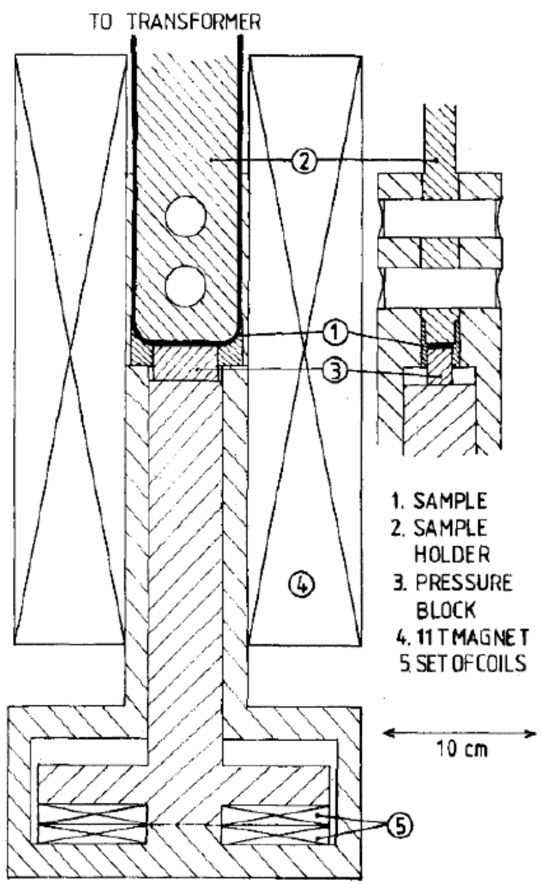

Figure 1: Schematic view of the press [1].

Investigation of what cable and strand used in the University of Twente's 2020 Bi-2212 cable test

Tengming Shen

Lawrence Berkeley National Laboratory

[1] H. Boschman, A. Verweij, S. Wessel, H. ten Kate and L. van de Klundert, "The efffect of transverse loads up to 300 MPa on the critical currents of Nb3Sn cables," *IEEE Transactions on Magnetics*, pp. 1831-1834, 1991.

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Technical Note	
document	TN07 UT-CERN-K2007/TE
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Transverse-pressure response of the critical current in a Bi-2212 cable

Research and Development on Superconductors and Magnet Technology for Next Generation Accelerators

- **Marc Dhalle sent a report "20200814 Draft Bi-2212 cable report v2-2" on 08/14/2020. It describes the test results of the transverse pressure dependence of a Bi-2212 Rutherford cable at 4.2 K as part of the EuCARD2 program. We didn't know what cable and strand were used.**

- **Searched emails and found an email from Eric Hellstrom that shows the cable ID and from there I found presentations from Emanuela Barzi about the cable and the strand.**

Rutherford cable at ASC for OP heat treatment

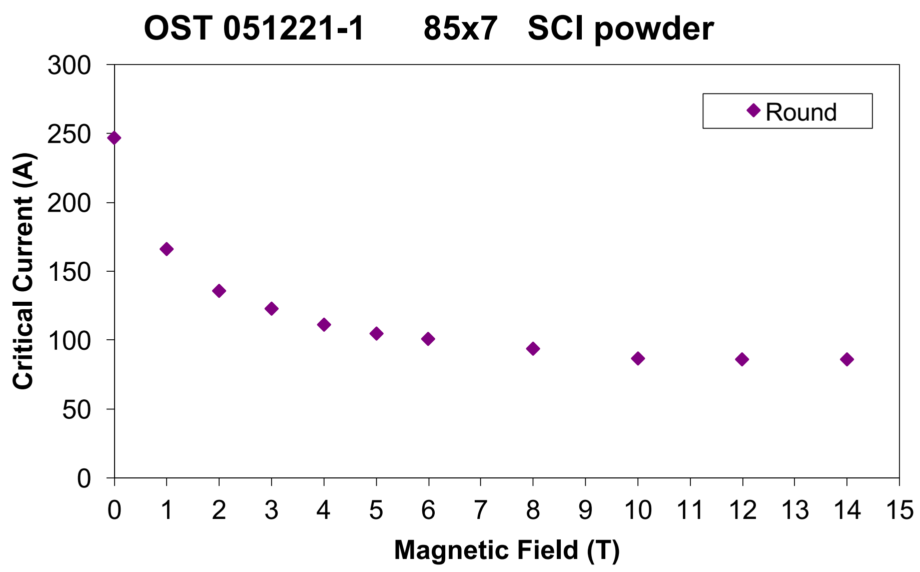
Eric Hellstrom

Sept. 19, 2016

Details of the Rutherford cable we have from Arno Godeke for the CERN/Twente experiments

The cable is R&DT 090520_24_0. The strand is a CDP strand PMM051221, SCI powder, 85x7 design.

CABLE ID	No. Strands	Strand Size mm	Ave. Thickness mm	Ave. Width mm	Lay Angle deg.	Packing Factor %	Length m
R&DT_090520_24_4	24	0.8007	1.507	10.22	15.3	81.5	12
(PMM051221)	24		1.488	10.19	15.2	82.5	8
	24		1.449	10.13	15.2	84.9	8
	24		1.414	10.09	15.4	87.7	8.6



1 bar reaction by OST, I_c measurement by Fermilab.

Another search found that this same strand was used to fabricate the LBNL HTS-SC04 and SC06.

Supercond. Sci. Technol. **23** (2010) 034022 A Godeke *et al*

Table 3. Summary of witness sample I_c values, measured on stainless-steel barrels with the wires soldered to the barrels.

Coil ID	Applied field (T)	I_c at 10^{-5} V m^{-1} (A)	n-value	Total field (T)[a]	I_c at 10^{-4} V m^{-1} (A)[b]
HTS-SC04	0	66	6	0.05	96
	4	29	6	4.02	44
	8	24	5	8.02	37
	12	21	6	12.02	32
	14	21	5	14.02	31
	15	20	5	15.01	30
HTS-SC06	0	181	18	0.10	206
	4	76	14	4.04	89
	6	63	13	6.04	76
	12	53	12	12.03	63
HTS-SC08	6	131	18	6.07	149
	12	110	16	12.06	127

[a] Using a self-field correction of 4.94×10^{-4} T A^{-1} and the 10^{-4} V m^{-1} I_c value.
[b] Calculated from the 10^{-5} V m^{-1} I_c and n-value.

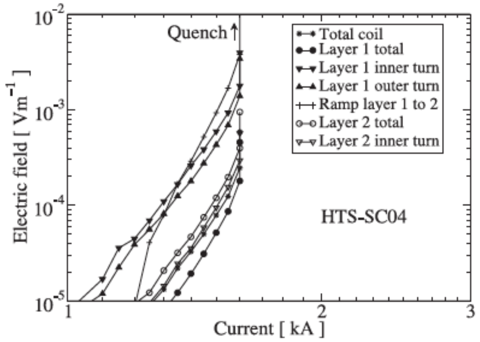


Figure 4. Electric field as a function of current during a DC I_c test of coil HTS-SC04 at 4.2 K.

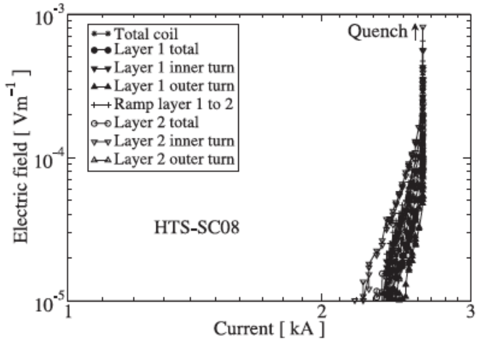


Figure 6. Electric field as a function of current during a DC I_c test of coil HTS-SC08 at 4.2 K.

Supercond. Sci. Technol. **23** (2010) 034022

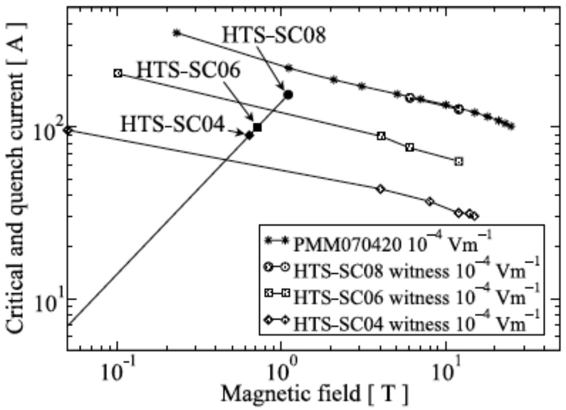


Figure 7. Comparison of coil performance and the witness sample $I_c(B)$ data. The points are measured and the lines are a guide to the eye.

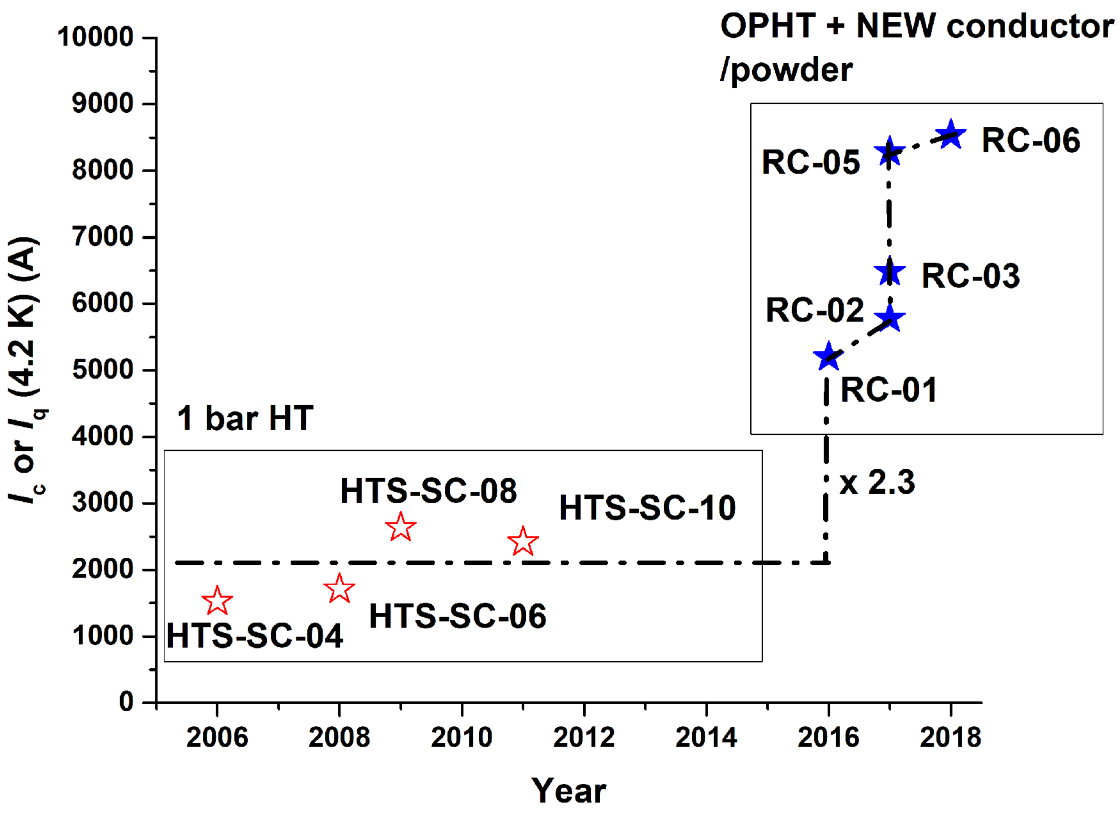
Table 4. Summary of coil I_c values at 10^{-4} V m^{-1} and $T = 4.2$ K.

	HTS-SC04		HTS-SC06		HTS-SC08	
	I_c (A)	n-value	I_c (A)	n-value	I_c (A)	n-value
Total coil	1526	14	1711	17	2636[a]	—
Layer 1 total	1564	16	1702	17	2636[a]	—
Layer 1 inner turn	1290	11	1580	14	2608	23
Layer 1 outer turn	1323	10	1740[b]	19	2636[a]	—
Ramp layer 1 to 2	1319	17	1635[c]	15	2589	24
Layer 2 total	1481	14	1727	17	2636[a]	—
Layer 2 inner turn	1506	14	—[a]	—	2557	18
Layer 2 outer turn	—[d]	—	1738[b]	18	2636[a]	—

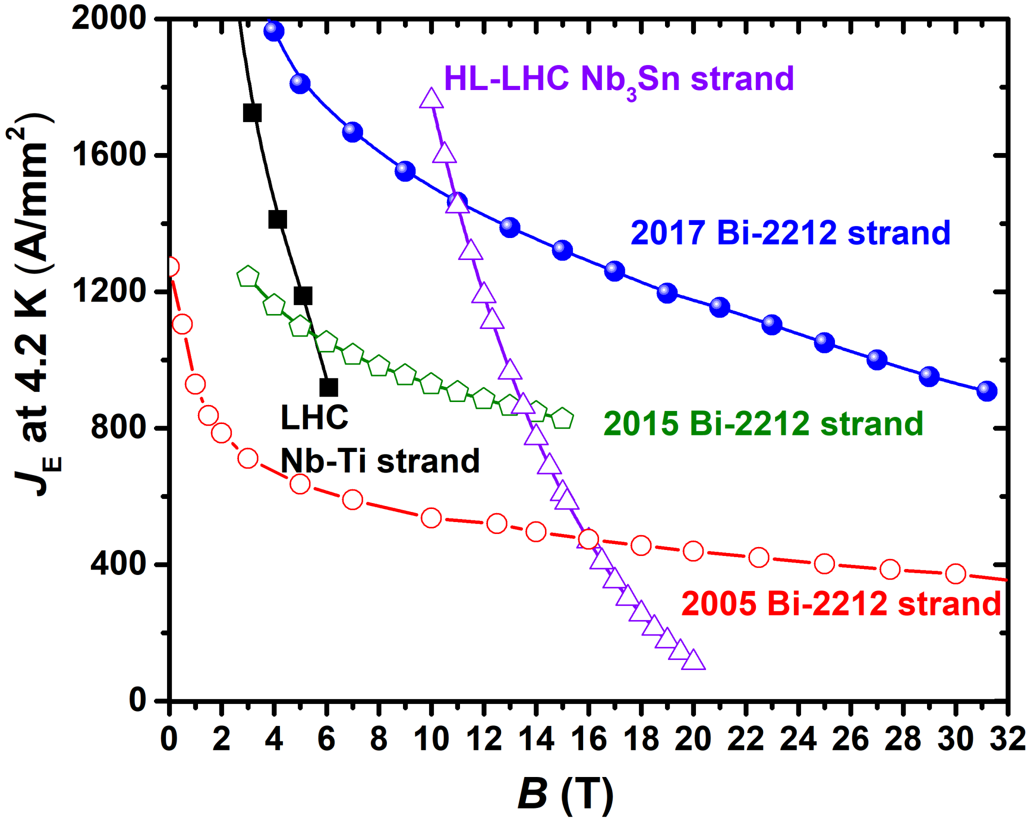
[a] Quench value. [b] Outer two turns.
[c] Transition and coil 2 inner turn combined. [d] Open contact.

The strand used is ‘old’.

LBNL’s subscale racetrack coil

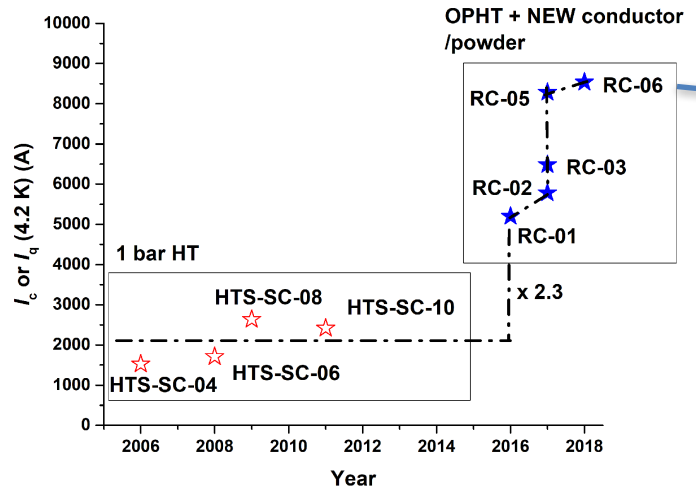


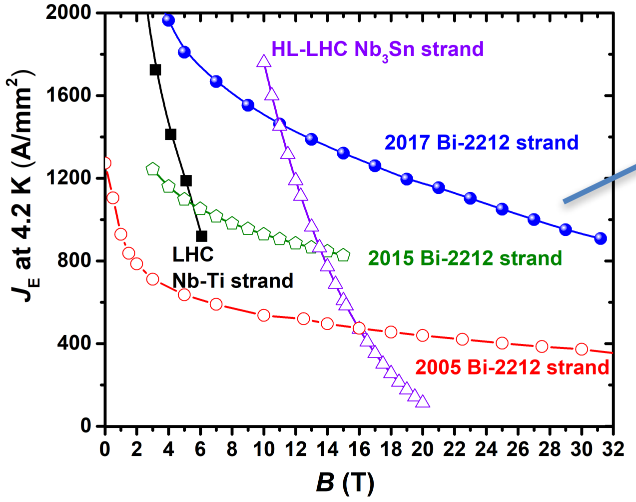
Record performance 2212 strand since 2005



T. Shen, L. Garcia Fajardo, Instruments 4 (2), 17 (2020); **T. Shen et al. Sci. Rep.,** 9 (1), 1-9 (2019).
J. Jiang et al., IEEE TAS, 29, 6400405, (2019)
K. Zhang et al., Superconductor Science and Technology 31 (10), 105009

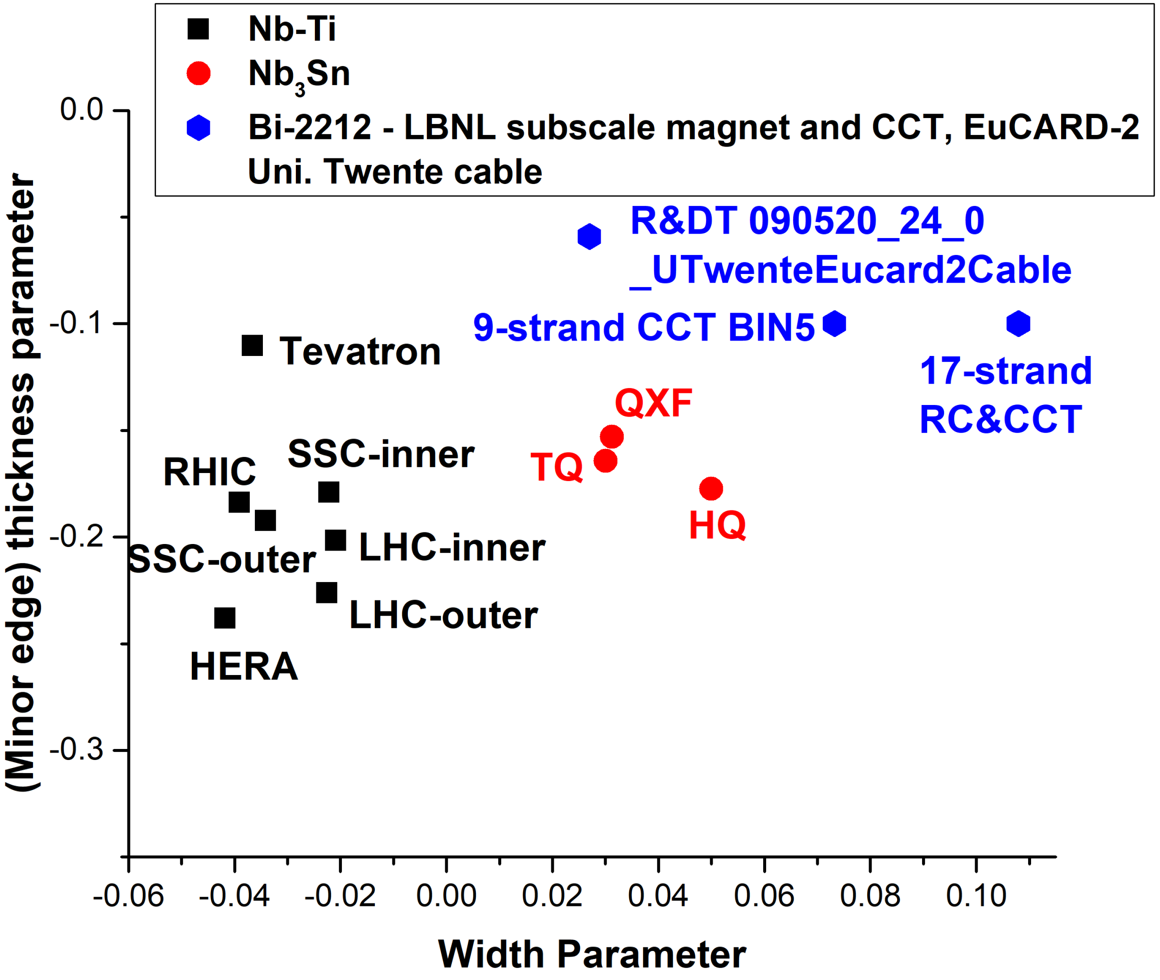
A 4.5 m record performance cable is reserved for future cable transverse pressure tests





Cable	LBNL-1088
Width (mm)	7.8
Thickness (mm)	1.44
Number of strands	17
Pitch length (mm)	58
Insulation	Mullite sleeve
Insulatoin wall thickness (mm)	0.15
Strand	PMM170123
Manufactuer	Bruker OST LLC
Power	LXB52
Power manufactuer	nGimat (now Engi-Mat)
Strand I_c (4.2 K, 5 T) abfter NHMFL 50 bar OPHT (A)	500-900
Strand diameter - before reaction (mm)	0.8
Strand diameter - after reaction (mm)	0.778
Twisting	No

Zoom out – 2212 Rutherford cable engineering is not optimized yet. Your transverse pressure experiment will play a key role.



IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, VOL. 17, NO. 2, JUNE 2007 1481

Cable R&D for the LHC Accelerator Research Program

Daniel R. Dietderich, Emanuela Barzi, Arup K. Ghosh, Nathan L. Liggins, and Hugh C. Higley

III. Cable Parameter Determination

LBNL has developed a simple empirical formula for determining an acceptable cable dimensions for the odd strand configuration. This strand configuration in Fig. 1 is the widest section of the cable and it is from this that the ideal "theoretical width" (W_{th}) is calculated in (1). The input for this calculation is the number of strands in the cable (N), the strand diameter (d), and the cable pitch angle (PA) [2]. The Width Parameter (WP) for a cable is defined by (2).

$$W_{th} = d * (N/2) * [\text{Cosine}(PA)]^{-1} \quad (1)$$

$$WP = (w - W_{th})/W_{th} \quad (2)$$

A value of $WP > 0$ means that a cable has been fabricated wider than its theoretical width and the opposite is true for values of WP less than zero.

U.S. MAGNET DEVELOPMENT PROGRAM

U.S. DEPARTMENT OF ENERGY | Office of Science

Summary

- **The cable is a 24-strand, 10.22 mm x 1.507 mm cable made at the Fermilab.**
- **The strand is a 2005 CDP strand with SCI powder. It is old, and two generations behind.**

- **But thank you so much for your work. We now know more about the transverse pressure dependence of Bi-2212 Rutherford cables, and the operation mechanical limits of high-field Bi-2212 magnets.**

EuCARD²

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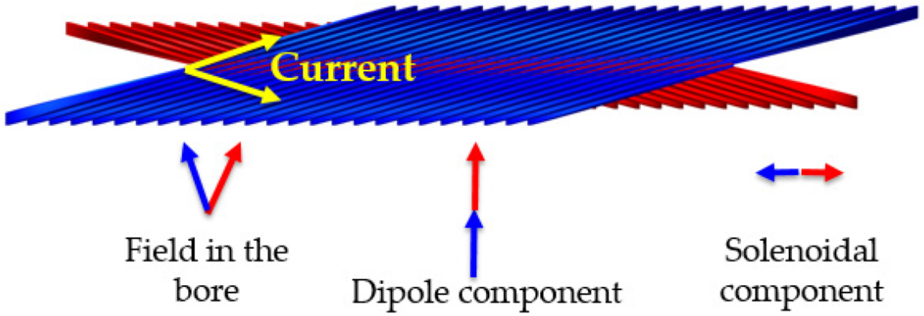
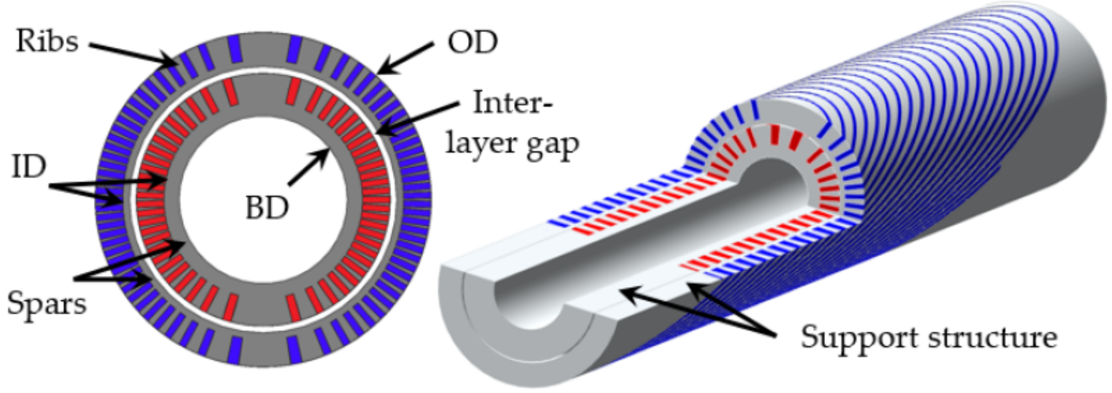
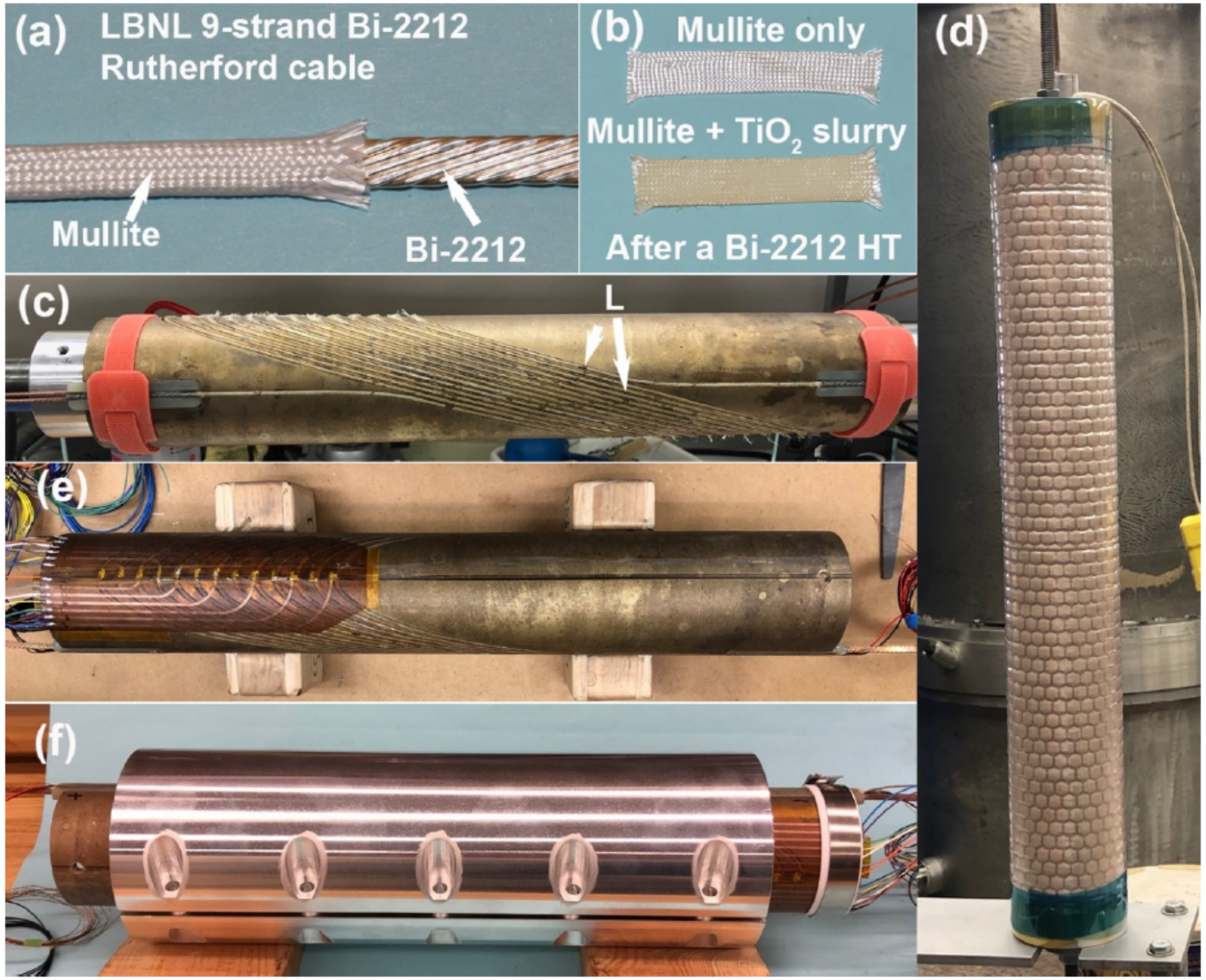
- **Back up slides.**

- **Bi-2212 accelerator magnet engineering is moving out of its infancy.**

CCT design now has gone through several prototype coils, including BIN5a and BIN5b that were reacted at the NHMFL

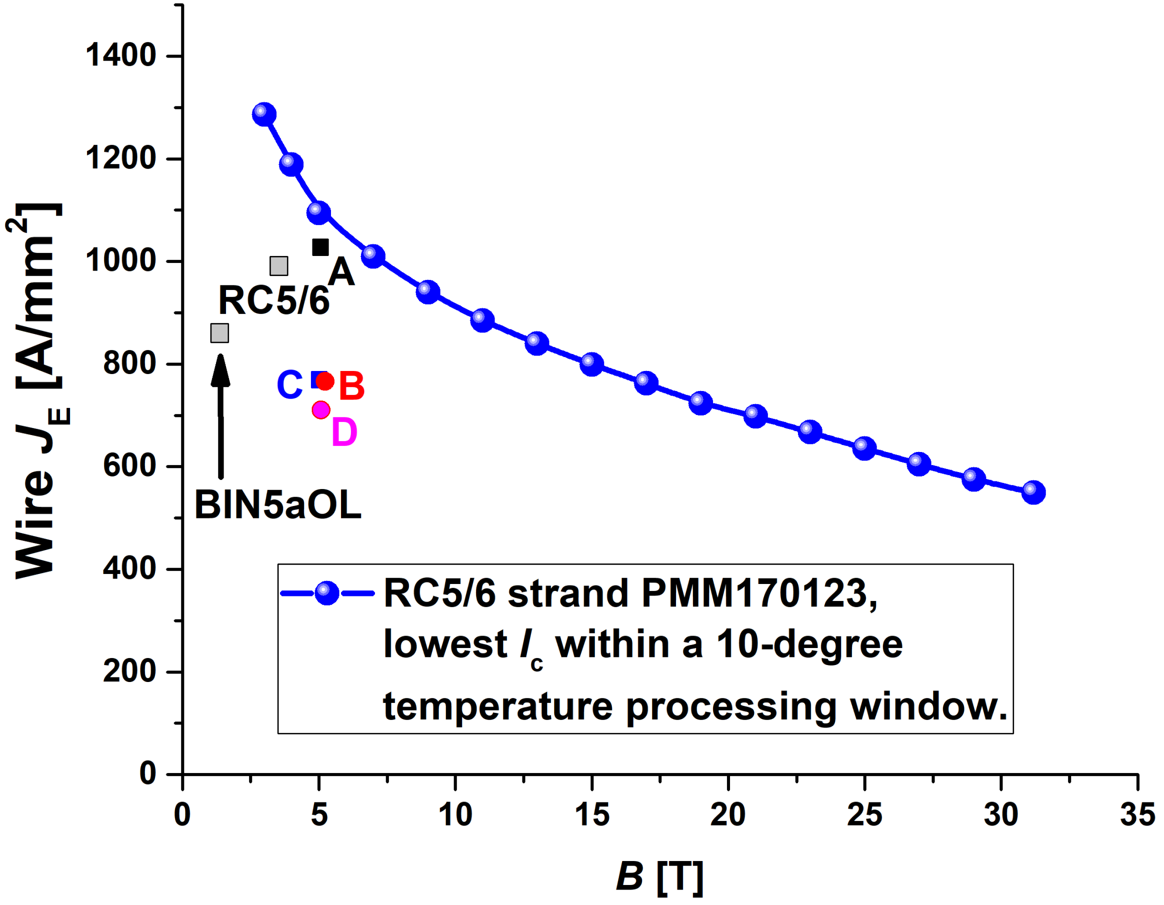






T. Shen, L. Garcia Fajardo, Superconducting Accelerator Magnets Based on High-Temperature Superconducting Bi-2212 Round Wires, *Instruments* **2020**, *4*(2), 17; https://doi.org/10.3390/instruments4020017

5 T/14.6 T, ~1 m long CCT Bi-2212 dipole magnet in design phase



A, B, C, D are working points of four potential ~1 m long CCT dipole magnets (standalone 5 T, and 14.6 T in 11 T Nb_3Sn background magnets (SSL – 15.9 T)).

New cable designs for B,C,D.

Compared to the record wire J_E