Electrical characterization of CFD CORC® cables between 65 and 77 K

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https://borealconductors.com

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All-electrical hydrogen powered aircraft

- Liquid hydrogen (20 K)
- Fuel cells
- Electric propulsion with superconductors

https://www.airbus.com/en/innovation/energy-transition/hydrogen/zeroe

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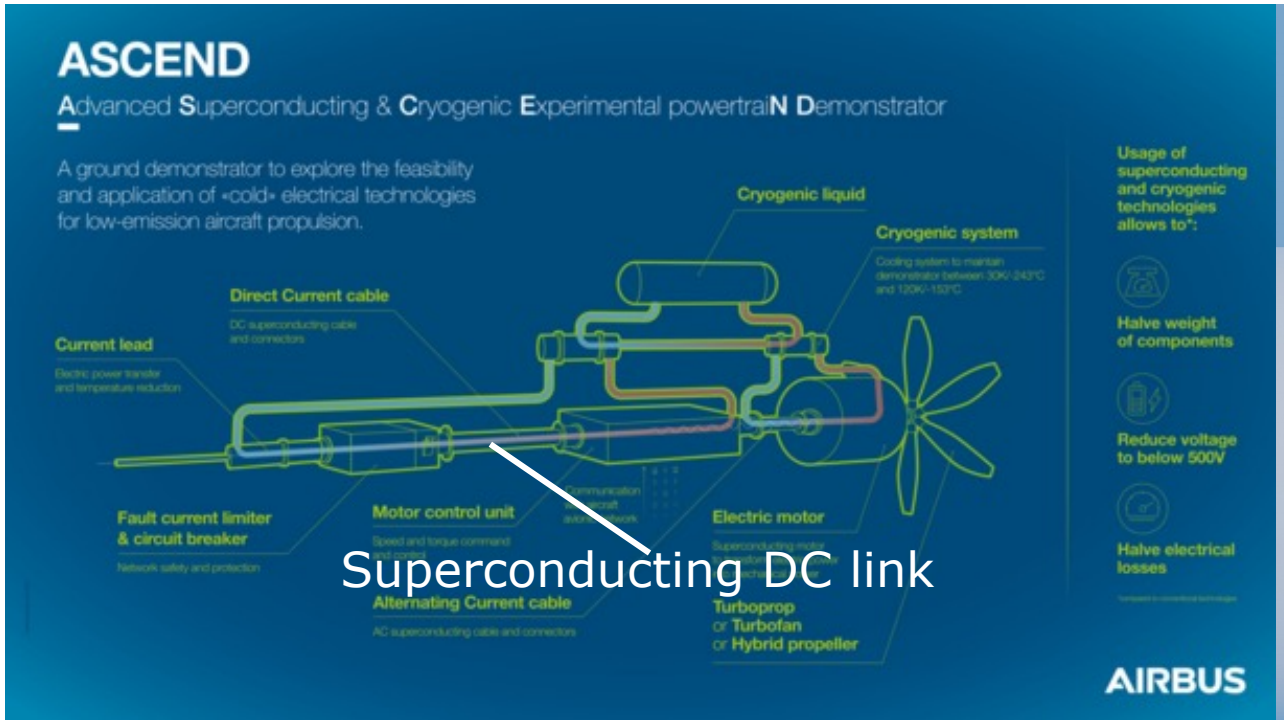
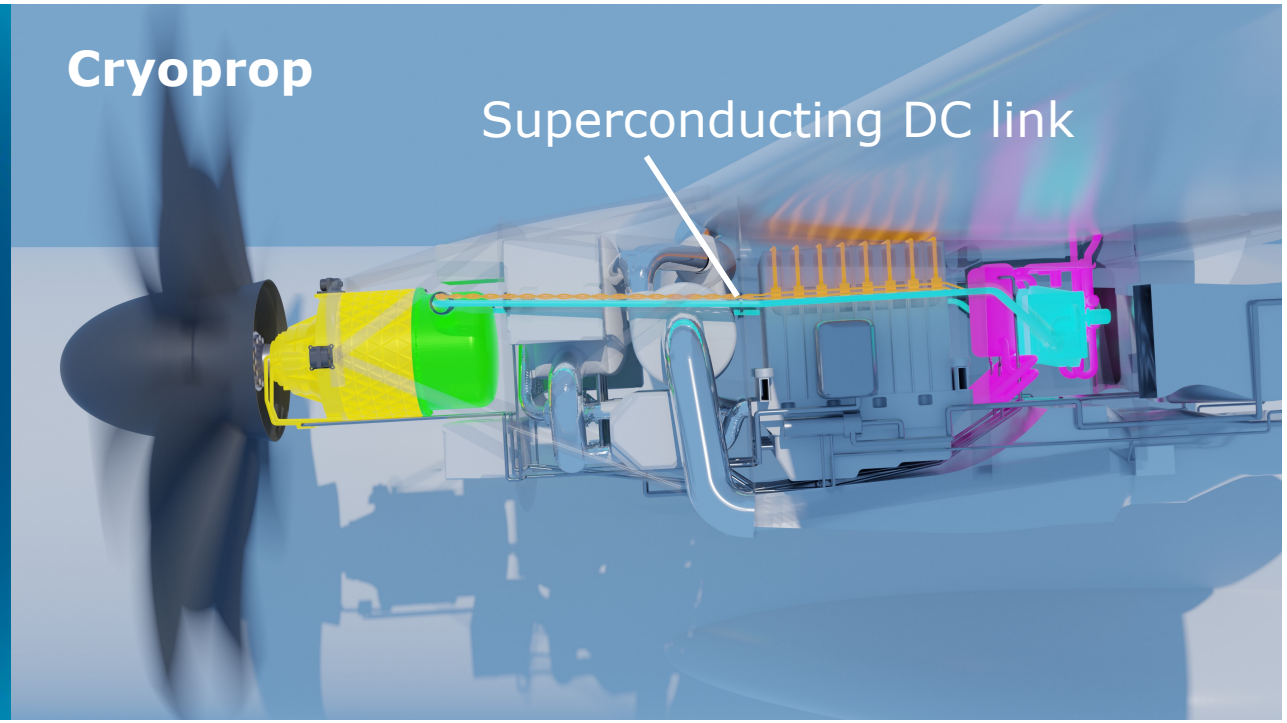
Superconducting electric propulsion system demonstrators

Airbus: aim to demonstrate a 2 MW superconducting powertrain with GHe recirculation





https://www.airbus.com/en/newsroom/stories/2021-03-cryogenics-and-superconductivity-for-aircraft-explained
https://www.airbus.com/en/newsroom/press-releases/2024-05-airbus-takes-superconductivity-research-for-hydrogen-powered

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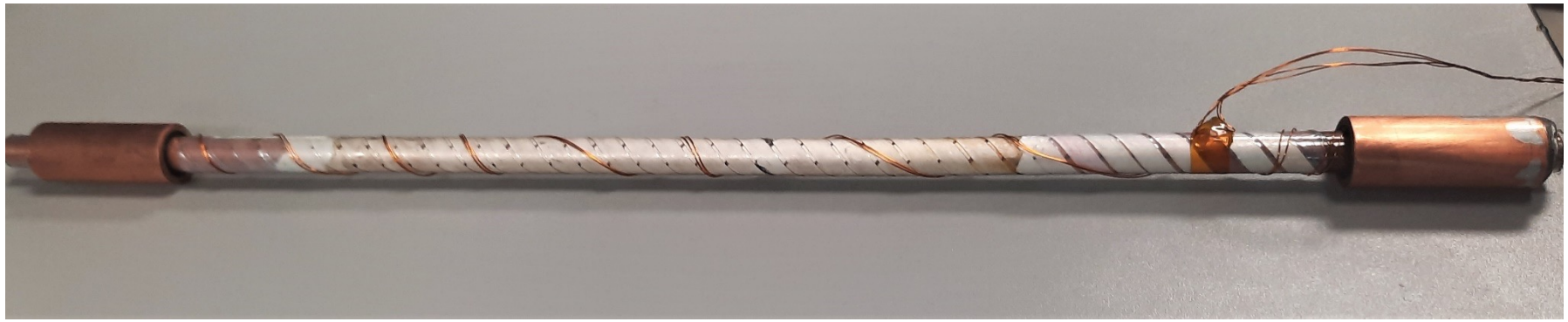
CORC® REBCO cable

CORC® cable



- CORC® cables can comprise up to 120 REBCO tapes, twisted helically on copper or aluminum formers
- High current carrying capacity (more than 500 A/mm^2 at 65 K)
- Mechanical flexibility, thermal stability, and round cross-section
- No interlayer insulation between the REBCO tapes
- Fault current limitation capability

[https://www.advancedconductor.com/corccable/

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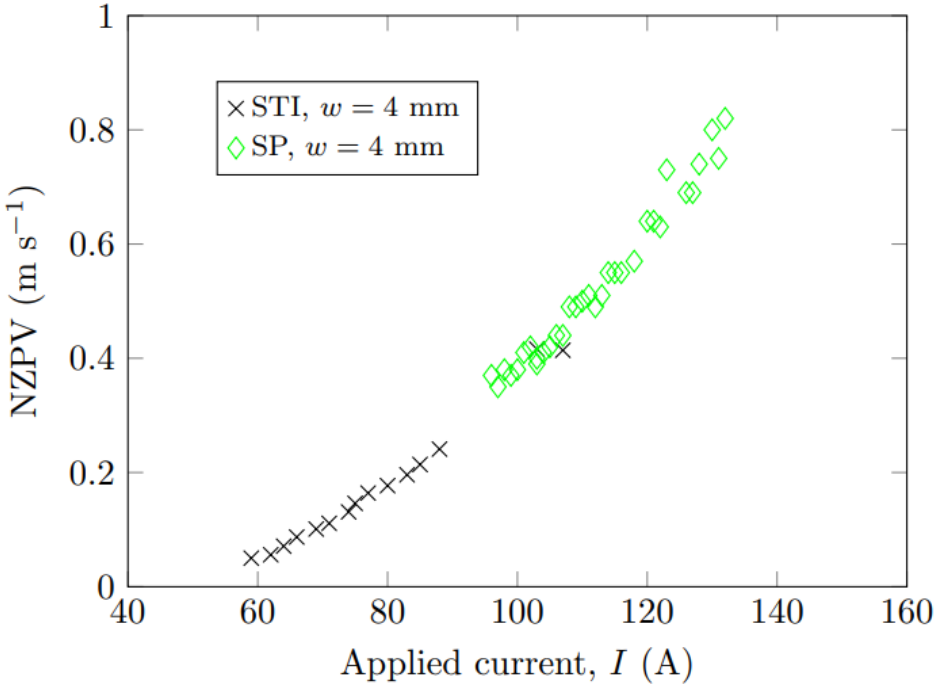
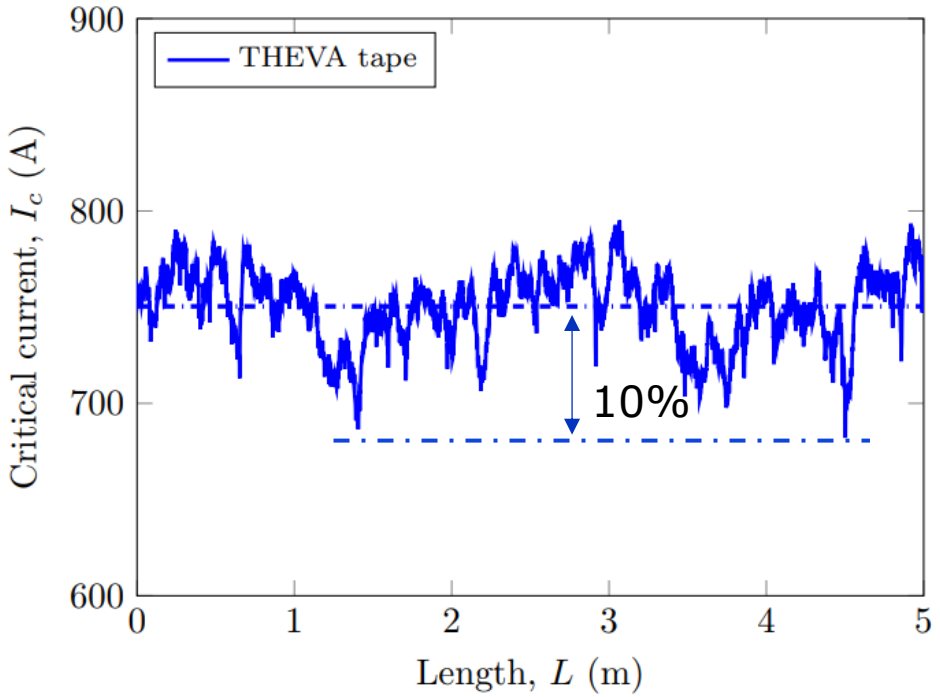
Quench in REBCO tapes

NZPV measurements of commercial tapes at 77 K and in self-field



Non-uniform critical current I_c along their length (10-15% of variation)



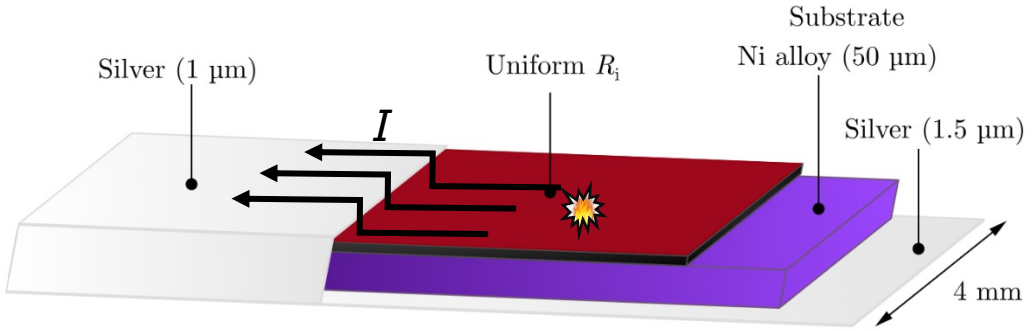
1. Presence of destructive hot spots increased

2. Reduced limitation performance

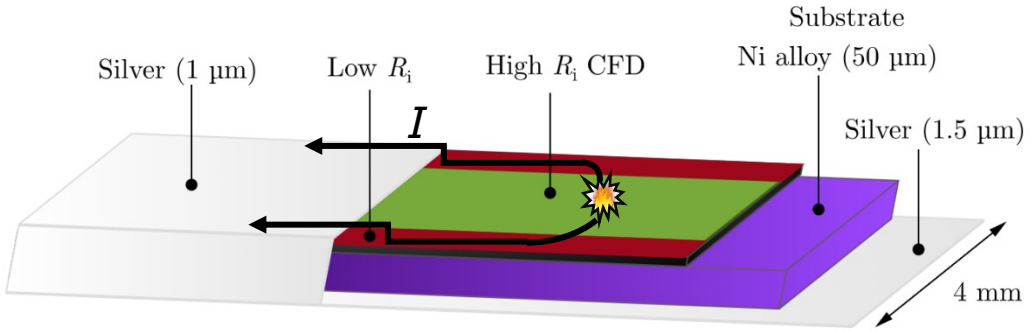
Solution: increase the NZPV of REBCO tapes to improve quench resilience and limitation capabilities

Current flow diverter (CFD) concept

R_i: interfacial resistance

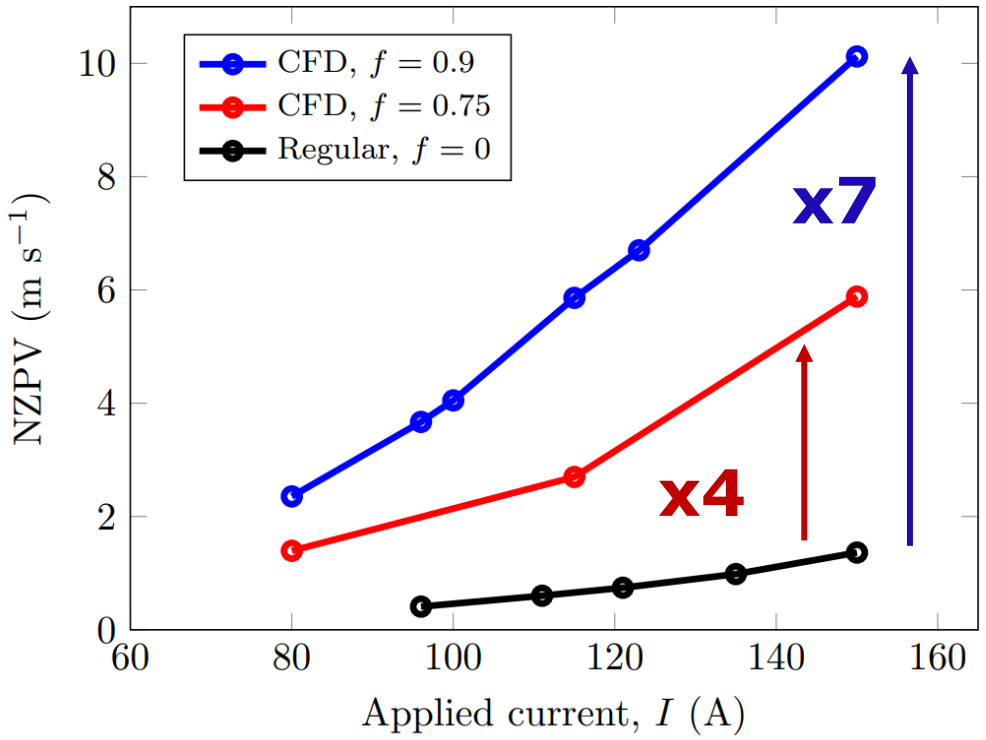


Regular architecture



CFD architecture

NZPV obtained at 77 K and in self-field



$$f = \frac{\text{Width of the CFD layer}}{\text{Width of the tape}}$$

Lacroix et al. SUST 27, 035003 (2014)
US Patent: Lacroix et al. US9029296B2

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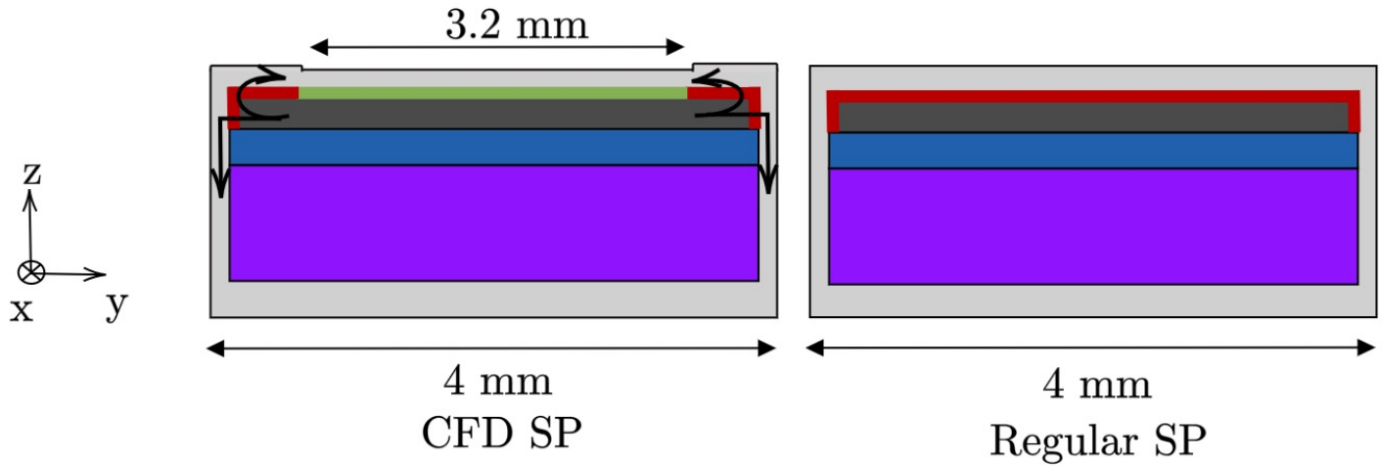
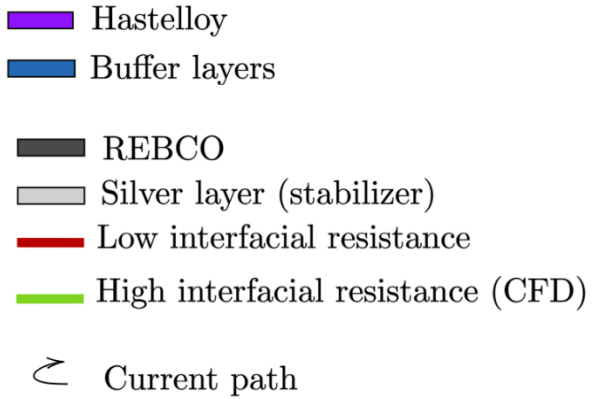
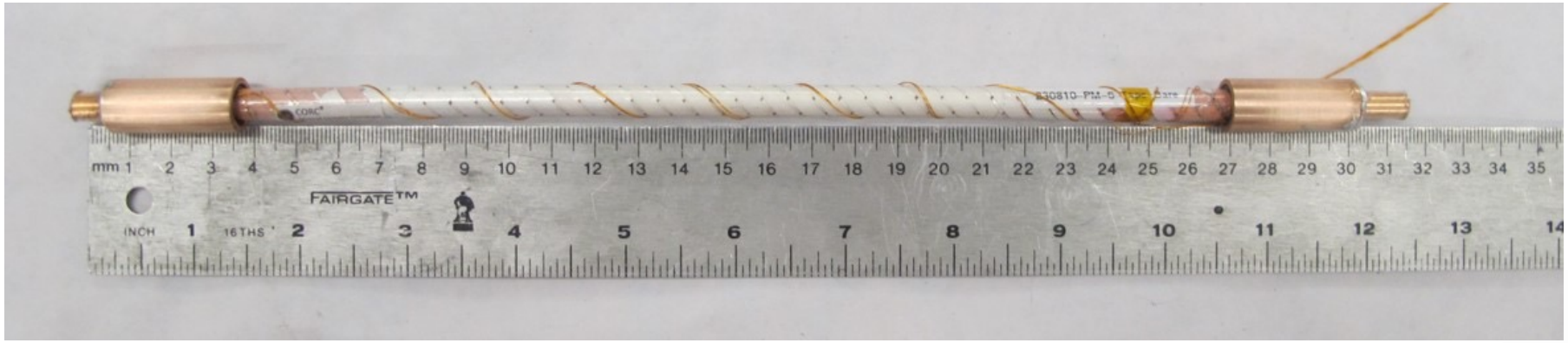
CFD-CORC® cables parameters

Cross-section view





Number of layers: **2**, number of tapes per layer: **3**



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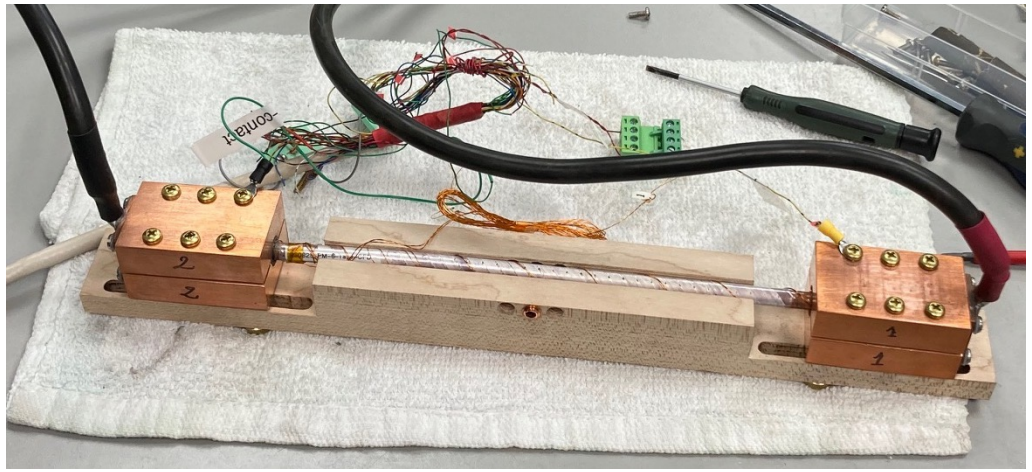
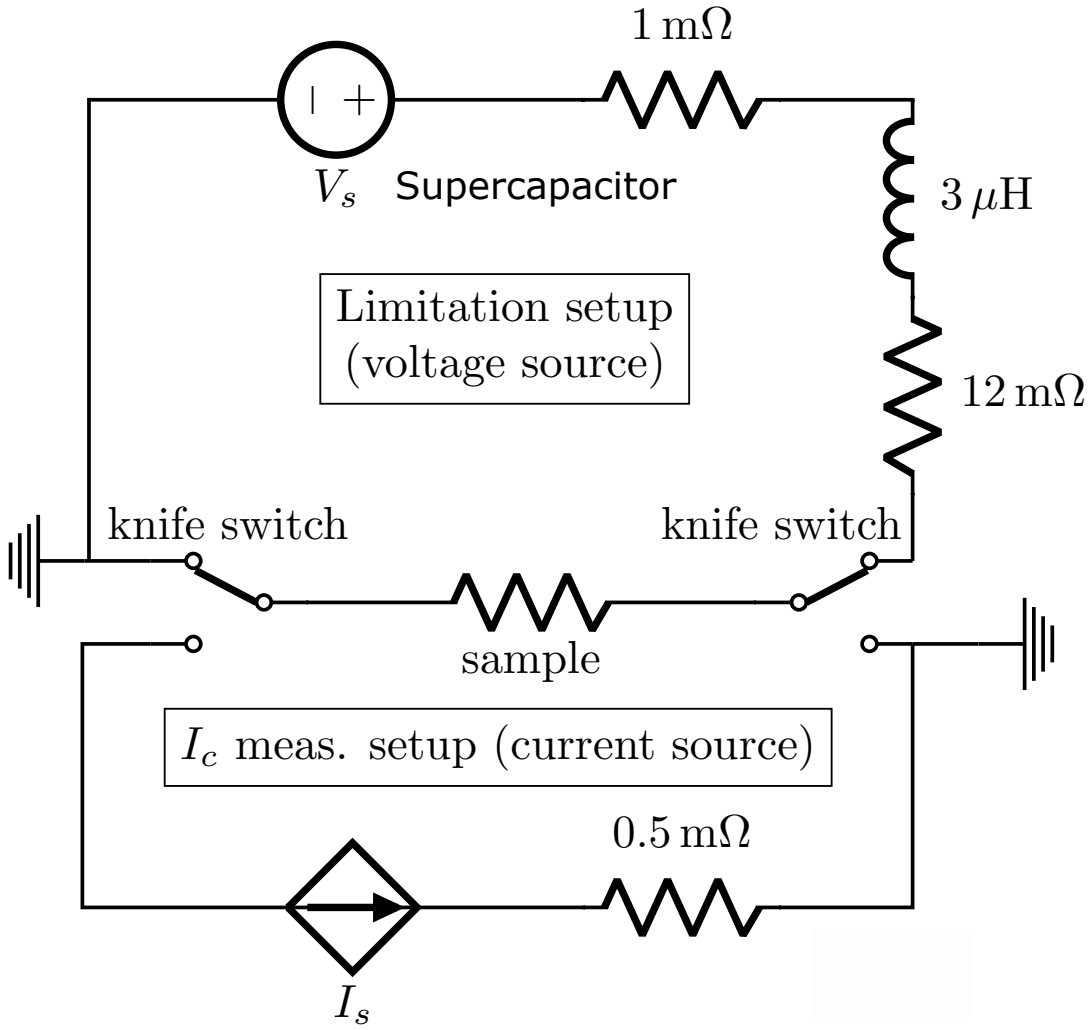
Measurement setup

Methodology:

- Measurement of I_c and NZPV using pulsed current measurements





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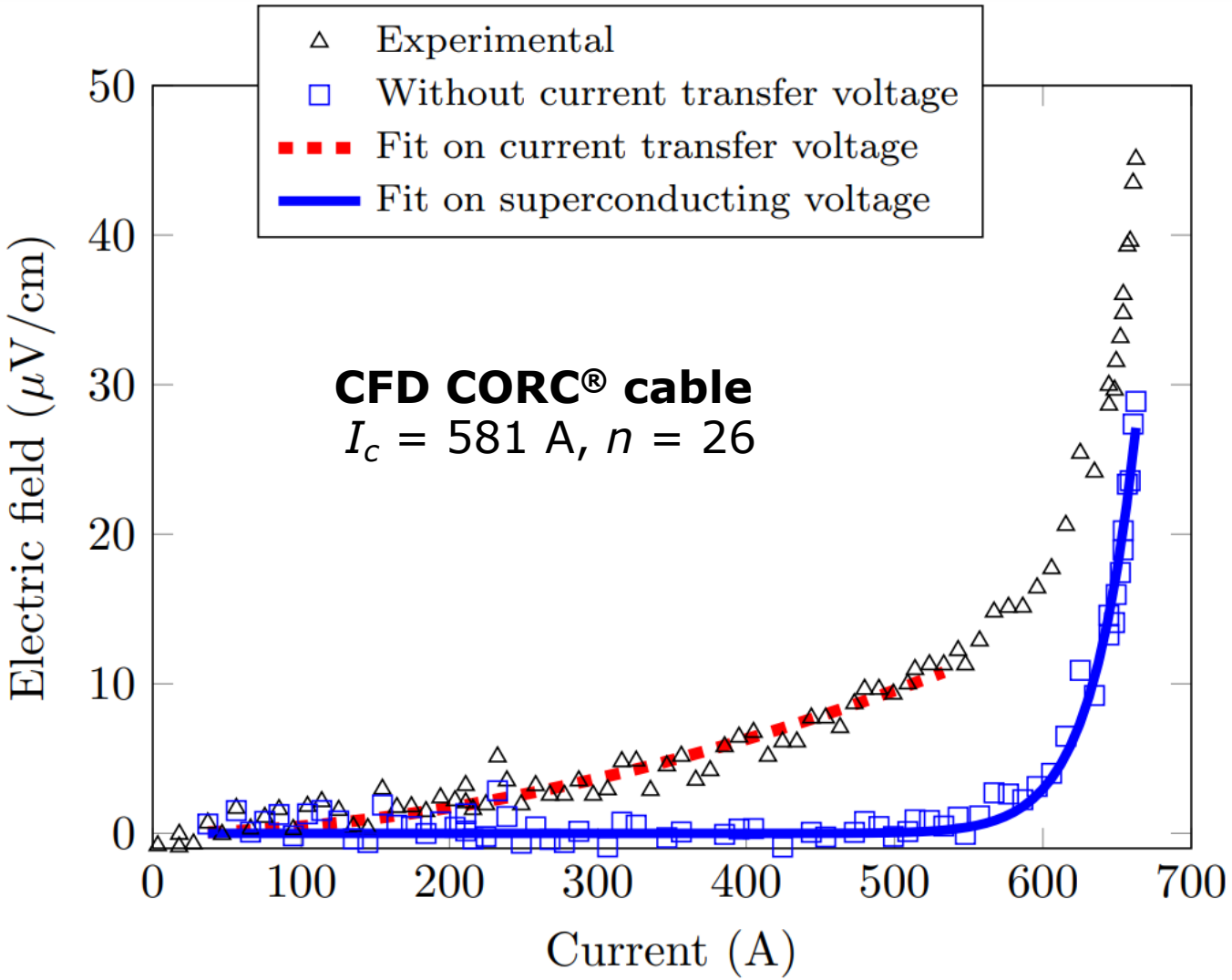
Critical current measurement on CFD CORC® cable

I_c measurements at 77 K and in self-field, at E_c = 1 μV/cm



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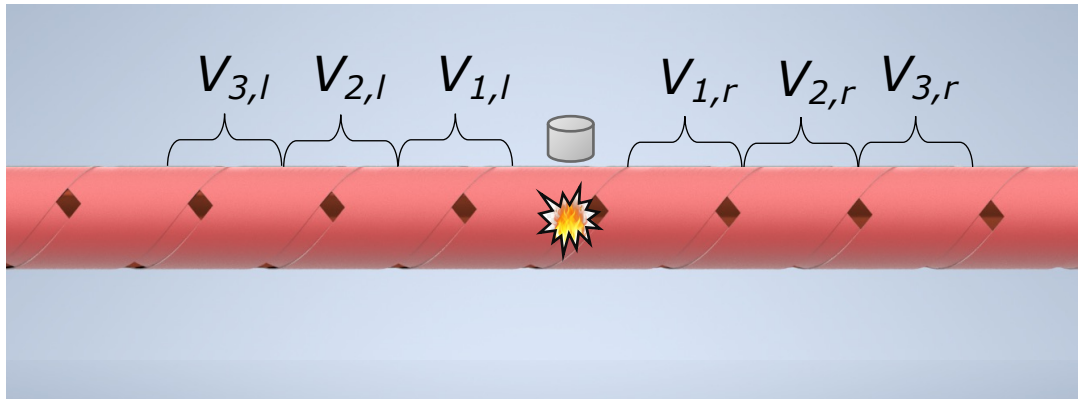
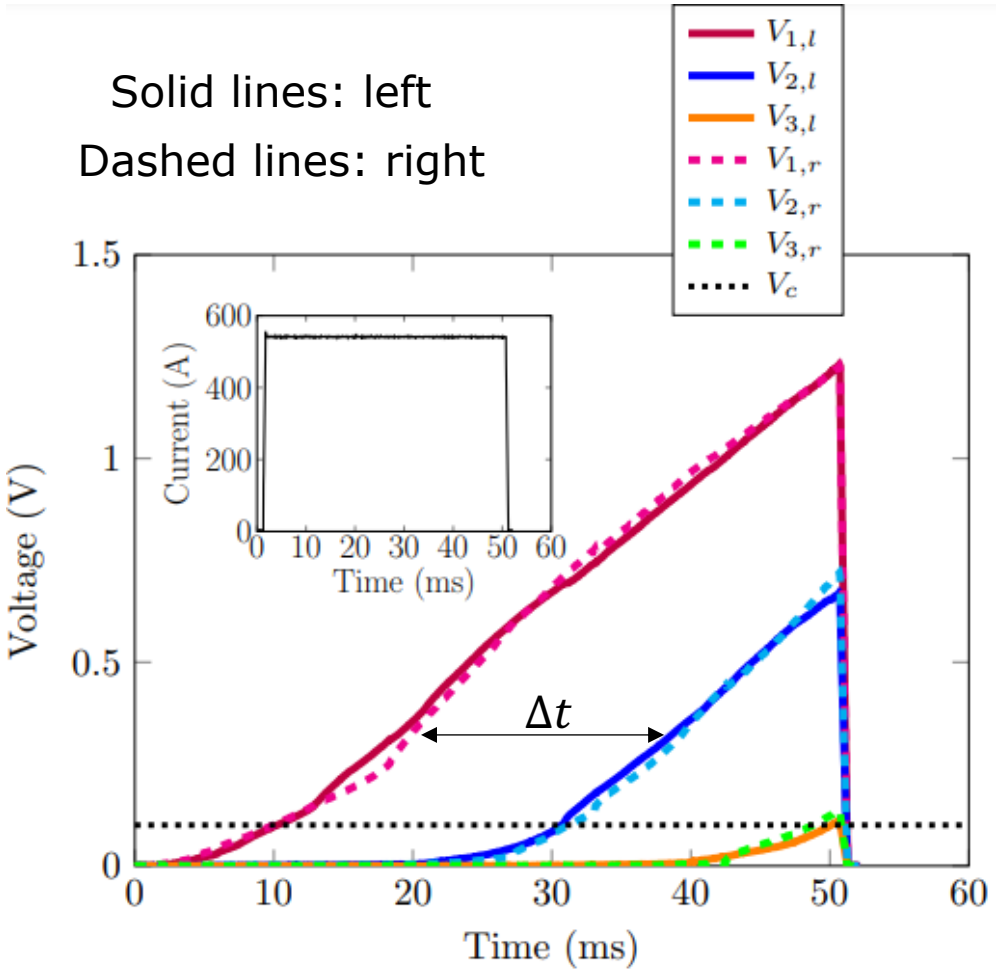
NZPV measurements

Schematic of the position of the voltage taps



$$\text{NZPV} = \frac{d}{\Delta t}$$



the normal zone propagates similarly in both directions

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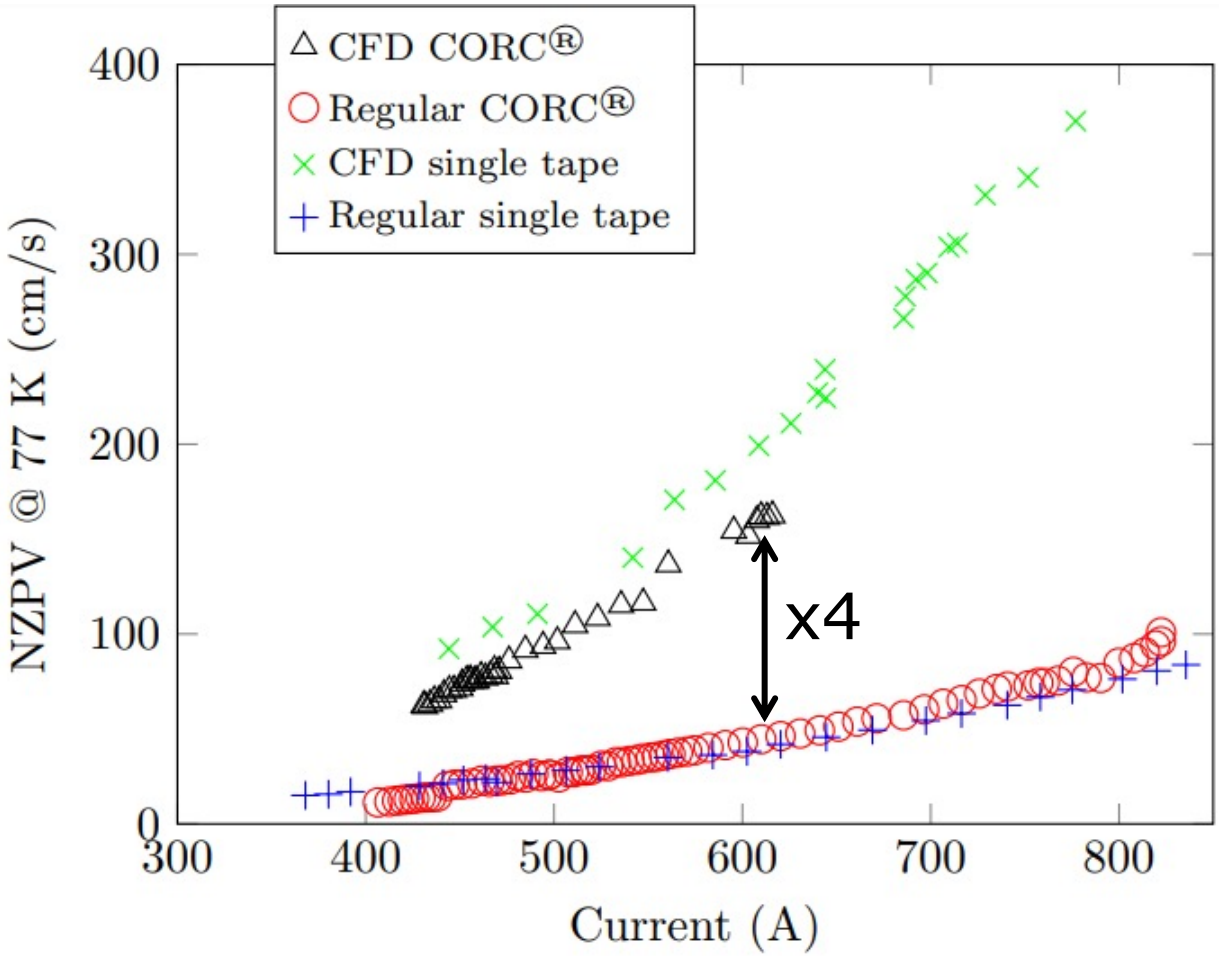
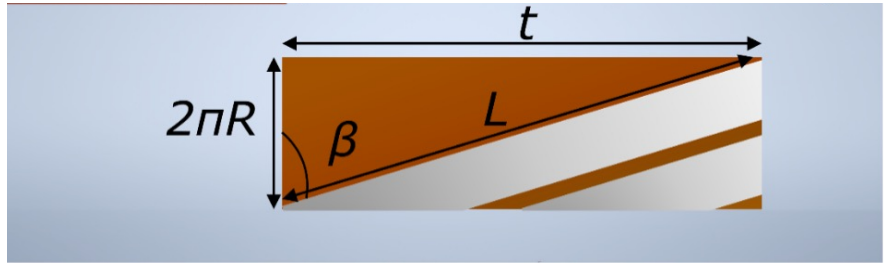
NZPV measurements on CFD CORC® cable at 77 K



- The symbols **X** and **+** represent the NZPV of single tapes divided by the ratio p
- The applied current applied on the single tapes was multiplied by 6



$$p = \frac{L}{t} = \frac{1}{\sin(\beta)} = 1.6$$

Integrating CFD tapes in a CORC cable arrangement does not diminish the CFD effect

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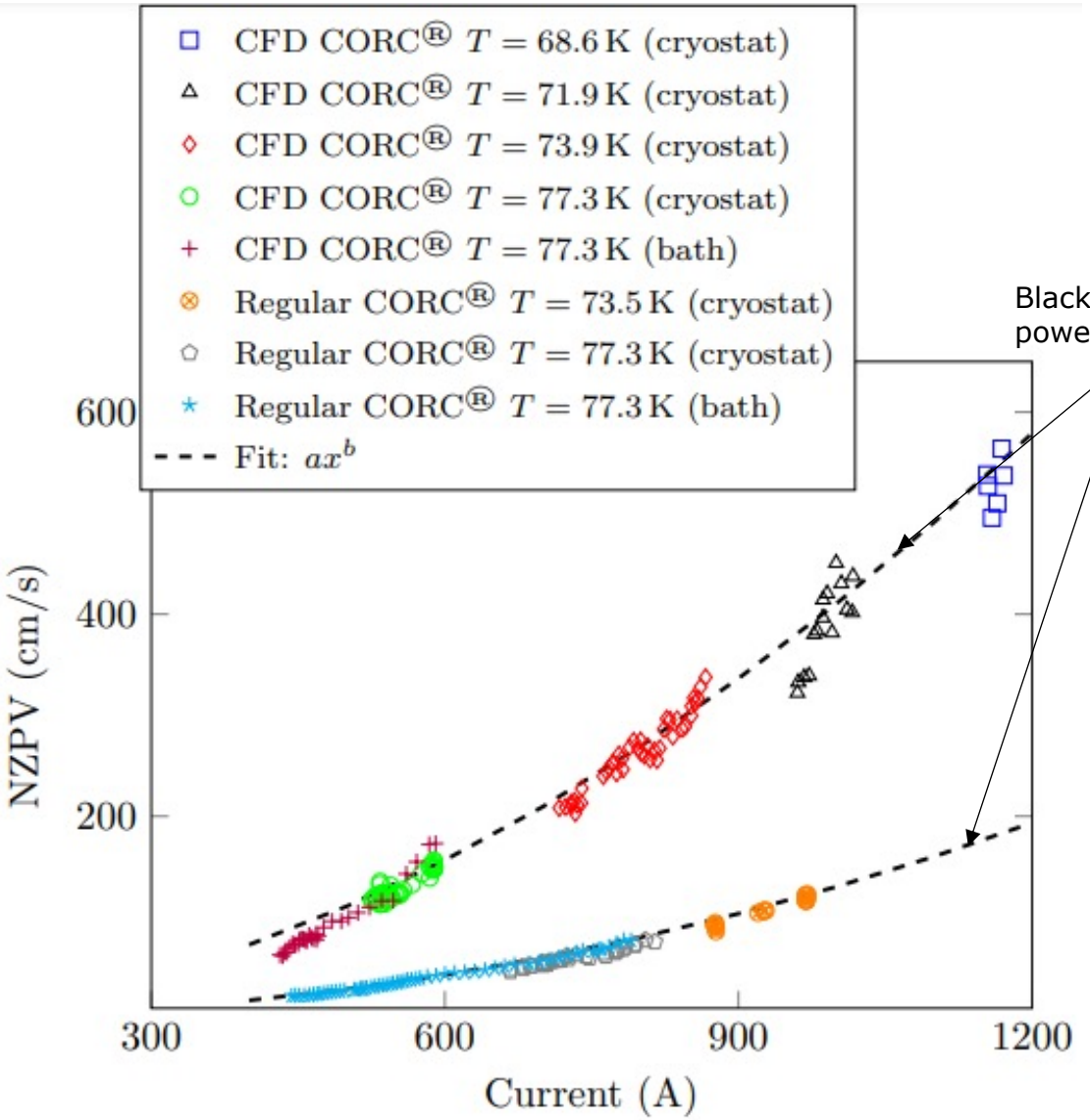
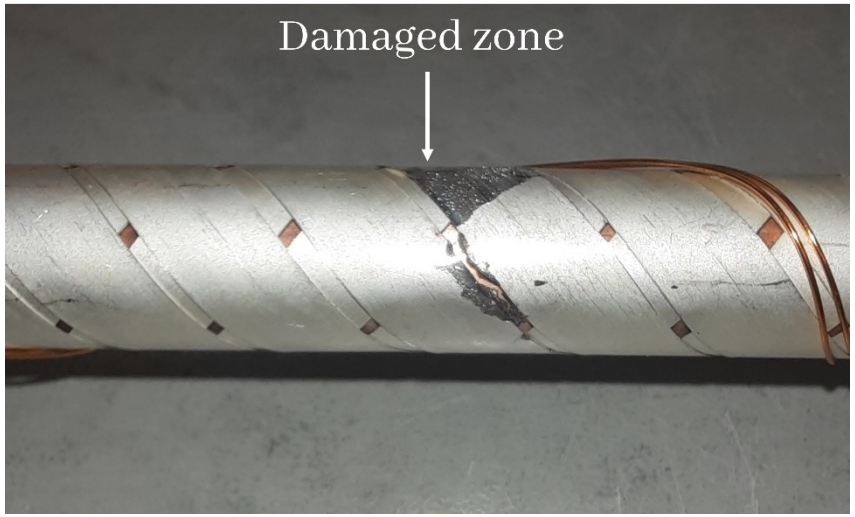
NZPV measurements at 67-77 K



Black dashed line: power law fit



- The regular CORC® cable did not survived the quench measurements
- NZPV vs. applied current could be well-fitted with a power law function
- The NZPV depends only on the applied current

Van Nugteren, J et al. (2015), *Physics Procedia*, *67* 945
Bonura, M., & Senatore, C. (2016), *Applied Physics Letters*, *108*(24)

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Conclusion

- Successful fabrication of CFD CORC® cables
- NZPV enhancement in CFD CORC® cables
- CFD CORC® cables are promising for quench resilience and fault current limitation applications

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