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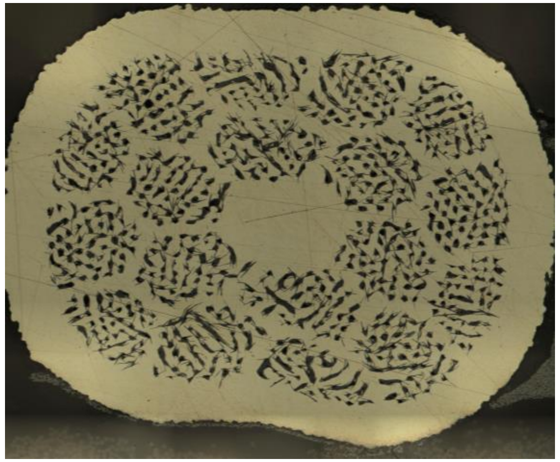
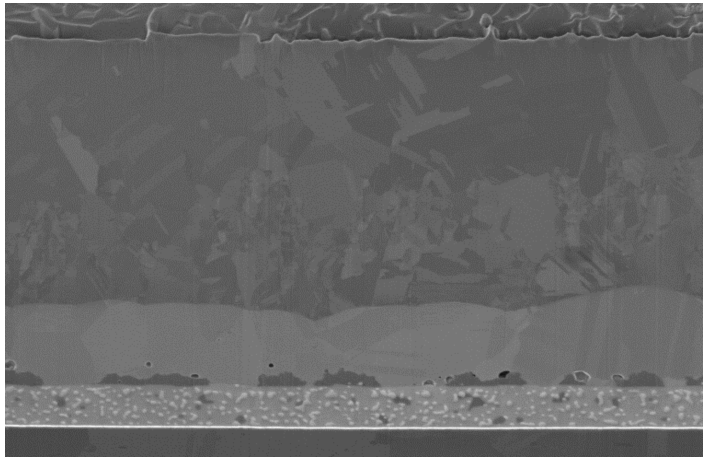
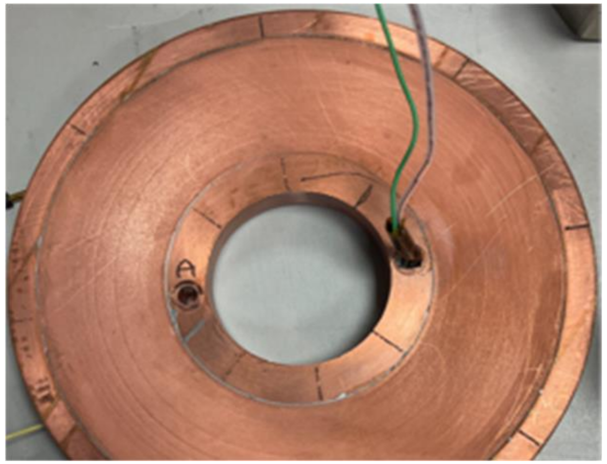
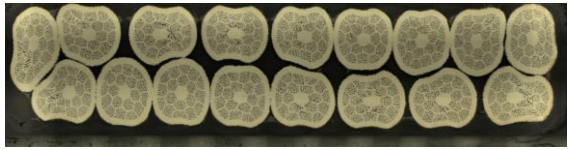
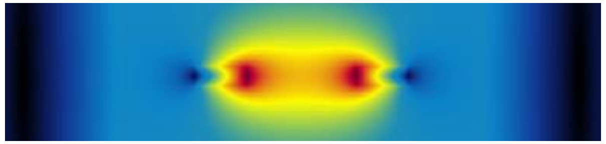
CERN

R&D on HTS conductors, cables and coils at UTwente

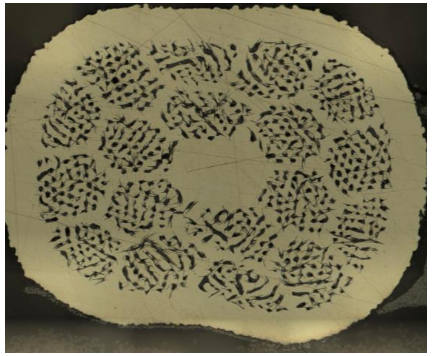


Anna Kario, Arend Nijhuis, Marc Dhalle, Simon Otten, Thomas Nes, Sander Wessel and Herman ten Kate

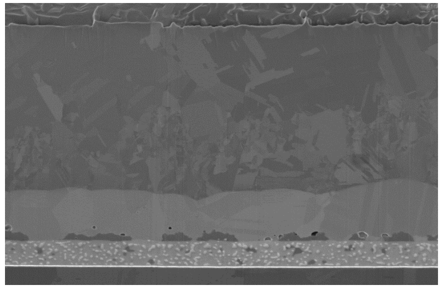
Outline

Understanding transverse stress of Rutherford BSCCO-2212 cables

LBNL+NHFML: T. Shen, U. Trociewitz, D. Davis, E. Bosque



The ReBCO as elemental material for future accelerator type magnets



- Novel impregnation approach for ReBCO cables

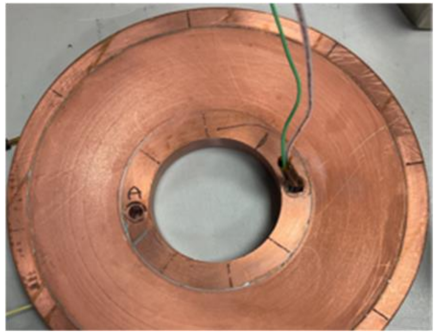
  UTwente: T. Boelens, S. Wessel

- Understanding mechanical behavior of ReBCO tapes and cables

  UTwente: S. Otten, M. Dhalle, S. Wessel

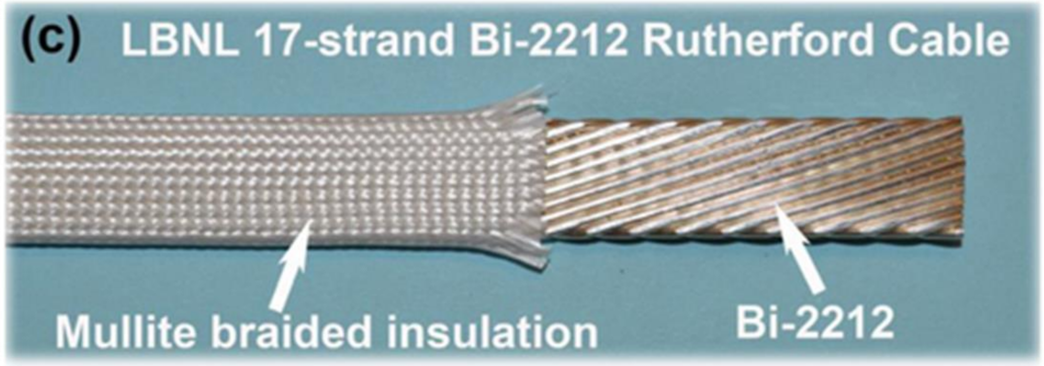
- ReBCO coils in background magnetic field

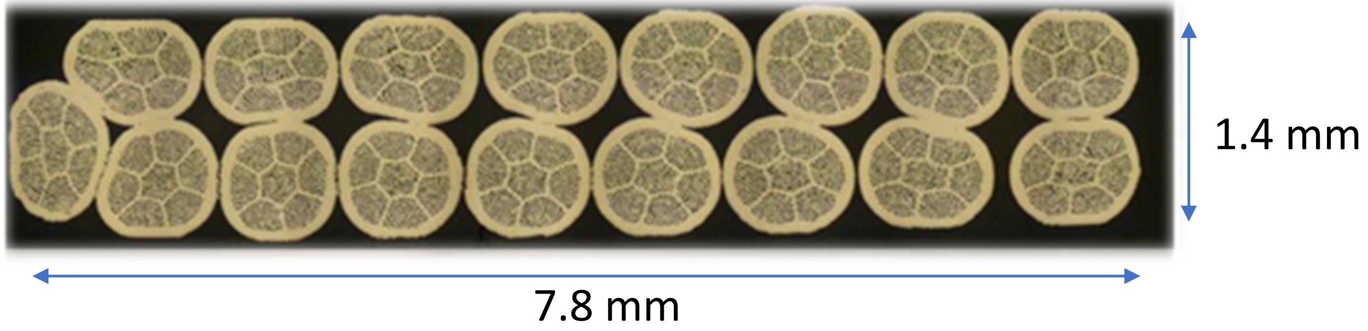
  UTwente+CERN: T. H. Nes, J. M. Boerma, F.O. Pincot, J. Liberadzka-Porret, G. de Rijk, H. H. J. ten Kate



Rutherford BSCCO-2212 cable samples

Cable No.	Specifications	Wires
LBNL2002	17-strand subscale magnet cable, nominal 7.8 mm x 1.4 mm	PMM190118, 55x18, 0.8mm, Engi-mat LXB156
LBNL1088	17-strand subscale magnet cable, nominal 7.8 mm x 1.4 mm	PMM170123, 55x18, 0.8 mm, nGimat LXB52
LBNL1068	17-strand subscale magnet cable, nominal 7.8 mm x 1.4 mm	PMM101111, 37 x 18, 0.8 mm, Nexans batch #77 powder
LBNL1109	17-strand subscale magnet and CCT magnet cable, nominal 7.8 mm x 1.4 mm	Non-twisted PMM180207_4, 5, 6 ,7, 55x18, 0.8mm, Engi-mat powder LXB103





Reaction holder for BSCCO-2212 Rutherford cable

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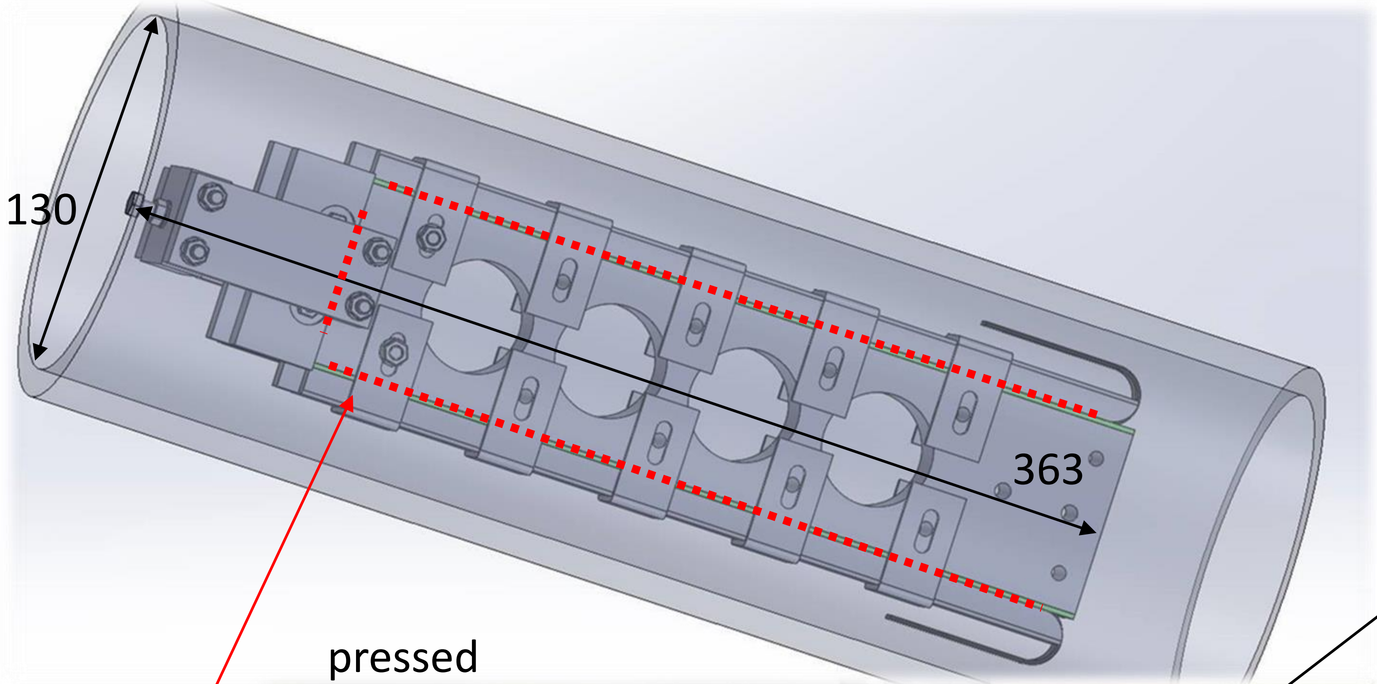
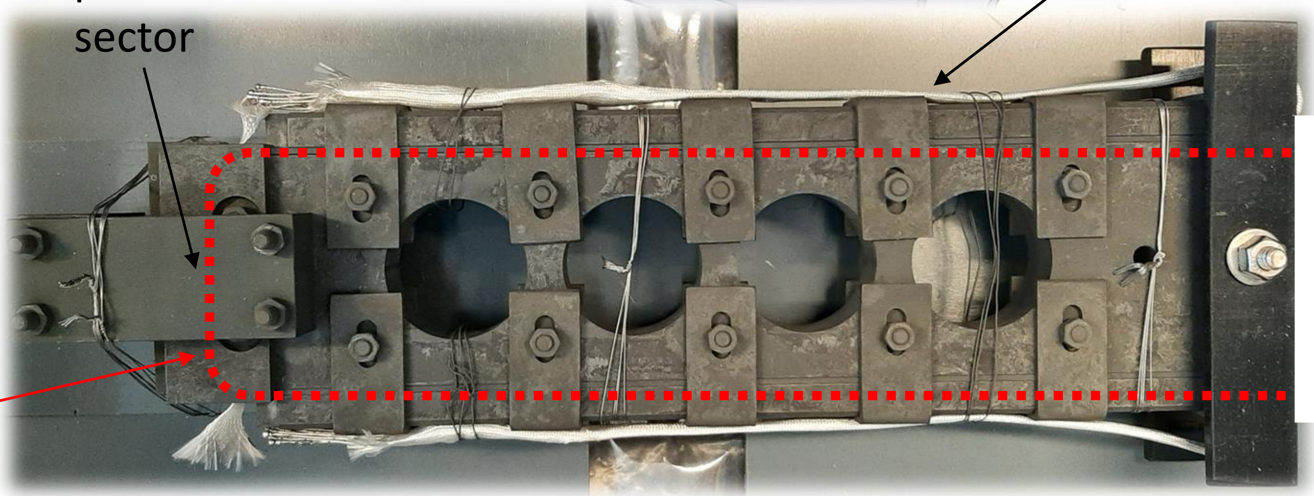
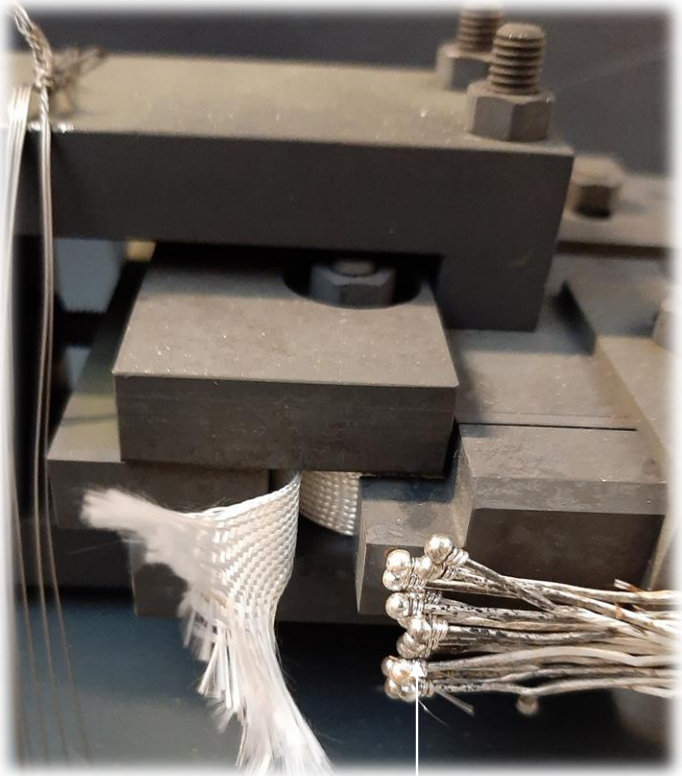


Additional length of the cable

pressed sector



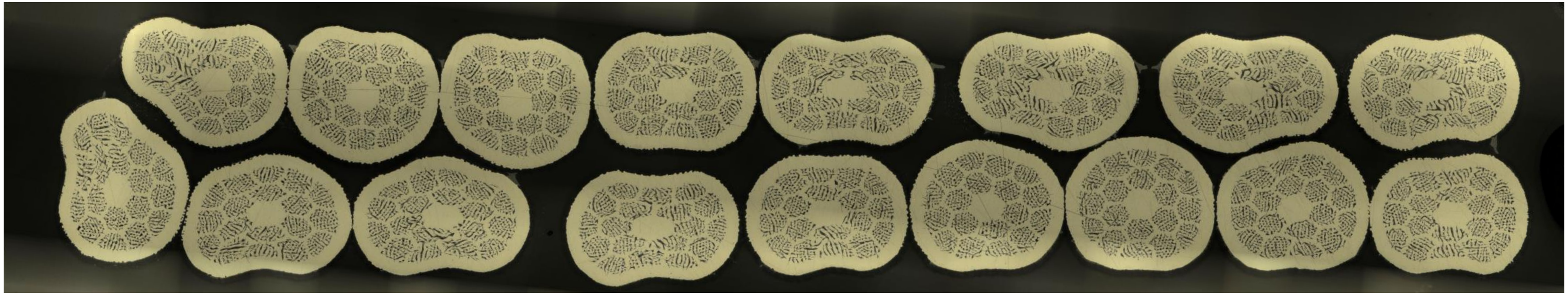
Cable used for transverse stress experiment

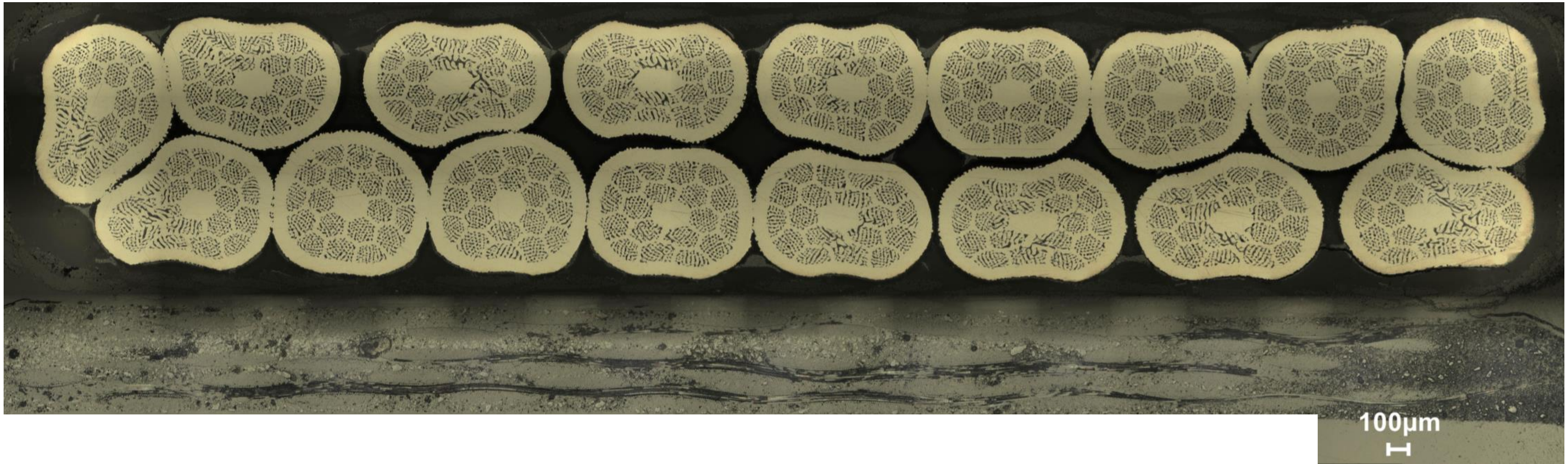


Closed BSCCO-2212 wires before heat treatment

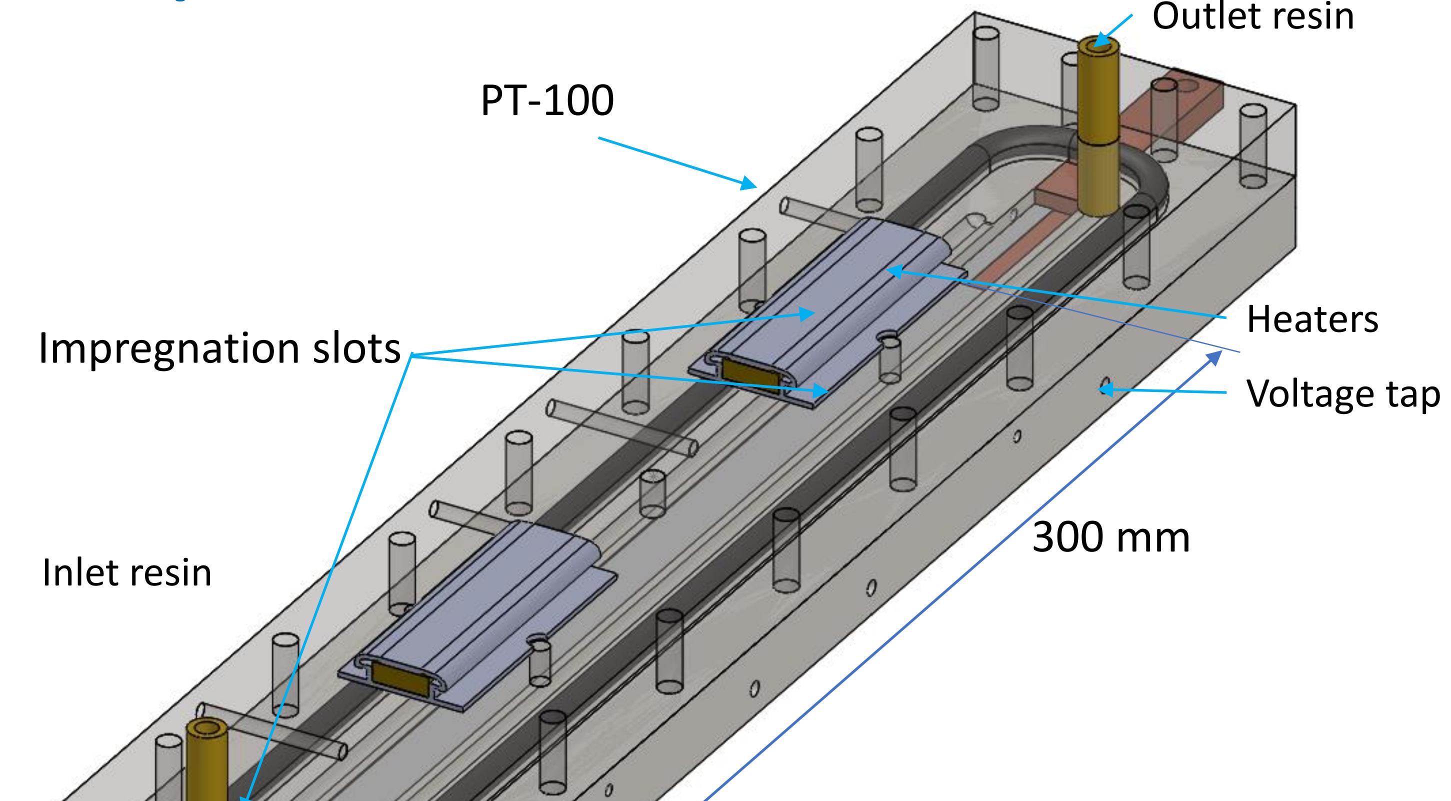
Reaction: E. Bosque @FSU

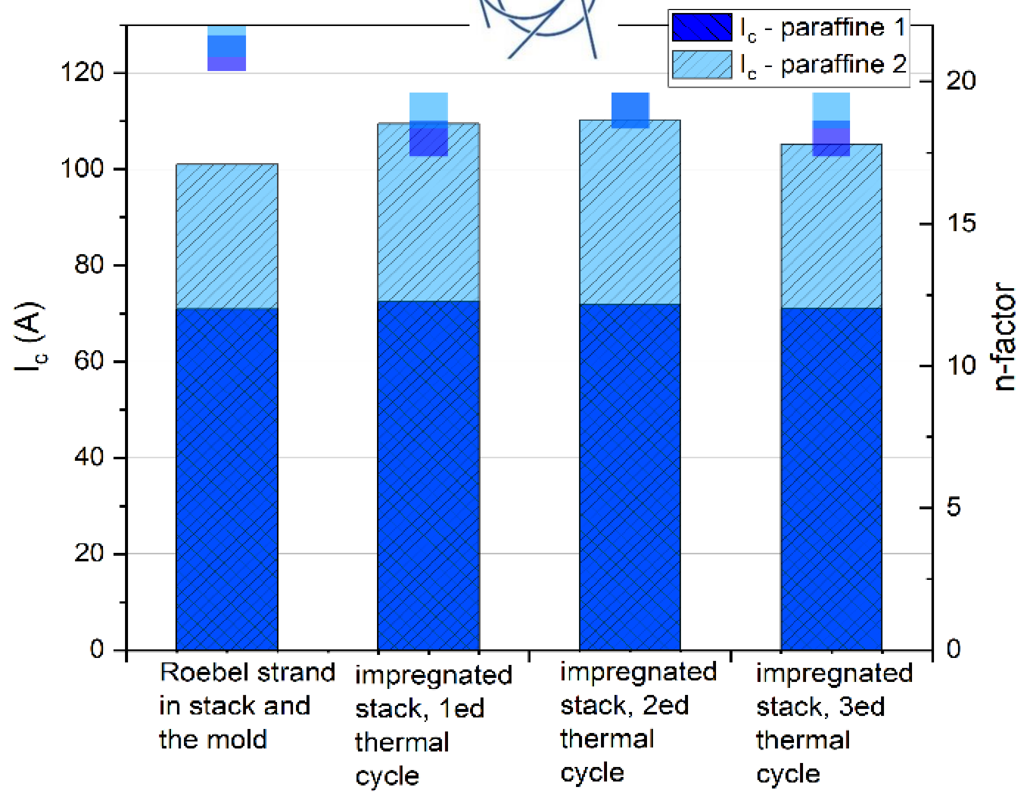
BSCCO-2212 Rutherford cable after heat treatment and transverse stress

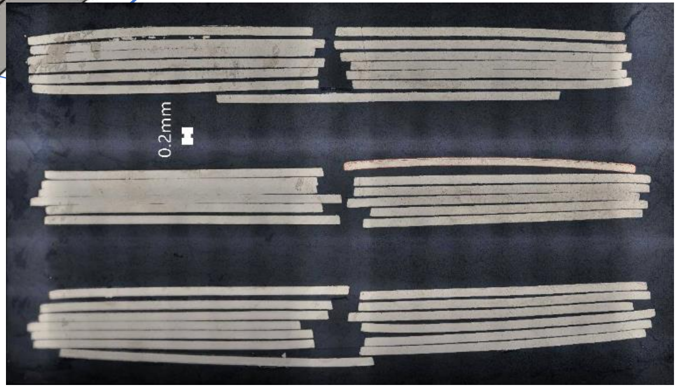




Delamination mitigation by impregnation method choice and pre-stress

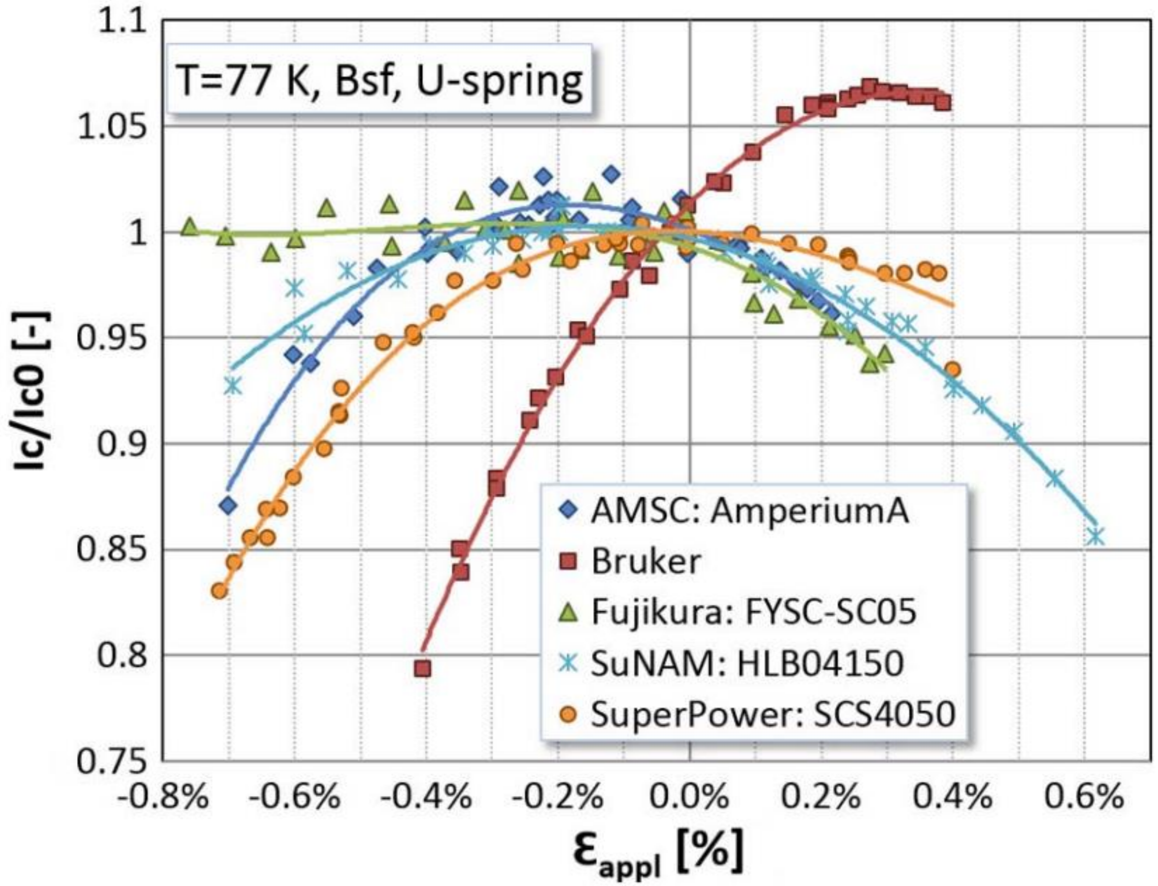


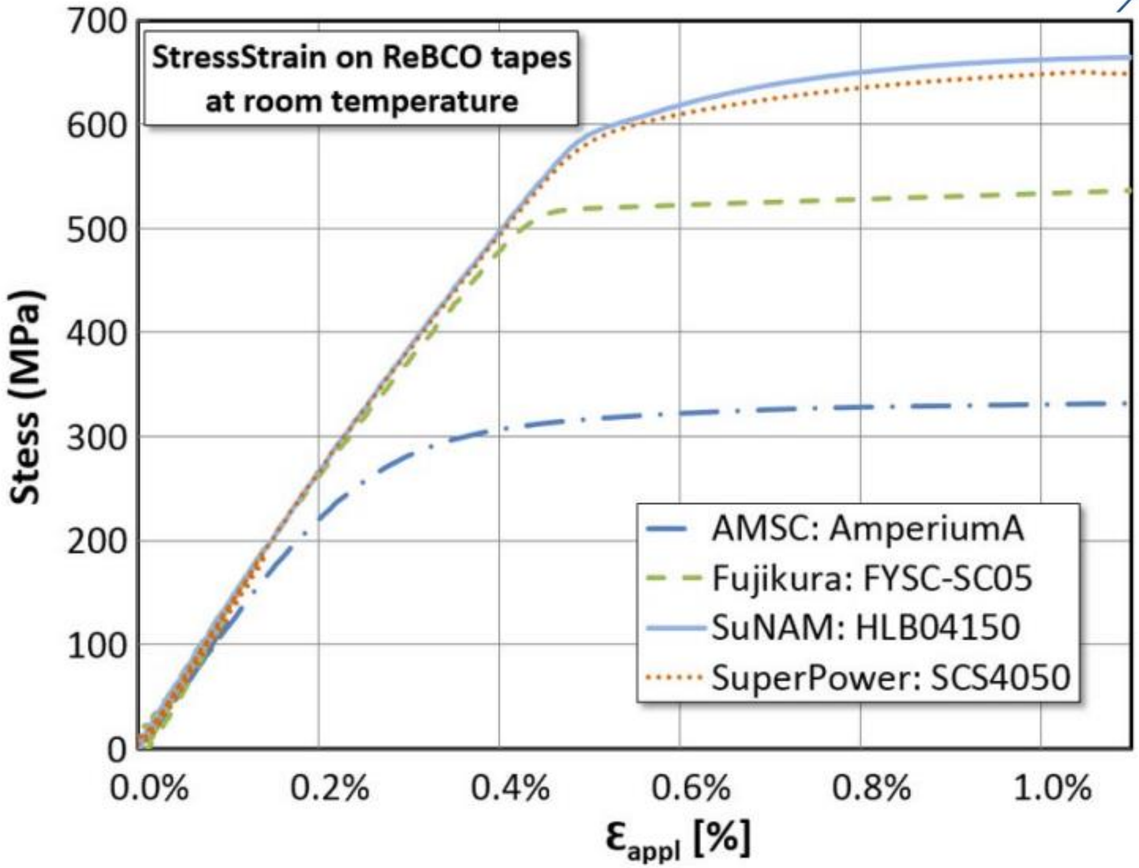




- Study of delamination mitigation using prestress and/or debonding layers
- Examination of I_c at 77K and self-field in multifunction mold
- Modelling tools for understanding thermal and electromechanical effects

Understanding mechanical behavior of ReBCO tapes





- C. Zhou et al., IEEE Transactions on Applied Superconductivity, Vol. 26, No. 4, June 2016

- Importance of study ReBCO tapes mechanical properties, together with simulations, for understanding limits for future high current cables and further high field magnets

Impregnated *Re*BCO Roebel cable withstand stresses up to 400 MPa

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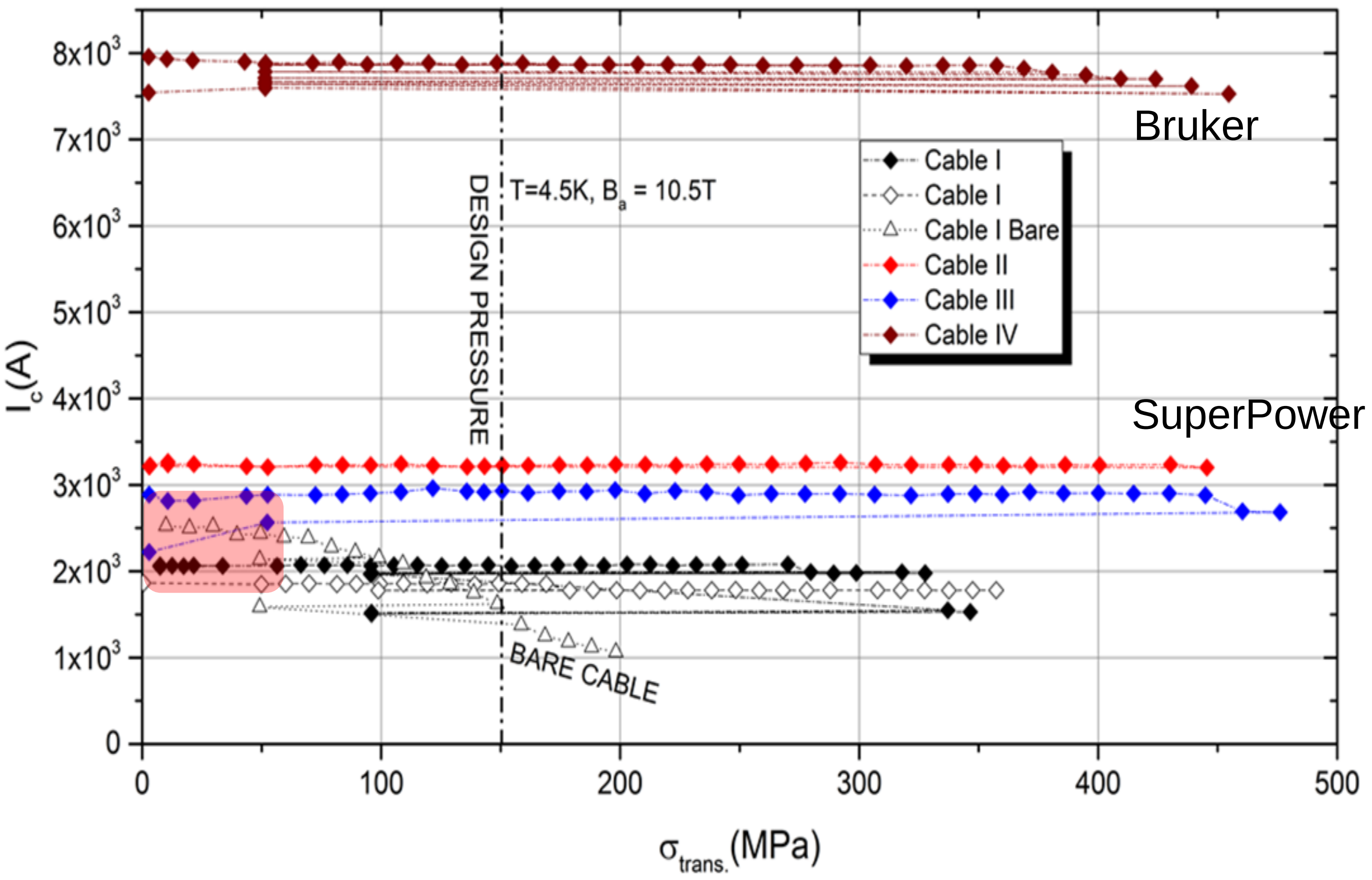
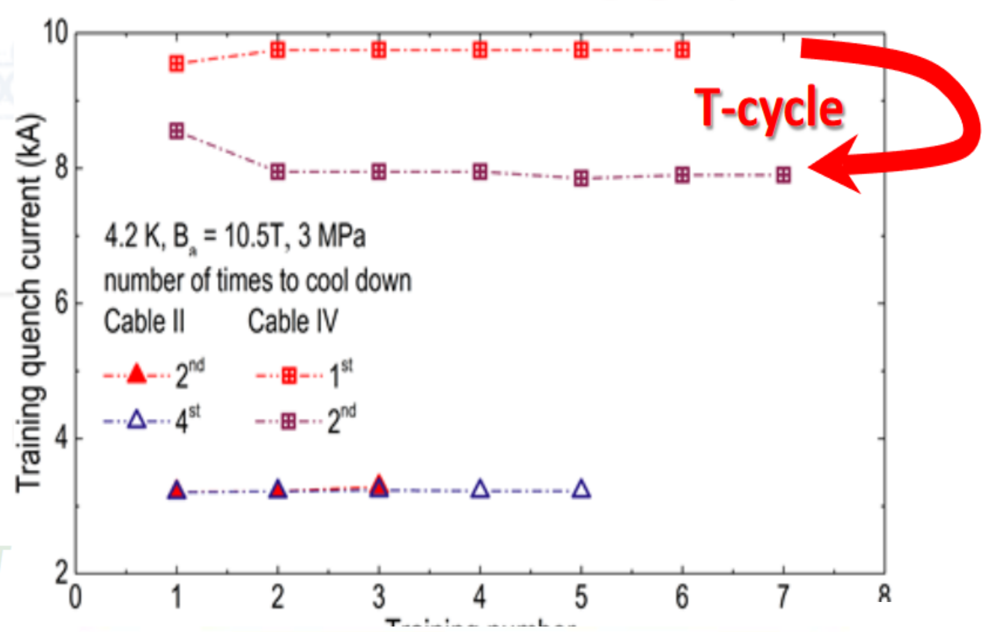
P. Gao et al 2019 Supercond. Sci. Technol. 32 055006





Cable II

- J. Fleiter, A. Ballarino, L Bottura, P. Tixador, Supercond. Sci. Technol., Vol. 26, No. 6, 2013.

- Importance of study ReBCO cables in transverse stress to understand the limits for future high field magnets
- Relevance of electromagnetic and thermal cycling effect on critical current of ReBCO cables

Small *Re*BCO coils and measurements in background magnetic field

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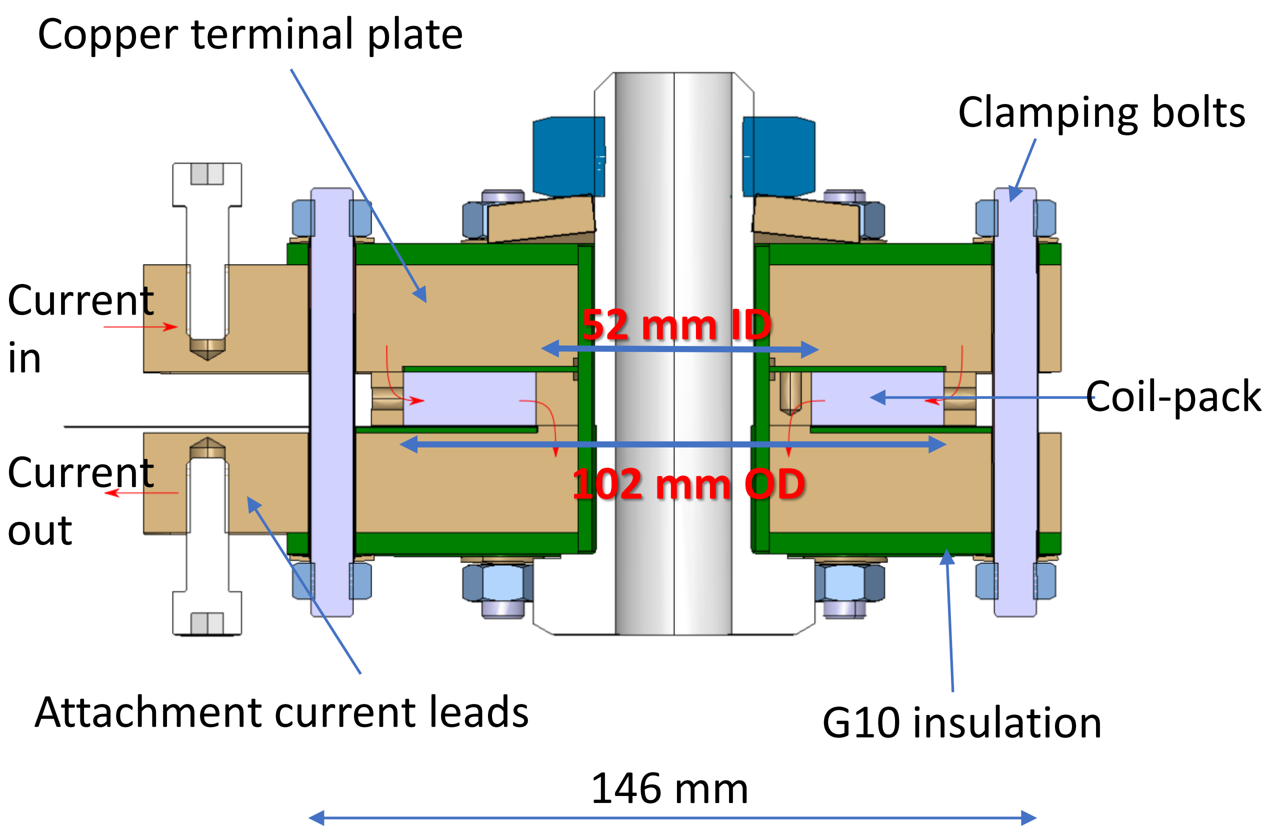
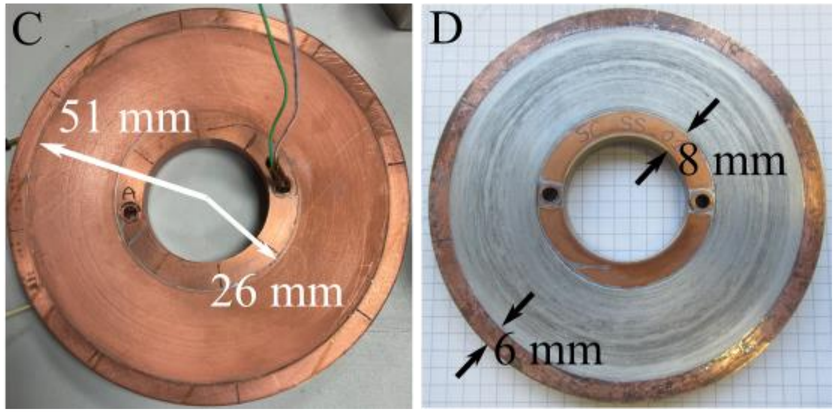
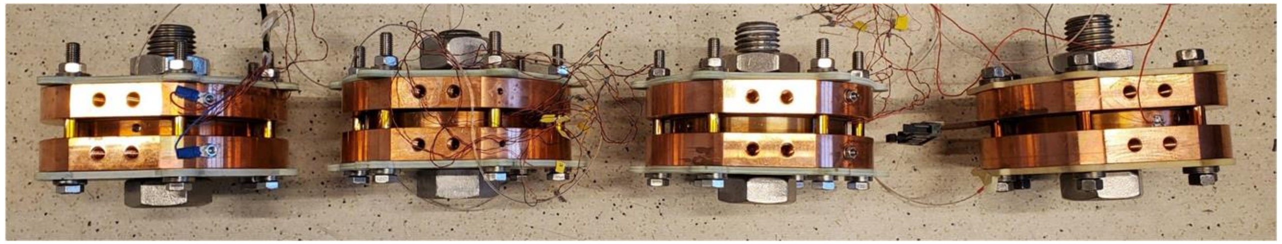




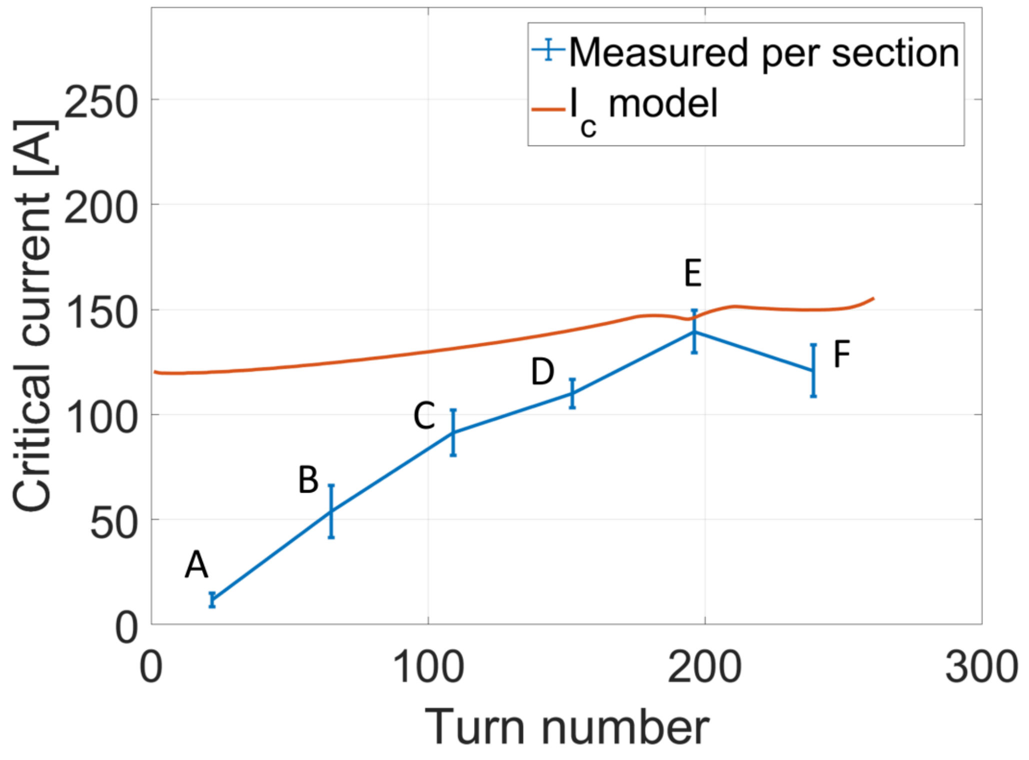


- Motivation:
  - Gain winding experience with *Re*BCO
  - Determine time constants to extrapolate to larger coil designs
  - Study dynamic behavior of such coils in comparison with a model

- Lessons learned from small coils applied to larger coils (for example Cloverleaf)

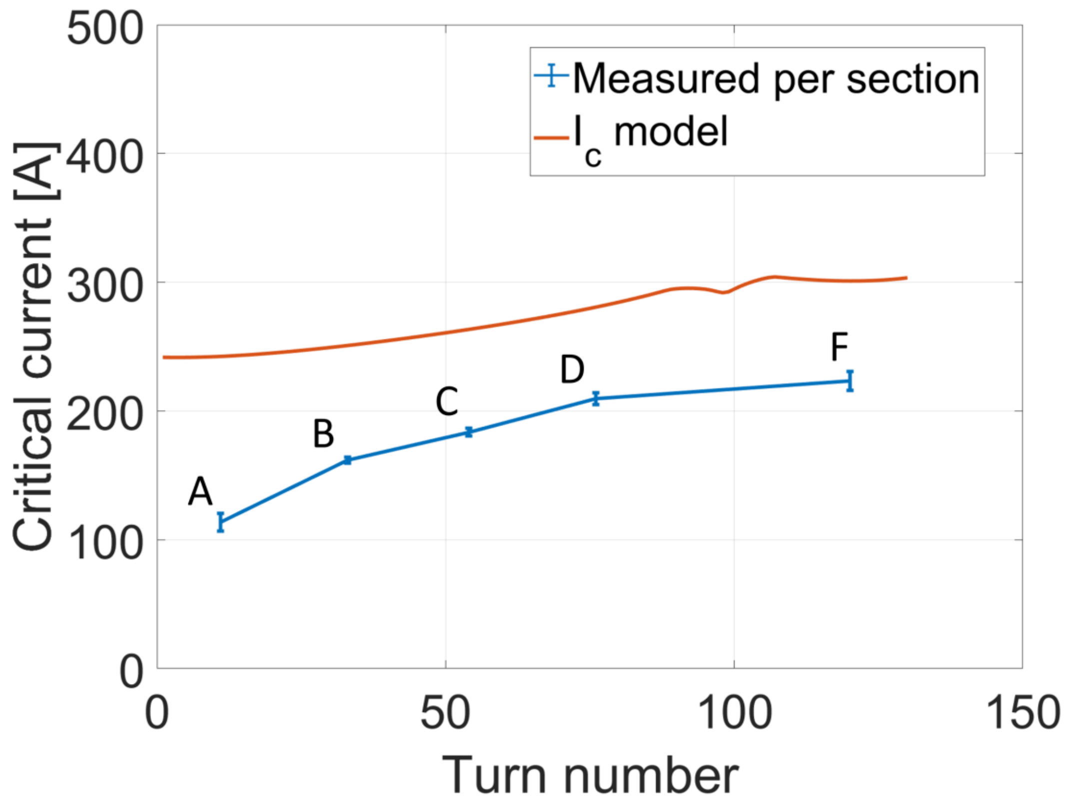
Small *Re*BCO coils and measurements at 77K and self-field

Soldered single tape



- Coil critical current = 38 ± 16 A
- Quench current > 400 A

Soldered double tape



- Coil critical current = 163 ± 6 A
- Quench current > 240 A

Small *Re*BCO coils and measurements at 77K and self-field

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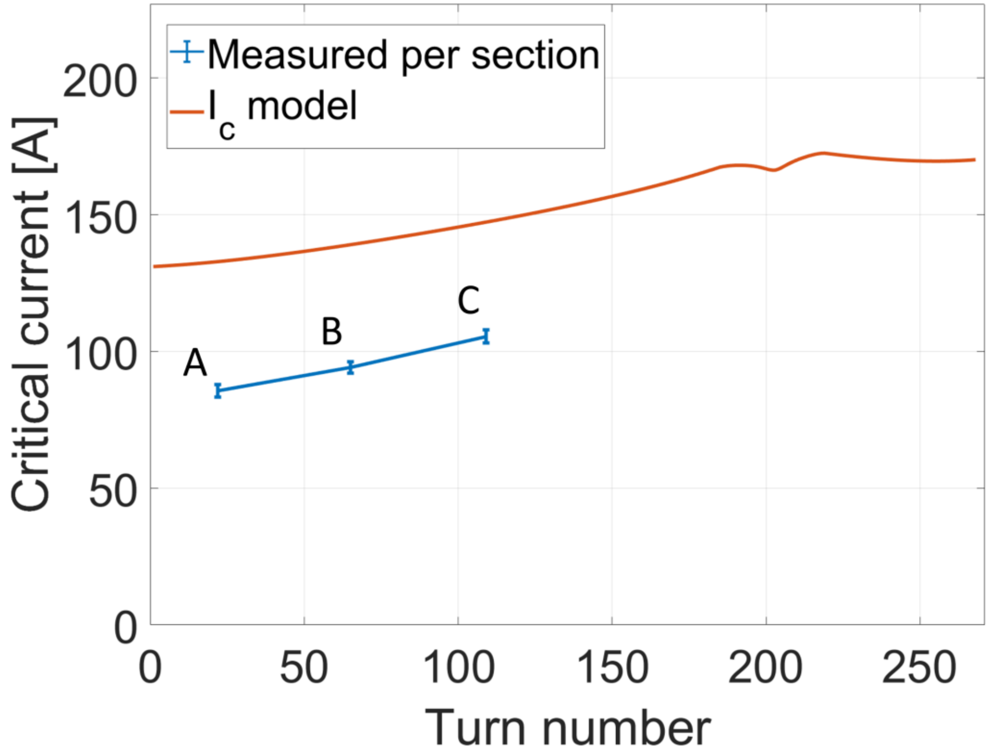
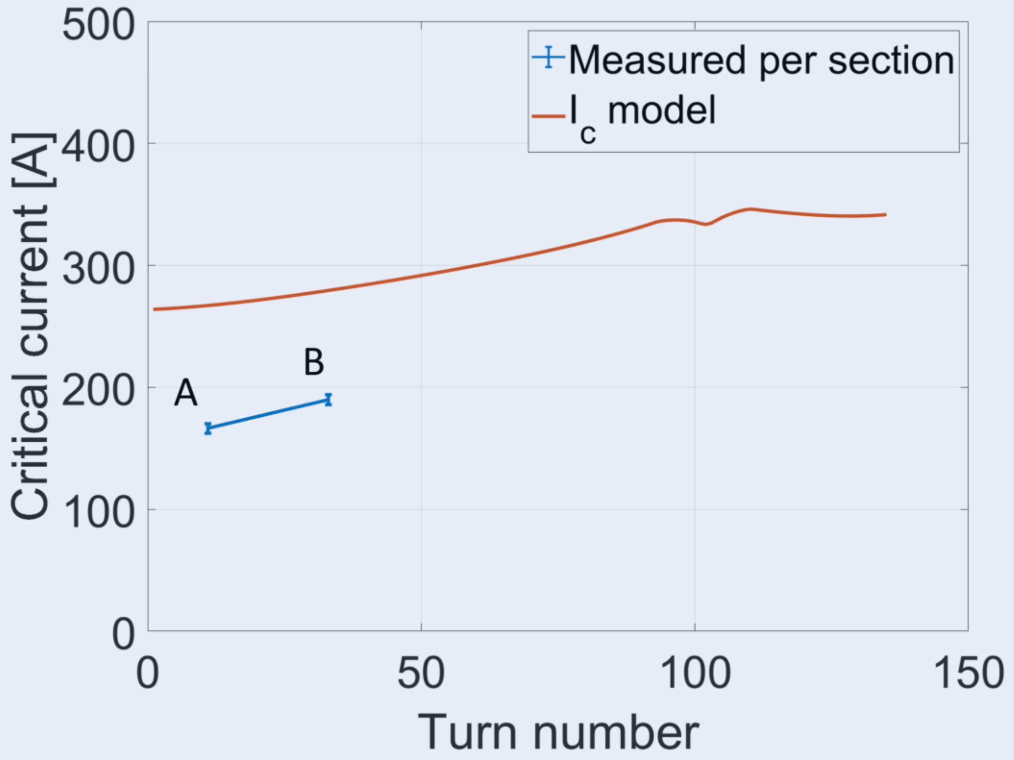
Dry-wound single tape



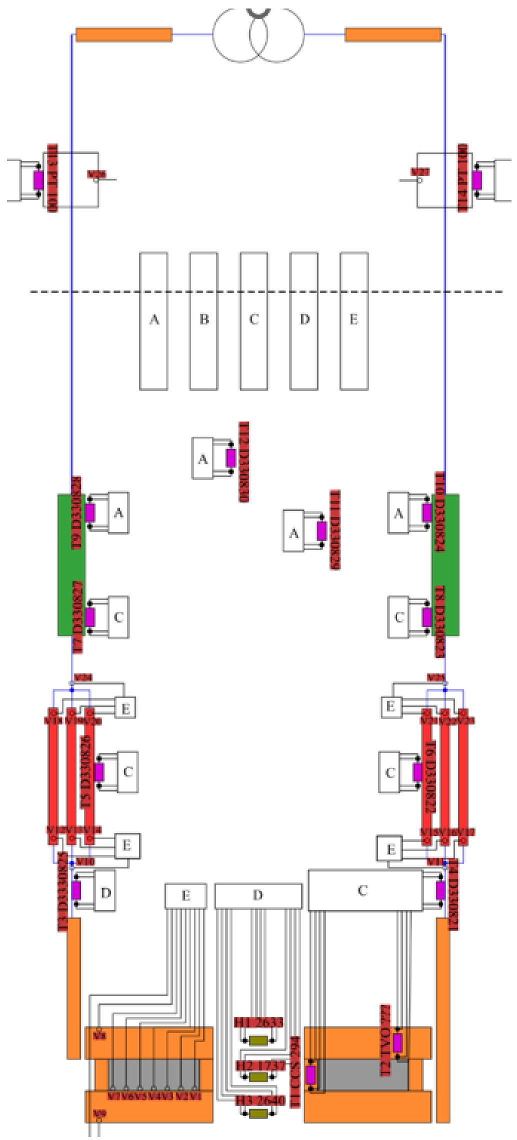
- Coil critical current = 95 ± 3 A
- Quench current = 116 ± 3 A

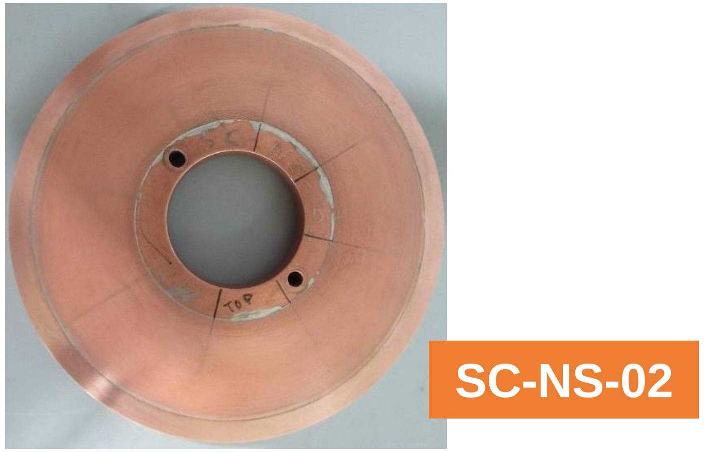
Dry-wound double tape



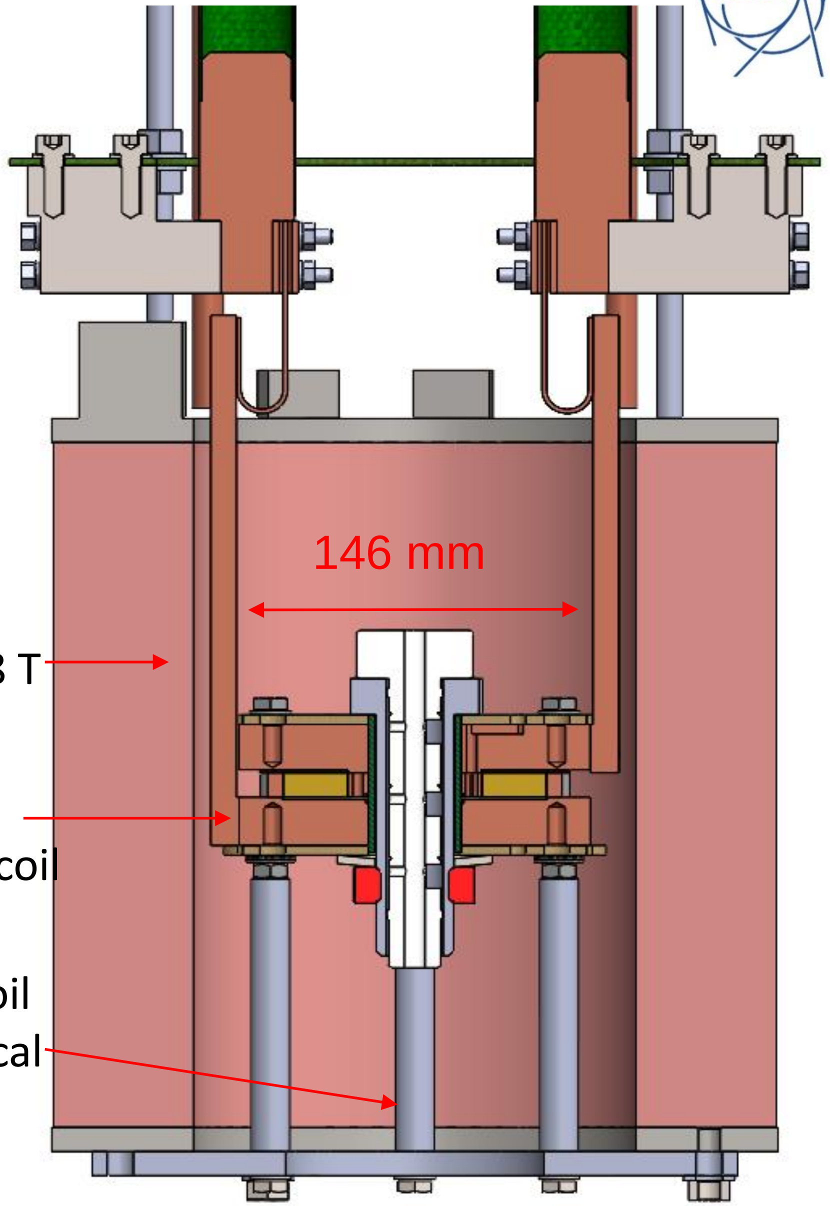
- Coil critical current = 180 ± 3 A
- Quench current = 194 ± 3 A

Non-insulated coil small demonstrator at background field





- Understanding of behavior of small ReBCO demonstrator
- Modelling using full characteristic of used ReBCO material
- Measurements standalone and in background magnetic field



Cloverleaf-racetrack *Re*BCO accelerator type magnet

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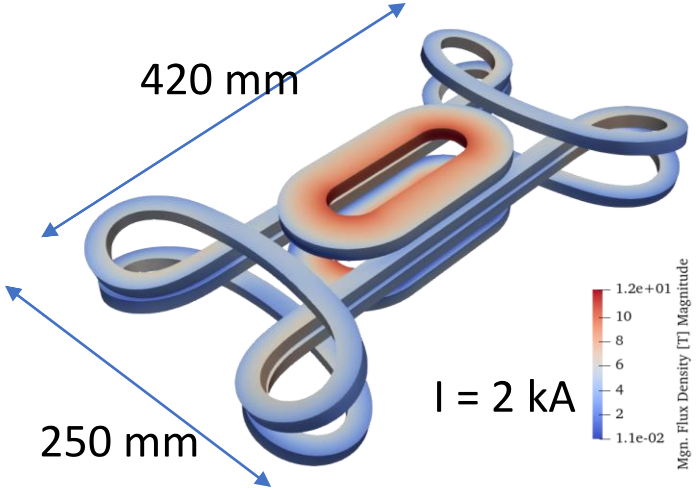
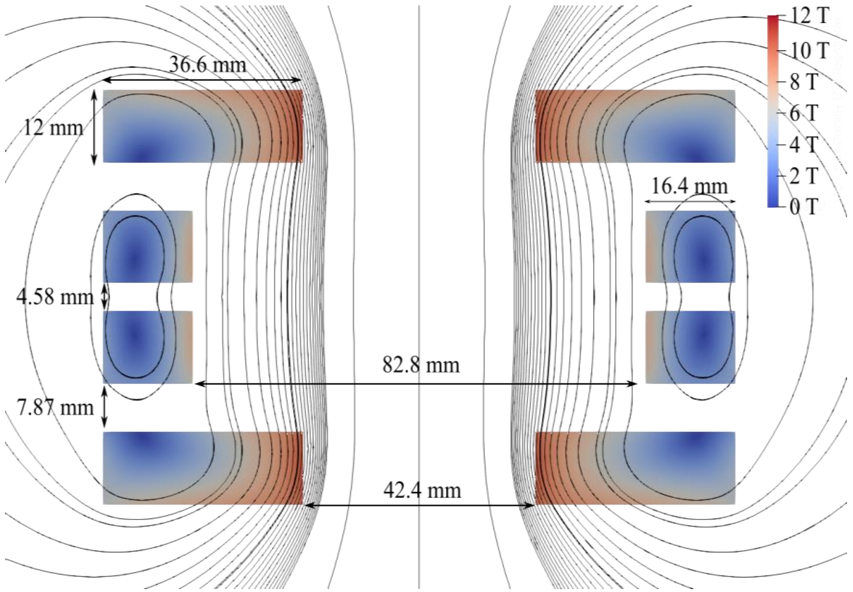
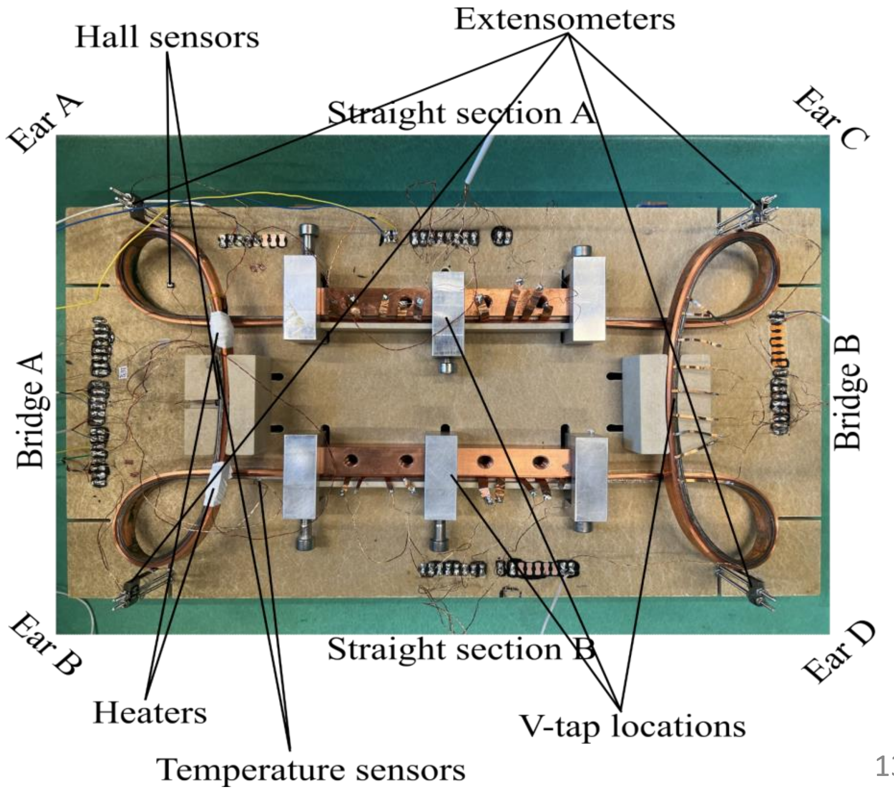




<u>Liquid nitrogen measurements</u>

- measurement of the critical current
- linear and stair ramp
- multiple thermal cycles
- instrumentation: hall probes, extensometer, thermometers, voltage taps

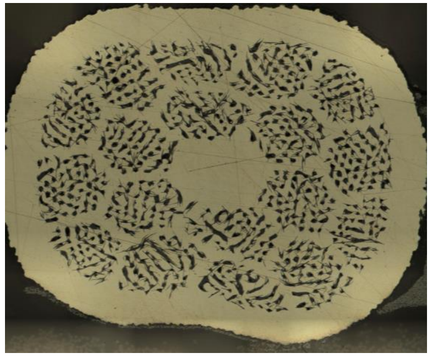


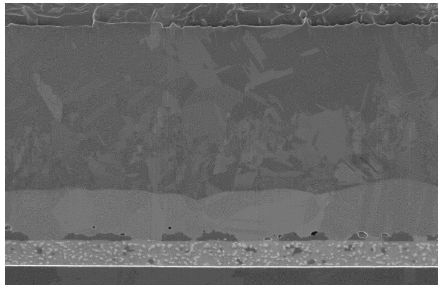
- Prototype which serves as first step towards 20 T accelerator dipoles
- Cloverleaf shape is solution to hard-way bend problem
- 12 mm double ReBCO tape used as conductor
- Full HTS magnet with 8 turns

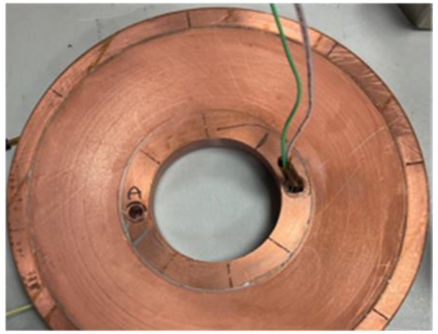
Summary

The ReBCO as elemental material for future accelerator type magnets

- Impregnation/delamination
- Mechanical behavior
- Wires & Cables
- Small demonstrators







Plans

- Mitigation of delamination, novel impregnation materials
- Smart testing, design of problem-oriented experiments supported by simulations, for example ReBCO pancake joints and leads
- Understanding electromechanical limitations of wires, cables and coils using modeling and experimental