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Measured transverse pressure dependence of the critical current in a Bi-2212 Rutherford cable

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Introduction

- Collaboration between US LARP and EU Eucard II programs;

- LBNL: cable (see presentation Tengmin Shen);
  FSU: heat-treatment;
  CERN: materials / logistics;
  UT: measurements (this presentation)

- Goal is to assess the transverse pressure response of Bi-2212 Rutherford cables,
  in view of their possible use in accelerator magnets.

Introduction

Single-strand behavior well-studied (under *axial* tension/compression), e.g.:

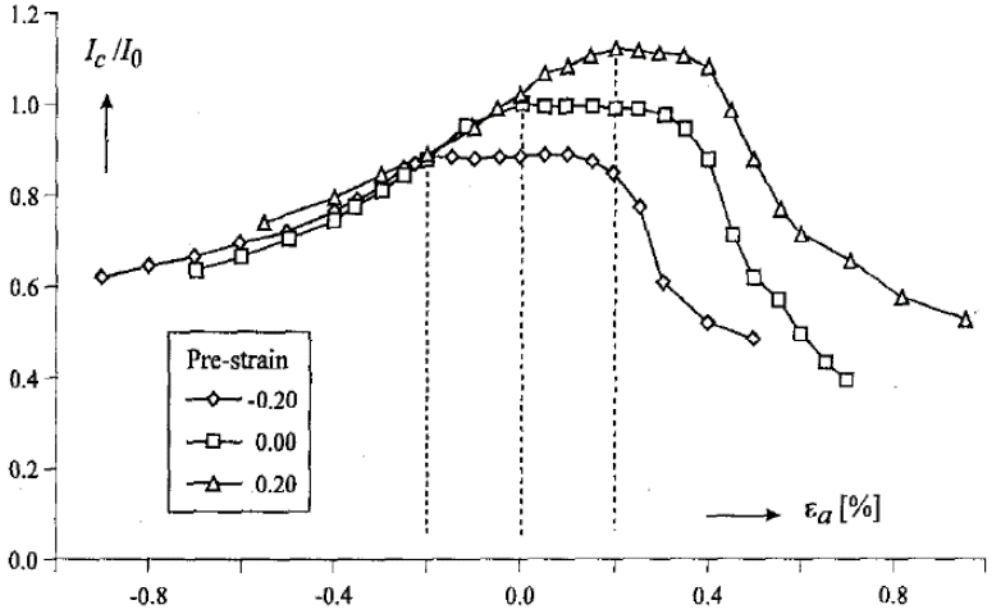
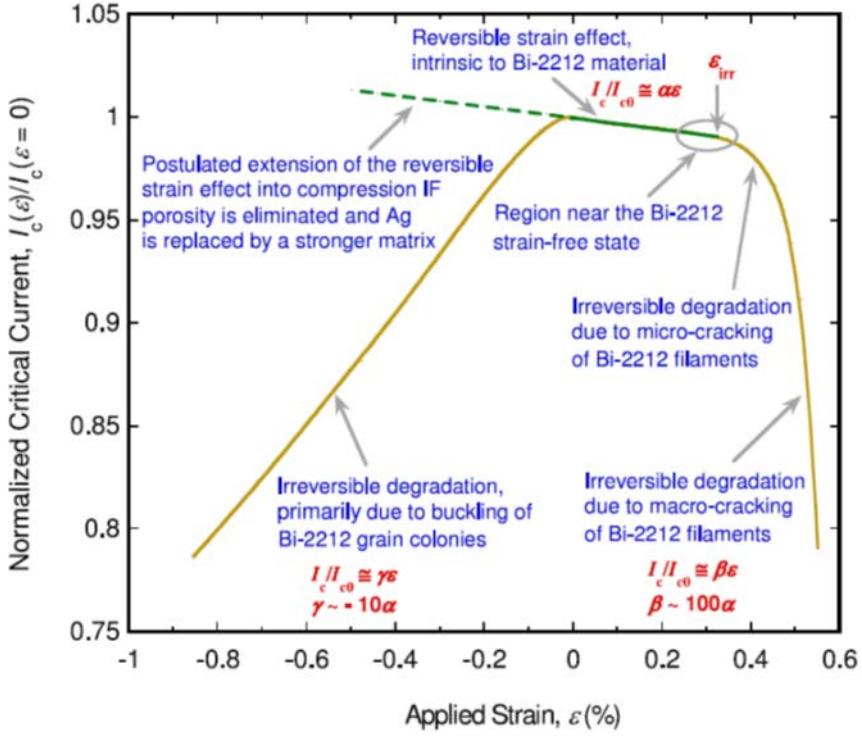


Fig. 3. The normalised critical current as a function of the axial strain measured on three pairs of pre-strained samples (measured at 4.2 K and 16 T).

B. ten Haken et al., IEEE Trans. Mag. 1996



N. Cheggour et al., Supercond. Sci. Techol. 2012

- Reversible electronic variation under low strain;
- micro-structural degradation at higher strain;
- irreversible strain limit a few ppm, depending on pre-strain.

Introduction

Cable behavior less well documented (under *transverse* compression)

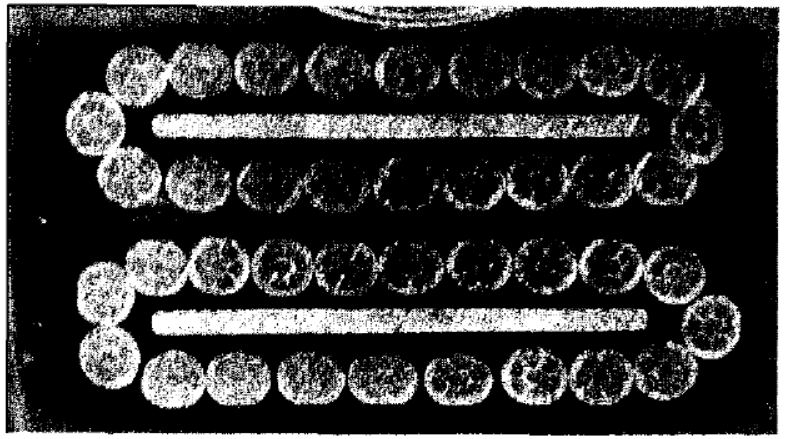


Fig. 1. Optical photograph of two cables of 689. The cross-section shows the potted cables as measure in face loading. The cable thickness and width were 2.35 mm and 8.94 mm, respectively.

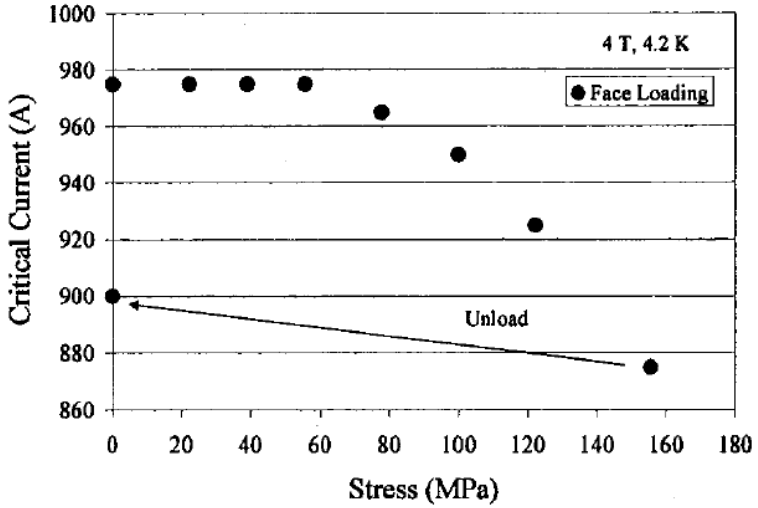
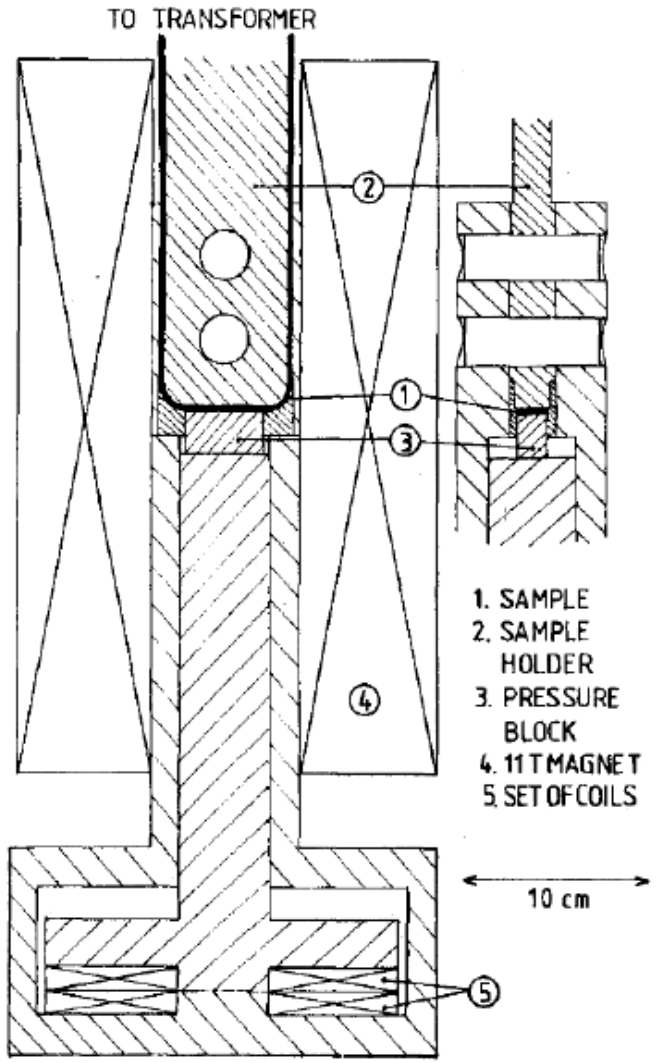


Fig. 3. Variation of the critical current (4 T, 4 K) with stress for a cable loaded on the broad face of the cable.

D. Dietderich et al., IEEE Trans. Appl. Supercond. 2001

- Transverse irreversible stress limit ~ 60 MPa.

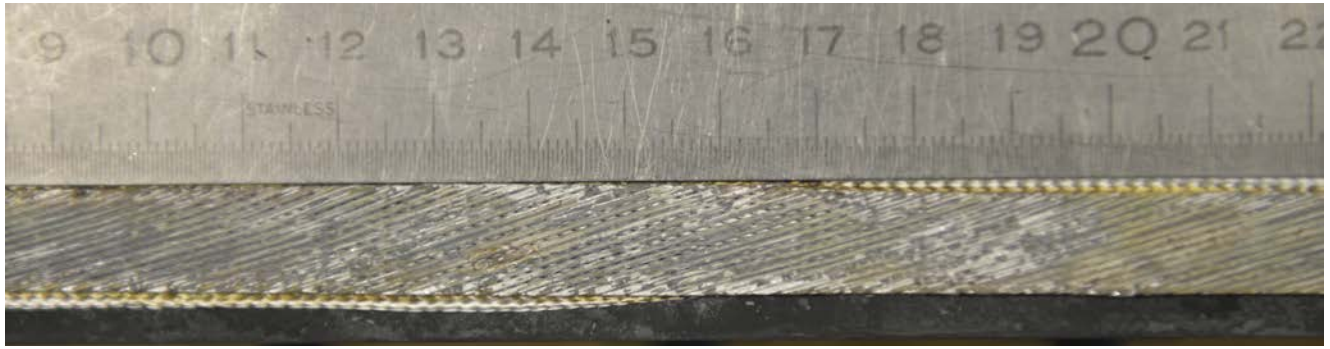
Measurement method / visual sample inspection



H. Boschman et al., IEEE Trans. Magn. 1991

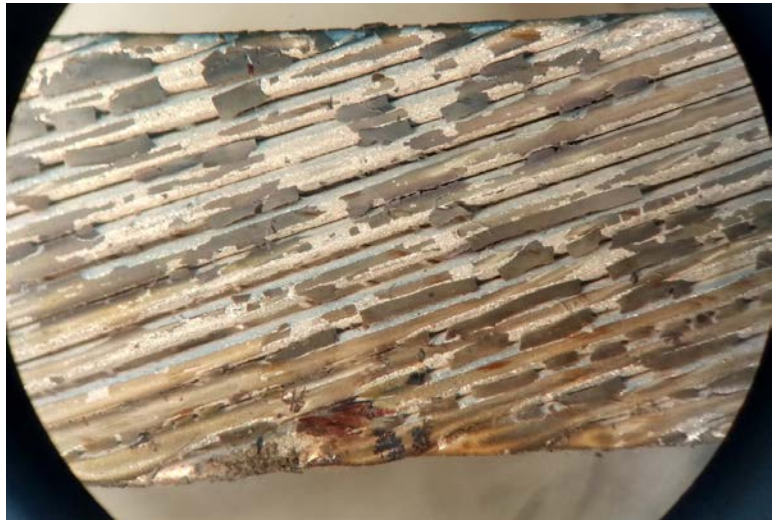
- Inconel reaction holder / mullite cable sandwich

- Width ‘legs’ 10.8-11.8 mm



Visual inspection

- Surface deposits



- Joints polished before pre-tinning with Sn97Ag3

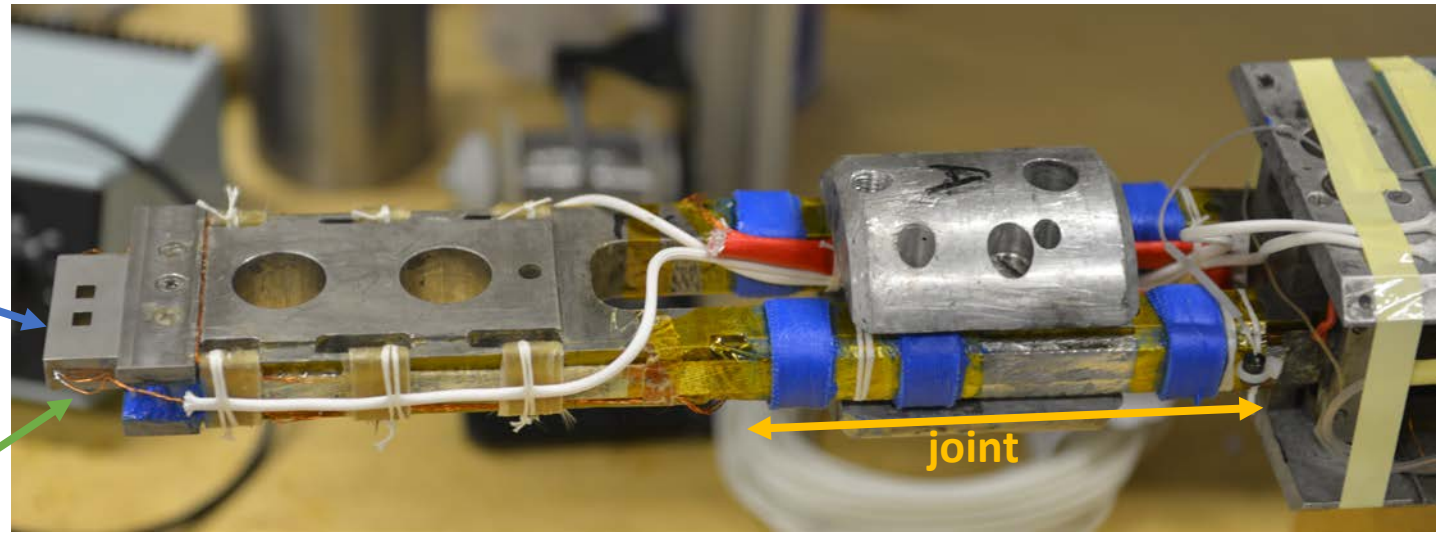
- Imperfect fit on reaction holder

- Expected to be mitigated by impregnation

The prepared cable

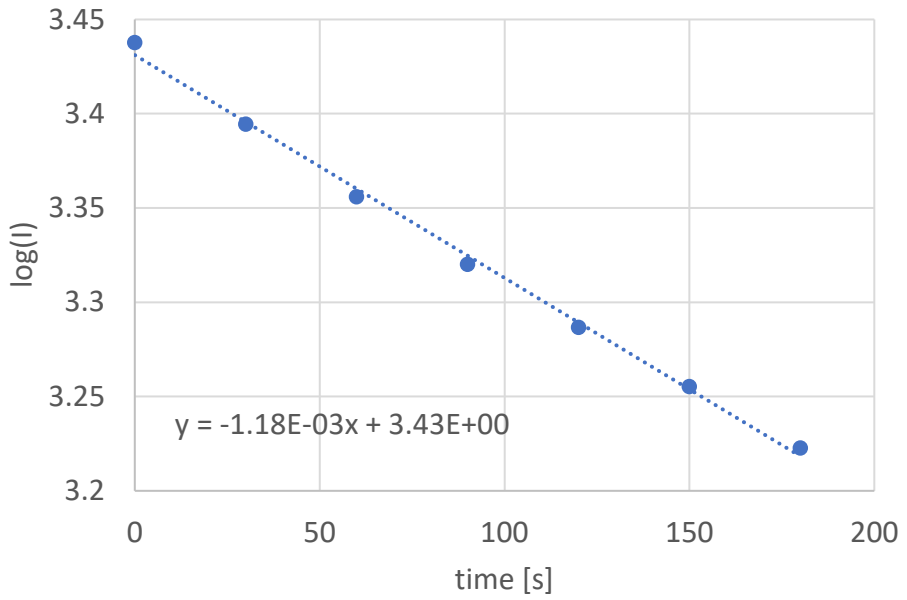
- Vacuum impregnated with CTD-101k
- Joint length is 144 mm (approx. two twist pitches)
- Pushing block area is (46 × 10.8) mm^2
- 2 × 3 voltage pairs, each spanning 2 twist pitches

Preliminary post-mortem section



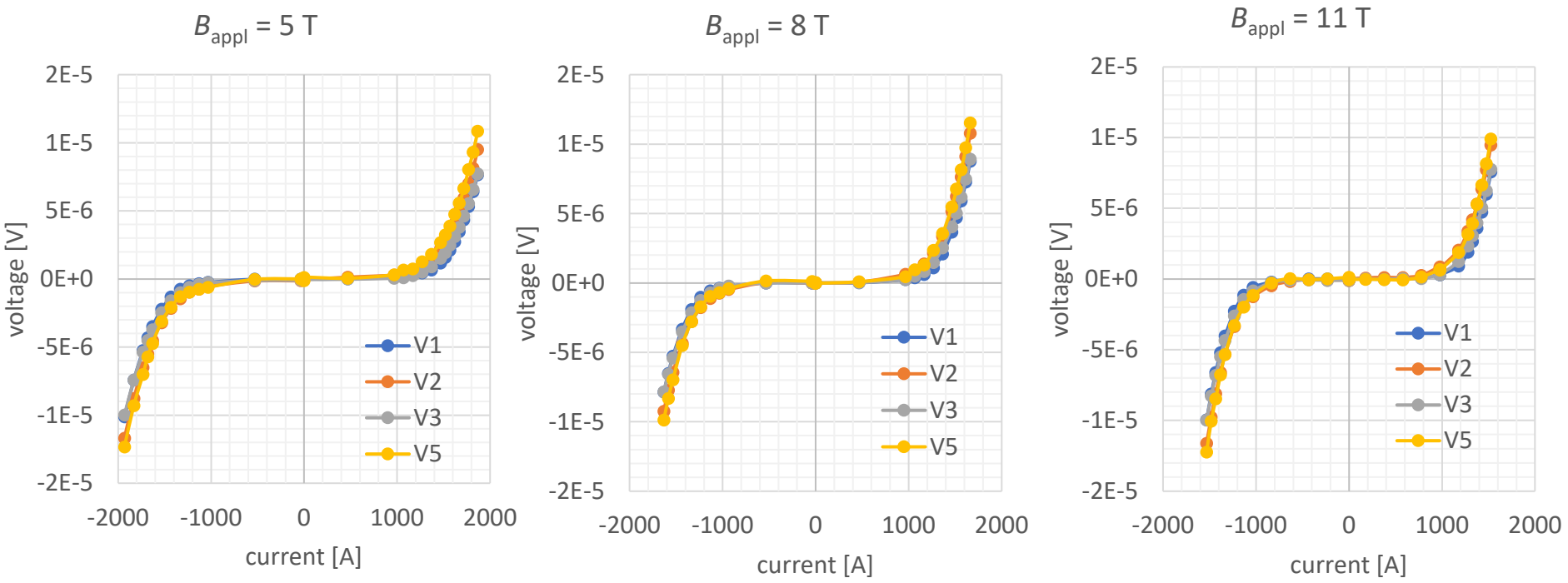
Transformer time constant (R_{joint} check)

- Current decay measured at $B = 0$ and no pressure
- Time constant $\tau = 850$ s
- Inductance $L \approx 1$ μH
- Resistance $R_{joint} \approx 1.2$ nΩ (both joints in series)



Critical current before pressing

- T = 4.2K; 4 voltage tap pairs over a length 2 twist pitches



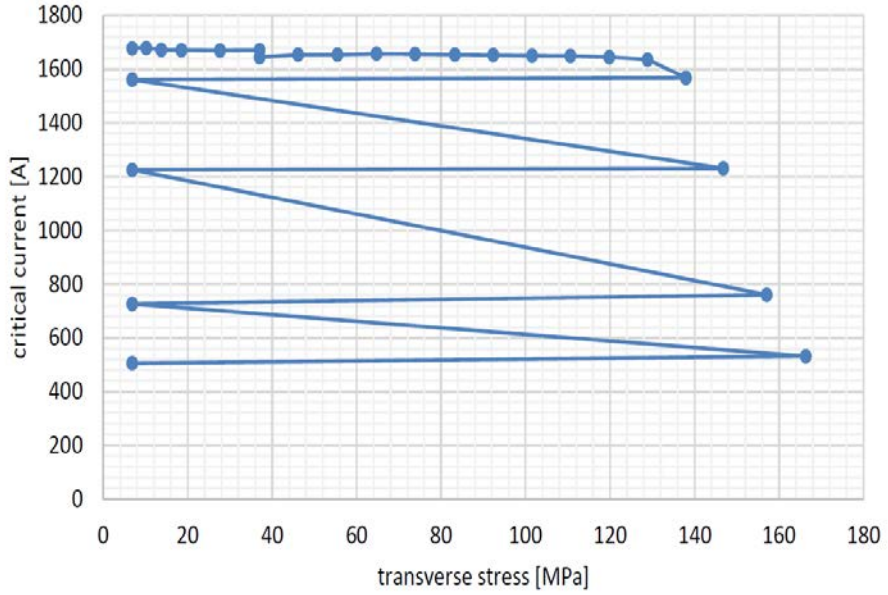
- Critical currents

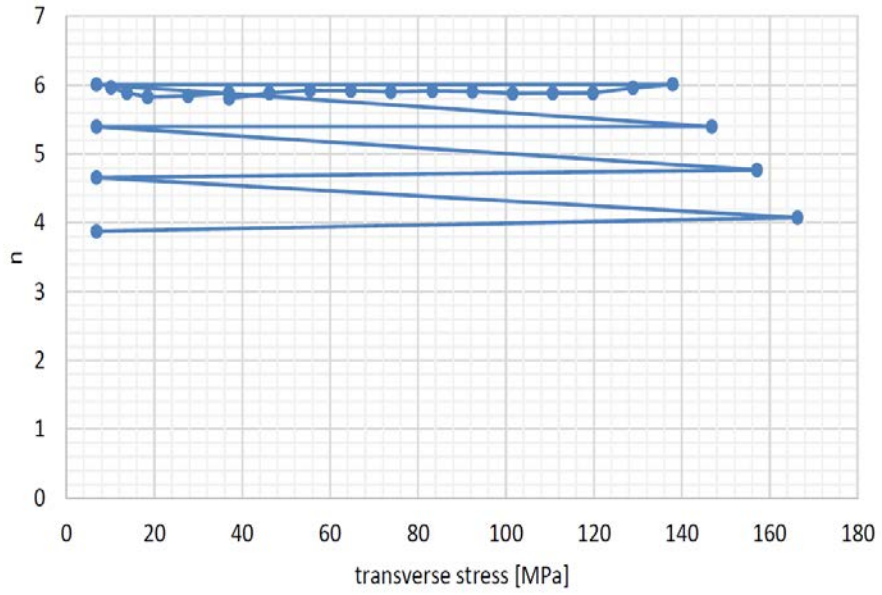
B_{appl} [T] (*)	I_c [A]	n
5	1685	6.5
8	1476	6.4
11	1360	6.4

(*) without self-field, estimated ~ 60 mT/kA

Transverse stress test (averaged data)

- T = 4.2 K; B_{appl} = 5 T; E_c = 10^{-4} V/m (V_c = 4.6 μV)

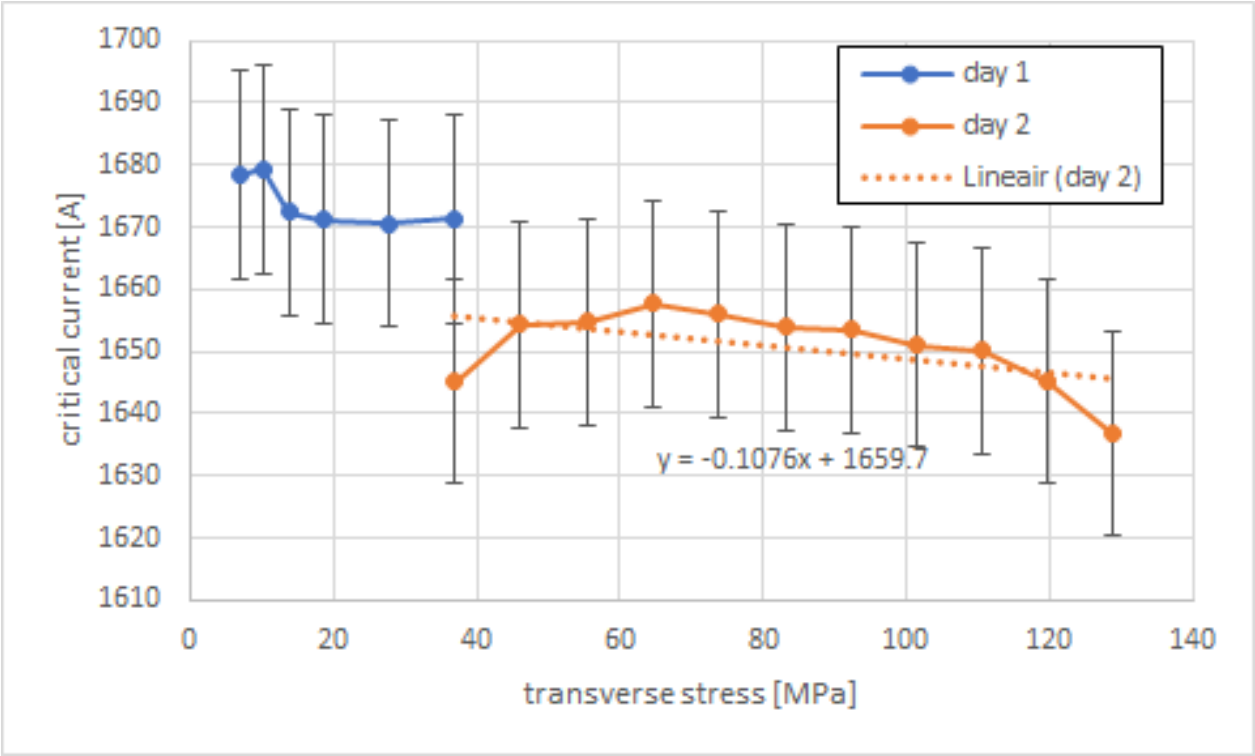




- ~ 5% degradation at 138 Mpa ; 65% degradation at 166 MPa

Transverse stress test (zoom on 'reversible' part)

- T = 4.2 K; B_{appl} = 5 T; E_c = 10^{-4} V/m (V_c = 4.6 μV)



- No significant reversible variation

Conclusion

- *Early-stage Bi-2212 cable was measured in UT $I_c(\sigma)$ press;*
- *Relatively modest I_c and n-values (without pressure);*
- *No significant reversible I_c variation observed with pressure;*
- *Degradation sets in at $\sim$130 – 140 MPa;*