Design and Manufacturing of Two New CORC Cable-In-Conduit Conductors

T. Mulder[1,2], D. van der Laan[3], J. Weiss[3], A. Dudarev[1] and H.H.J. ten Kate[1]

[1] CERN, Geneva, Switzerland

[2] University of Twente, Enschede, the Netherlands

[3] Advanced Conductor Technologies, Boulder, Co, USA

Advanced Conductor Technologies LLC
www.advancedconductor.com

UNIVERSITY OF TWENTE.

Outline

- Introduction
- New CORC Cable-In-Conduit Conductors
- Six-Around-One CORC Cable
- Joint Terminals
- Jacketing and Cooling
- Conclusion and Outlook

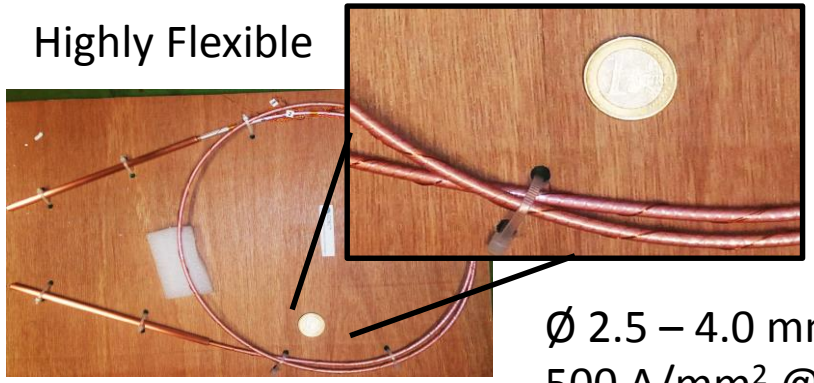
Introduction

CORC (Conductor On Round Core)

Flexible, Round, Stable ReBCO Wires and Cables

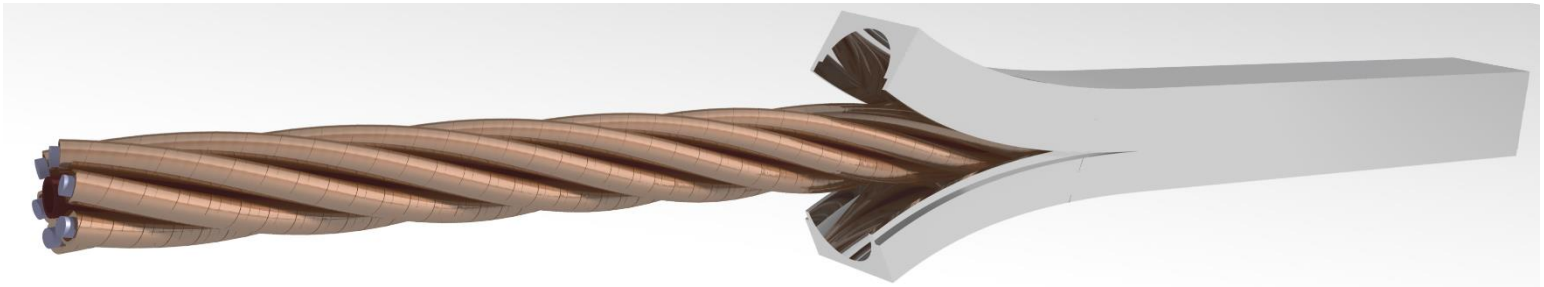
CORC Wires

Highly Flexible



Ø 2.5 – 4.0 mm wires
500 A/mm^2 @4K/10T

CORC Cable-In-Conduit Conductor



High stability and high currents of 100 kA and more

UNIVERSITY OF TWENTE.

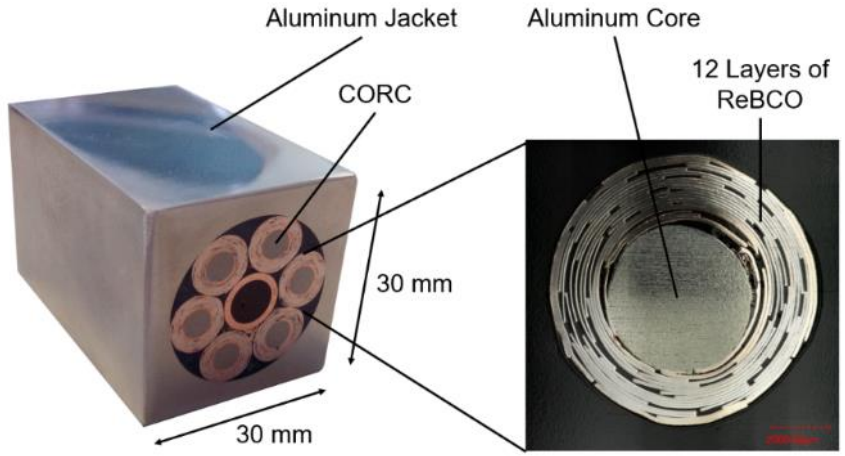
Advanced Conductor Technologies LLC
www.advancedconductor.com

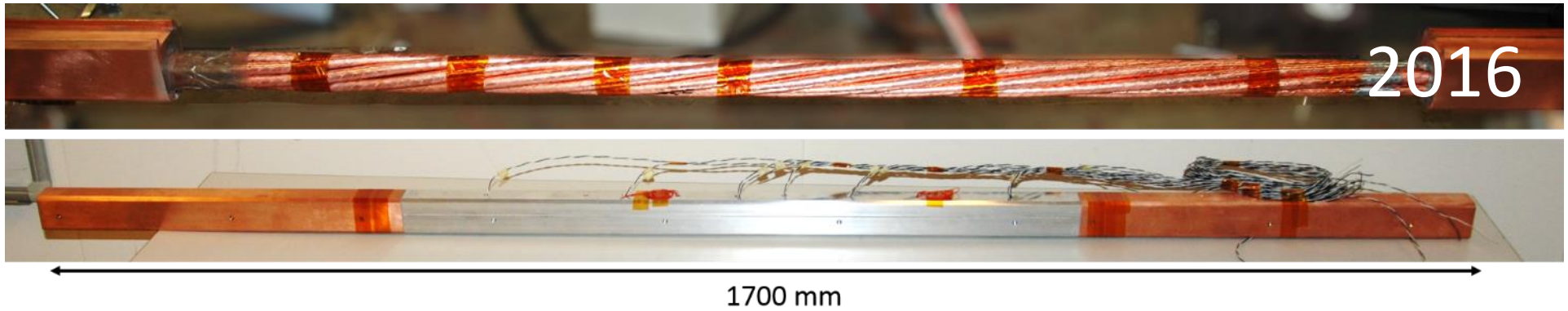
CERN

Introduction

First ReBCO CORC Cable-In-Conduit-Conductor (2016)

- Six-Around-One Layout
- Aluminum alloy jacket
- Liquid Bath Cooling (LN_2 & LHe)
- Testing of Production Techniques
- 48 kA @ 4K/10T and 13 kA @ 77K/Self-Field





UNIVERSITY OF TWENTE.

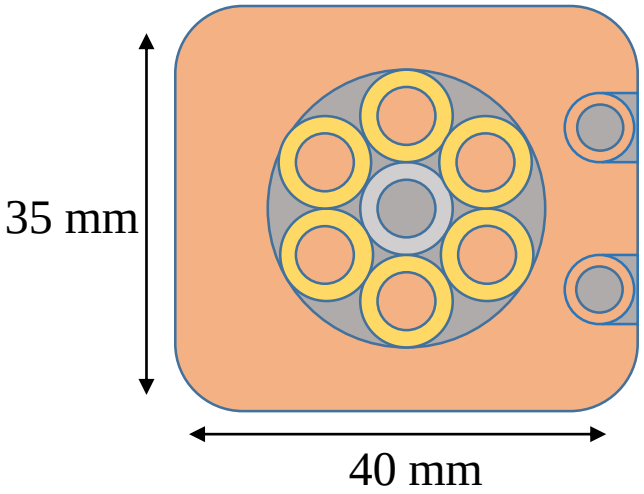
Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Two New CORC Cable-In-Conduit Conductors

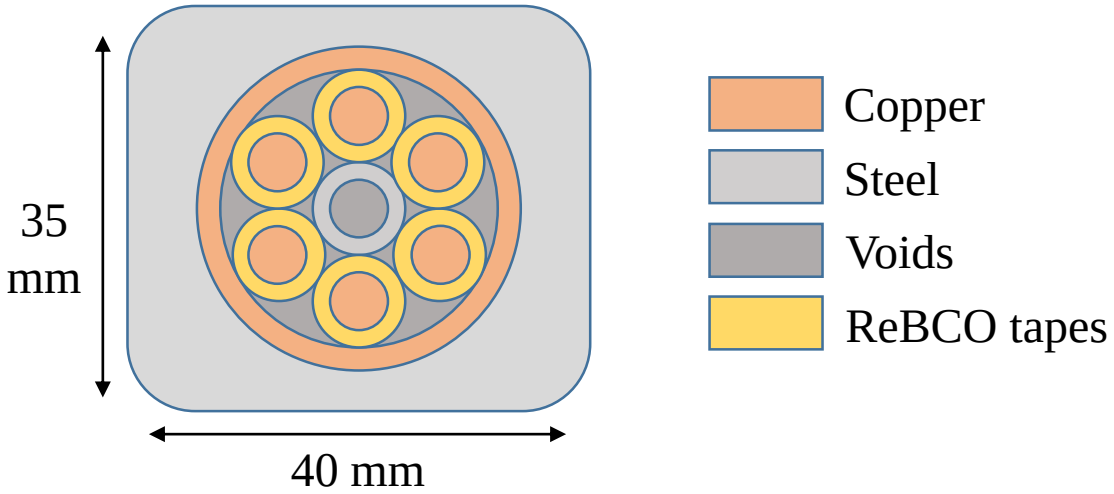
Detector magnets and Bus Bars

- High thermal & electrical stability
- Practical cooling
- 80 kA at 12T/4K



Fusion magnets

- Can sustains High Stress
- Can Cope with large heat loads
- 80 kA at 12T/4K



UNIVERSITY OF TWENTE.

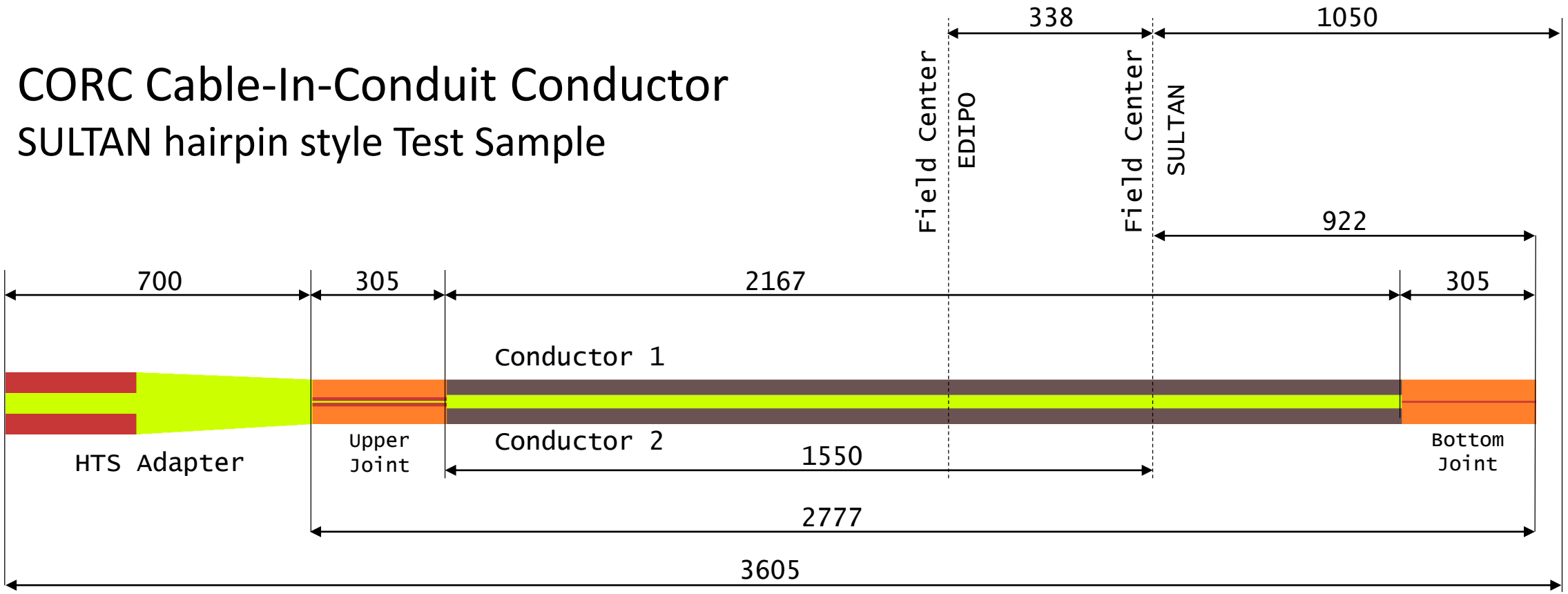
Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Sample Dimensions

CORC Cable-In-Conduit Conductor

SULTAN hairpin style Test Sample



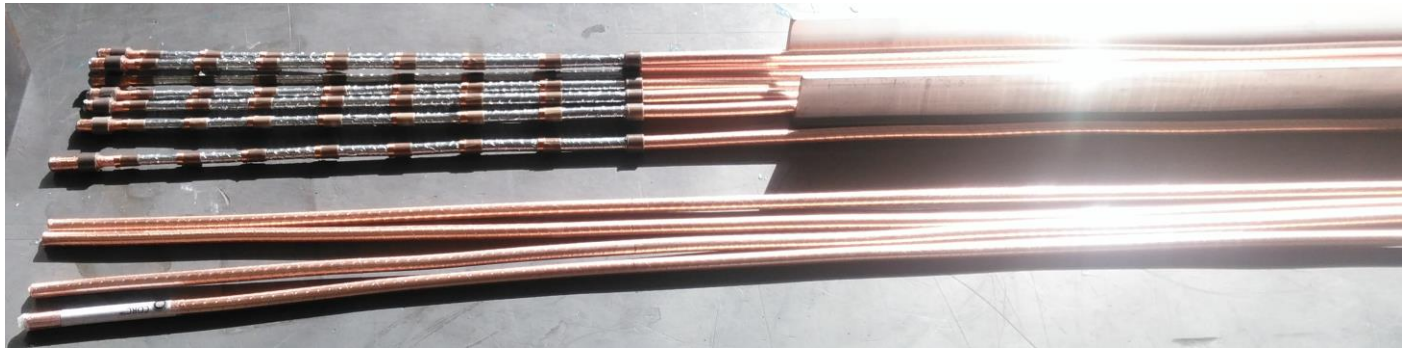
UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

CORC Strands

	2016 Sample	CORC CICC for Fusion	CORC CICC for Detectors
Nr. of tapes	38	42	42
Nr. of layers	12	14	14
Tape Type	SCS 4050	SCS 4050	SCS 4050
Copper plating [µm]	40	10	10
Core Material	Aluminum	Copper	Copper
Solid Core Diameter [mm]	4	5	4
Core Diameter [mm]	5.2	5.4	5.4
Outer diameter [mm]	7.6	7.7	7.7
Strand Current density (4K/12T) [A/mm^2]	154	300	300



UNIVERSITY OF TWENTE.

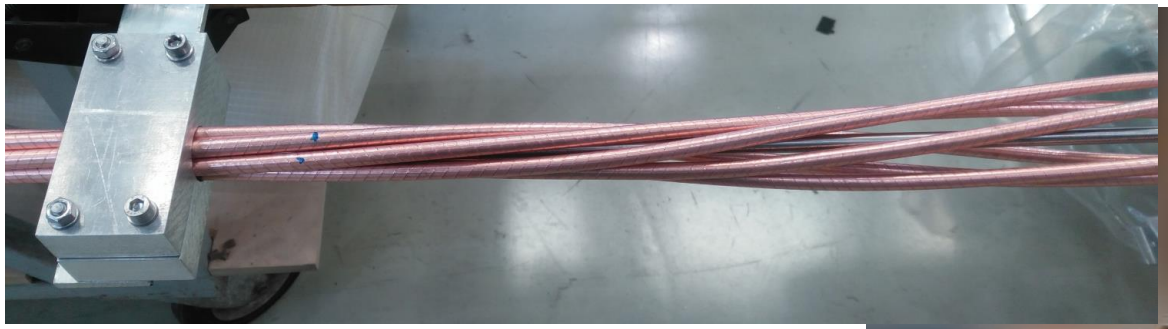
Advanced Conductor Technologies LLC
www.advancedconductor.com

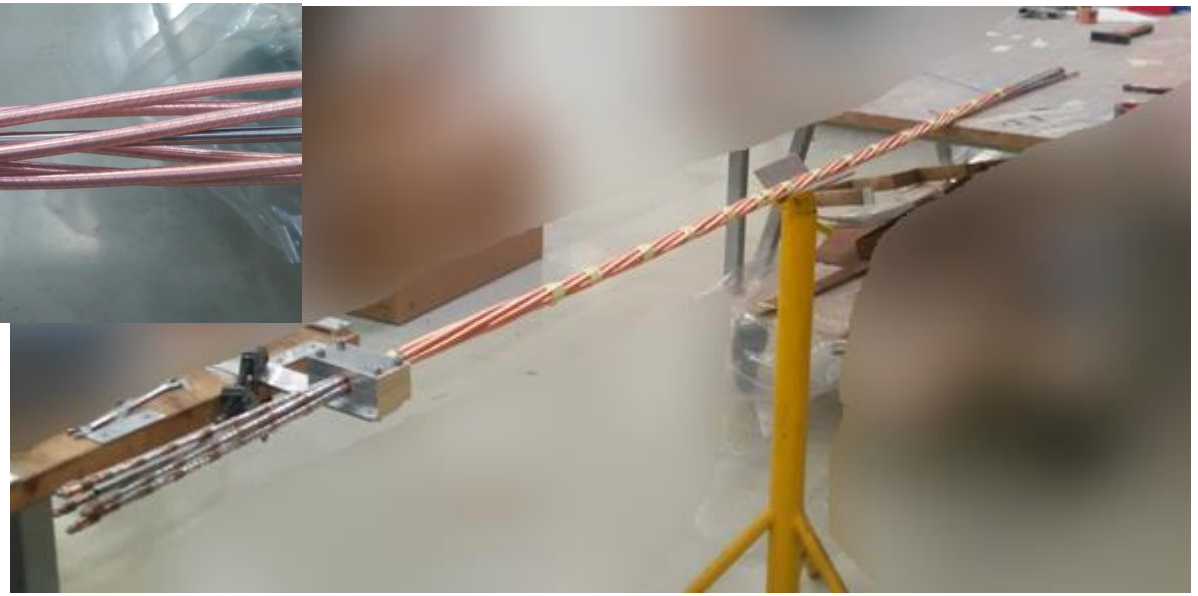
CERN

Cable Winding

Cabling:

- Cabling of the six-around-one cable is done manually
- A cable pitch is 400 mm
- 4.5 pitches in between the joint terminals



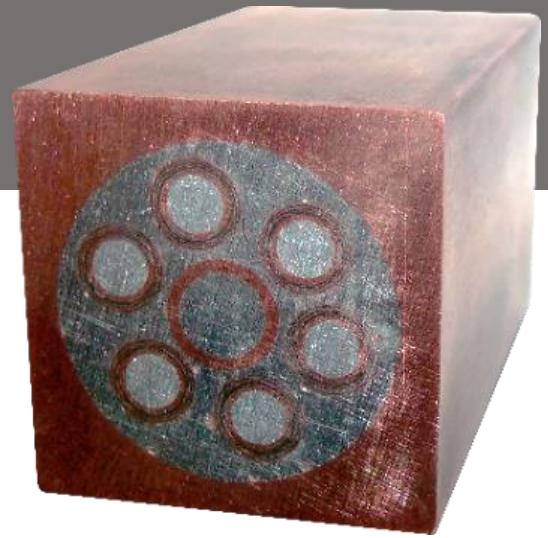


UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

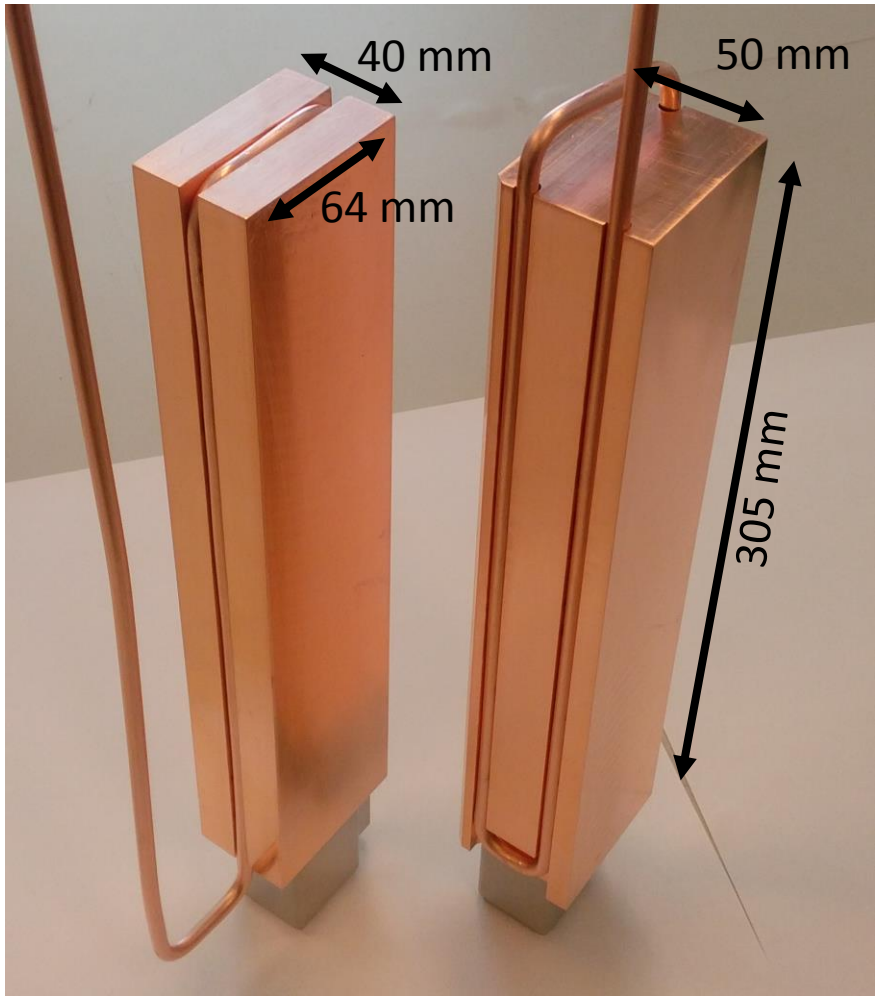
Joint Terminals



CORC CICC Joint Terminals

- Solder filled
- Tapered Stands
- Embedded conduction cooling

Temperature (K)	Bottom Terminal Resistance (nΩ)	Top Terminal Resistance (nΩ)	Loop Resistance (nΩ)
5	1.7	1.5	6.4
10	2.0	1.7	7.5
30	4.0	3.0	14
50	6.5	5.4	24



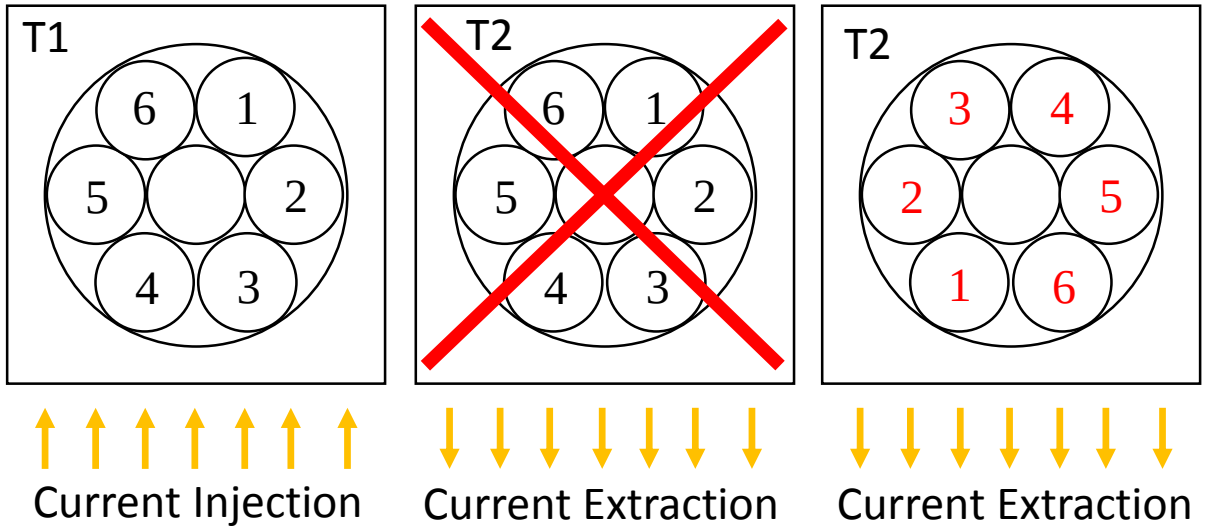
UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Current Distribution

- Short sample current distributed in terminals
- Strands are tapered
- Strands are straight inside the terminal
- Half a cable pitch difference between terminals



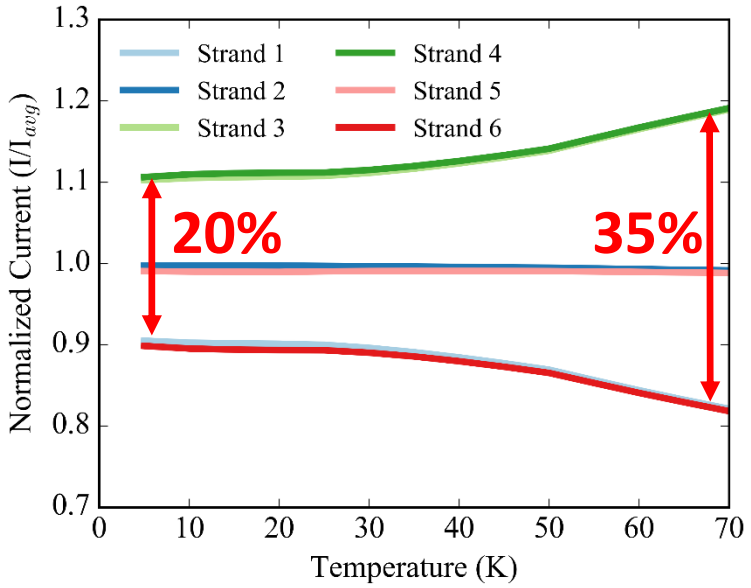
UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

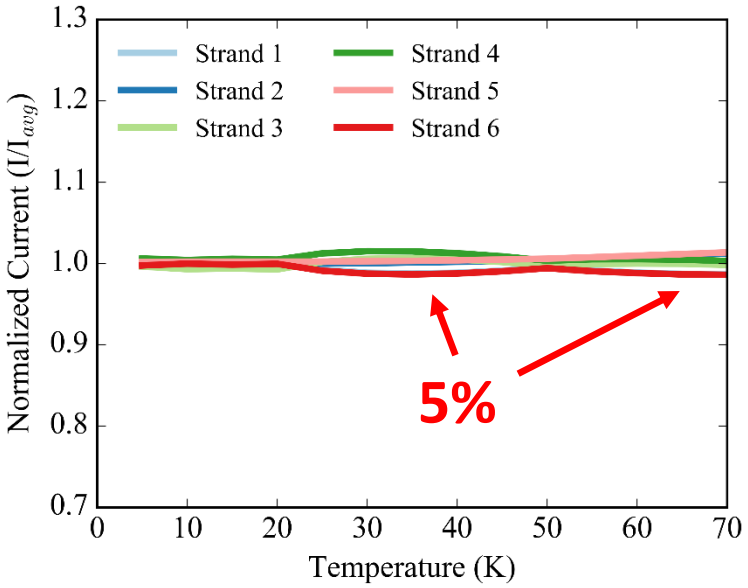
CERN

Current Distribution

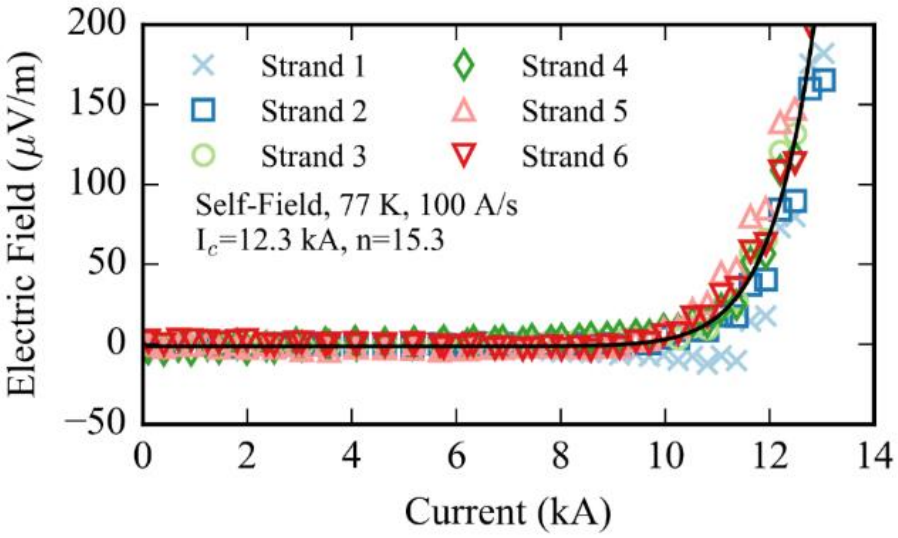
Full pitch between terminals



Half pitch between terminals



Experimental Results (2016)

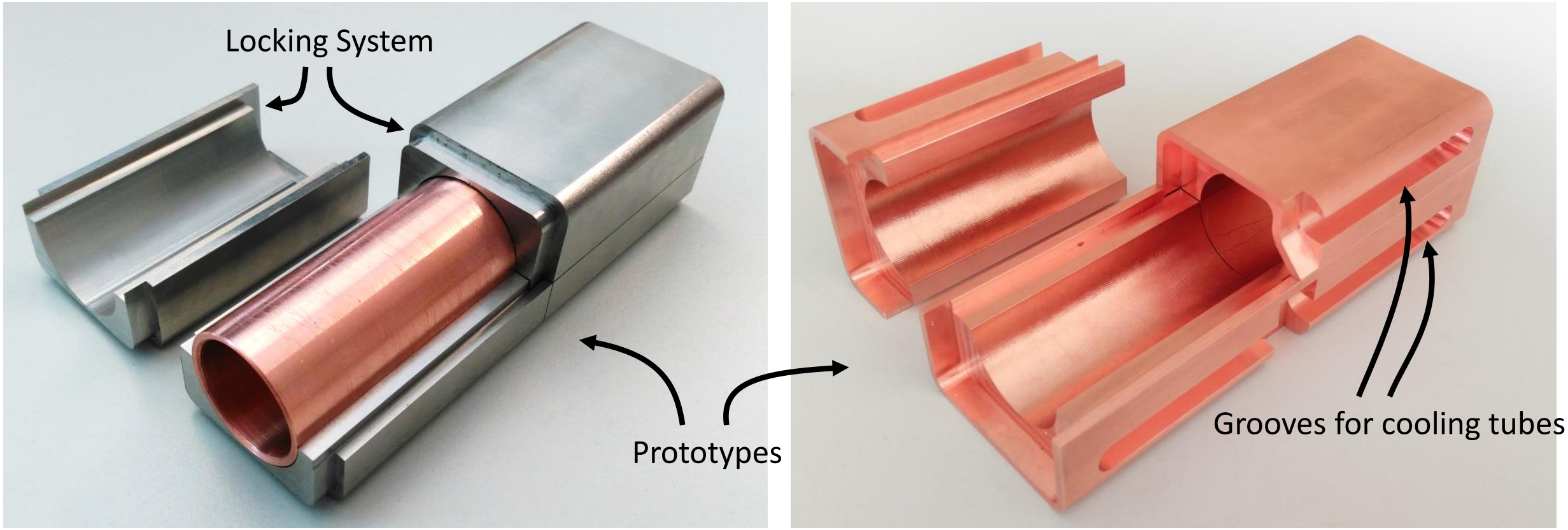


UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Jacket Design

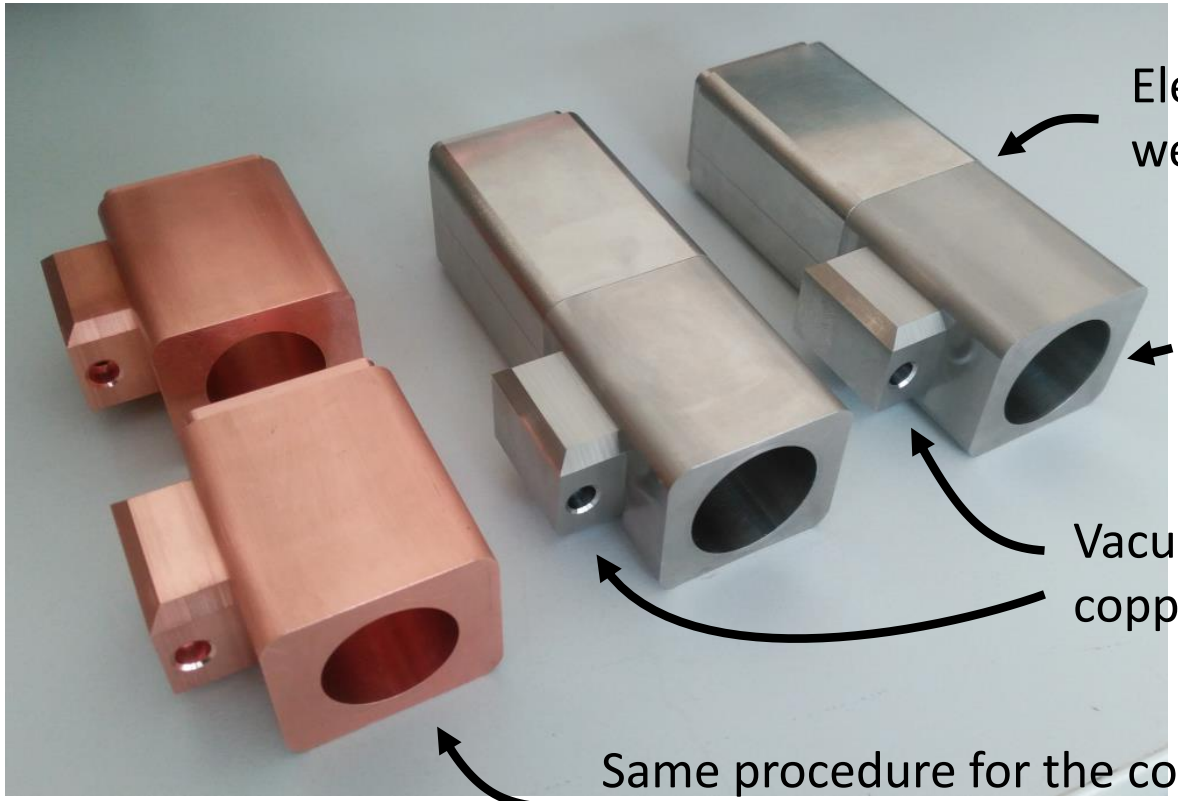


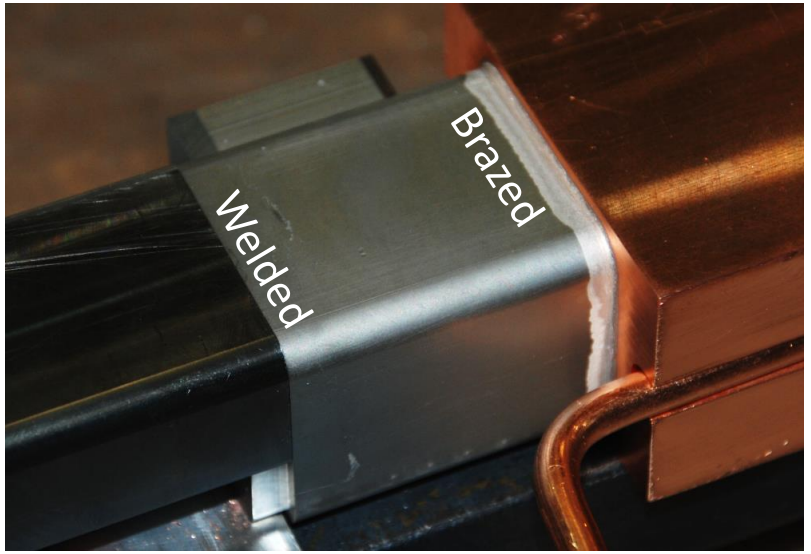
UNIVERSITY OF TWENTE.

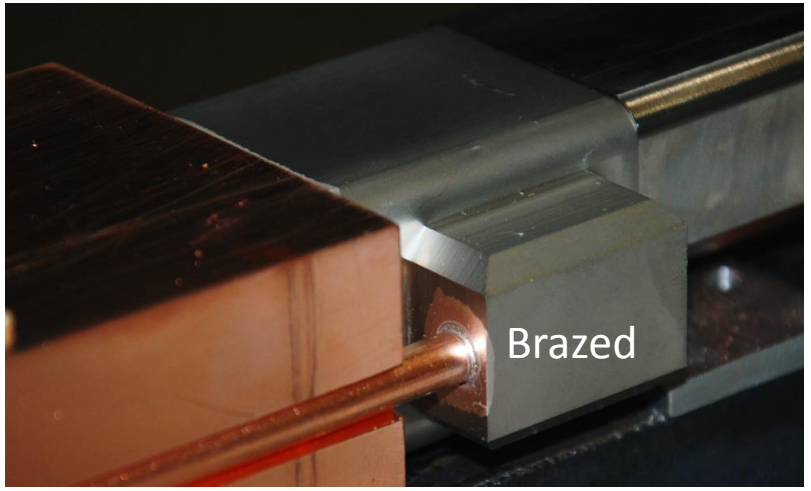
Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Jacket to Joint connection





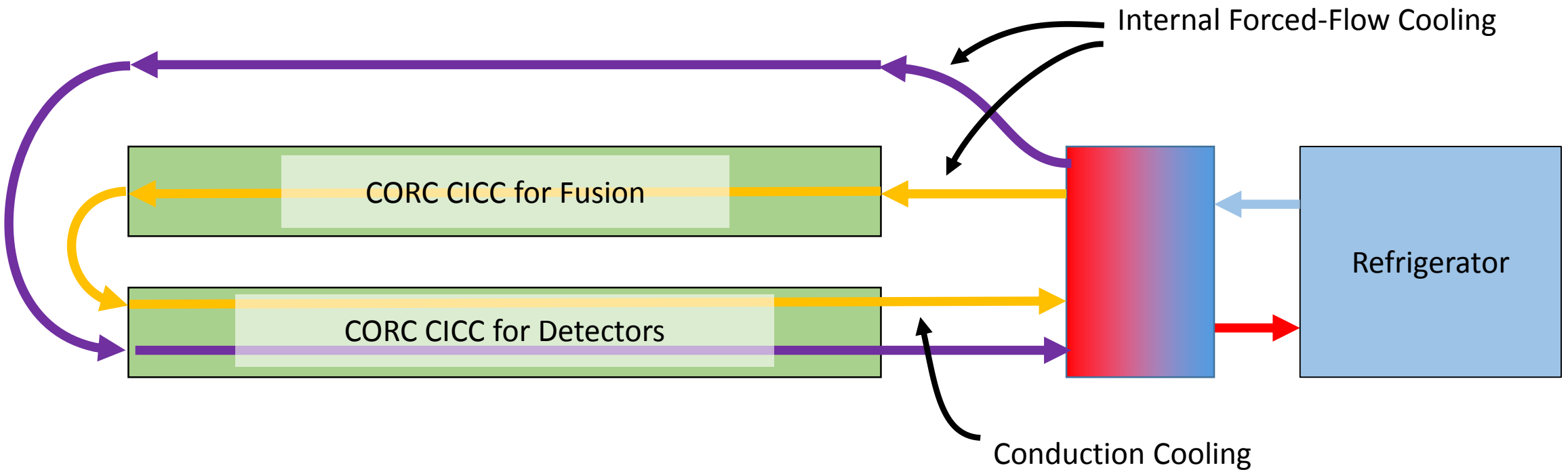


UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Cooling Scheme for the SULTAN test



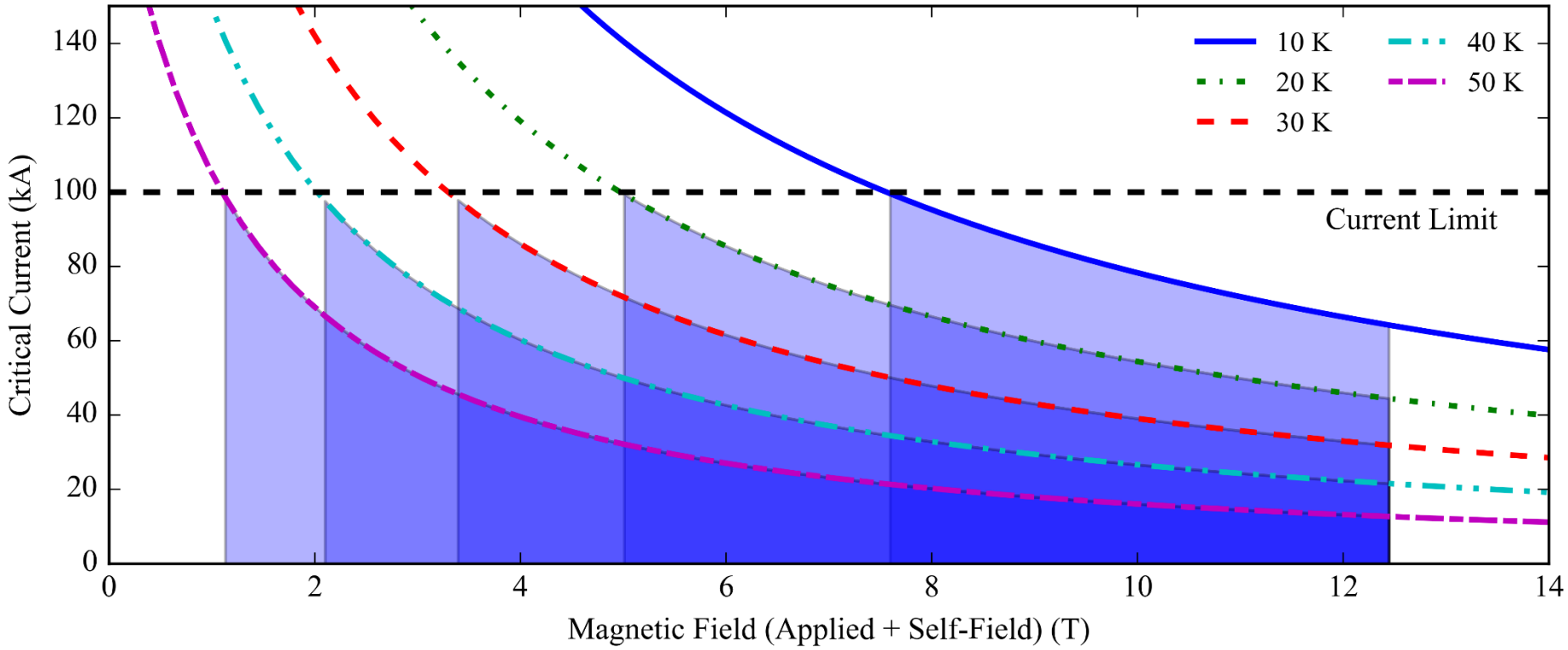
UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Expected Performance

Self-Field is about 1 T at 50 kA



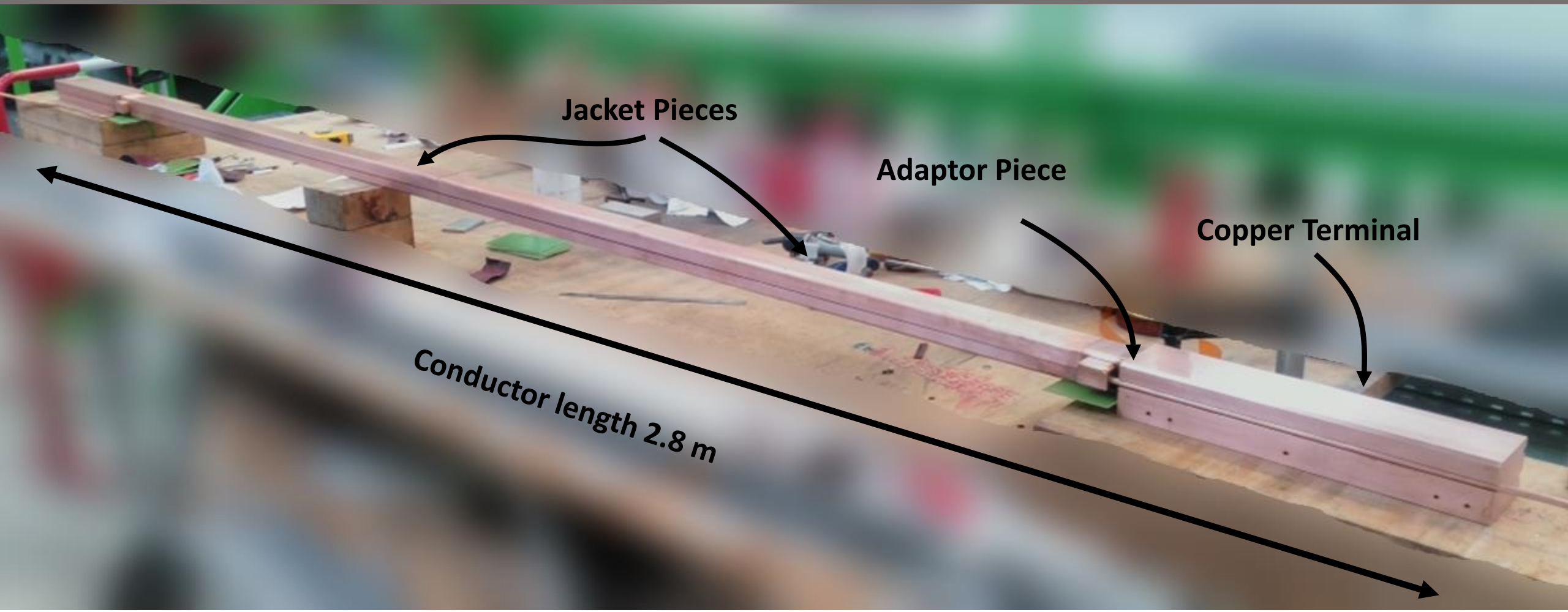
Current limit of SULTAN test facility

UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Final Product

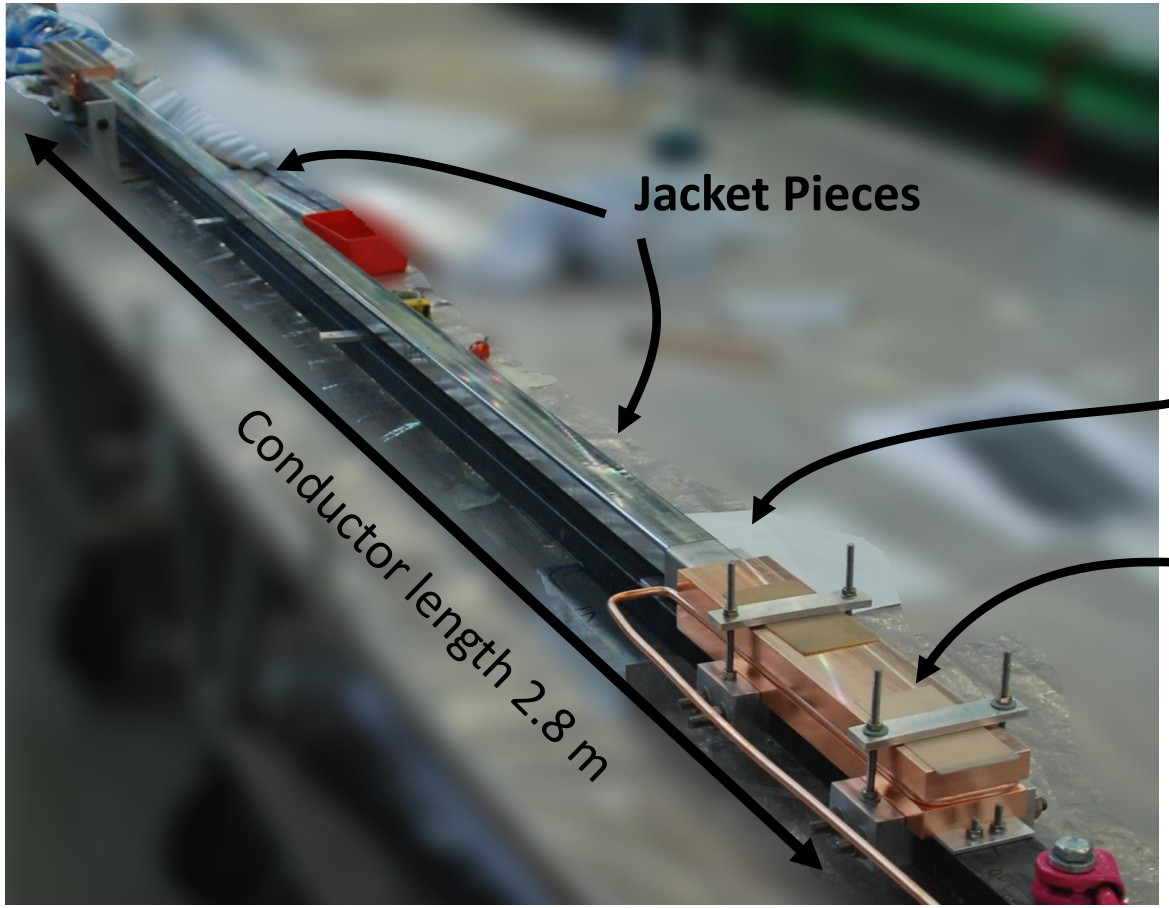


UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Final Product



UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN

Conclusions And Outlook

- ✓ Two New 2.8 m long CORC Cable-In-Conduit Conductors are manufactured
- ✓ Both conductors are rated for 80 kA @ 12T/4K
- ✓ First conductor has a copper jacket and conduction cooling
- ✓ Second conductor has stainless steel jacket and internal forced flow cooling
- ✓ Terminals feature 2 nΩ @ 4 K and 6 nΩ @ 50 K
- ✓ Measurements are scheduled for next August
- ✓ Research on CORC is ongoing, more CORC wires and CORC CICCs are expected!

UNIVERSITY OF TWENTE.

Advanced Conductor Technologies LLC
www.advancedconductor.com

CERN