Summary of recent tests of “React and Wind” coils

A. K. Ghosh, BNL

Dec. 14, 2004

Outline

- " React and Wind" Technology to build Nb_3Sn magnets
- 10-Turn Coil Program
  - Magnet performance
  - Conductor Properties
    - Magnetic Instability
    - Effect on magnet performance
- Summary

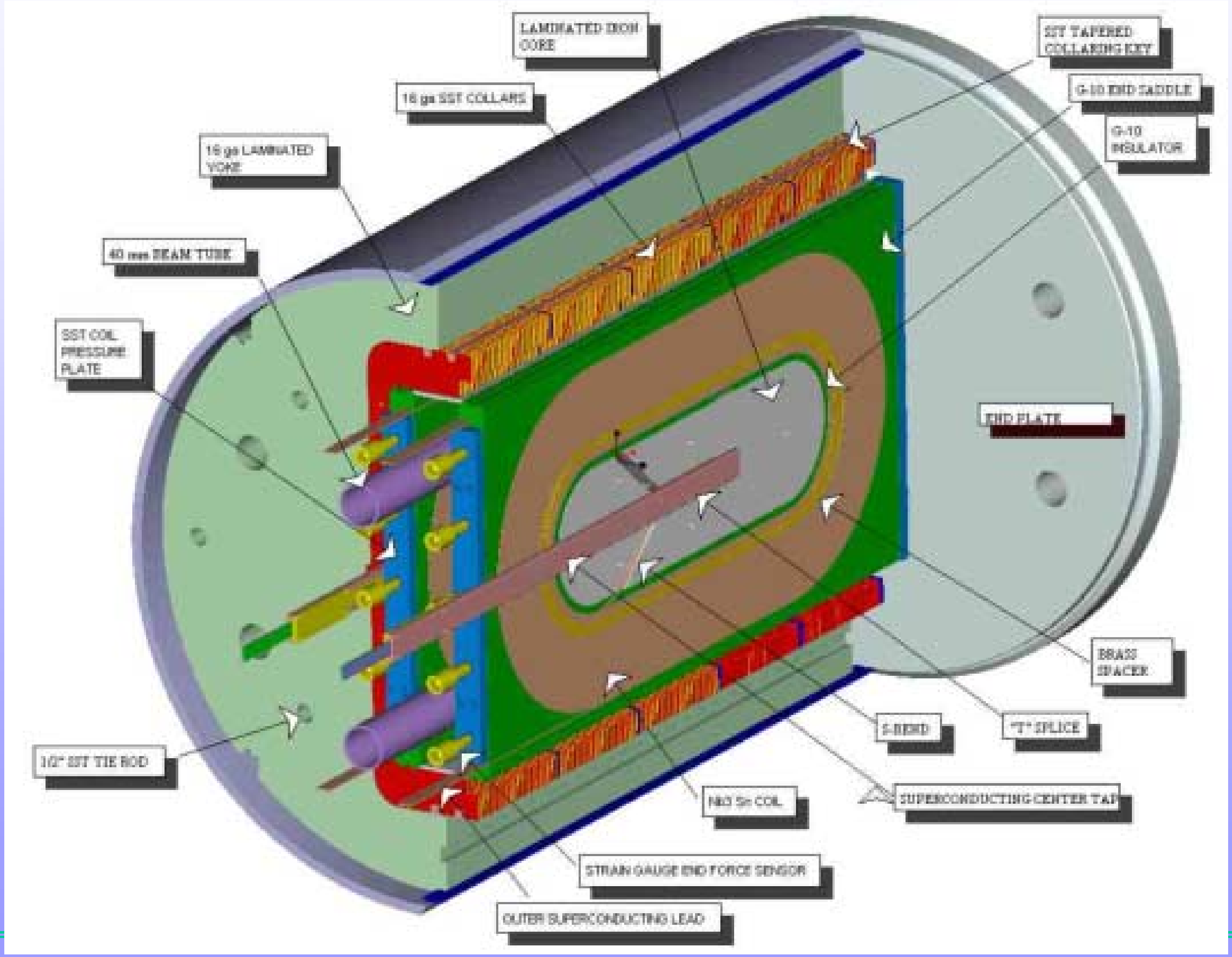
Challenges with "React & Wind"

- The conventional pre-reacted Nb_3Sn Rutherford cable is brittle and is prone to significant degradation or even damage during winding and other operations.
- *Bend-strain* degradation is an important issue and plays a major role in developing conductor designs, magnet designs and magnet tooling.
- The magnet design and manufacturing process must be developed and proven by a successful test to demonstrate that the react and wind technology can be used to build high field Nb_3Sn accelerator magnets.

Conductor R&D for "React & Wind"

- Bend strain issue is much more critical for "React & Wind" designs than "Wind & React"
- Nb_3Sn superconductor made with different conductor designs may have quite different bend strain properties.
  - Need to quantify strands made using Modified Jelly Roll, Rod Restack Process, Powder-in-Tube.
- Reaction process is important. *Sintering between wires within the cable must be avoided.*
  - Use of Synthetic oil before reaction
  - Chrome plating of strand ⇨ITER
  - Low-temperature anneal ~ 200 C/8hrs ⇨cable shrinkage
  - Design of reaction spool, etc.

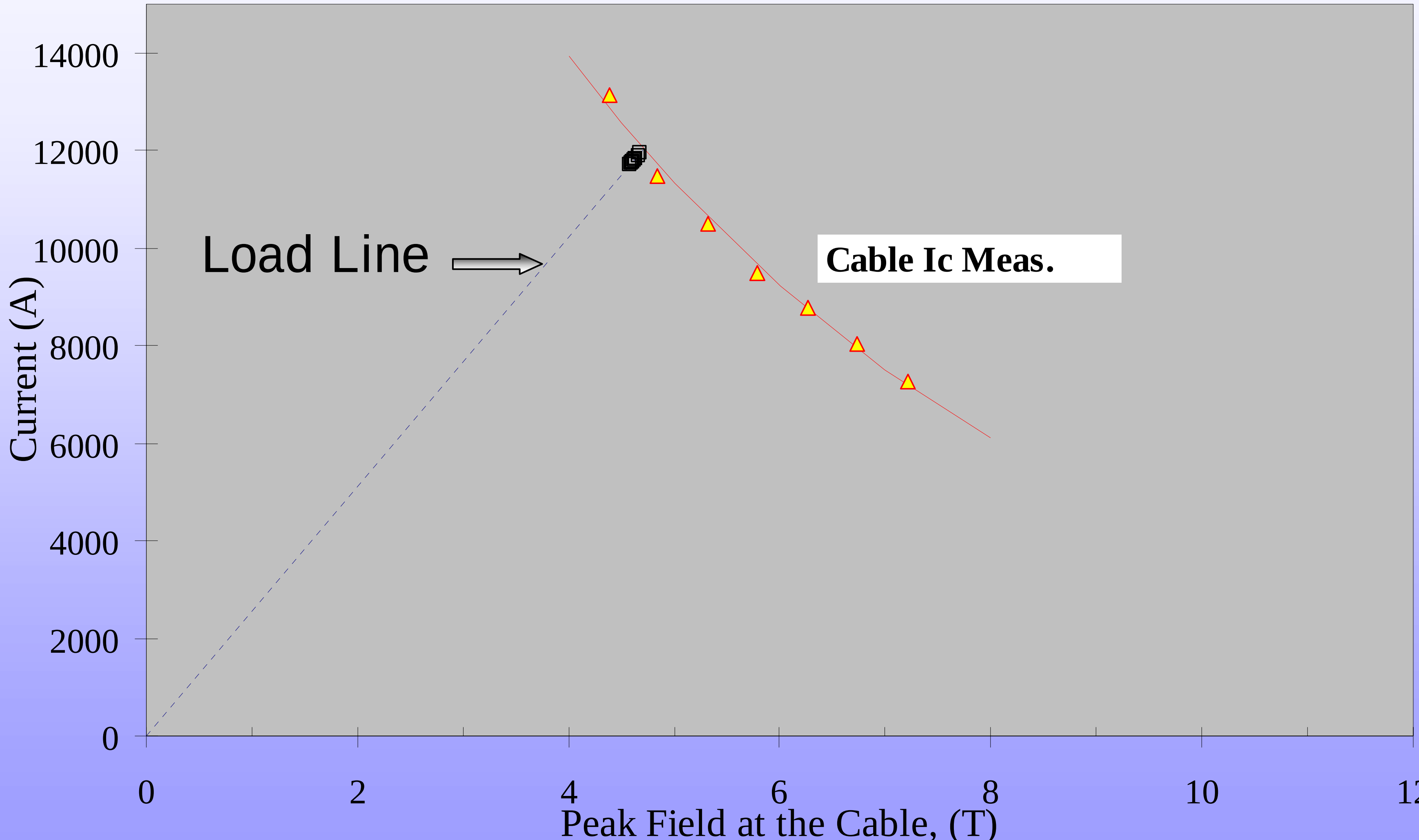
Common Coil 12T Dipole



Test of a pair of 10-turn Coils

10-Turn Coil Module

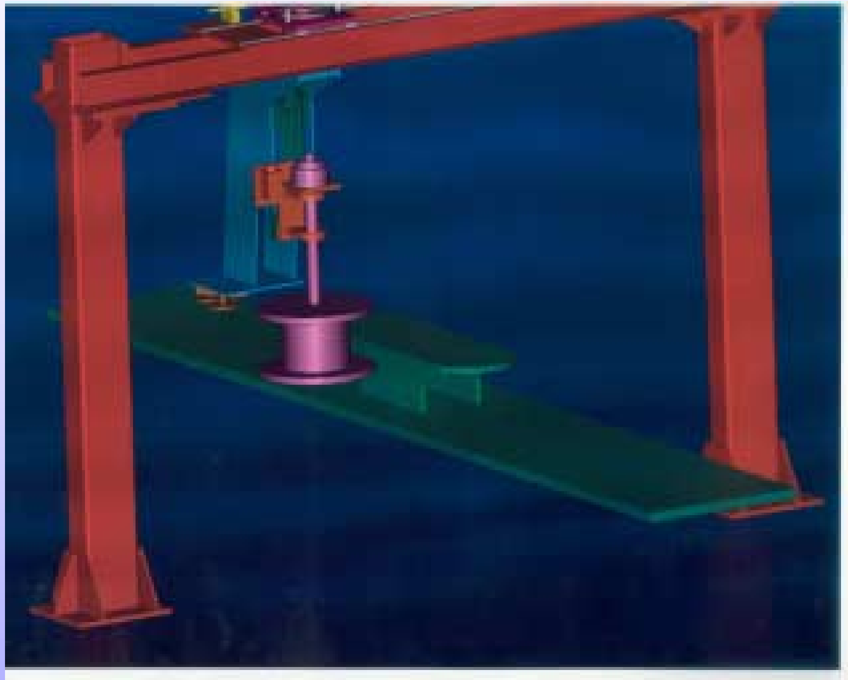
DCC008-ITER cable (2002)

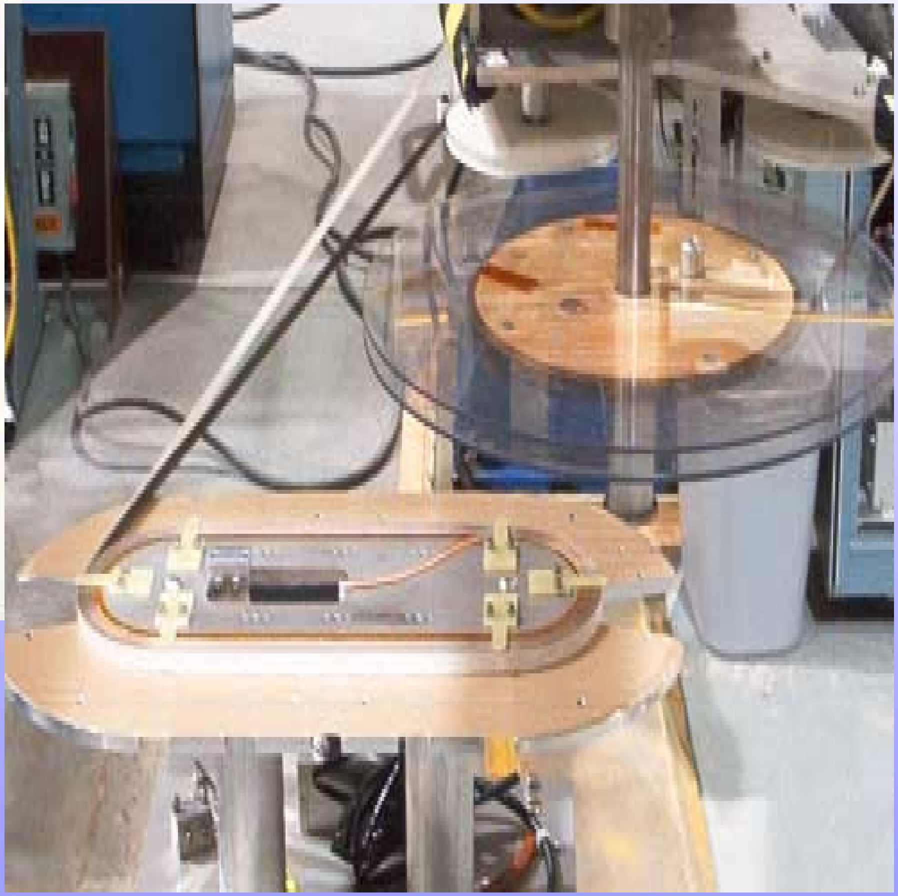


History of Coils with high-Jc strands

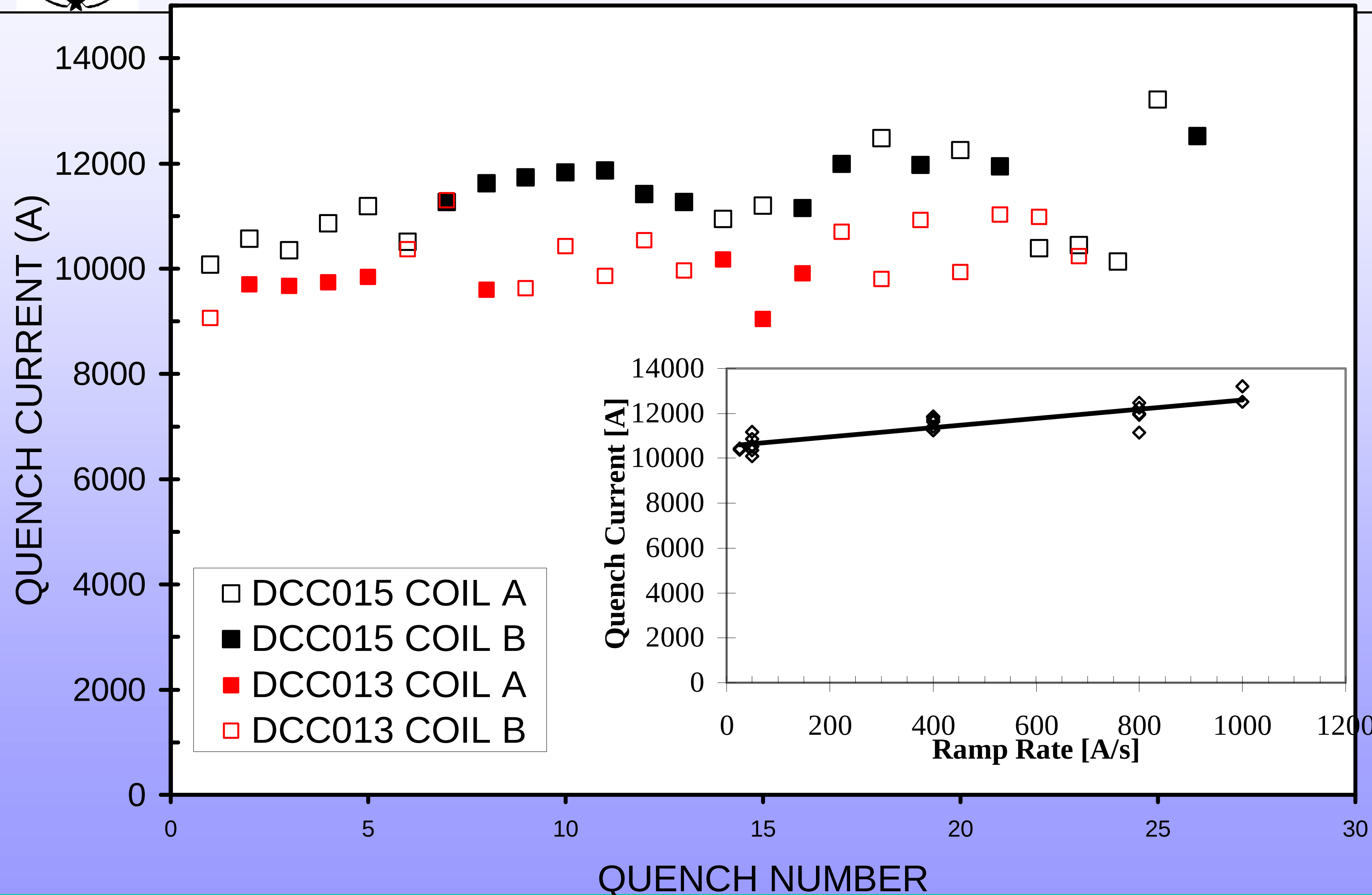
Magnet	Test Date	Strand Type	# of strands	Jc (12T)	% Copper	Iq (Cal) A	Iq (Max) A
DCC009	Sep-02	IGC-Int-Sn	18	2400	38%		4128
DCC010	Oct-02	IGC-Int-Sn	18	2400	38%		6579
DCC011	Nov-02	OST-MJR	29	1950	60%	19800	5700
DCC013	Jul-03	OST-MJR	29	1950	60%	19800	11295
DCC015	Jun-04	OST-MJR	30	1950	60%	20500	13207

New Versatile Coil Winder

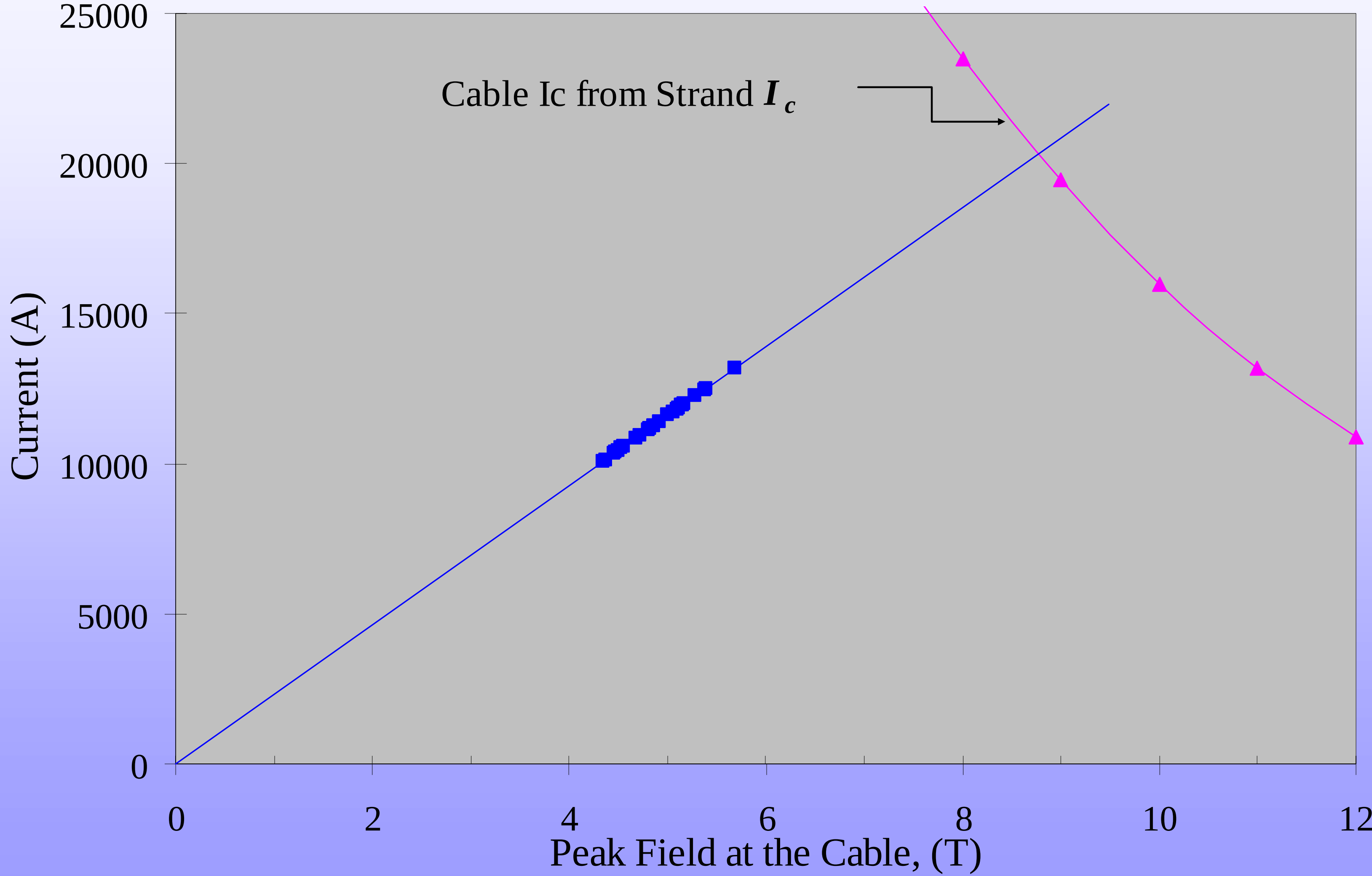




DCC013 and DCC015

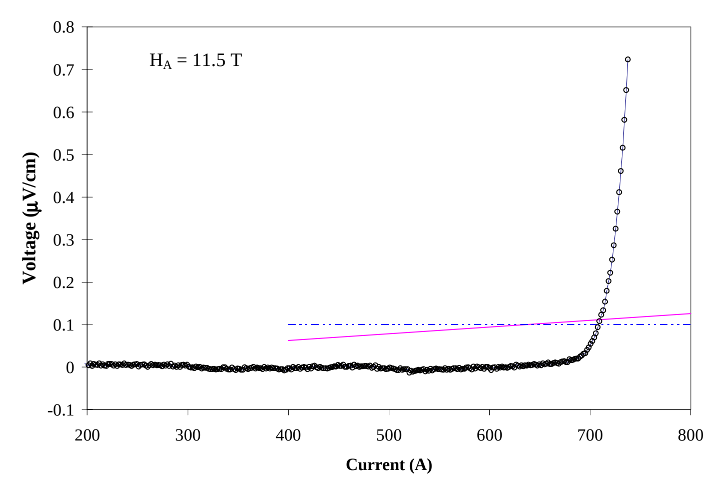


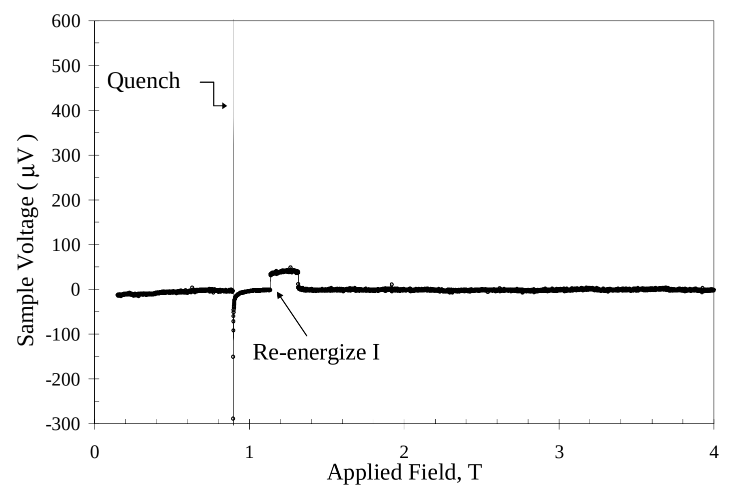
DCC015 MJR Cable RRR ~5 (2003)



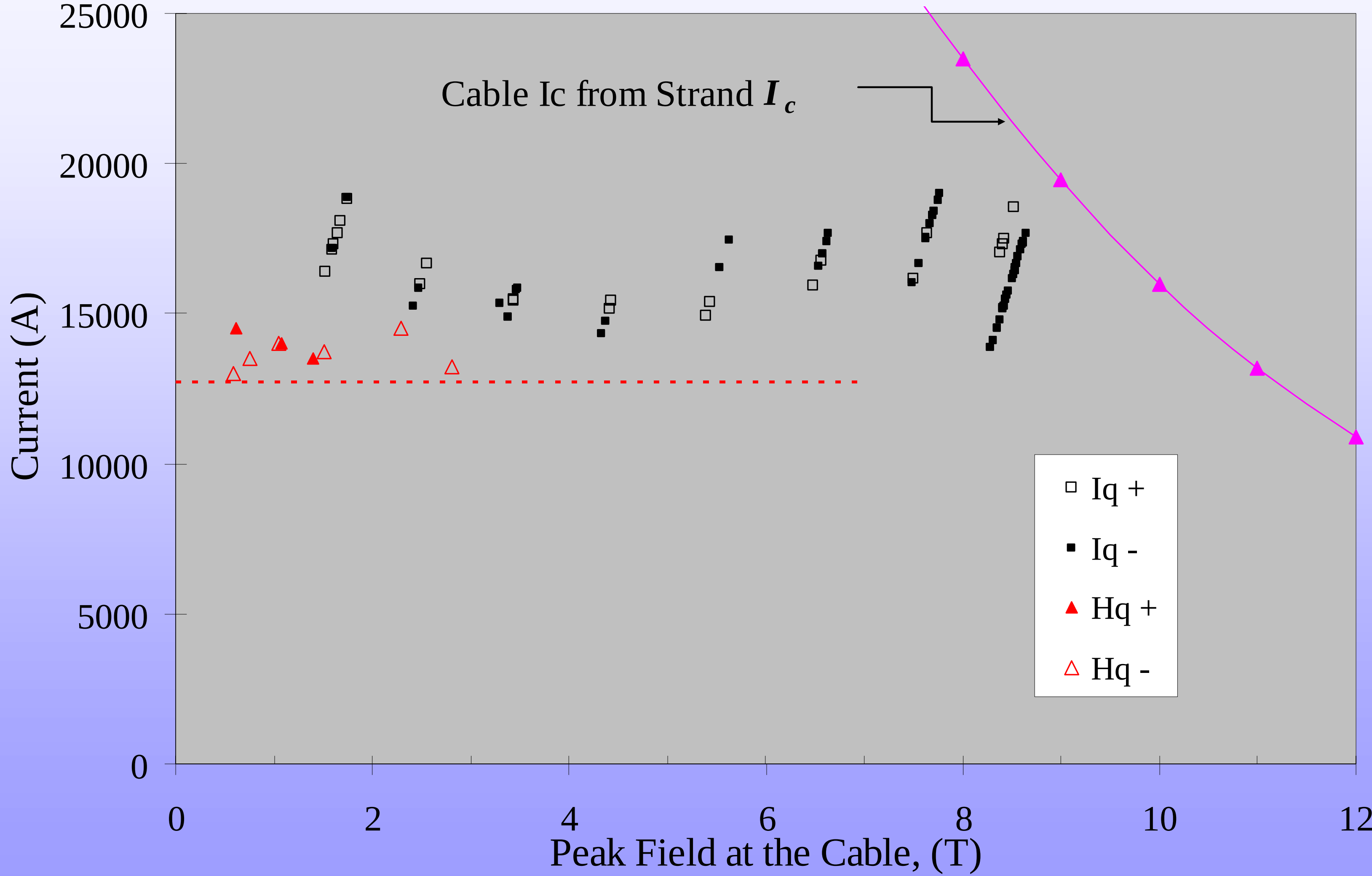
Quench Current

- One can approach a quench in a superconducting strand or cable in two ways:
- Set the field and ramp up current to quench
  - Voltage current measurement *V-I*
    - *Determine Critical current density J_c*
    - *Probes self-field stability*
- Set the current and ramp up field to quench
  - Field-sweep measurement *V-H*
  - *Used by M. Wilson & C. Walters (1970)*
    - *Measurement sensitive to magnetic stability (flux-jump)*
    - *Analogous to magnetization measurements with transport current*
    - *Extract J_s : quench stability current density*

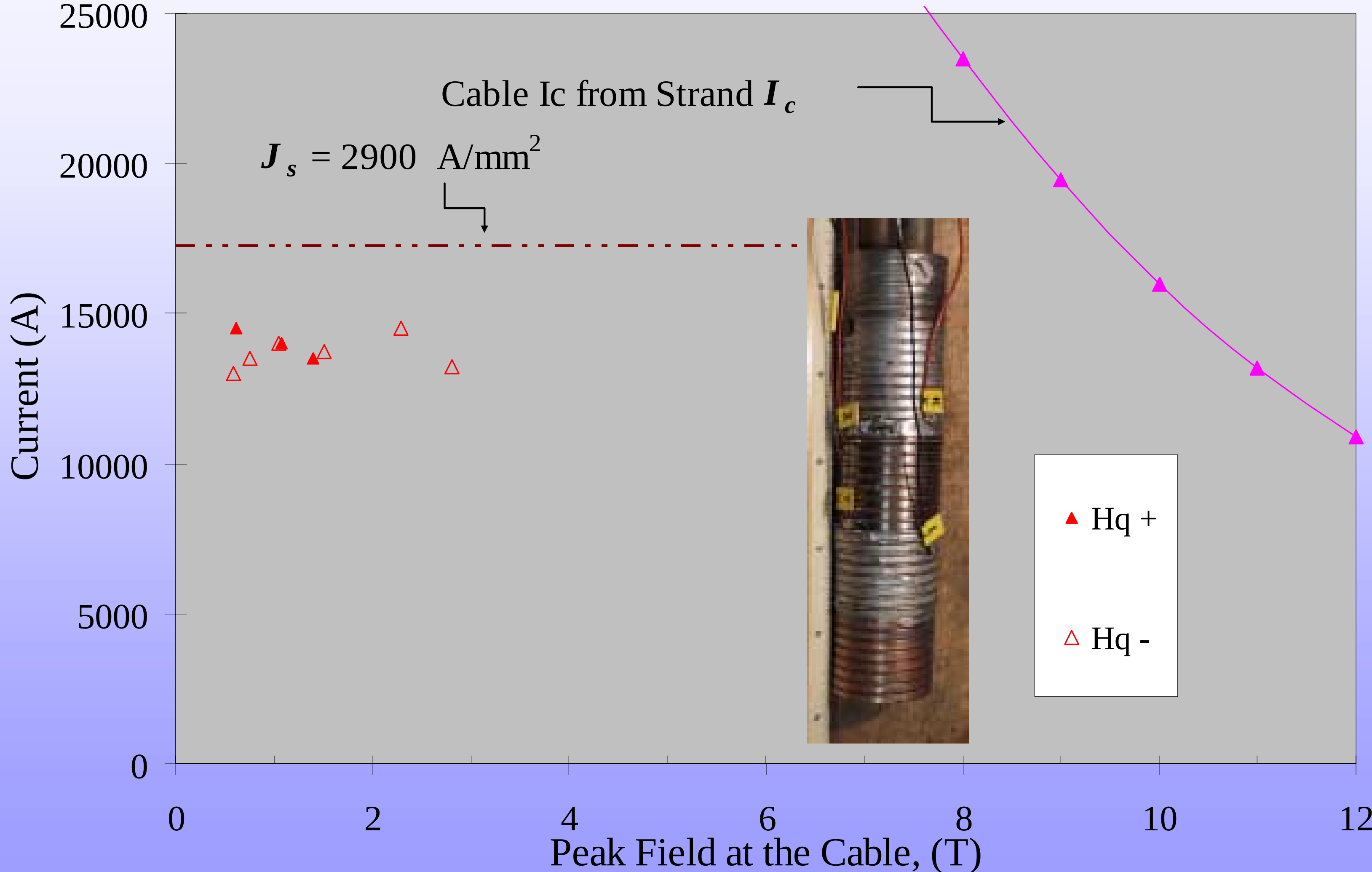




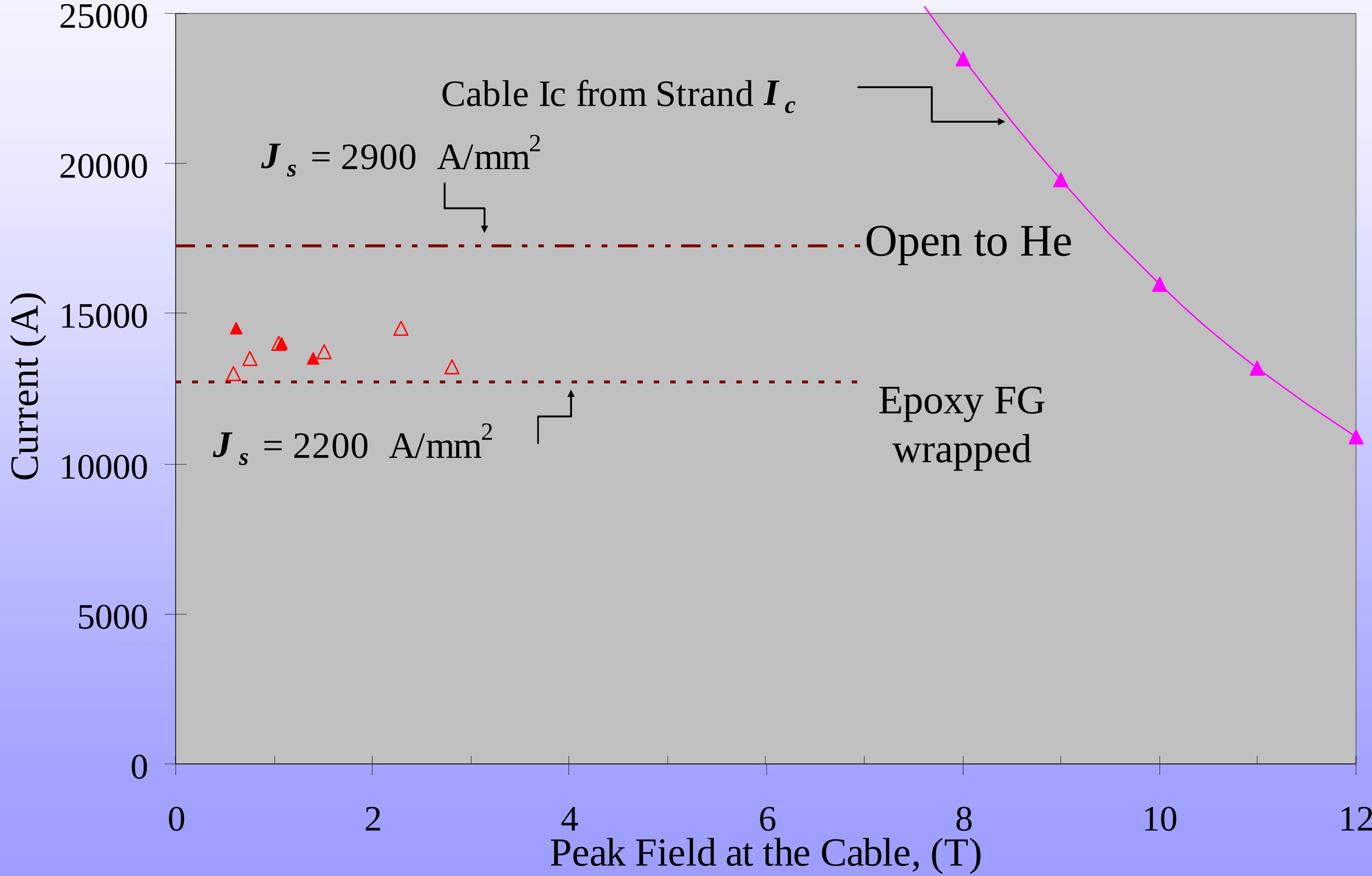
DCC015 Cable Measurements RRR~5



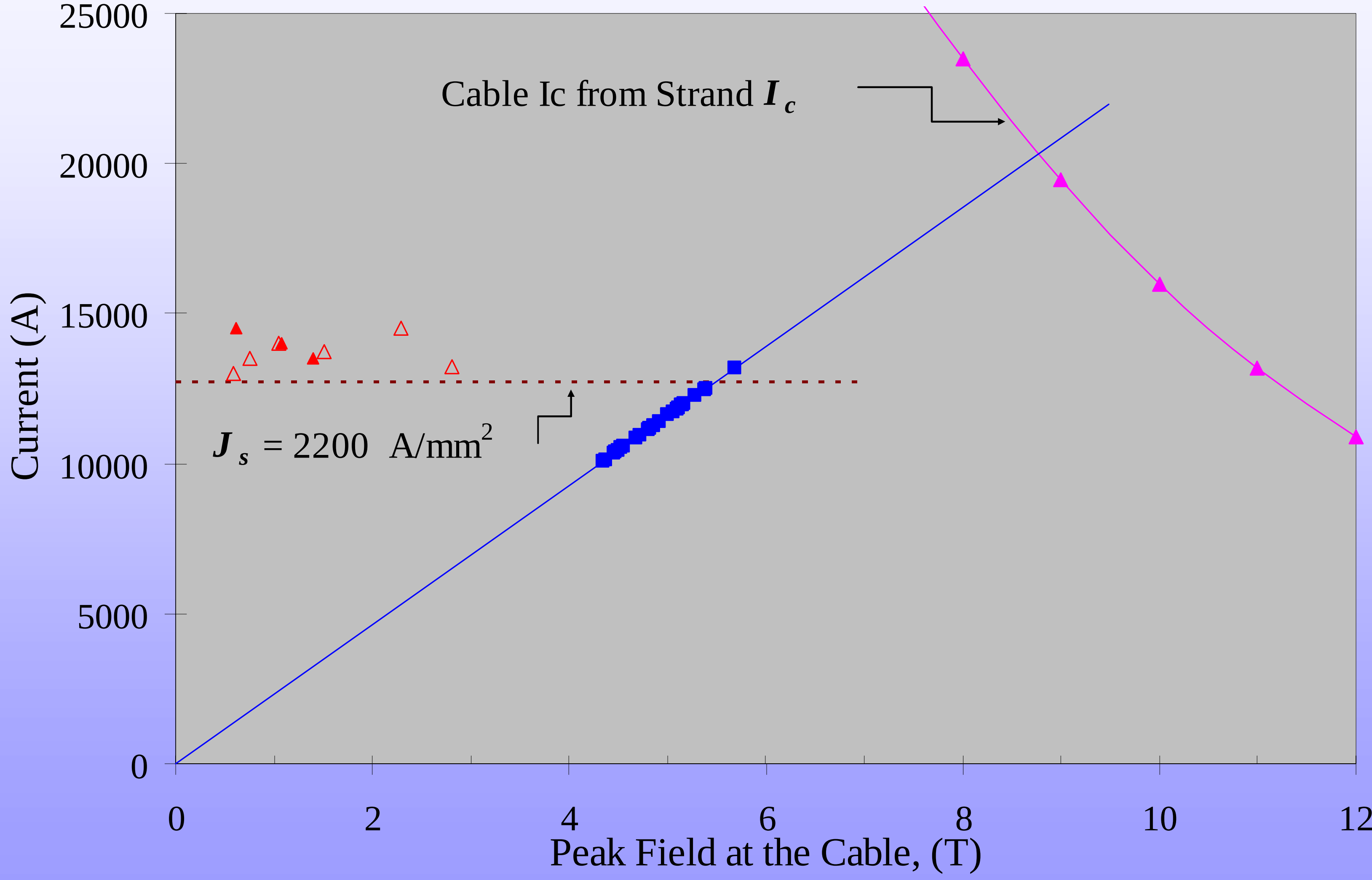
Stability Threshold Js from Strand
RRR~5



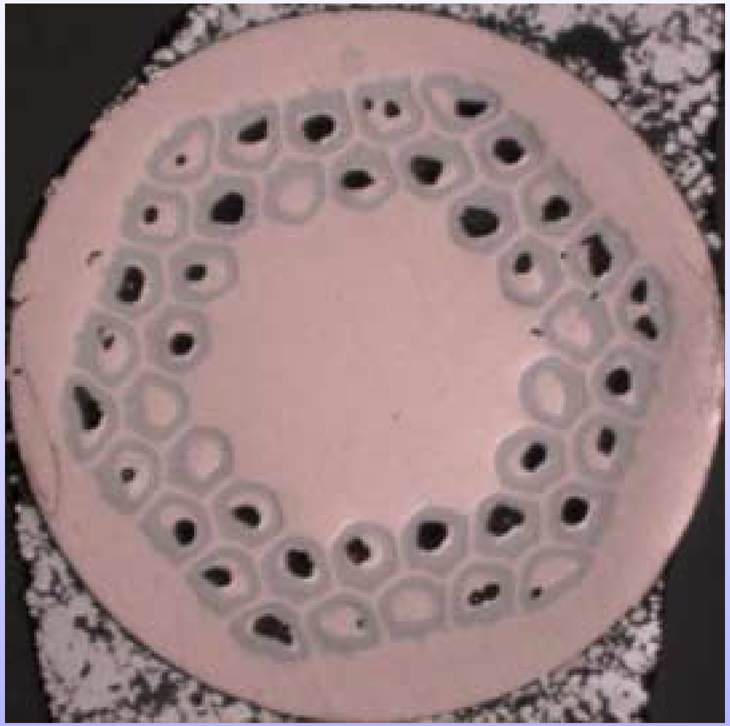
Epoxy coated strand Js

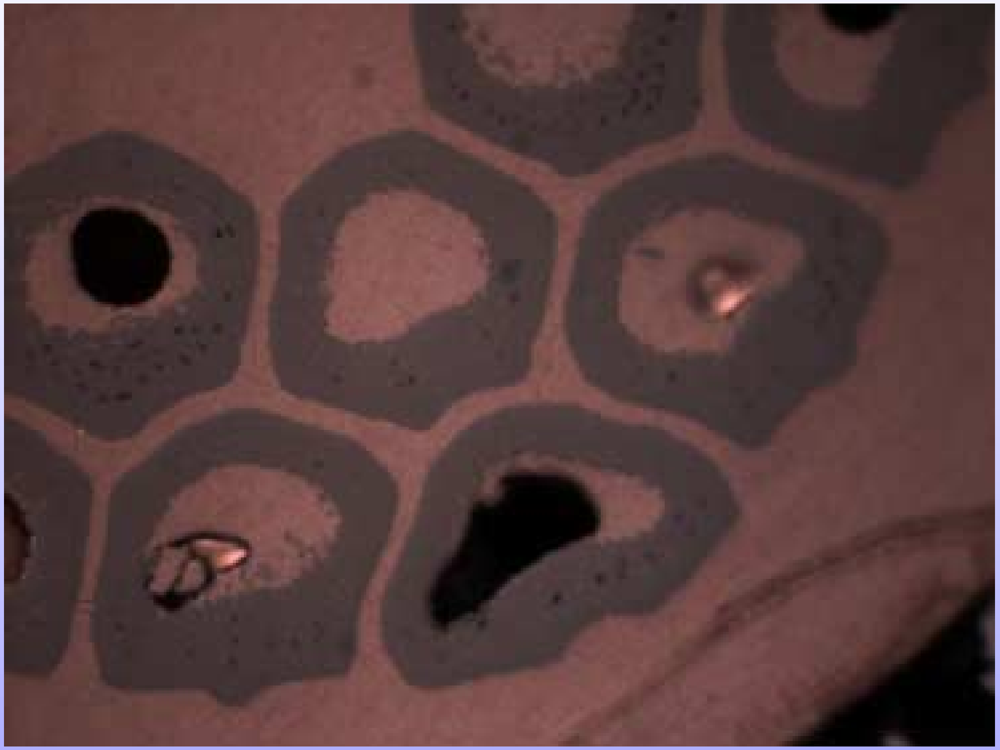


Comparison of DCC015 with Cable



Strand from outer cable

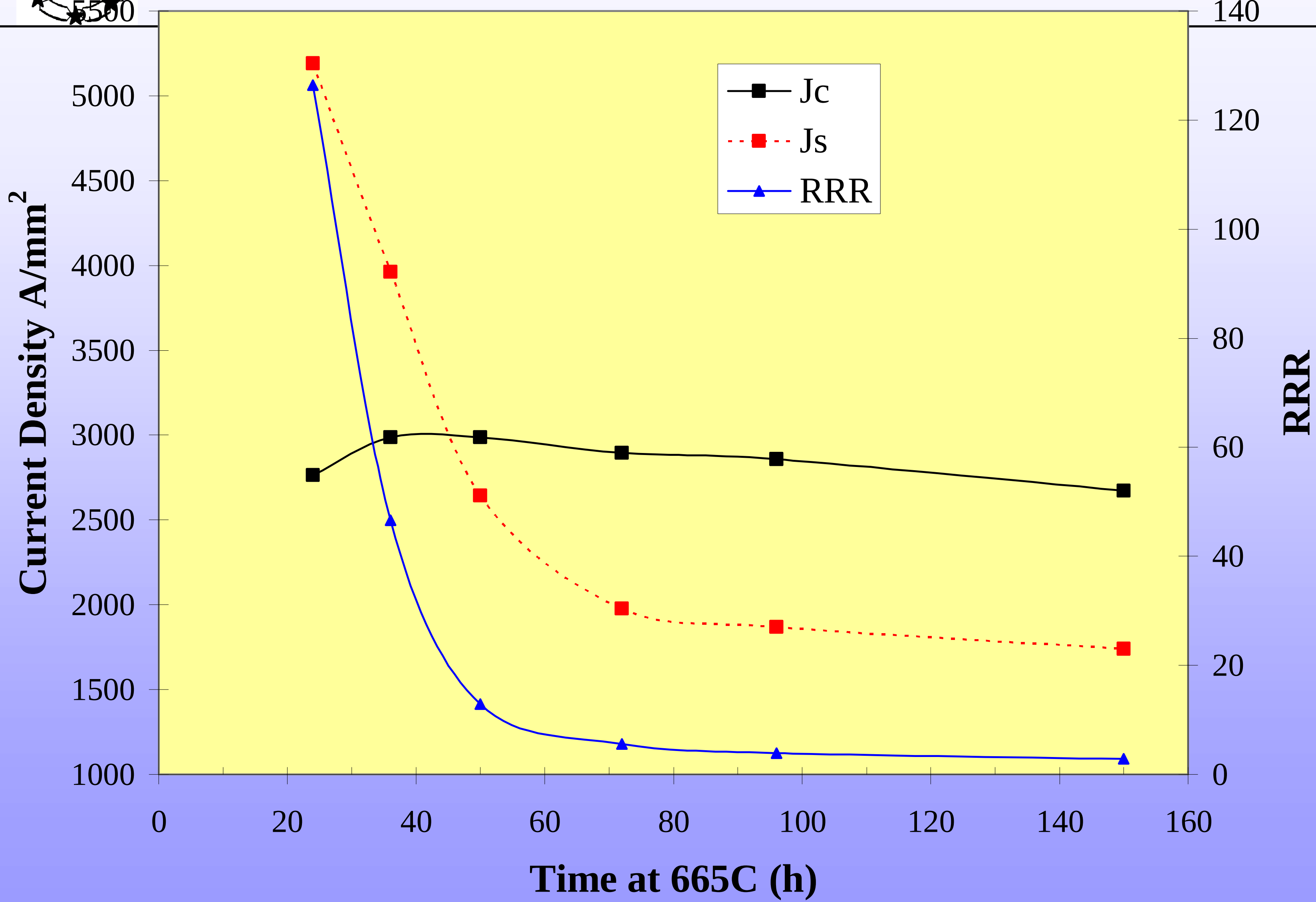




For 150 hrs/675 C, Barrier is fully reacted in sections of the sub-element

Sn leaks out poisoning the Copper

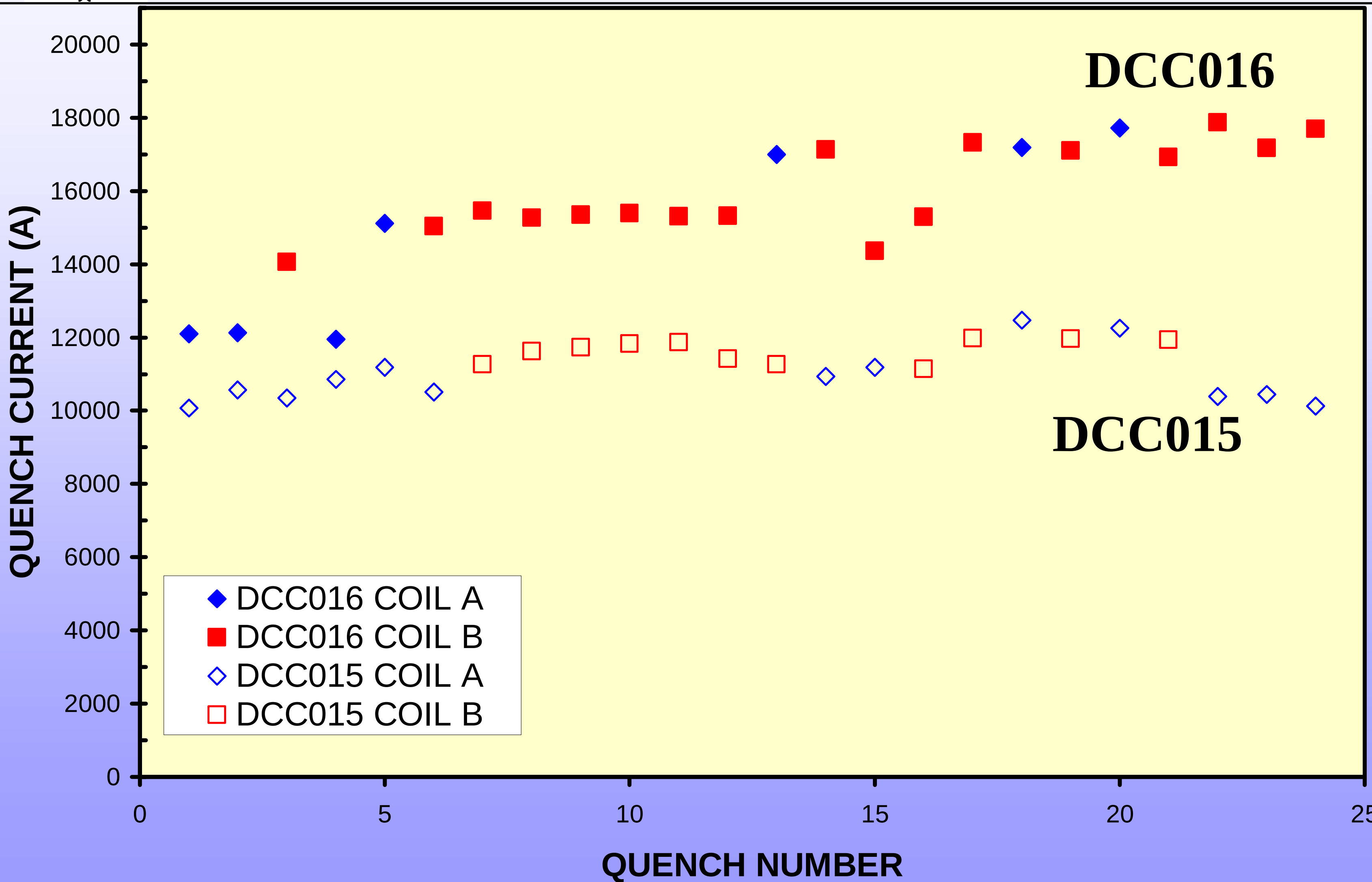
Jc, Js and RRR Supercond. Sci. Technol. 18 (2005) L5-L8



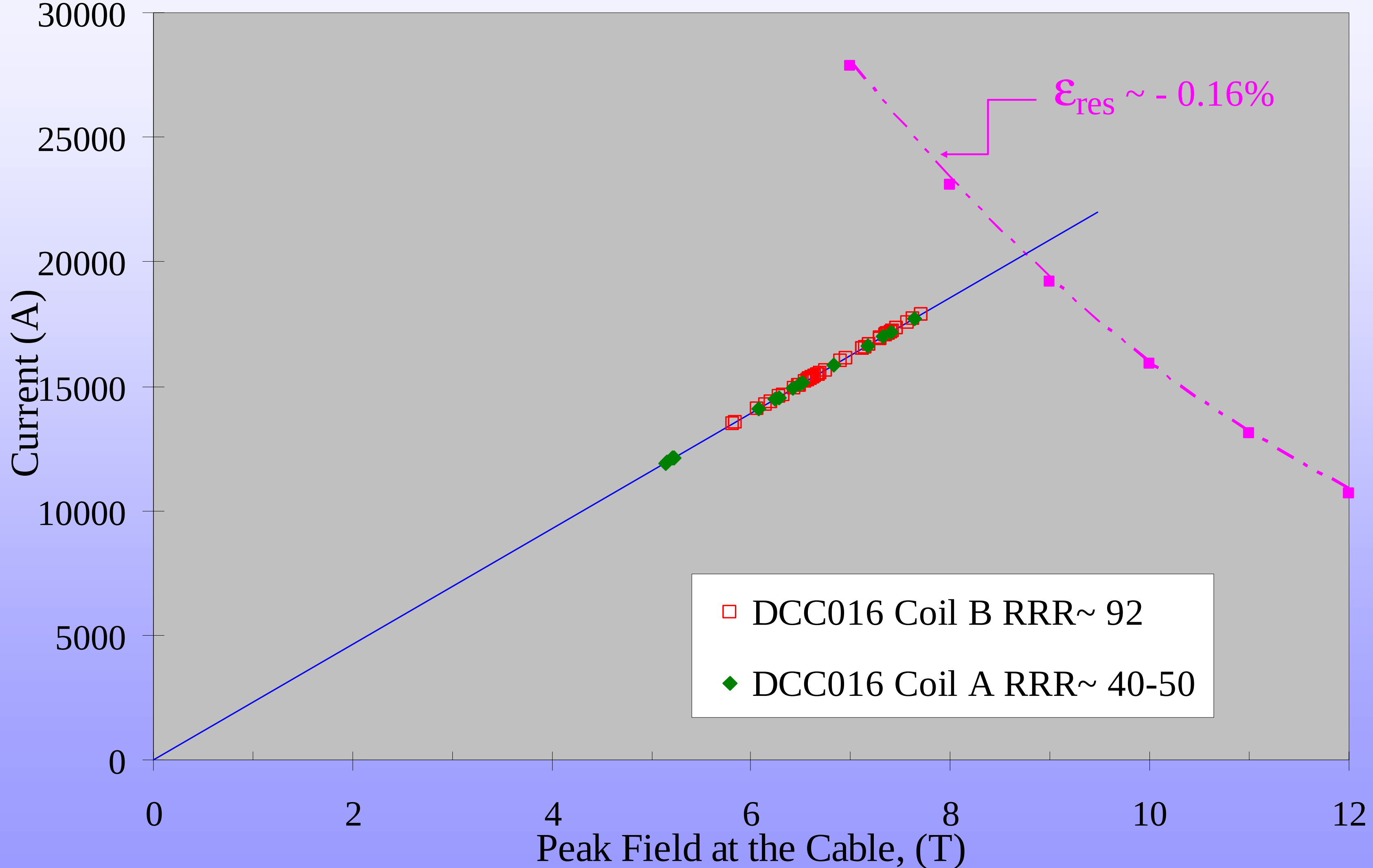
Heat Treatment Optimization of cable in DCC015

- DCC015
  - Manufacturer reaction HT 675C/150 hrs
  - RRR ~ 5
- DCC016
  - Modified HT 665C/72 hrs
  - Coil A ➢ RRR ~ 50
  - Coil B ➢ RRR ~ 90
  - No change in Jc(12T)

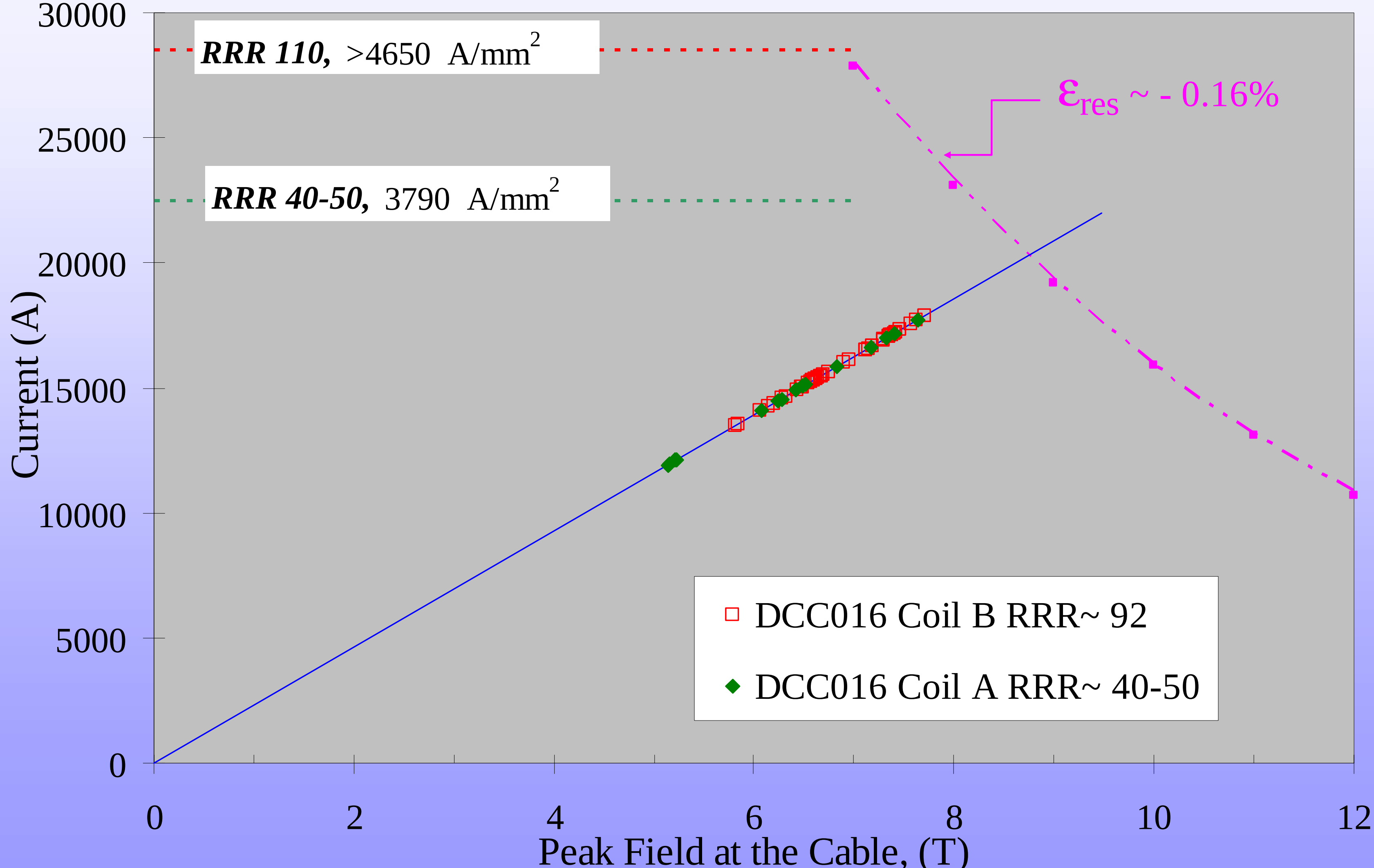
DCC016 RRR ~ 50-90 (2004)



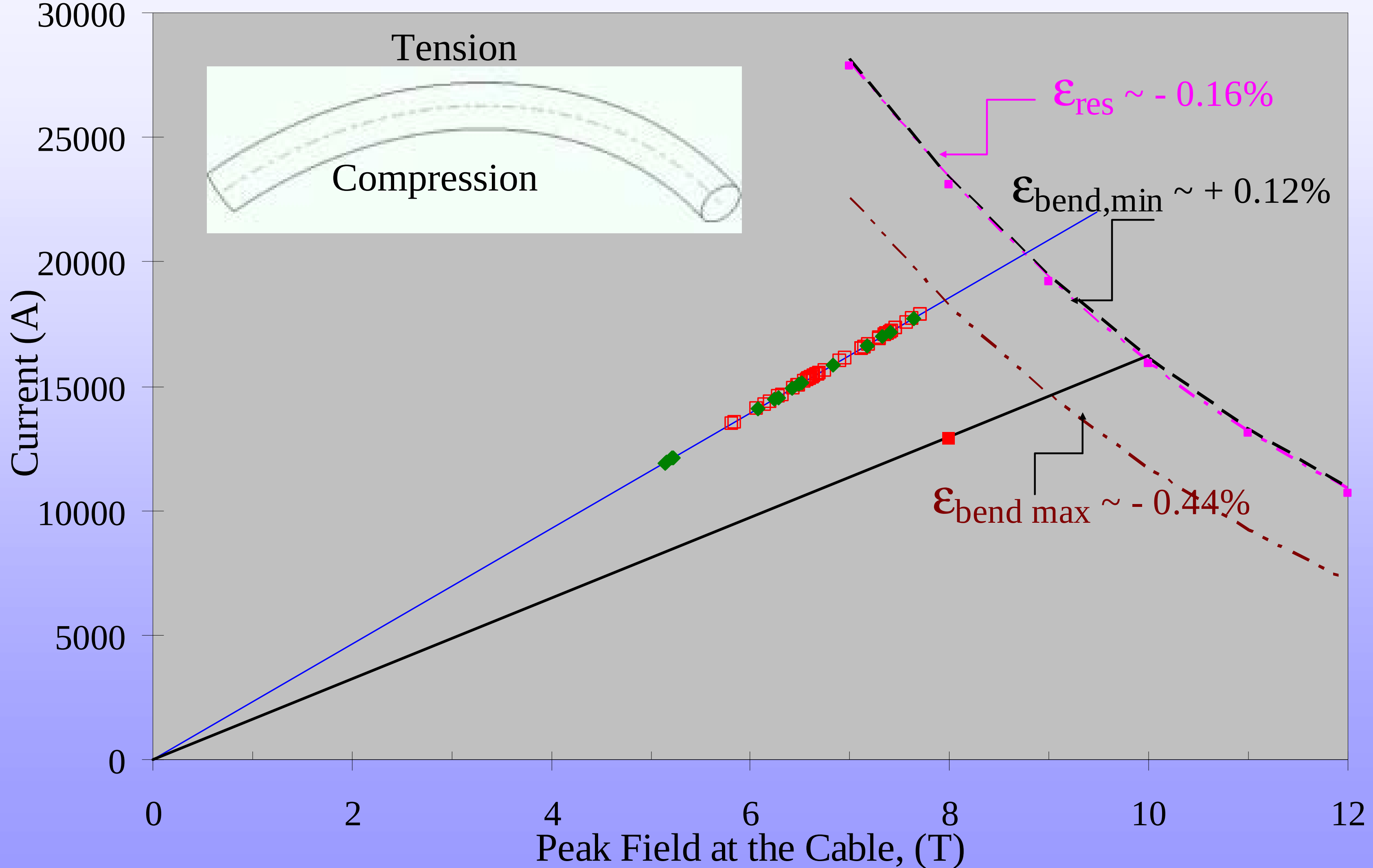
Analysis of DCC016 Performance



Low Field Instability ? Strand data



Bend Strain Degradation ?



Summary

- Magnetic Instability can limit magnet performance
  - However the threshold J_s can be increased by HT optimization such that it does not limit magnet performance
- Quench performance of DCC016?
  - Reached 80% of 30x virgin strand Ic
  - Cabling degradation is small ➢ From extracted strand test < 5 %
  - Flux-Jump magnetic instability ➢not likely as the quenches are in both coils
  - Bend strain degradation not known ➢ max. bend strain ~ 0.28%
  - Erratic quench behaviour ⇨ conductor motion
  - Ramp rate dependence

Summary (contd.)

- "React and Wind" technique still looks viable for 11-12 T magnets
- Bending strain effects are not catastrophic at 12 T.
  - Bending strain can be reduced by decreasing wire diameter →0.7mm from 0.8 mm, and increasing bend radius in magnet design.
  - However for 14 – 16 T magnets, bend-strain degradation could preclude the use of "React and Wind"
- Since in these magnets the inter-strand resistance is high, the question of current sharing remains to be examined.

End of presentation