MCTF

HTS Collaboration

A work in Progress

- **The development of NbTi and Nb_3Sn based magnets has happened thru a very successful collaboration between the University Community, the National Labs and the Conductor Manufacturers. The High Temperature Superconductors operated at LHe temperature offer new and exciting opportunities for magnet design.**
- **The HTS Collaboration is being formed to develop and exploit these possibilities:**
  - **High field solenoids, dipoles, and quadrupoles for HEP**
  - **NRC panel COHMAG (Committee on High Magnetic Field Research and Technology) set 30 T goal for new NMR and magnets used in scientific studies.**

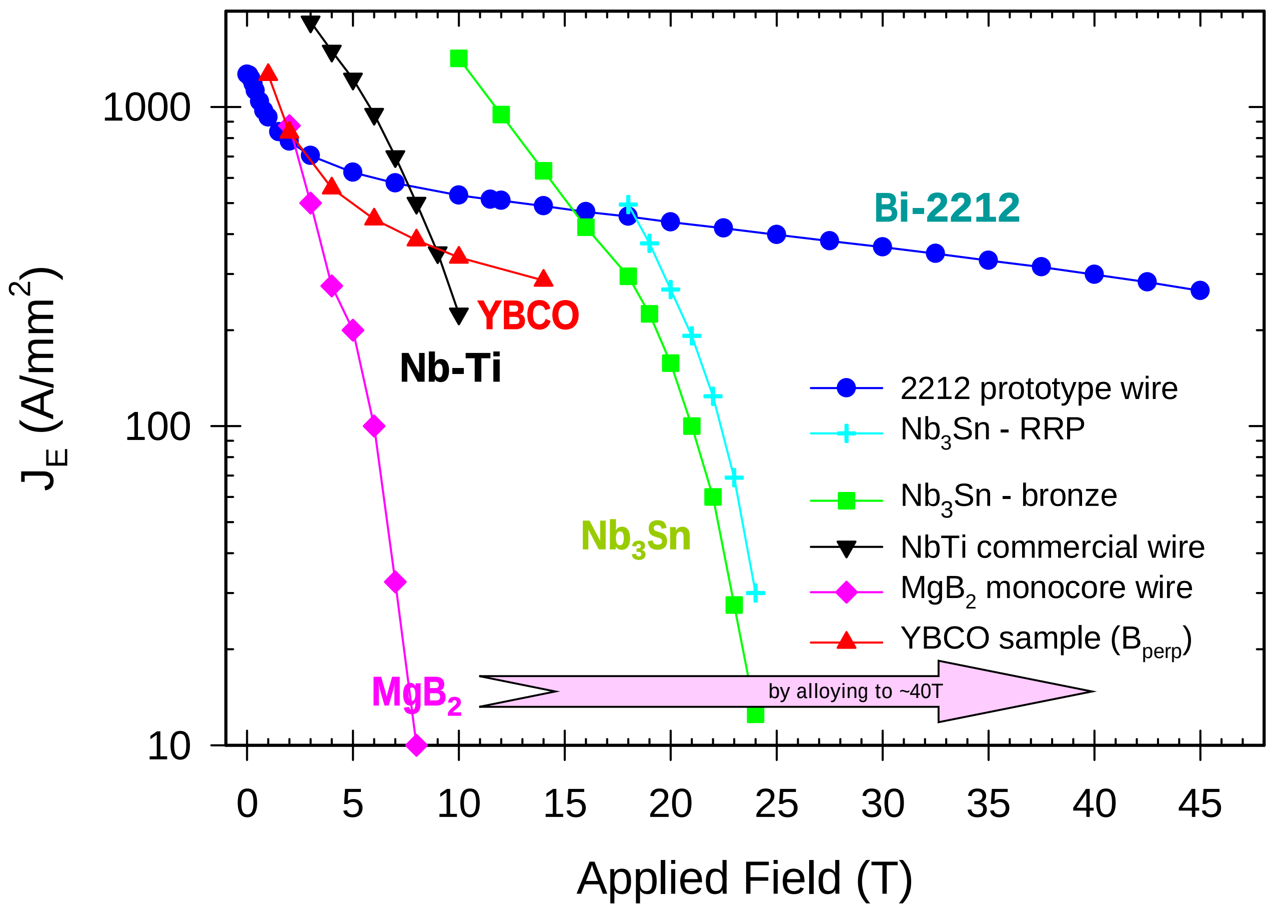
Proposed HTS Collaboration

- We are proposing an organization similar to NFMCC or LARP to develop the magnet technology necessary for the construction of magnets with fields > 25 T using HTS.
- The Labs are:
- BNL, FNAL, LANL, LBNL, NHFML, NIST

  Plus Universities
- Funding of the order of $2 M /year

MCTF

The way to fields > 20 T

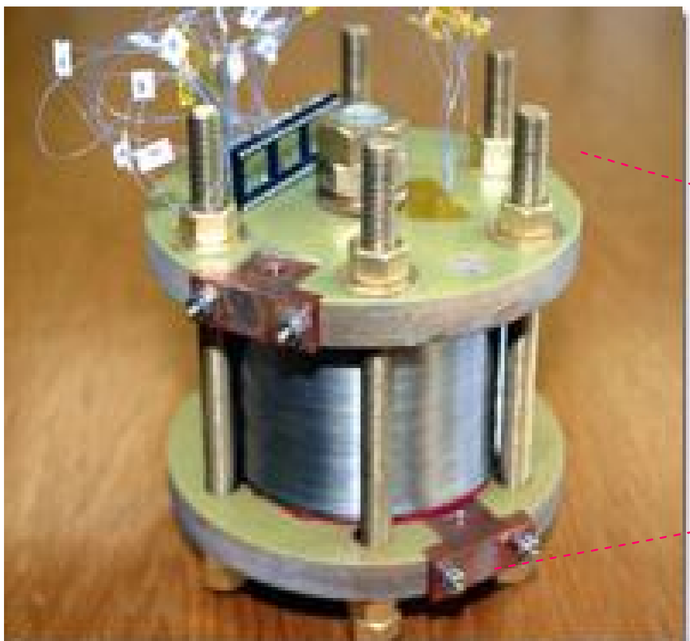


LABS, INDUSTRY, AND UNIVERSITY FURNISH A SOLID RESOURCE BASE

A few results on following slides

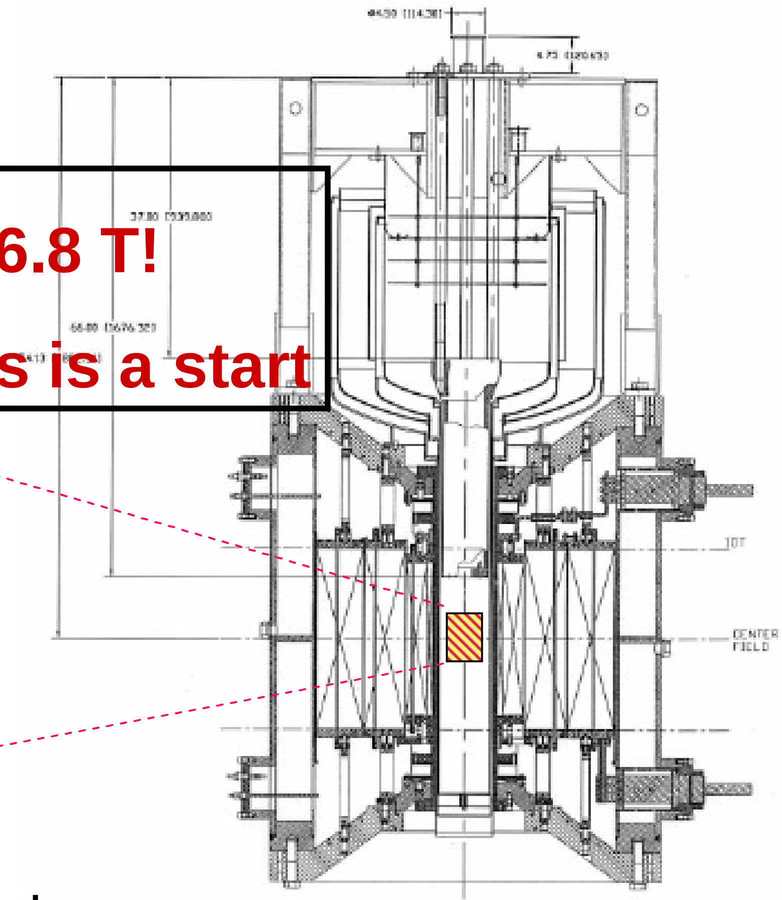
NHMFL facilities provide 19T axial background field

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



26.8 T!

This is a start



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

Superpower YBCO coil at NHMFL

High field insert coil construction **We need bigger!**

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)

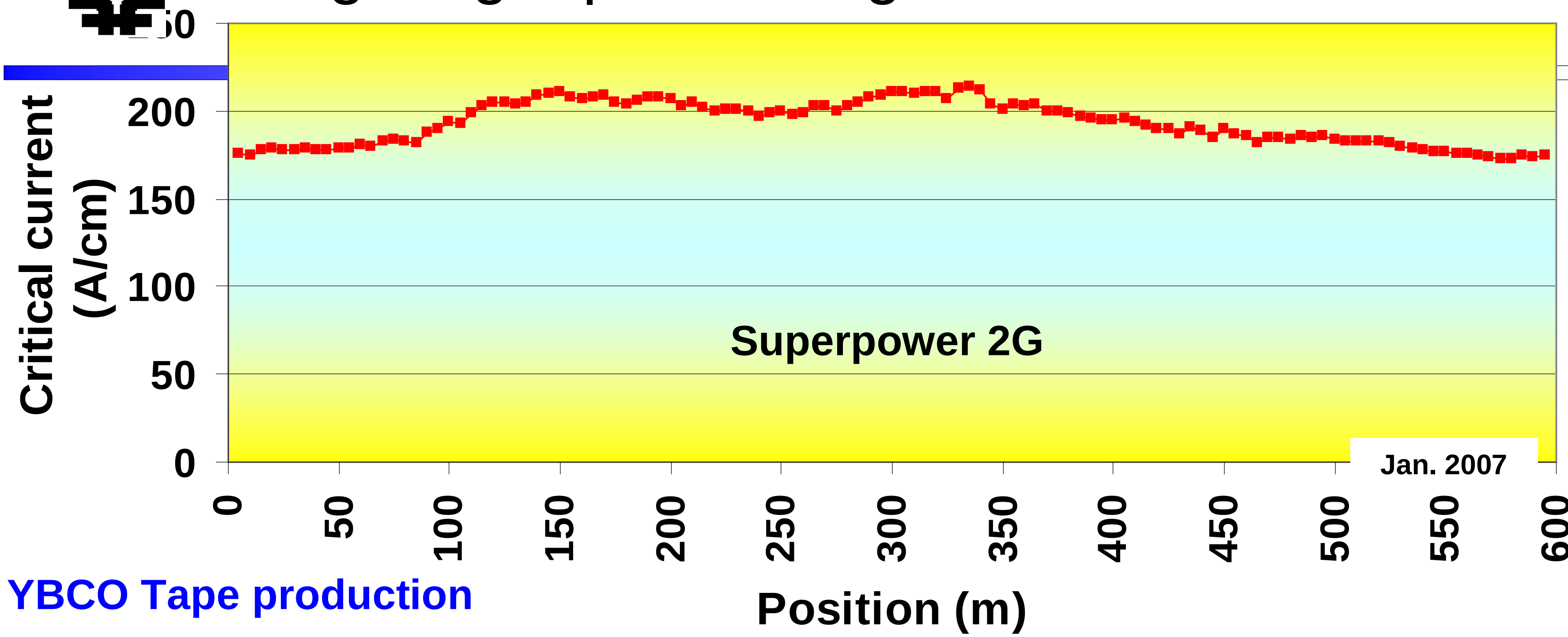
Kapton polyimide insulation (co-wound)

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

MCTF

Long length processing of 2G wire demonstrated



YBCO Tape production

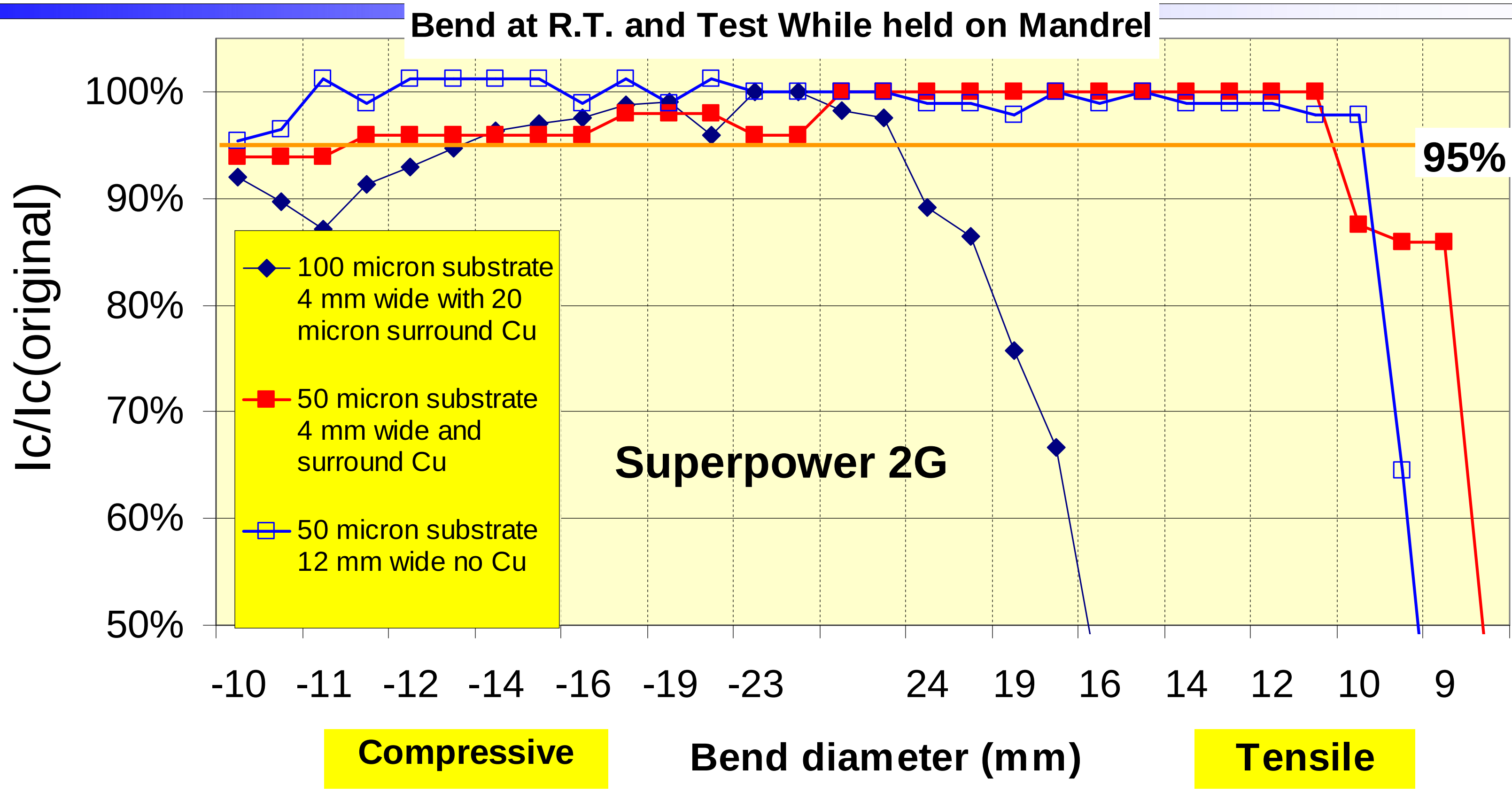
77 K, Ic measured every 5 m using *continuous dc currents over entire tape width of 12 mm (not slit)*

- 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

MCTF

50 micron substrate tape shows superior bend strain characteristics

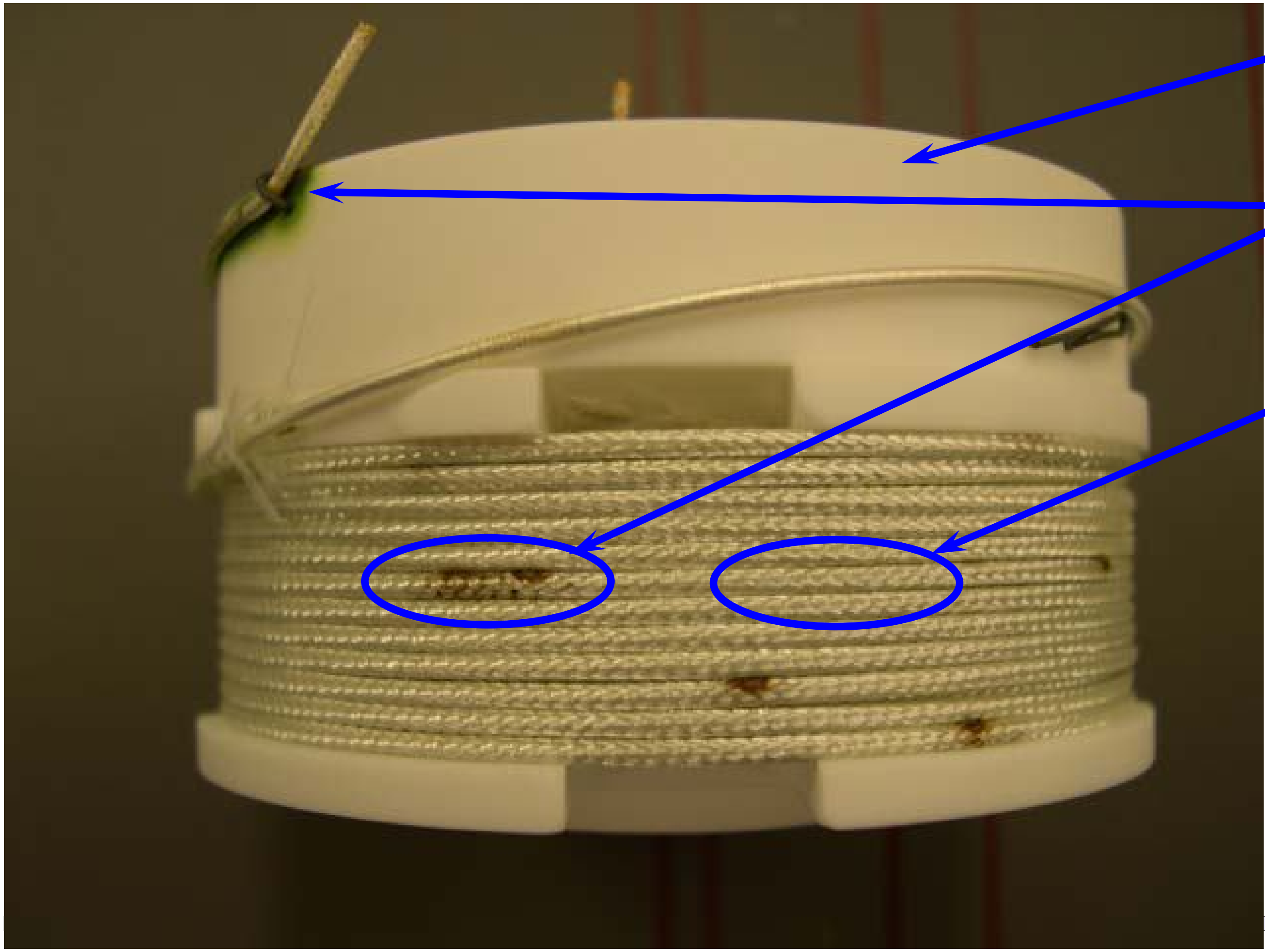


Maximum Bend Strain = +/- t / D ~ 95 μm / 11000 μm = 0.86 % (~ 0.45 % on the YBCO)

Bending can be a problem for HTS material!

MCTF Reacted 2212 coil leaked in a few regions - braided Al_2O_3-SiO_2 insulation

Test Coil at NHMFL (Eric Hellstrom)



Macor mandrel

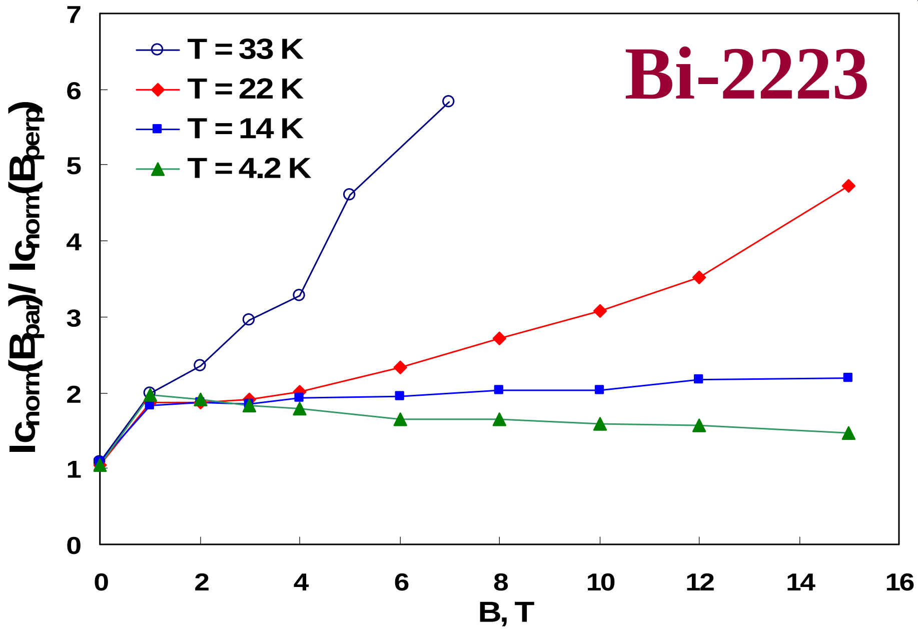
Leak

No leak

Macor
46 wt.% SiO_2
17 wt.% MgO
16 wt.% Al_2O_3
10 wt.% K_2O
7 wt.% B_2O_3
4 wt.% F
morganadvanced ceramic)

MCTF

B and T Dependence of Anisotropy

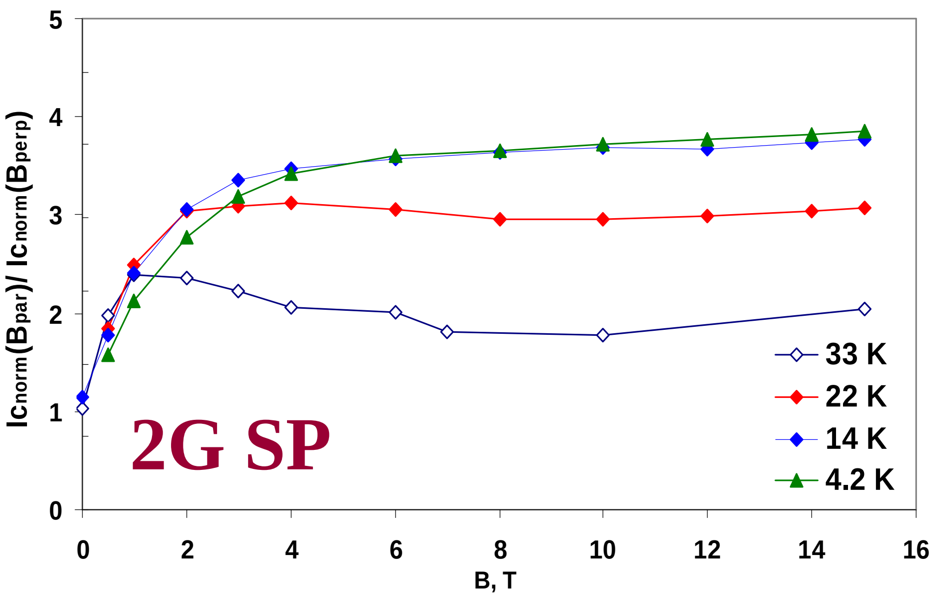


The B dependence has a linear trend, where the slope value increases with T.

Ratio saturates with B, but decreases with temperature.

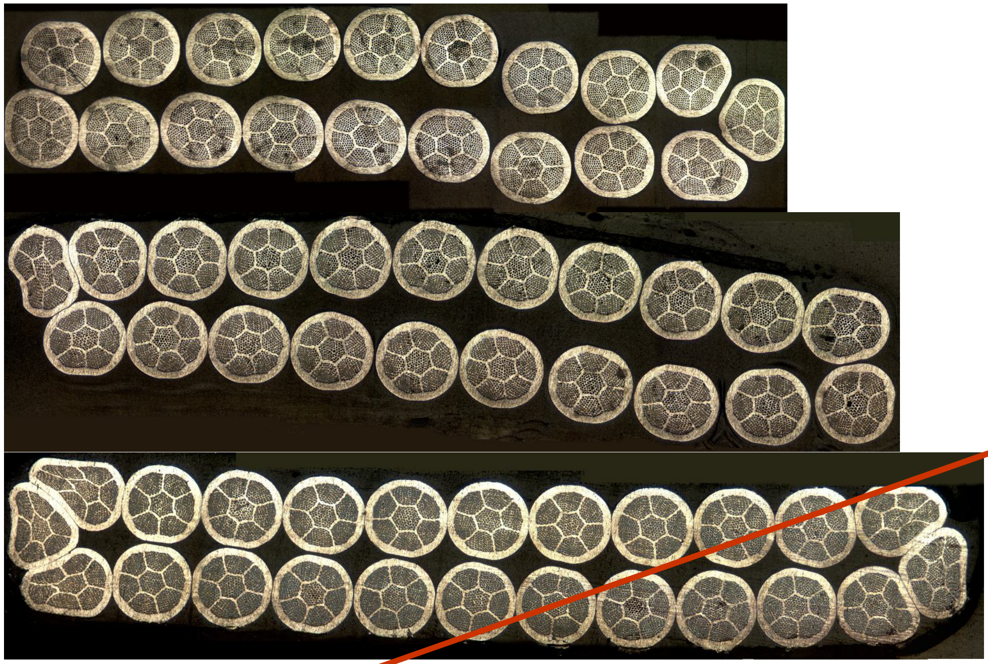
FNAL Measurements (E. Barzi)

$$\frac{I_c(B_{PAR})/I_c(77K,0\,T)_{PAR}}{I_c(B_{PERP})/I_c(77K,0\,T)_{PERP}}$$



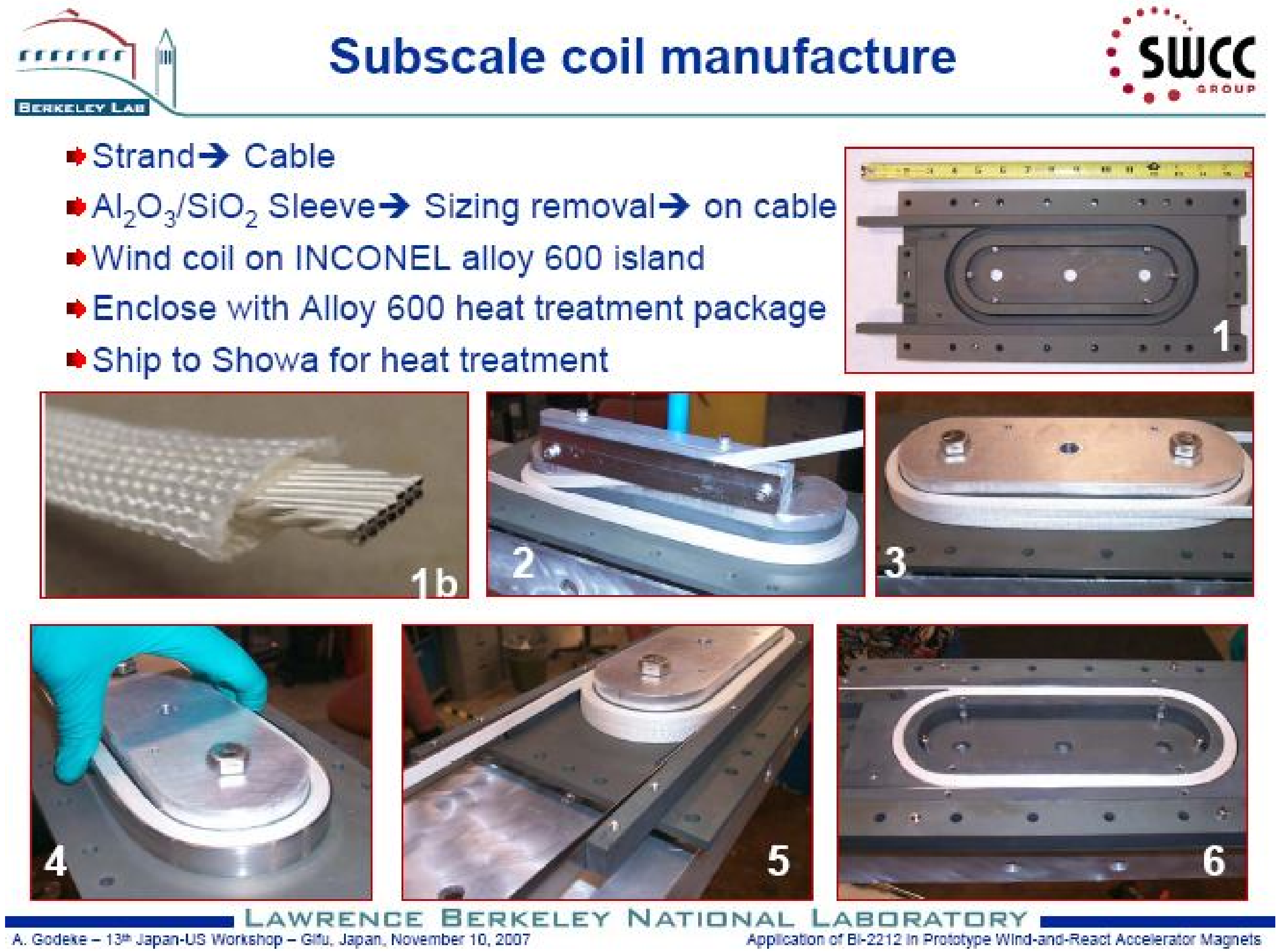
Bi-2212 Cable Study (FNAL with OST)

MCTF



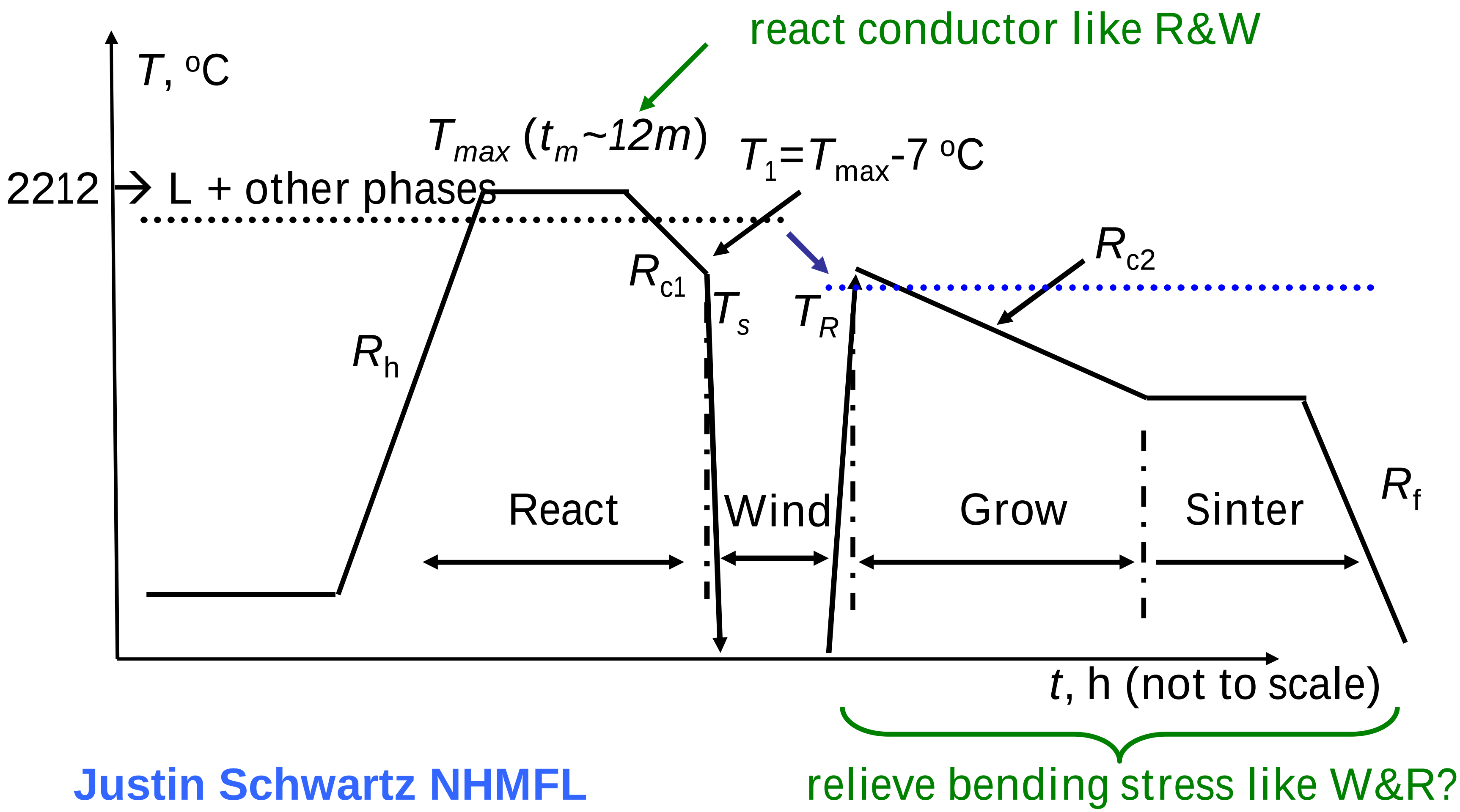
All cables had black spots after reaction at OST. SEM/EDS analysis showed that the black spots included Bi-2212 and MgO. Half a dozen cables were tested at self-fields of 0.1 to 0.3 T. For all, an I_c degradation of about 50% was measured. The extracted strands were fine and their degradation was less than 20%.

Small test coils at LBNL



MCTF

React-wind-sinter alternative



Justin Schwartz NHMFL

Some targets for study in magnets with B>25 T

- 1. Leakage.
- 2. Connectivity.
- 3. Dependence of J_c on angle wrt B.
- 3. Conductor insulation.
- 4. Containing the forces and controlling strain.
- 5. Quench protection.
- 6. Wind and React technology.
- 7. Cabling.
- 8. Radiation resistance.

- We had a very productive meeting at FNAL in December 2007 and discussed how we could collaborate. Collectively there are tremendous resources in the labs but they are under utilized (in some cases not even used).
- If we are successful, the HTS Collaboration will supply the base technology for the high field magnets we need.
- The muon collider R&D is synergistic with this effort in that it will furnish the "need" and it will also need to furnish the funding for model building of accelerator quality solenoids, dipoles, and quadrupoles.

A START

- **There is at present:**
- **Technical Committee that is looking at the best way to use our available resources and is preparing a detailed proposal for an R&D plan. This will be peer reviewed along with a request for funding.**
- **Steve Holmes is helping to set up the Laboratory Oversight Group. We would like to have things altogether by the middle of May**
- **There are two active groups using some material purchased from OST:**
  - **Insulation and Leakage: Leader Eric Hellstrom NHMFL**
  - **Conductor Characterization: Leader Dan Dietderich LBNL**

MCTF

Technical Committee

• David L.arbalestier	Ch.	NHFML
Dan Dietderich		LBL
Ken Marken		LANL
Lance Cooley		FNAL
Arup Gosh		BNL
Al McInturf		TA&M
Emanuela Barzi		FNAL
Justin Schwartz		NHFML
Arno Godeke		LBNL

WHAT WE WOULD LIKE FROM YOU!

- **There is great support for HTS at 77 K, high current and low self fields from the electric power industry. Science needs high current density at high fields. This is different and needs support! HEP in the past has played a leading role the development of NbTi and Nb_3Sn for high fields. High magnetic fields have been at the cutting edge of instrumentation since Zeeman. Your strong endorsement will help bring the HTS Collaboration into existence which will furnish the enabling technology necessary for very high field accelerator magnets.**