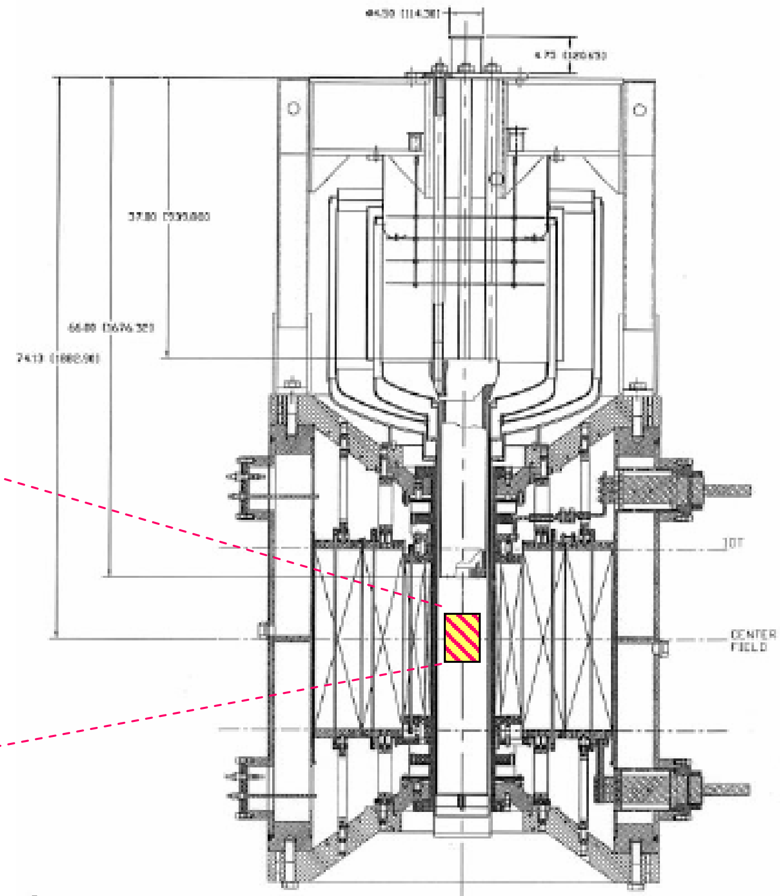
Overbanding: 316 Stainless Steel

Coil ID	9.5 mm (clear)
Winding ID	19.1 mm
Winding OD	~ 87 mm
Coil Height	~ 51.6 mm
# of Pancakes	12 (6 x double)
2G tape used	~ 462 m
# of turns	~ 2772
Coil Je	~1.569 A/mm^2 per A
Coil constant	~ 44.4 mT/A

NHMFL facilities provide 19T axial background field

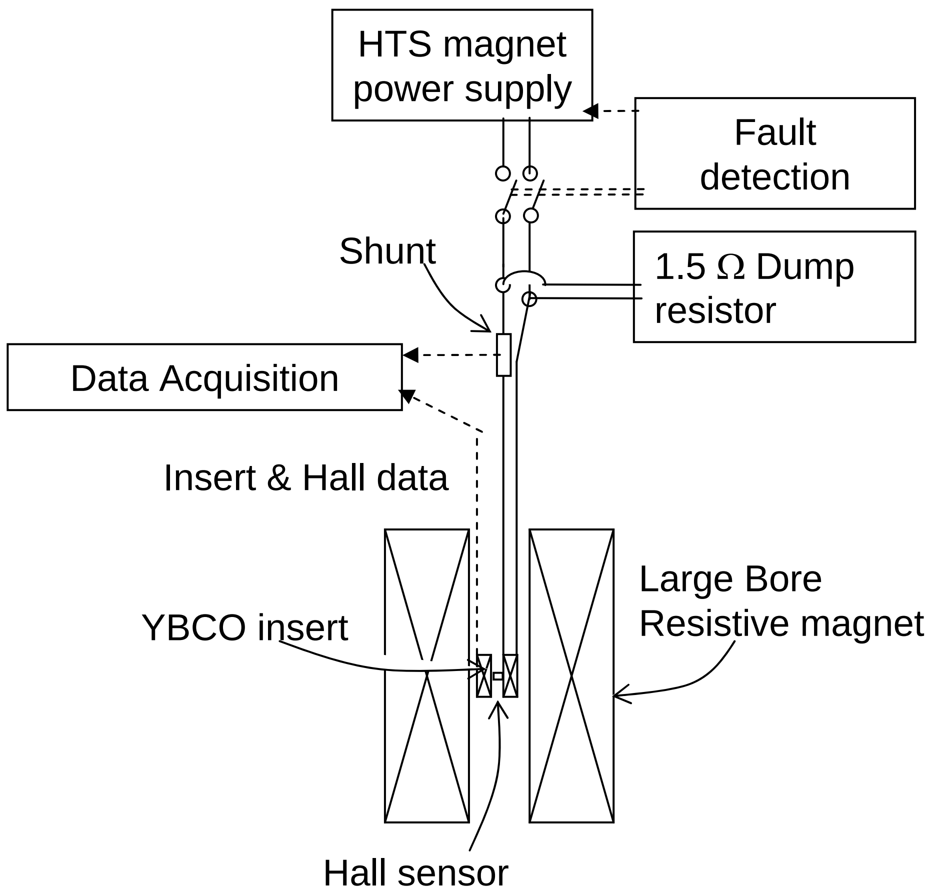
Insert coil tested in NHMFL's unique, 19-tesla, 20-centimeter wide-bore, 20-megawatt Bitter magnet



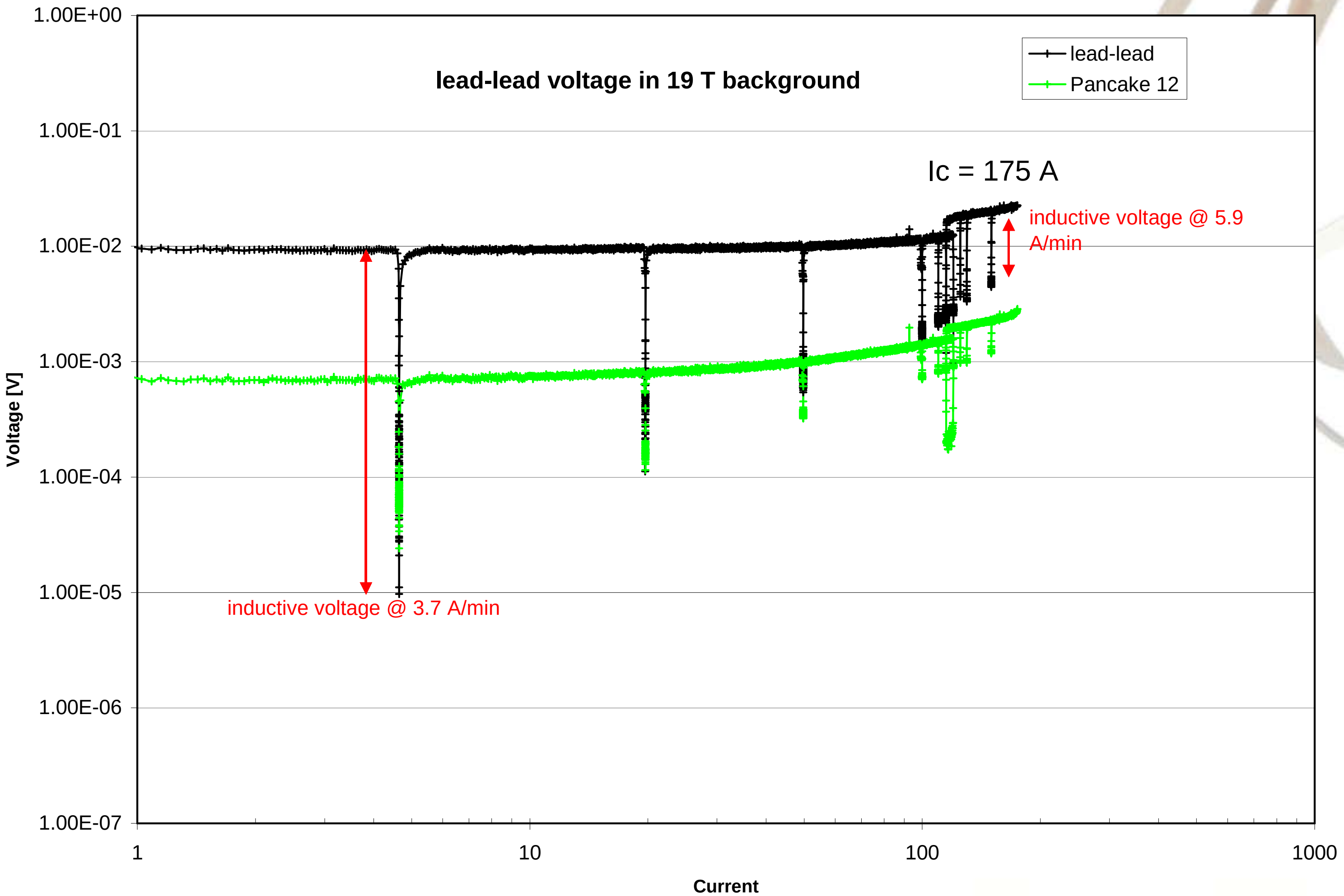


2G HF Insert Coil Showing Terminals, Overbanding and Partial Support Structure. Flange OD is 127 mm.

Test setup at NHMFL

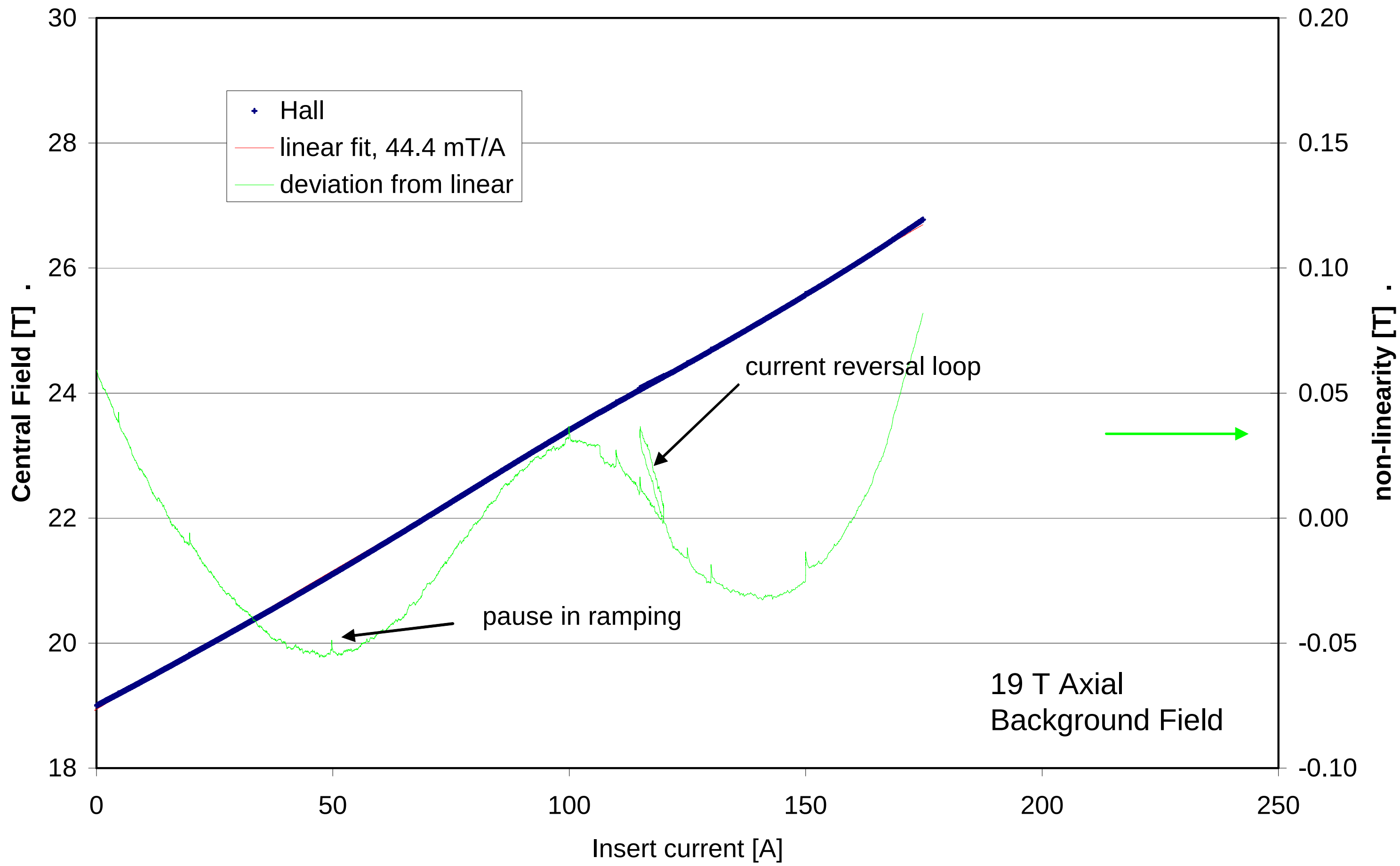


Typical V-I trace (19T background field)



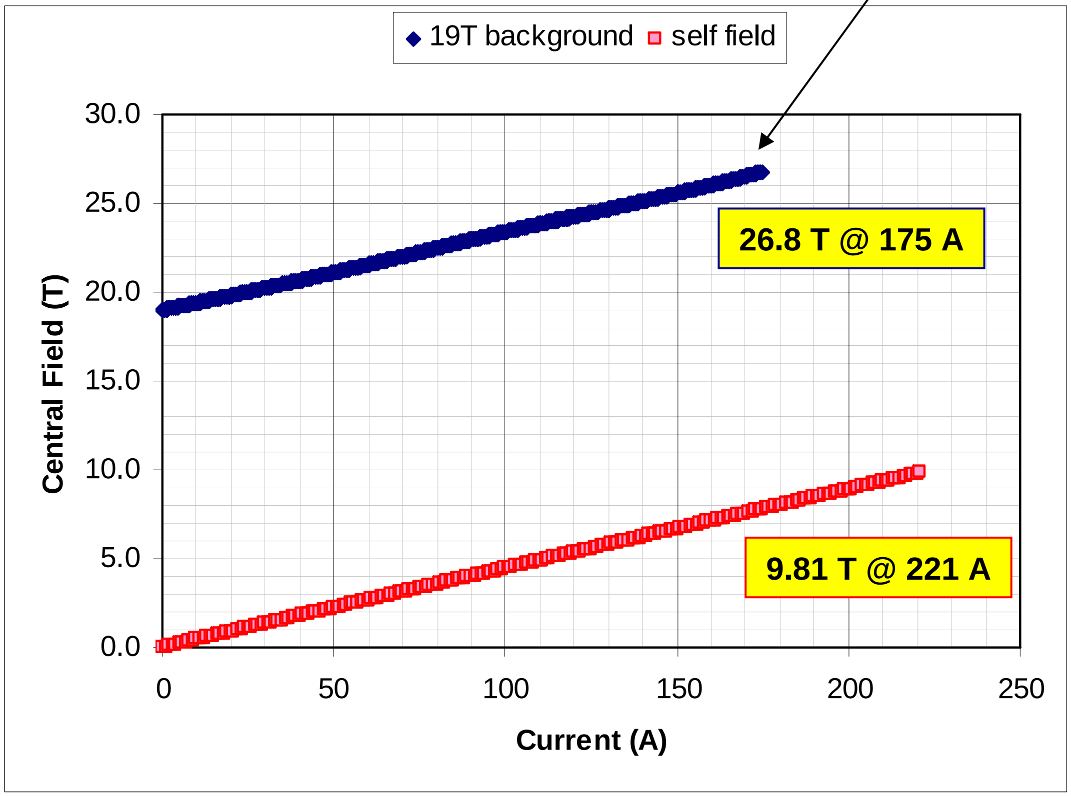
Hall probe data shows linear field generation

Hall probe signal showing non-linearity of sensor and near-perfect field generation by insert



High field insert coil achieves world records for highest HTS field, highest magnetic field by a SC magnet

Peak hoop stress ~ 215 MPa, well below tape limit



Ic of Tapes in Coil	72 A – 82 A (77K, sf)
4.2 K Coil Ic - self field	221 A
4.2 K Amp Turns @ Ic-self field	612,612
4.2 K Je @ Ic, self field	346.7 A/mm^2
4.2K Peak Radial Field @ Ic, self field	3.2 T
4.2 K Central field – self field	9.81 T
4.2 K Coil Ic – 19 T background (axial)	175 A
4.2 K Amp Turns @ Ic – 19 T background (axial)	485,100
4.2 K Je @ Ic, 19 T background (axial)	274.6 A/mm^2
4.2 K Peak Radial Field @ Ic, 19 T bkgd (axial)	2.7 T
4.2K Central Field – 19 T background (axial)	26.8 T

Summary

- We have not reached the limit of 2G HTS wire capability
- Coil performance limited by operation of Pancake 12
- Stress limit on the wire still has significant margin

  Hoop stress ~ 215 MPa vs. ~ 600 MPa limit

- 2G HTS wire with 50 micron Hastelloy substrate enables high winding pack Je
- 2G HTS wire is available in lengths and quantity to enable development in high field magnet design and construction
- 30 T (and beyond) is within our grasp……

Questions?

Thank you for your interest!

For further information about SuperPower and to see the coil,

please visit us at Booth No. 5

or at:

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or e-mail: info@superpower-inc.com