LARP Priorities and Plans – FY 04, 05 Conductor and Cable

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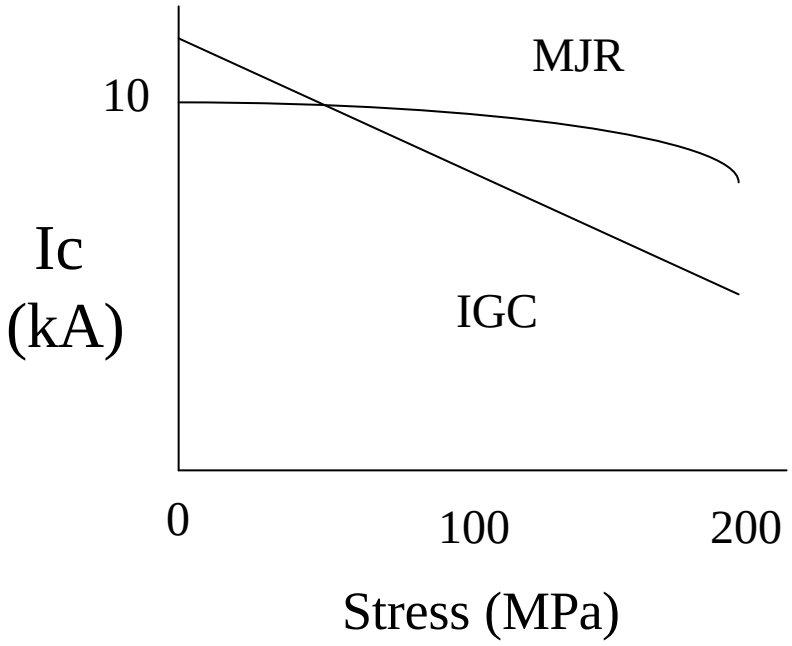
LARP Workshop, Sept. 16-18, 2003
Port Jefferson, NY

LARP Tasks

1. Determine strain limits during cabling
   - Restacked-rod process (RRP)
   - Hot-extruded rod (HER)
   - Powder-in-tube (PIT)
2. Evaluate effect of low temperature heat treatments prior to cabling
   - 210°C for 10-100h
   - 340°C for 48h
3. Evaluate new insulation and epoxies
   - Ceramic
   - Radiation hard

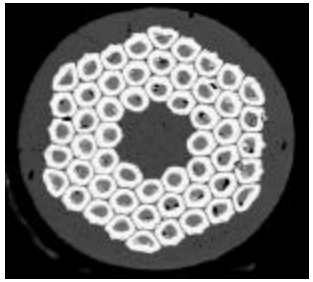
LARP Tasks cont.

- Stress Issues
  - New RRP comparison to MJR?
  - Less Cu more Nb_3Sn inside sub-element



NHMFL Test
150mm uniform field
122mm load length

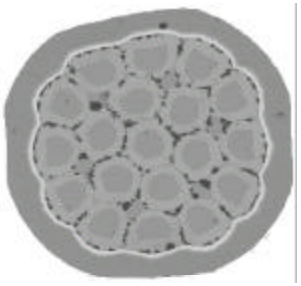
HD-1



RRP-Oxford

D-20

LBL Cable # 523
MJR-TWCA



LBL Cable # 522
IGC-Int. Tin

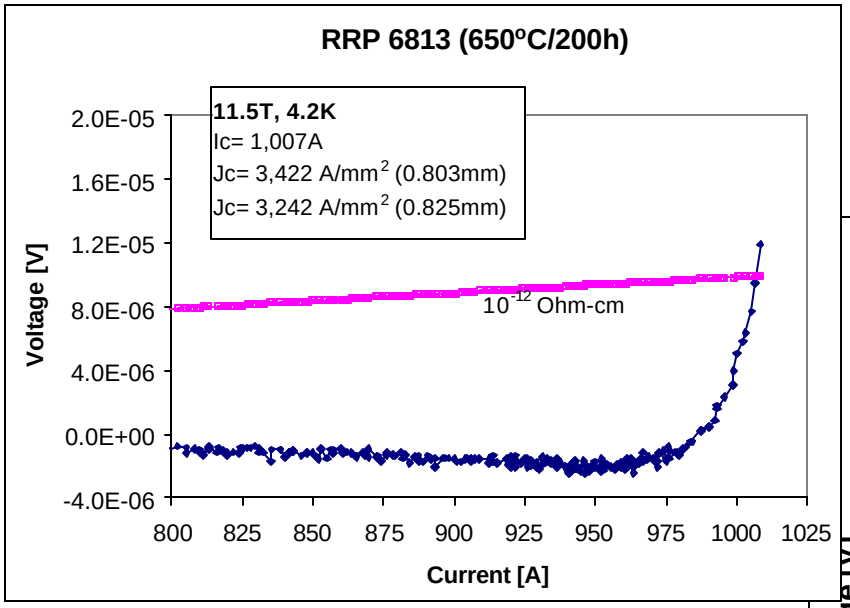
Steady progress toward program goals

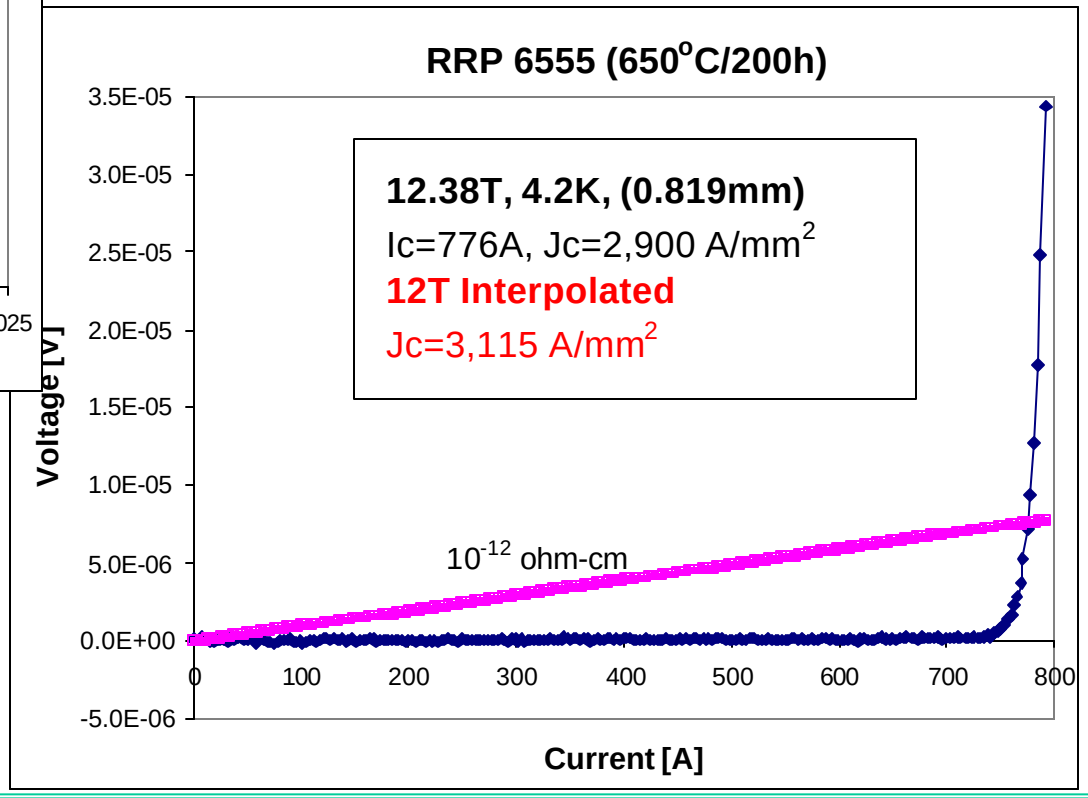
Started in 2000
Phase I : improve performance
Phase II : Scale-up, cost issues

- Long Range Goals
  - J_c = 3000 A/mm^2
    - Cu/Sc ~ 1, LARP needed 1.2-1.6
  - D_{eff}= 40 microns or less
  - Piece length > 10,000 m
  - Heat treatment < 400 hr
  - Cost: < $1.50/kA-m(12T, 4.2K)

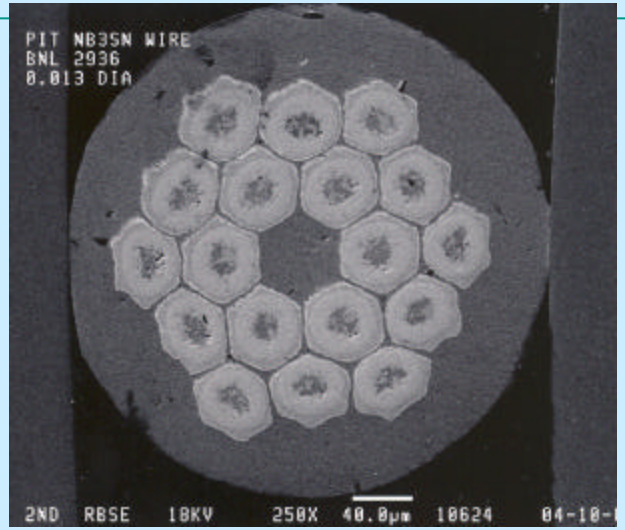
- Progress
  - J_c = 3000 A/mm^2 (FY03)
  - Proof of principle shown:
    - Fins and PIT (non-CDP)
    - Practical demos in progress
  - 250-1500m for both MJR and internal Sn processes
  - 150 hr (PIT)
  - $ 5.50/kA-m (Int. Sn)
    $7.75/kA-m (MJR)

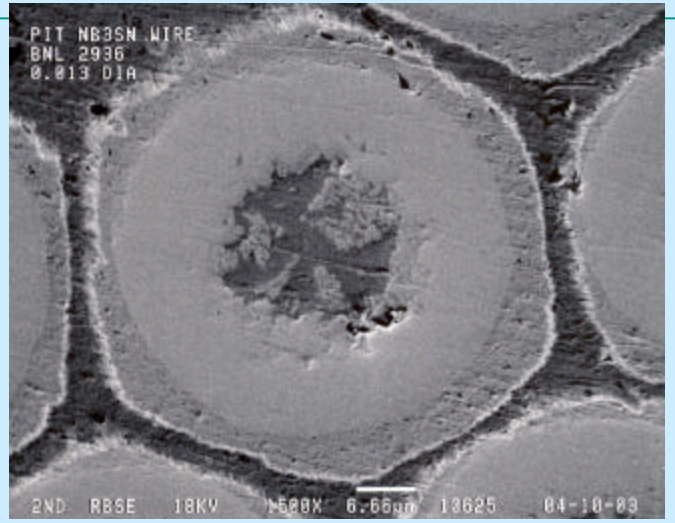
Oxford's RRP Strand





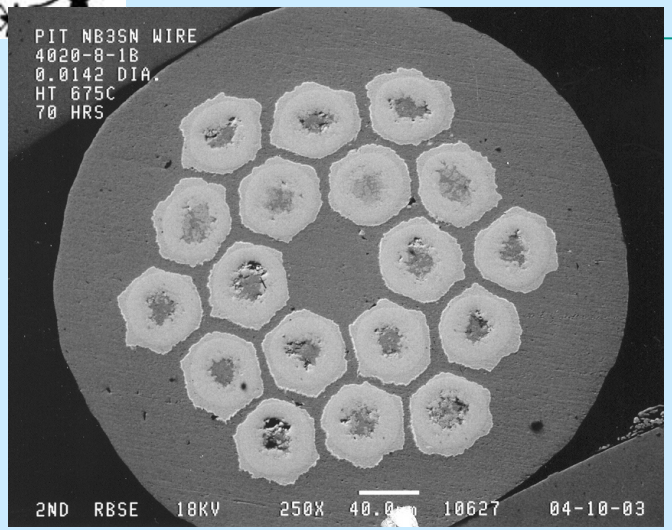
SUPERCON INC





- **Nb_3Sn PIT Wire, 0.33mm Diameter.**
- **55 mm Nb Filaments with Ta Barrier.**
- **Processed 13 kilometers.**
- **Piece Lengths up to 2000 meters.**
- **Estimated Layer Jc = 3280 A/mm^2.**
- **Non-Cu(44%SC) Jc(12T) = 1462 A/mm^2.**

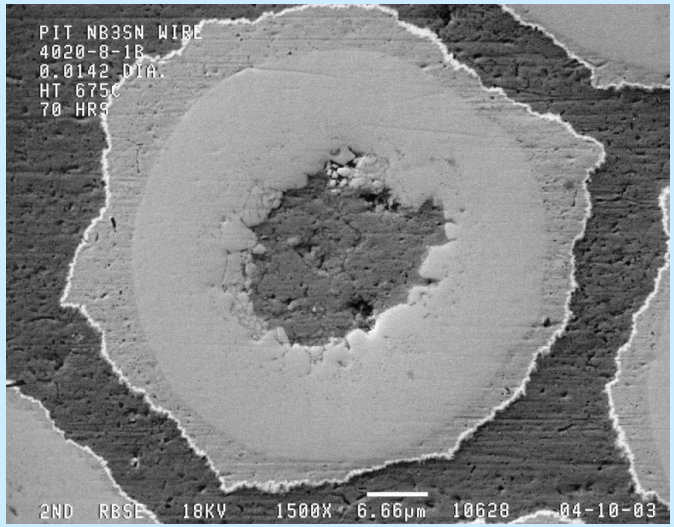
SUPERCON INC



PIT Nb-7.5Ta with Ta Barrier Development.
Filament Diameter 55 micron.
Wire Diameter, 0.36 mm.
Piece Lengths Limited by Billet Size.
Estimated Layer Jc = 4280 A/mm^2.
Higher Layer Jc may be due to Alloy.
Non-Cu (39%SC) Jc(12T) = 1994 A/mm^2.
1:1 Cu:non-Cu ratio feasible.

Near Term Technical Objectives

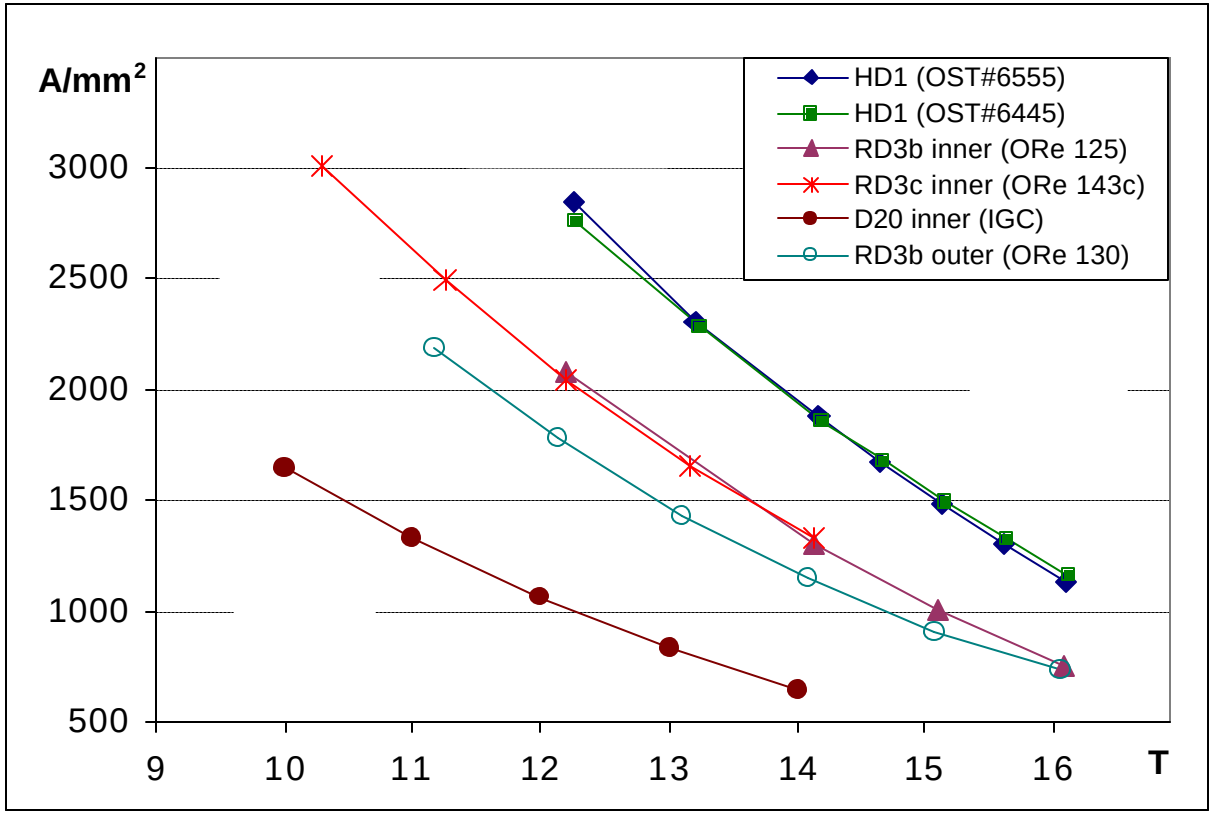
- **Increase restack billet size - diameter & length.**
- **Develop strand design to 91, 40 mm filaments at larger strand diameter (0.5 mm to 1.0 mm).**
- **Further increase non-Cu Jc through design modifications & heat treatment optimization.**
- **Develop engineered microstructures.**



Nb_3Sn Critical Current Density

Nb_3Sn wires for High Field Dipoles, 1996-2002

50% Increase
In 3 years



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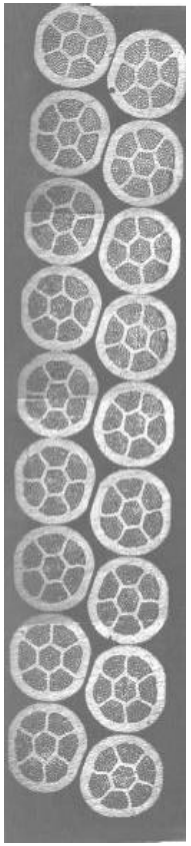
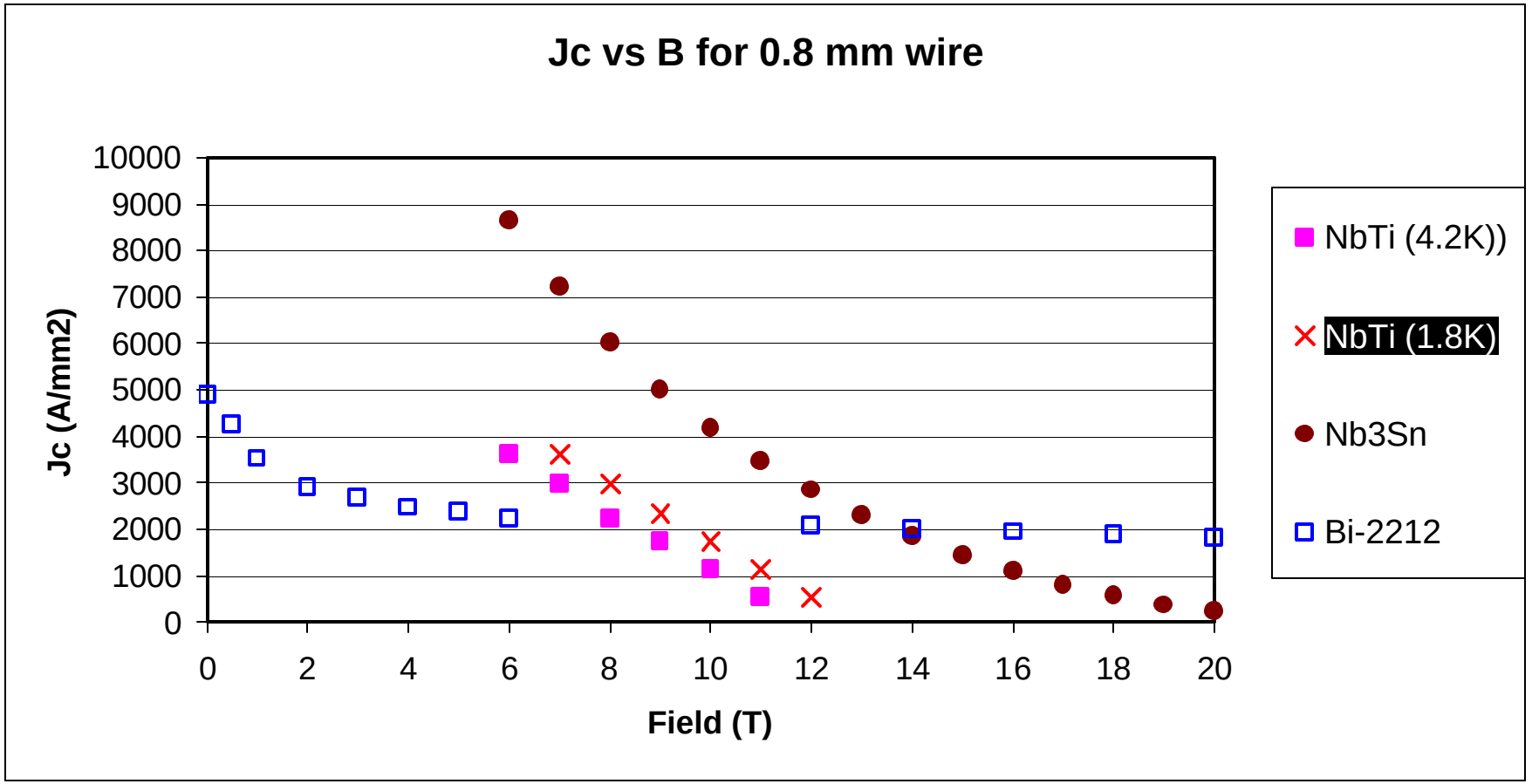
Bi-2212 round wire shows promise for accelerator magnets

- J_c(12T, 4.2K, non-silver) > 2000 A/mm^2 in new material (Showa)
- Long lengths(> 1500 m) are being produced
- New result: 30 strand cable; Ic = 6.8 kA at 6 T
- React/wind (BNL) and Wind/react (LBNL) coils are being made
- ***Not part of base LARP plan, but we will keep an eye on it … may be important for dipole-first IR.***



Cable made at LBNL

J_c "Crossover" for Bi-2212 and Nb_3Sn is near 14 T, but J_{eng} is x2 lower



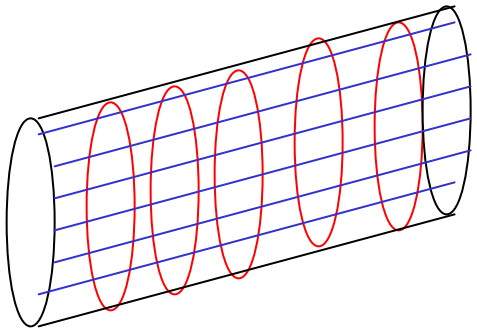
FY04 & 05 Priorities and Plans -- Conductor and Cable R&D

- Cable R&D
  - Deformation limits of strand – RRP, Internal tin, PIT
    - Keystone cabling
- Stress limits
- Conductor Development Program (HEP-DOE)
  - Reduce sub-element diameter (D-effective)
  - Reduce costs

Quad R&D Objectives

- Establish keystoned-cable parameter space
  - 4-layer design

Quantify Cable Deformation

- Pattern surface of strand before cabling
  - Blue axial
  - Red circumferential
- Measure local distortion of grid on surface of wire
- Determine local strain

Surface of strand