Thin REBCO CORC Wires with Current Densities of 400-600 A/mm^2 at 4 K & 10 T

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Outline

- CORC Wires, Cables and Cable-In-Conduit Conductors
- Wire Performance and Outlook
- CORC Racetrack Coil at CERN
- Conclusions

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(Picture courtesy of ACT)

CORC Wires

(Picture courtesy of ACT)

CORC Wire

CORC Cable/Strand

Advantages of CORC wires:

- Isotropic Bending
- Highly Flexible
- Internal Core Stabilized
- High current density

Applications of CORC wires:

- High-magnetic field magnets
- Fast ramp magnets
- Flexible bus bars and current leads

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Measurements @ University of Twente

Aim of the tests:

- Demonstrate ease of use of CORC wires
- Demonstrate high performance of CORC wires
- Optimize wire production and handling

Setup at the University of Twente:

- Up to 10.5 T background magnetic field
- Current is generated with a SC transformer
- Mandrel has an outer diameter of 60 mm
- CORC wire is wound into a few-turn solenoid
- Forces can point inwards/outwards

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Timeline of the Twente Measurements

Year	Tapes	Wire OD (mm)	Tape Width (mm)
2015	38	7.6	4
2016	24	4.5	3
2016	16	3.0	2
2016	50	4.1	2
2017	29	3.6	2

Several iterations were performed; optimizing wire production, optimizing wire geometry, improving joint terminal design and wire handling.

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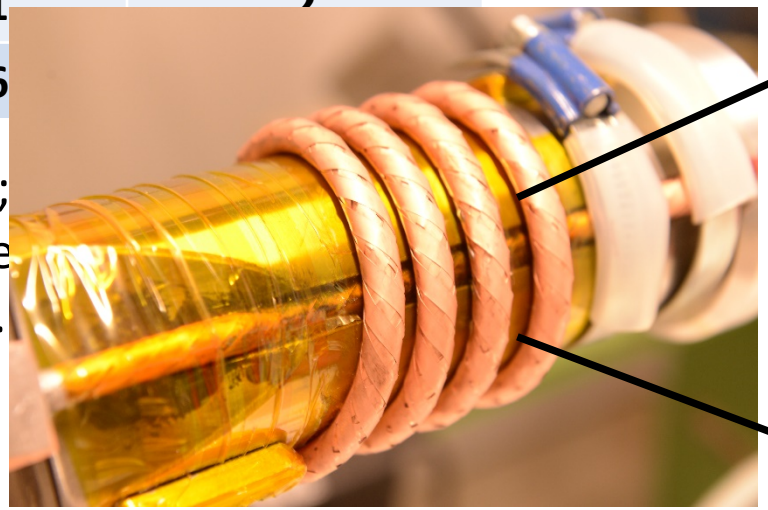
Conclusion:

1. CORC cable was too thick
2. ReBCO tapes were too wide



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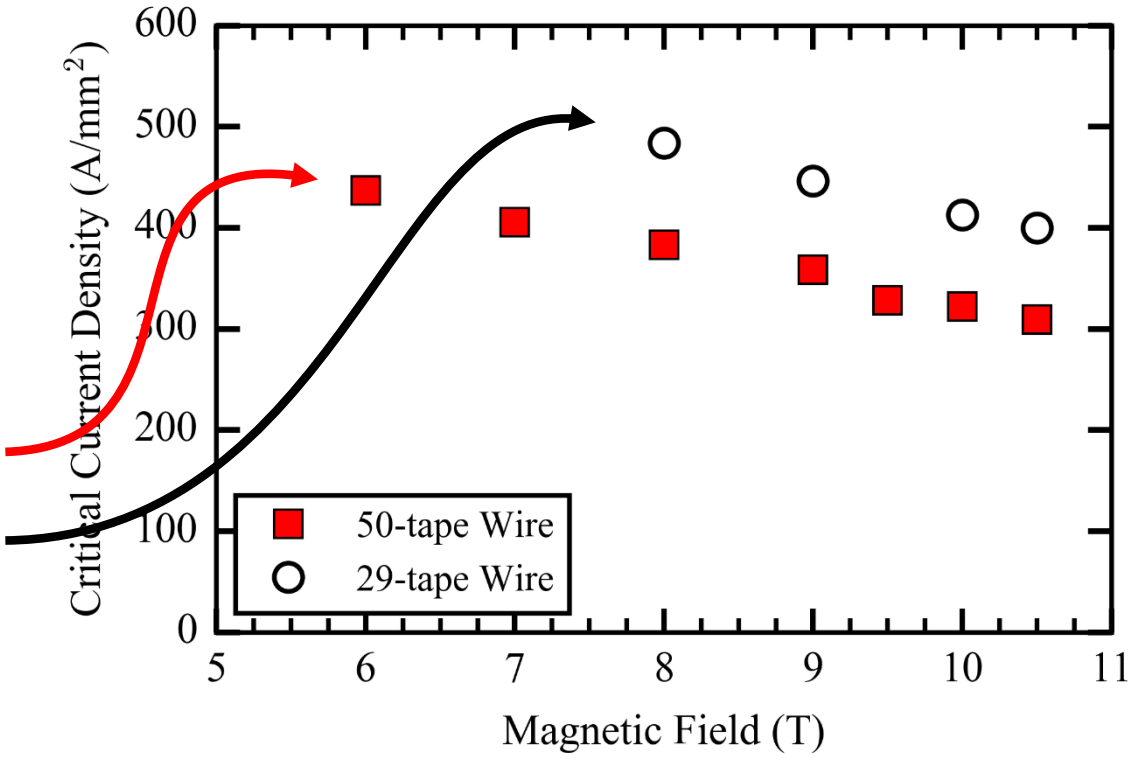

Expected J_c(10 T, 4.2 K): > 800 A/mm² for the 50-tape wire
700 A/mm² for the 29-tape wire

Both CORC wires performed worse than initial expectations.

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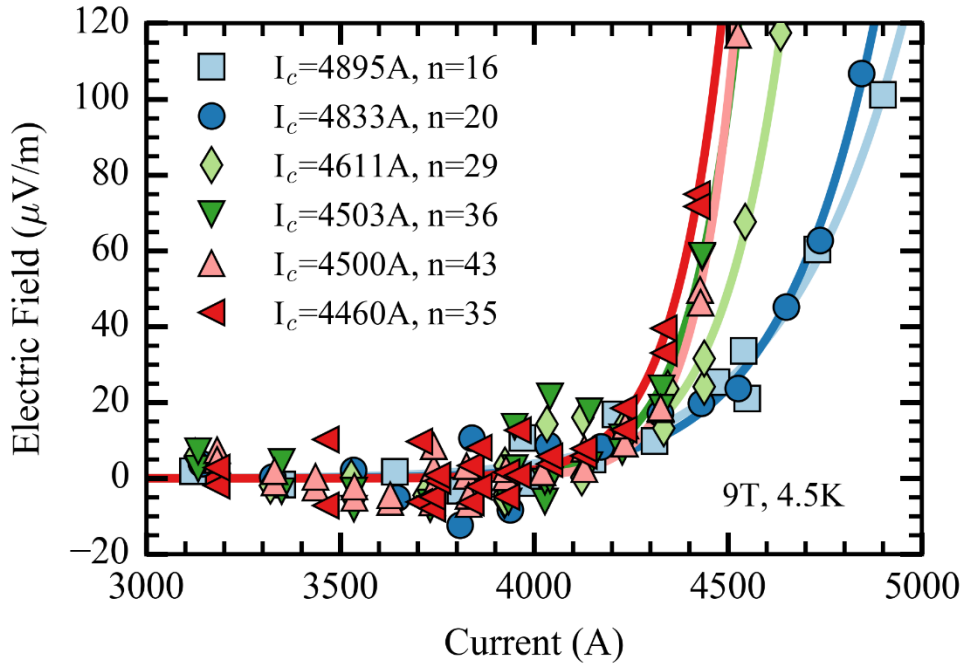
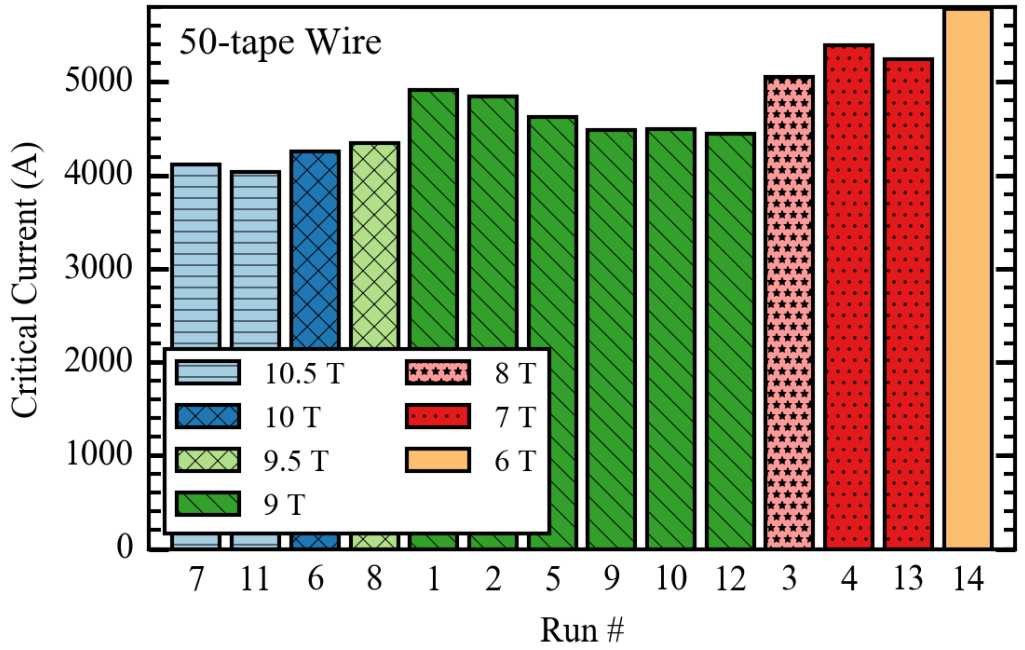
50 Tapes – 4.1 mm OD – CORC Wire





- Critical current decreases with each cycle.
- Current sharing starts around the same current, therefore the n-value is pushed up.

- 10% Degradation due to cycling.
- Lorentz forces pointed inwards. Possible increasing the strain within the tapes over their limit.

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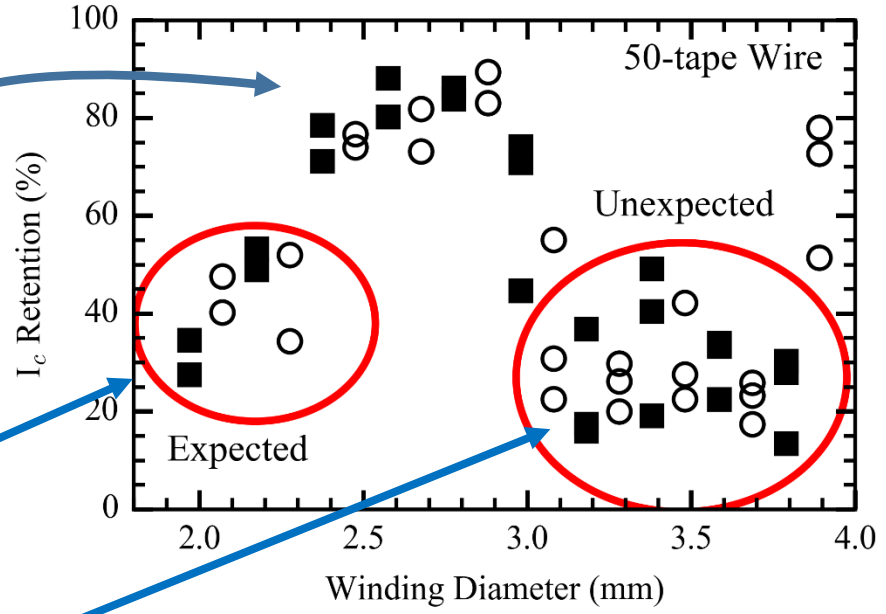
Extracted Tape Measurements @ ACT

Results for the 50-tape CORC wire:

- I_c reduction for winding diameters below 2.4 mm
- I_c reduction at larger winding diameters (possible inadequate winding tension)
- Overall I_c reduction of ~ 48%

(Courtesy of ACT)



Tapes extracted for I_c measurements @ ACT

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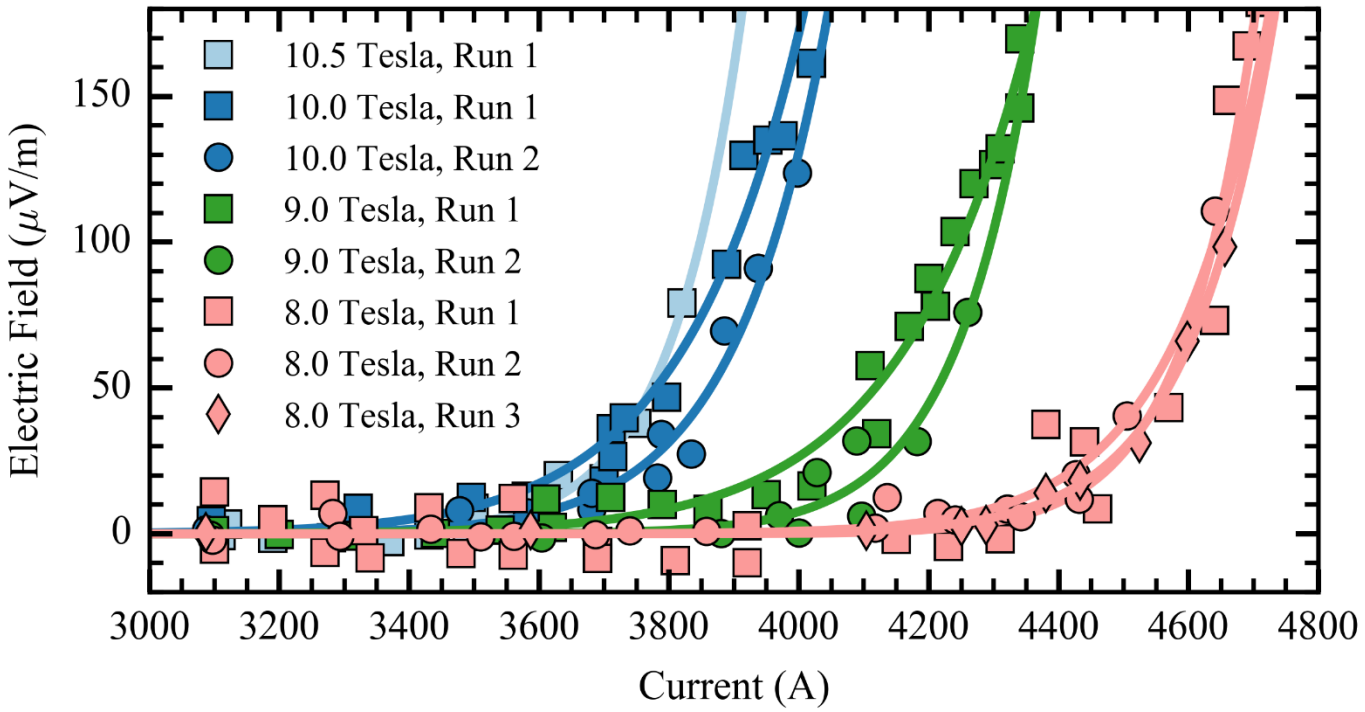
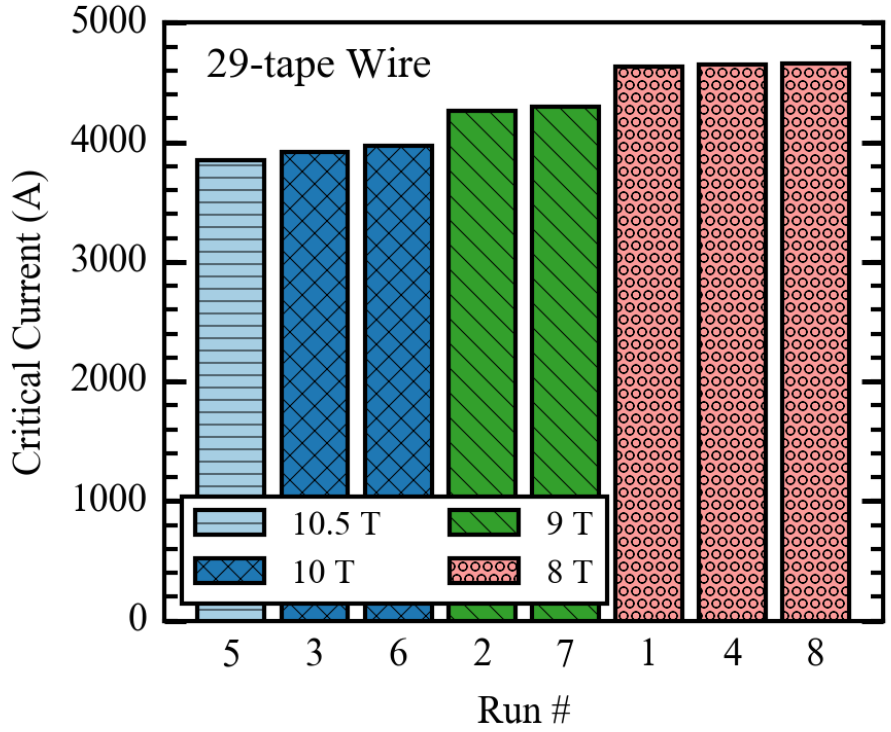
29 Tapes – 3.5 mm OD – CORC Wire





- No degradation due to cyclic loads.
- Lorentz forces point outwards.
- N-values of around 30

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Extracted Tape Measurements @ ACT

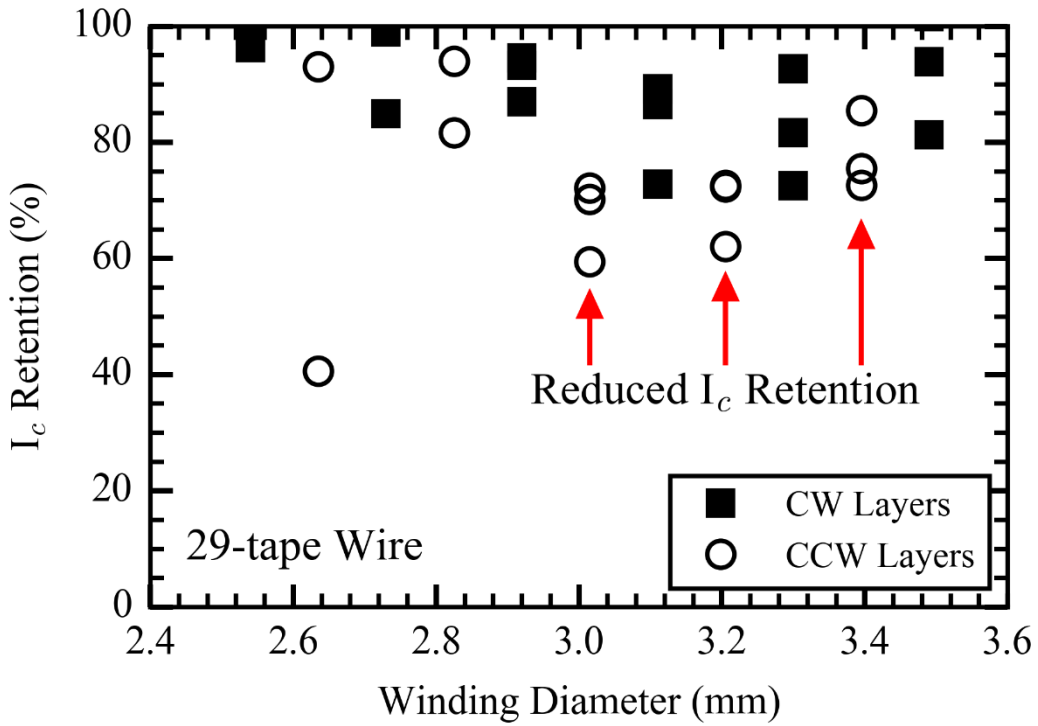
Results for the 29-tape CORC wire:

- No I_c reduction due to winding diameter
- Higher I_c retention in every other layer. Possibly the wire was torqued or the tape tension was varied during production.
- Overall I_c retention of ≈ 82%

412 A/mm^2 at 10 T and 4.2 K is lower than initially expected.
Underperformance was largely due to low pinning.

Batch lift factors were tested at Florida State University.
Typical lift factor is 2.7 at 10 T and 4.2K.

Lift factor of the tape batch used for the 29-tape wire was only 1.8!



Combination of low lift factor and 82% I_c retention gives an expected I_c of 400 A/mm^2 at 10 T and 4.2 K, close to the measured 412 A/mm^2.

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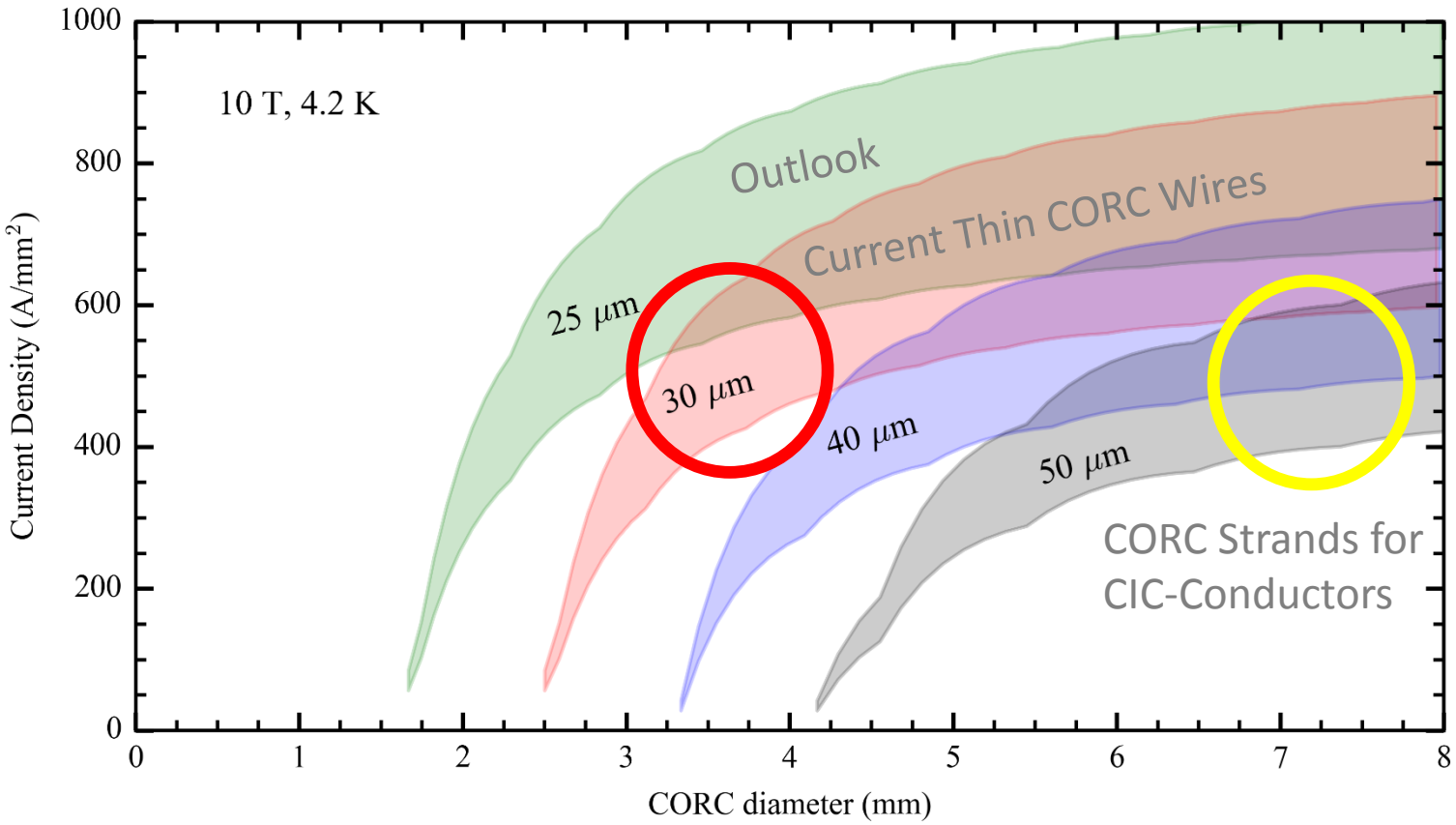
Outlook



CORC Wires are only made possible by the reduction in substrate thickness.

Another reduction from 30 to 25 μm provides another boost in current density!

Thicker & Less flexible ---------->

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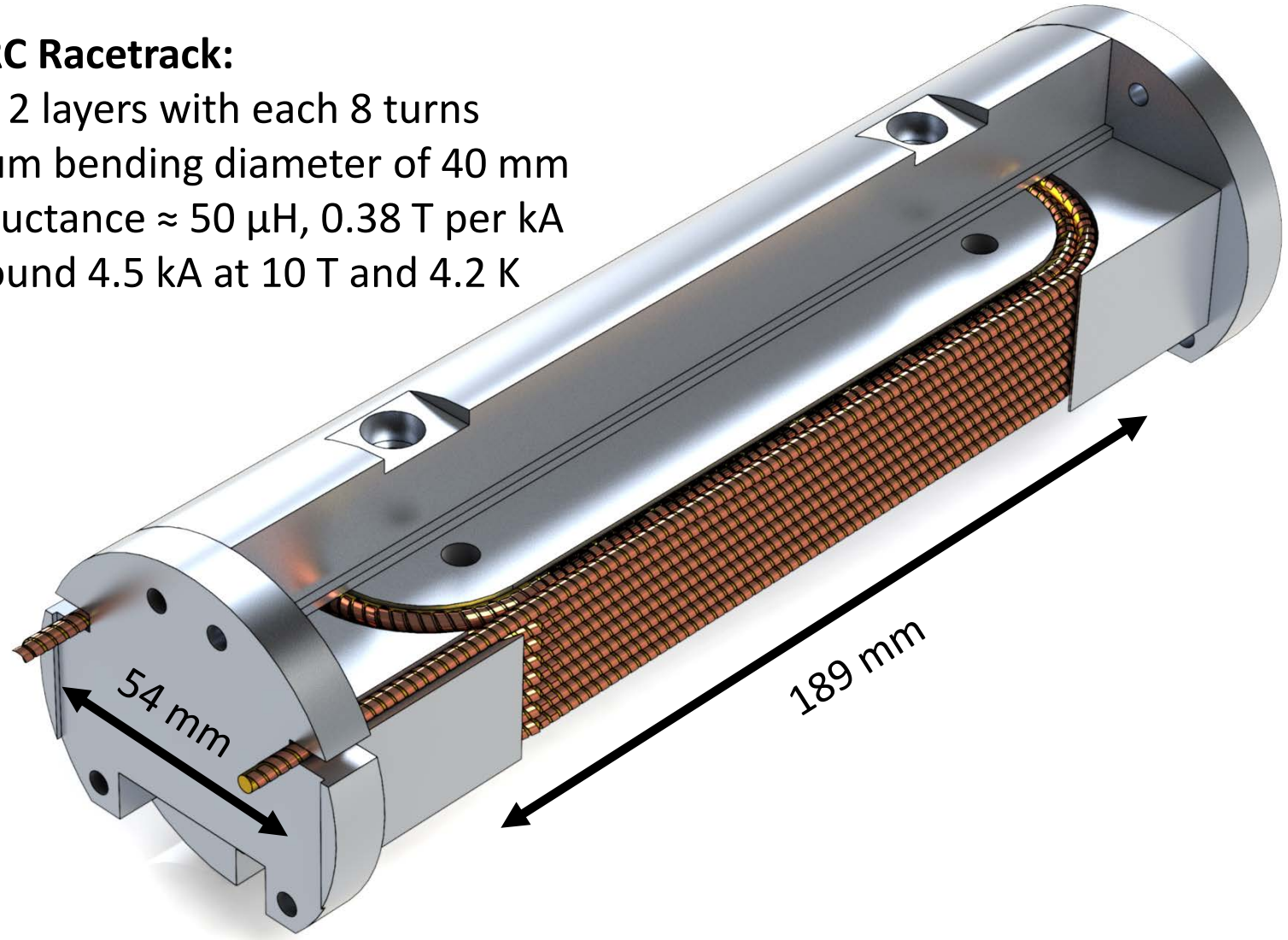
CORC Demonstration Racetrack

Solenoid (Twente/CERN)

CCT (Berkeley)

CERN CORC Racetrack:

- Layout: 2 layers with each 8 turns
- Minimum bending diameter of 40 mm
- Coil inductance ≈ 50 µH, 0.38 T per kA
- I_c of around 4.5 kA at 10 T and 4.2 K



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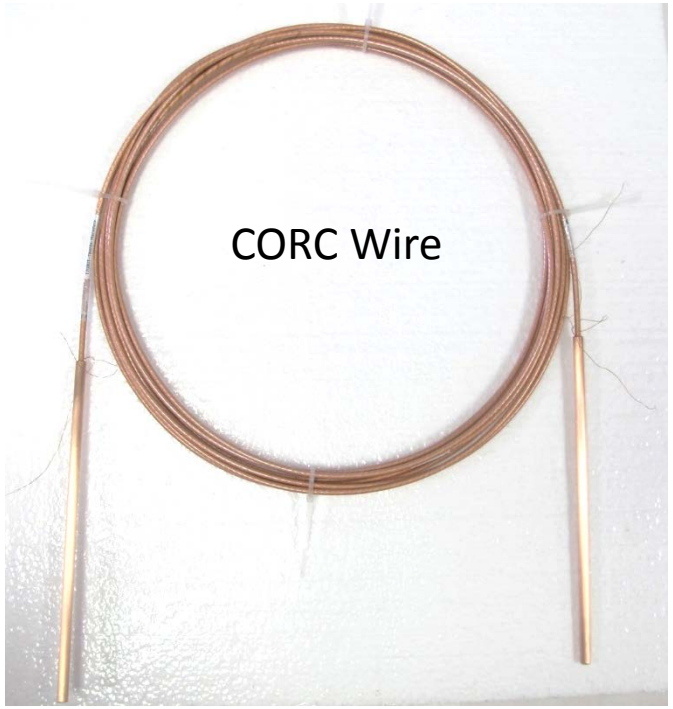
CORC Wires for CERN Racetrack

Dummy Wire:

- 7.96 m & OD of 3.40 mm
- Testing of Coil winding
- Thermal cycling of the coil
- 7 layers of steel tapes + 2 SC tapes

CORC Wire:

- 7.96 m & OD of 3.45 mm
- 27 SCS-2030 tapes
- I_c(77 K, SF) = 1500 A



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Conclusions

- ✓ Two CORC wires were tested at the University of Twente
- ✓ Critical current densities of 322 A/mm^2 and 412 A/mm^2 were measured
- ✓ Tape lift-factor has high impact on the performance of the CORC wires
- ✓ Extracted tape measurements localize degradation within the CORC wires
- ✓ Measurements provide valuable feedback to optimize wire production and handling
- ✓ 27-Tape CORC wire will be used for a CORC Racetrack Coil at CERN
- ✓ Research on CORC is ongoing, more CORC wires and CORC CICCs are expected!

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Wed. Morning Oral 21-02
11.00 @ Emerald Room

Wed. Morning Oral 21-05
11.45 @ Emerald Room