Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

EUROfusion

Manufacturing of HTS SECAS samples and preliminary tests in LN_2

WPMAG 2025 Final Meeting

Villigen PSI; January 14th - 16th, 2026

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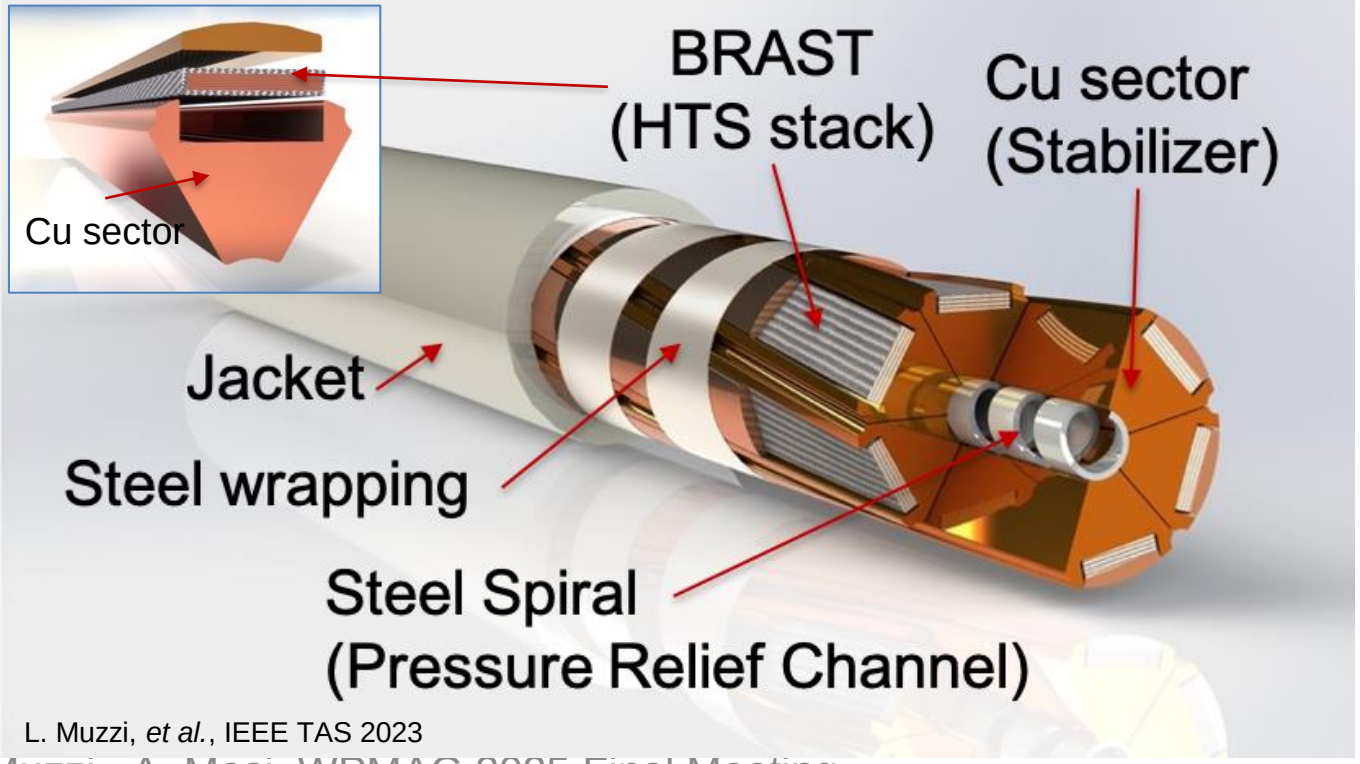
Main Task Objective

Manufacture of a SECAS Sample for SULTAN test, incl. qualification tests at LN_2

SECtor ASsembled cable (*SECAS*) CICC concept

BRAided Stack (*BRAST*)

Multi-Stage Cable Processing



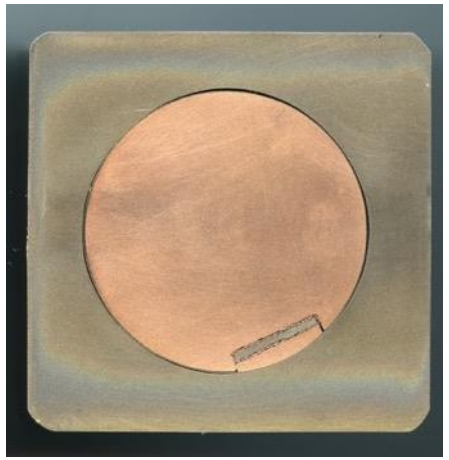
L. Muzzi, *et al.*, IEEE TAS 2023

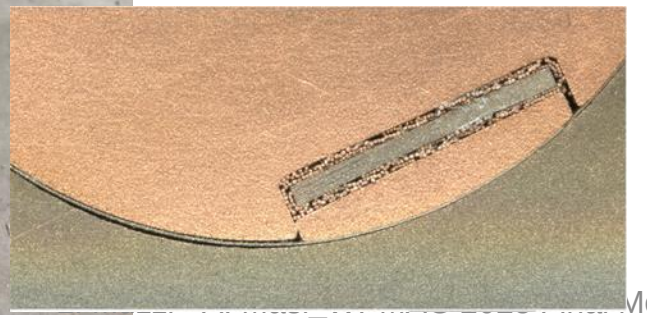
BRAST-SECAS Prototypes Qualification steps

BRAST of 10 Tapes, 12 mm x 0.08 mm

BRAST #3

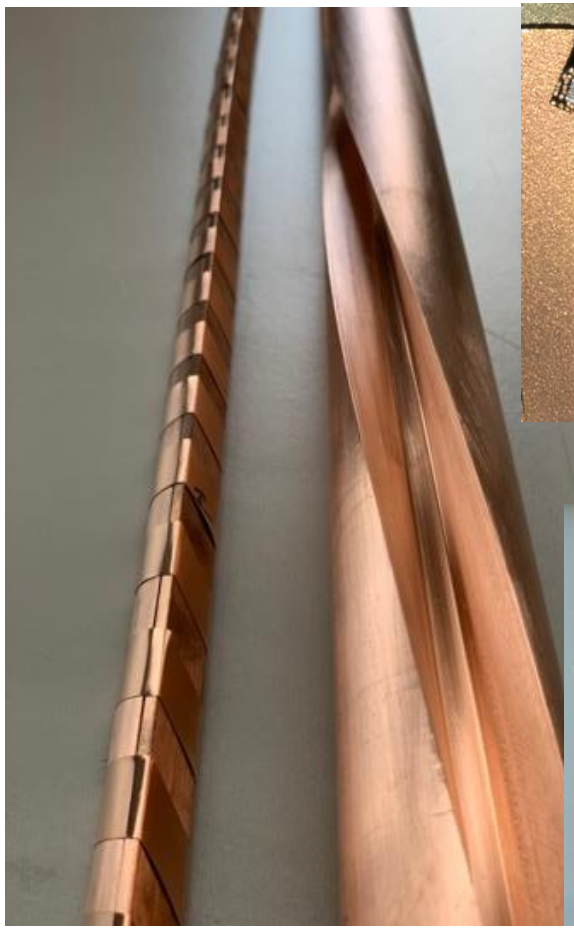
BRAST in spirally machined slot, and closing filler

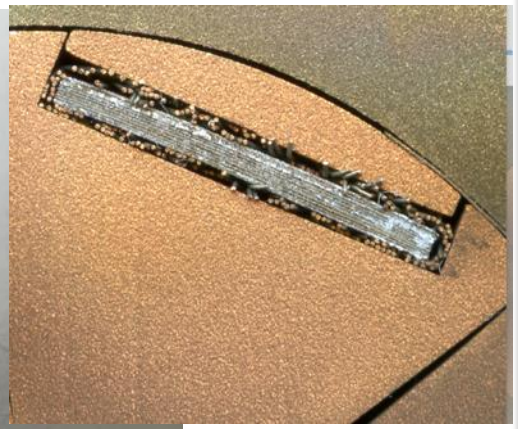


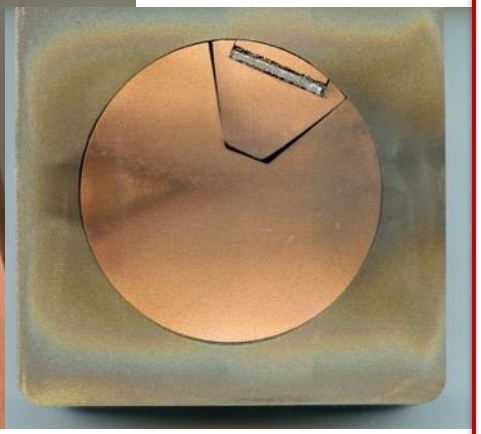


SECAS #1

BRAST assembled in straight sector, then inserted in spirally machined slot



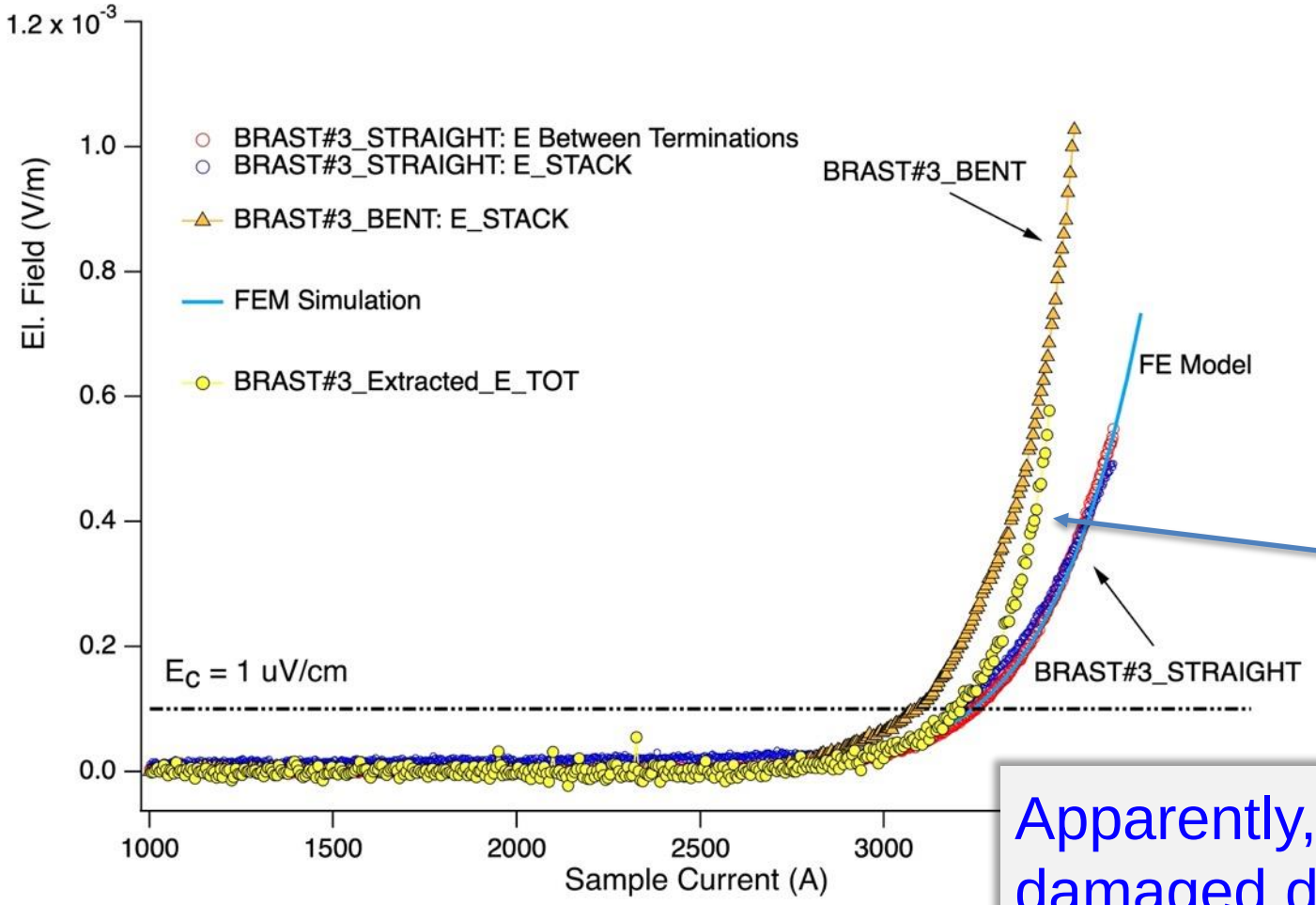




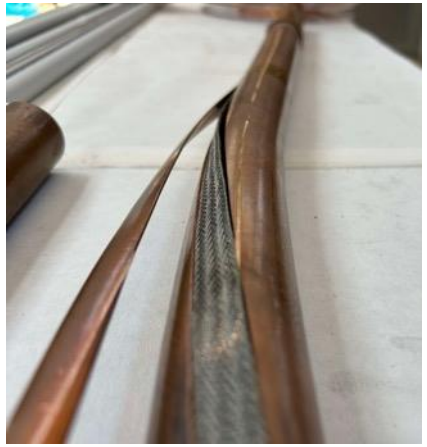
Initial qualification – BRAST (77K – s.f. tests) - bending

BRAST #3 (non soldered stack)

Effect of Conductor bending:



BRAST was extracted from **Bent** conductor and re-tested

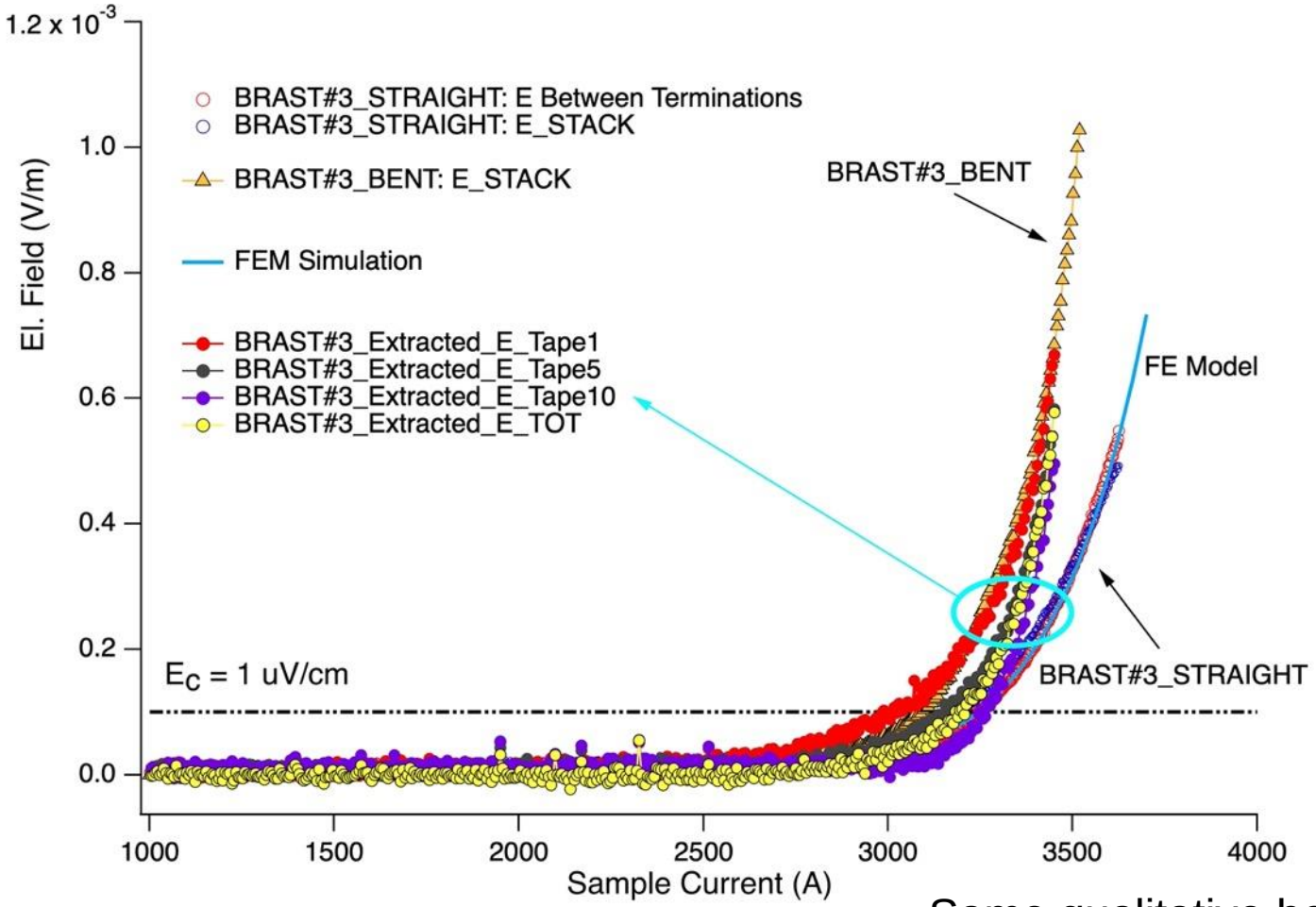


Apparently, the tape stack was not damaged during the bending

Initial qualification – BRAST (77K – s.f. tests) - bending

Electric field **along** different tapes

BRAST #3 (non soldered stack)



BRAST was extracted from **Bent** conductor and re-tested

Voltage development is different on the different tapes within the stack. Effects of self-field, and effects of current distribution / re-distribution (*at terminations, in these samples*) should be clarified.

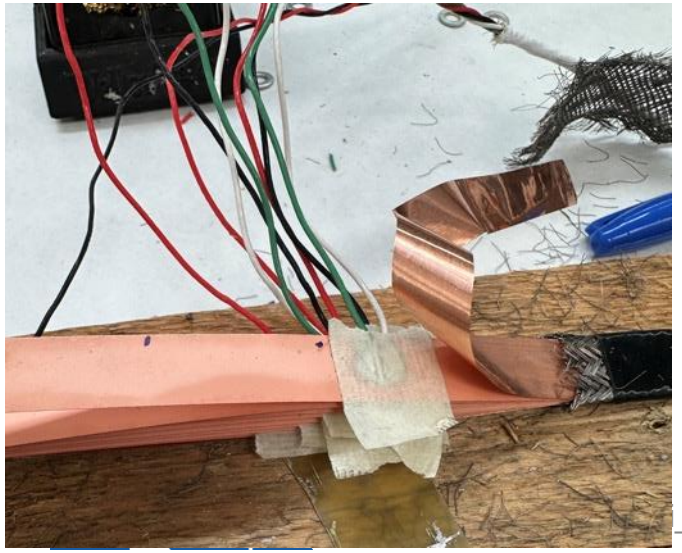
Either through modelling, or by means of dedicated tests.

Same qualitative behaviour observed an **all** tested prototypes

Current distribution study in BRAST (77K – s.f. tests)

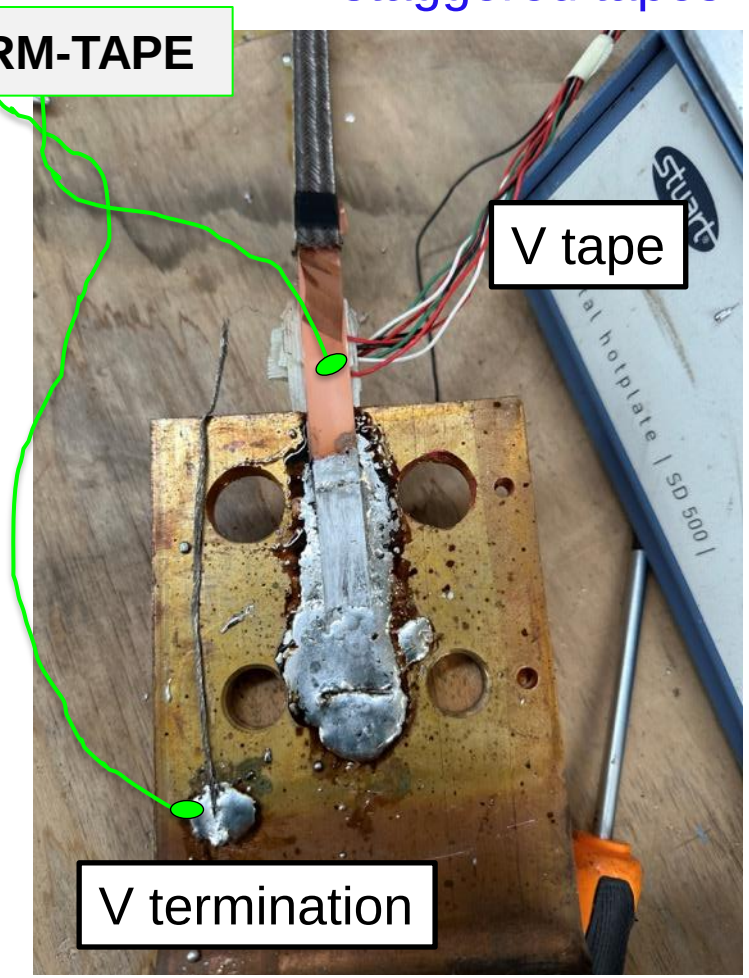
Sample for current distribution study: «free-standing» BRAST with 9 tapes (SST) 12 mm wide

Soldered terminations with staggered tapes



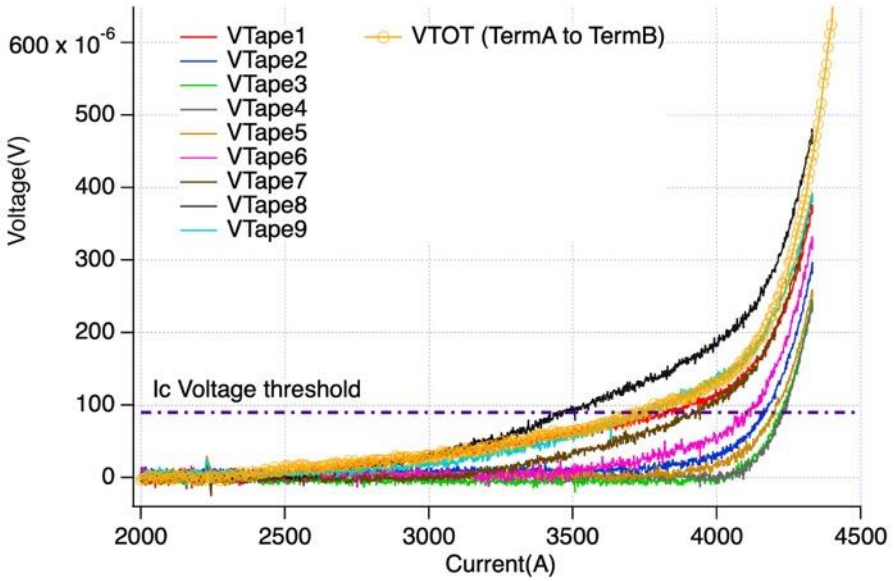
Voltage taps welded on tapes:

Voltage **between termination and tape**, as well as **along** each tape, can be measured



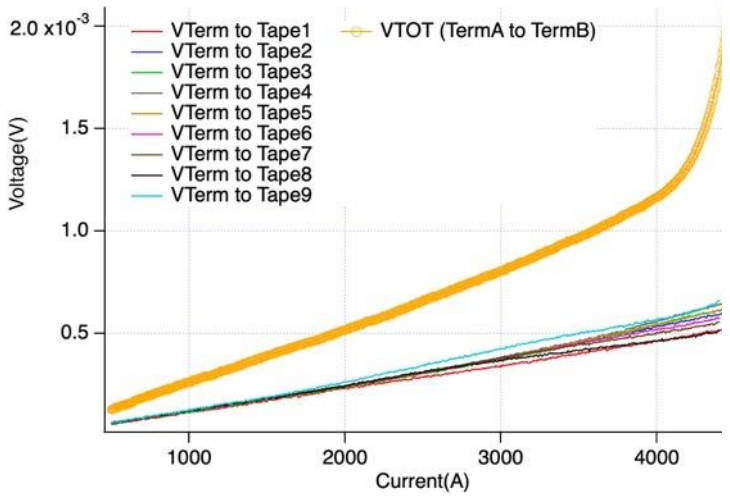
Current distribution study in BRAST (77K – s.f. tests)

Voltage along each tape during current ramp

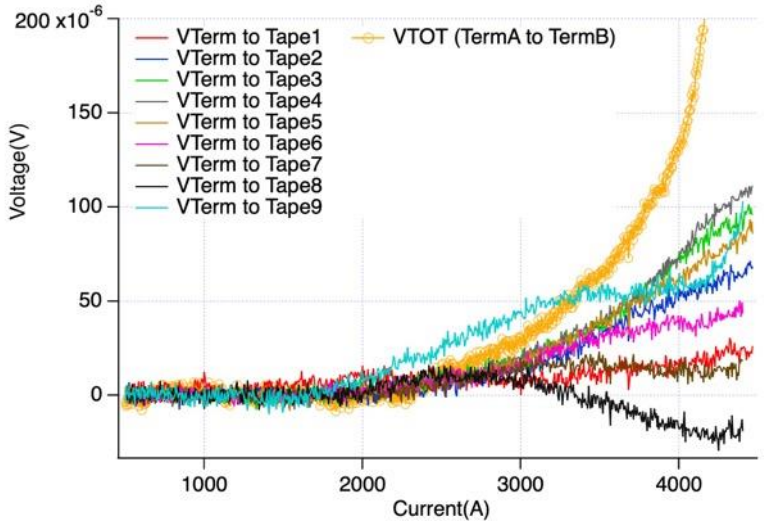


Voltage between termination and each tape

Raw data



V after subtraction of the resistive component



Wide transition «spectrum» for the different tapes.

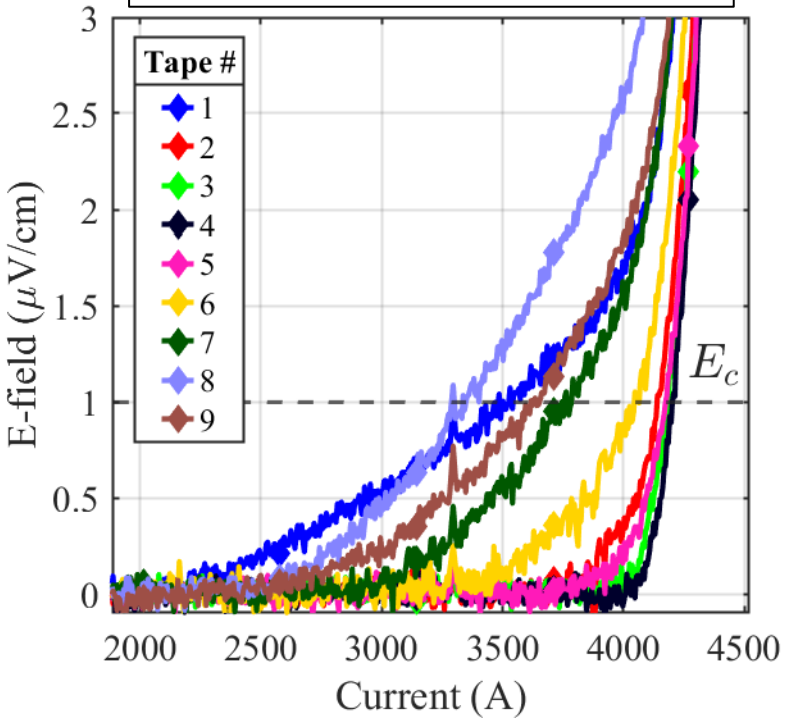
Resistance distribution at terminations.

Complex current re-distribution among tapes (*in these samples, occurring at terminations*); self-field effects also play a role.

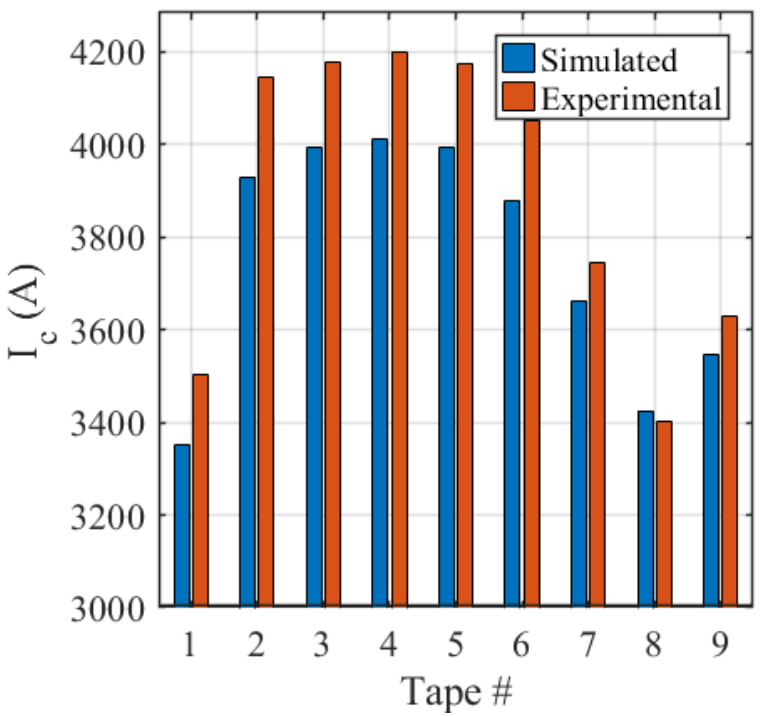
Same qualitative behaviour as observed on the BRAST extracted from the bent conductor prototype, tested as well in «stand-alone» mode.

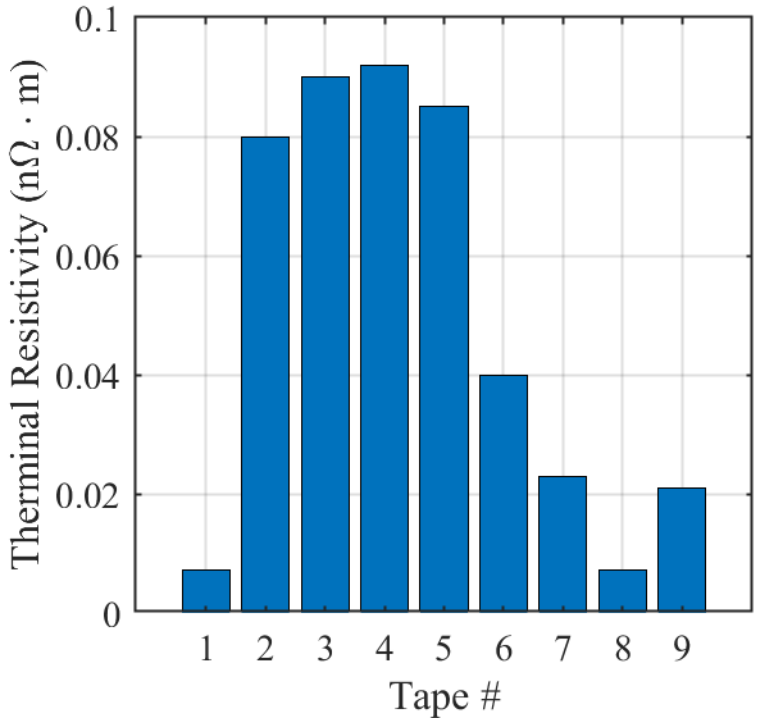
Current distribution in BRAST @77 K & self-field

Non-homogenous transition of the stack



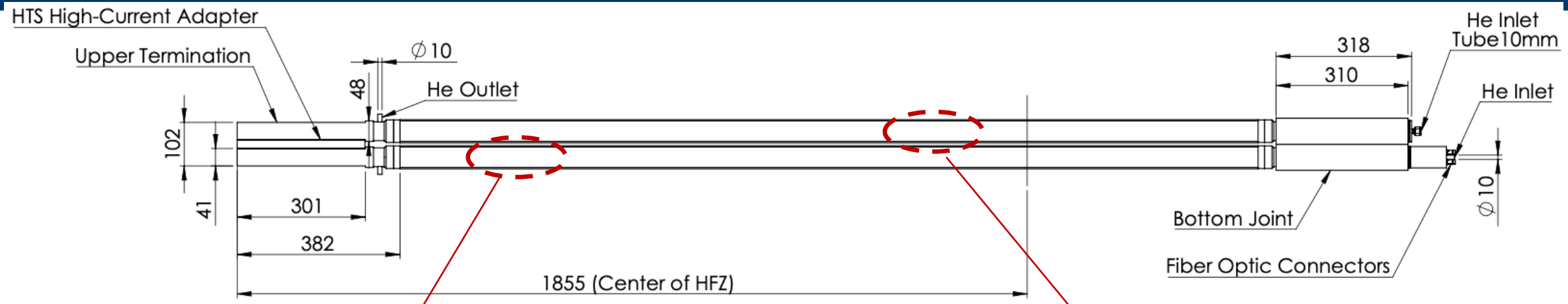
H-form. model by Dr. W. Hong (ASIPP)





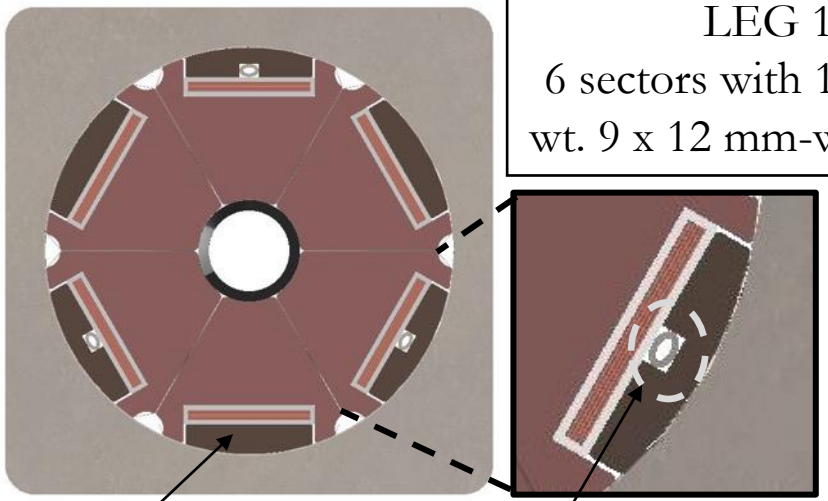
- Simulation results accurately reproduce this trend, indicating that in these **non-soldered**, **short samples**, the presence of **inhomogeneous tape terminal resistances** have a strong effect on the distribution of current among the tapes.

SECAS - SULTAN sample



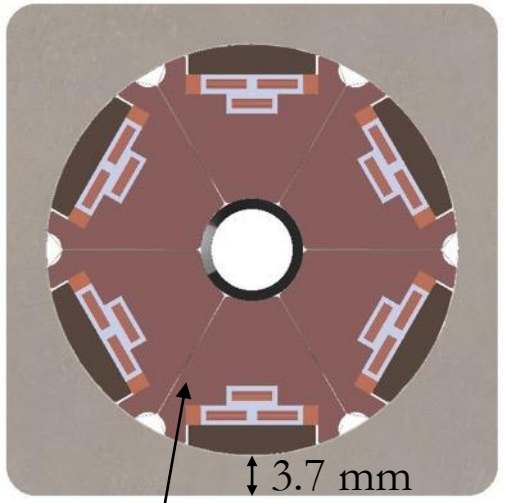
LEG 1
6 sectors with 1 BRAST
wt. 9 x 12 mm-wide tapes

LEG 2
6 sectors with 3 BRASTs
wt. 7 x 4 mm-wide tapes



EU DEMO target: stable operation @ 60 kA, 4.5 K, 18 T

SULTAN equivalent electromagnetic load → 11 T, ~ 100 kA



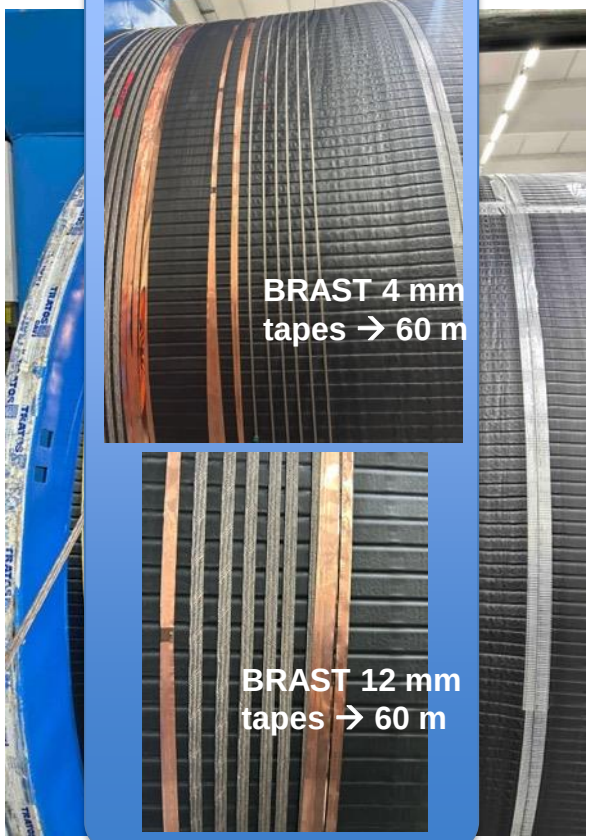
SULTAN sample preparation: some key steps

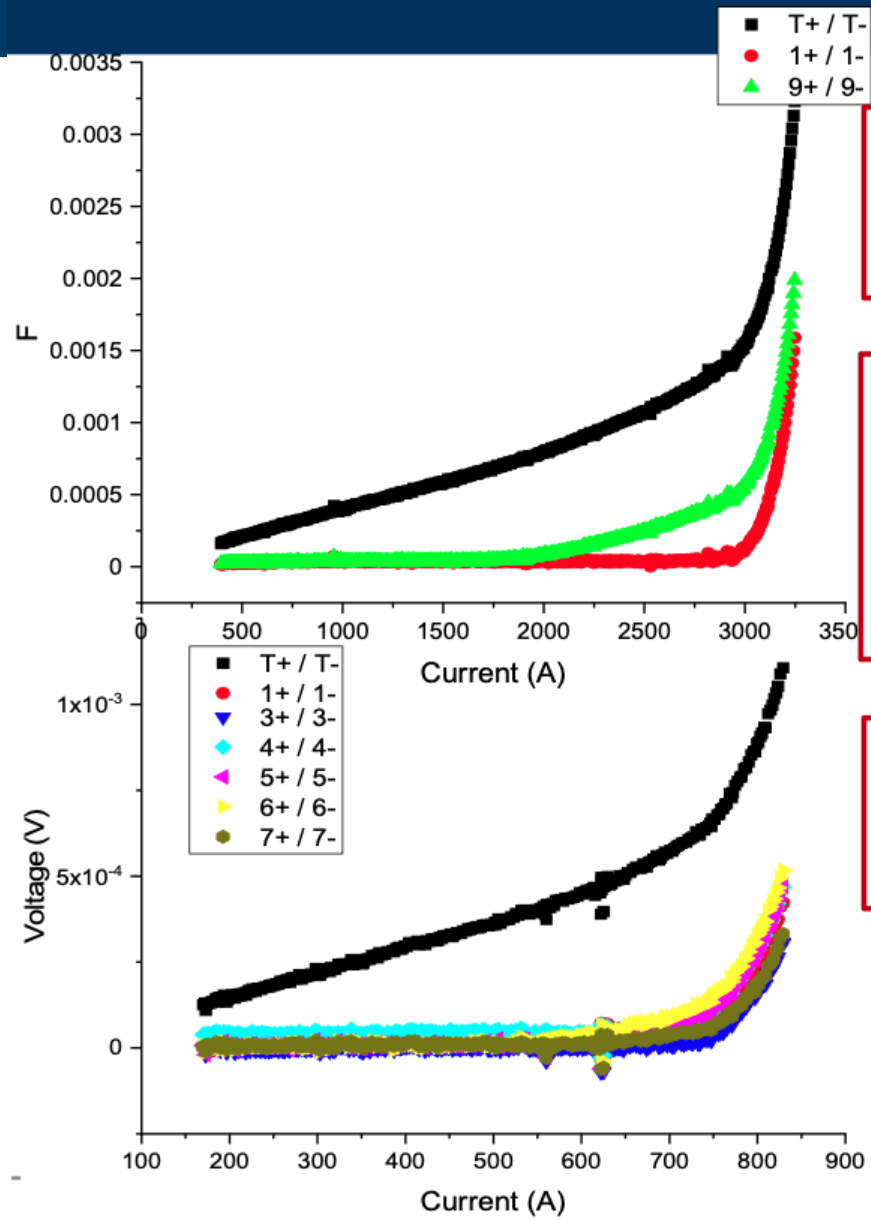
BRAST manufacture at: TRATOS CAVI

Using the existing ***in-line braid machine***

SULTAN sample preparation: some key steps

BRAST manufacture at:





#9 tapes (*FFJ*) 12 mm wide. I_c = 3000 A

Test @ LN2– s.f. on BRAST manufactured for SULTAN samples.

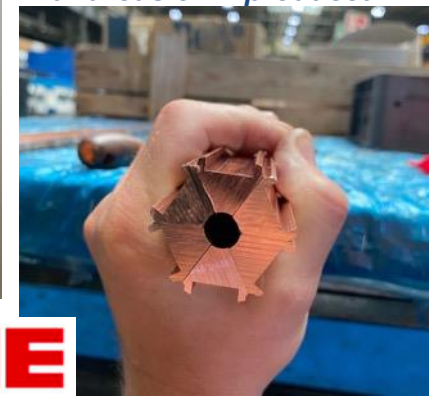
#7 tapes (*SST*) 4 mm wide. I_c = 770 A

Results in line with expectations

SULTAN sample preparation: some key steps

Extruded Cu sector

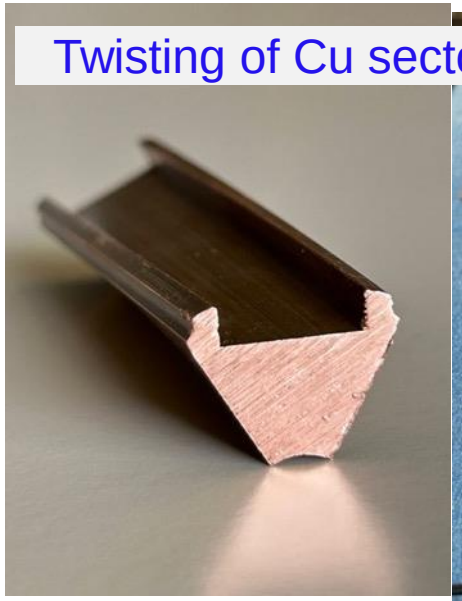
Extruded by KME (D)
Unit lenth 5 m
Hundreds of m produced

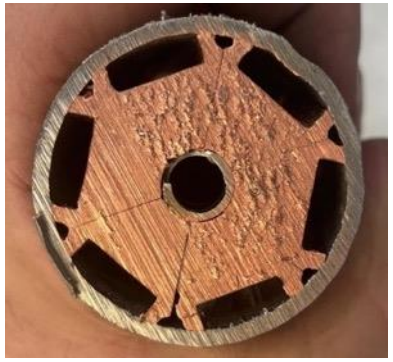


KME

Cable assembly trials:

Twisting of Cu sectors

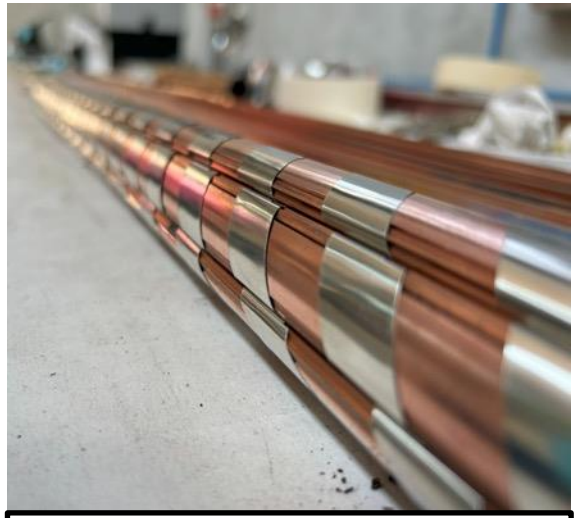




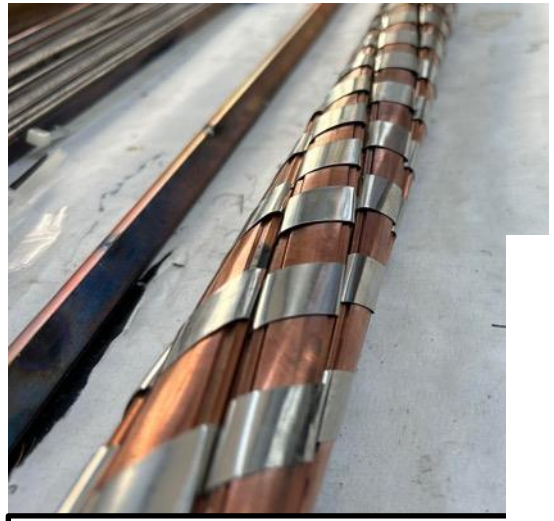
Short piece of assembled SECAS

SULTAN sample preparation: some key steps

SULTAN sample manufacturing:



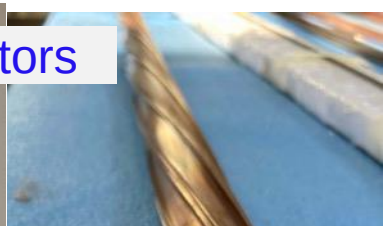
Sectors assembled, and wrapped in SS tape

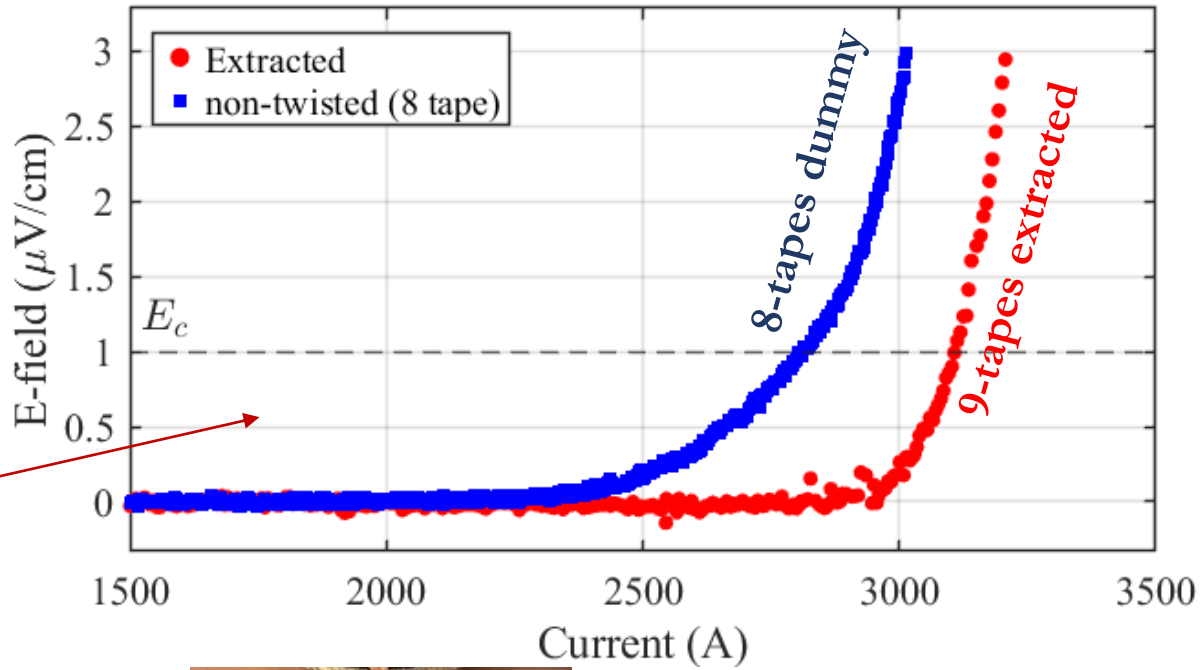


Nominal twist pitch of 1200 mm

Post-twist check at 77 K, self-field shows no evident sign of degradation

Cable assembly trials:

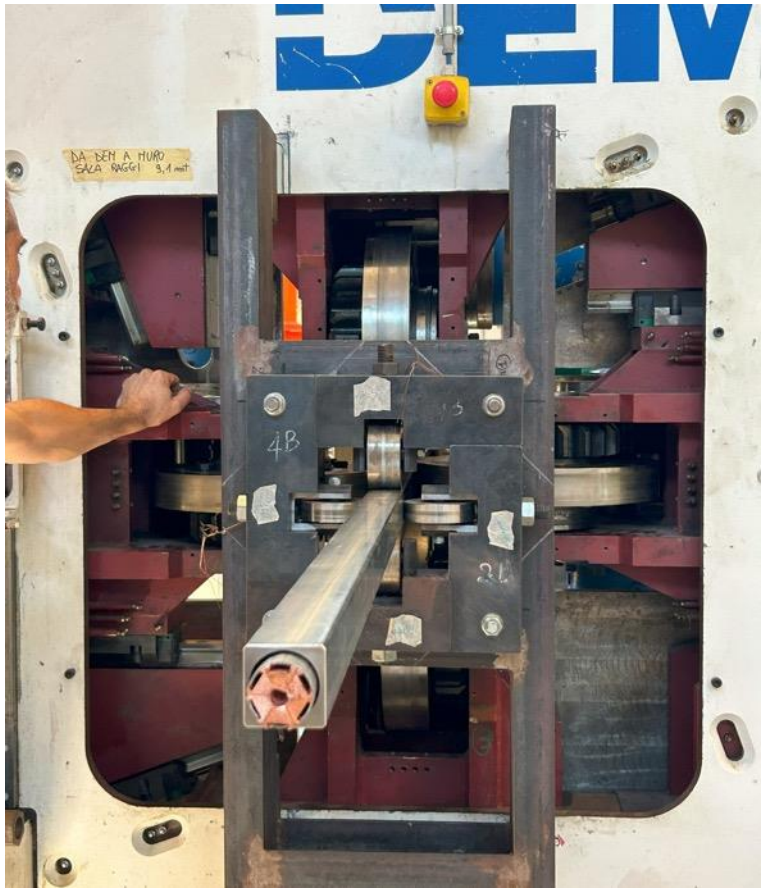


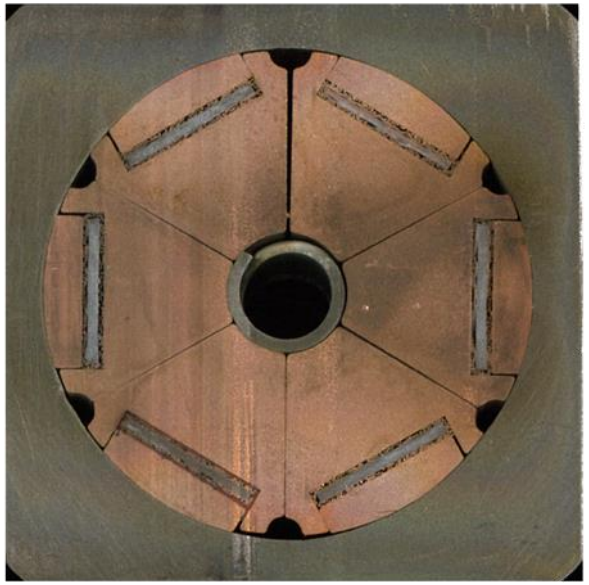


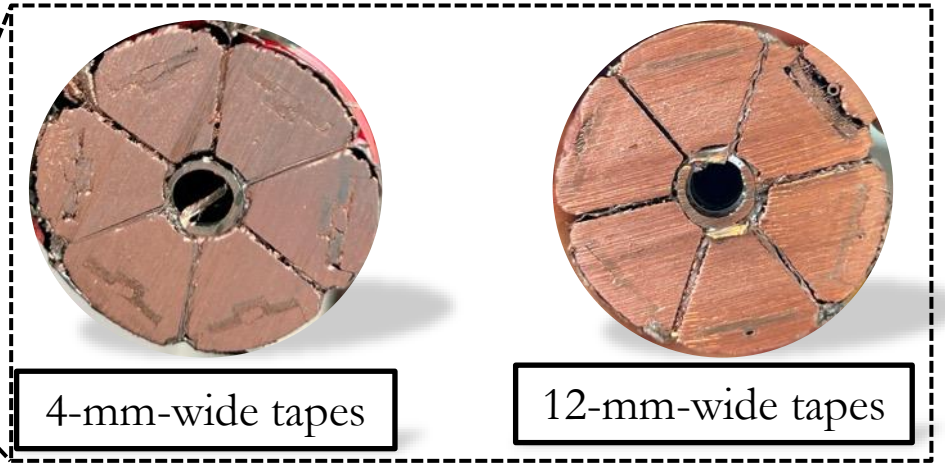
SECAS - SULTAN sample compaction

Jacketing and compaction:

Ciotec IMPIANTI S.r.l.







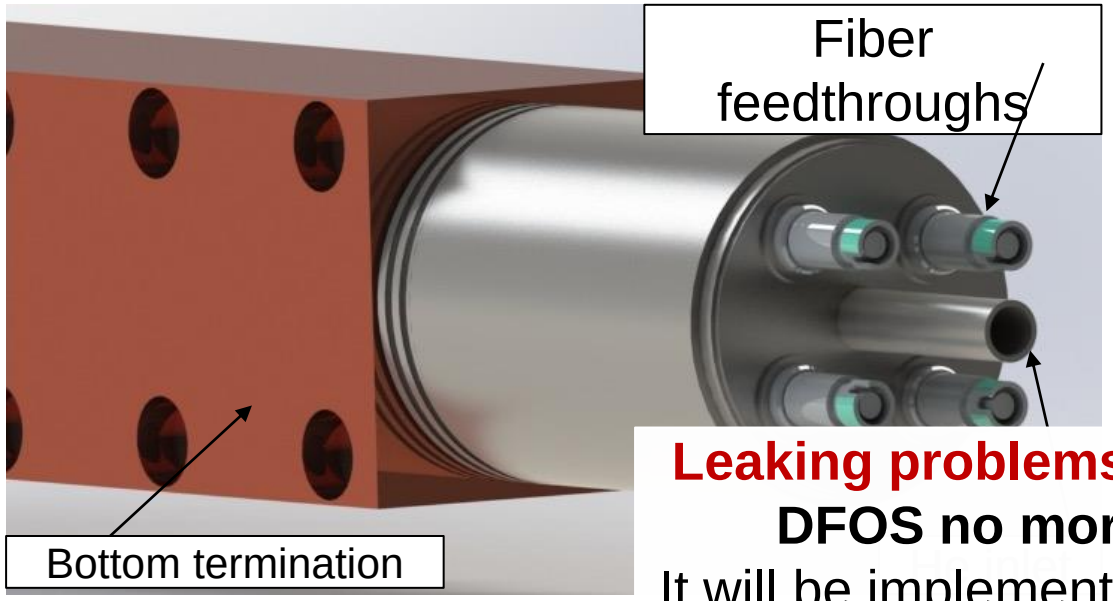
SECAS – SULTAN sample DFOS QD

SS capillaries for DFOS

One leg has been equipped with 4 SS capillary tubes for distributed or quasi-distributed temperature monitoring:

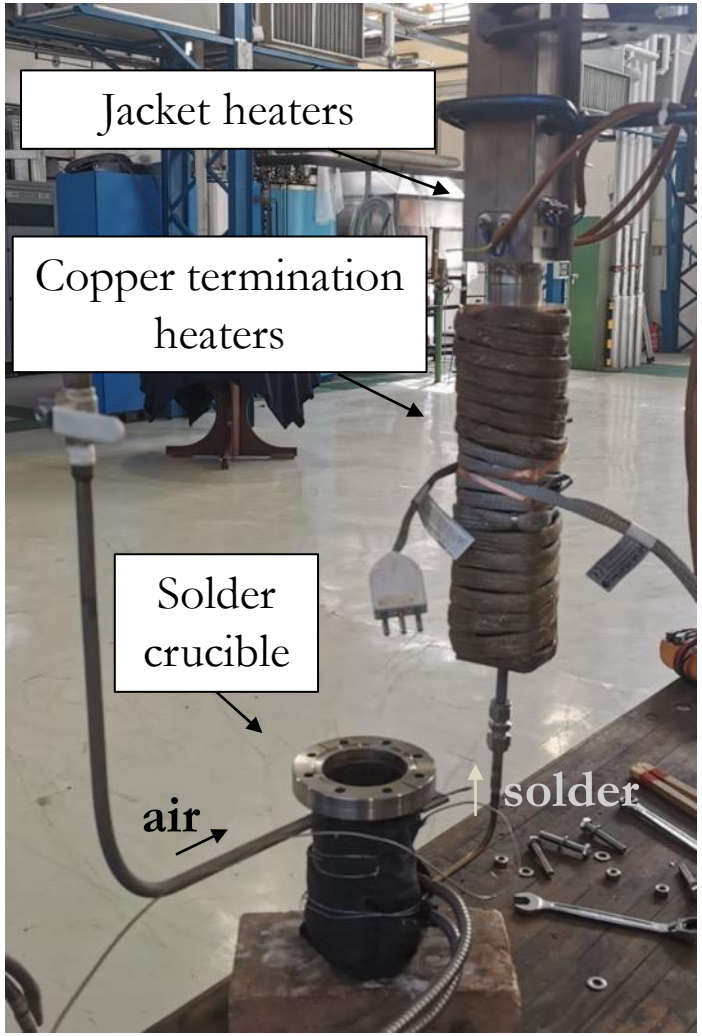
3 DOFS

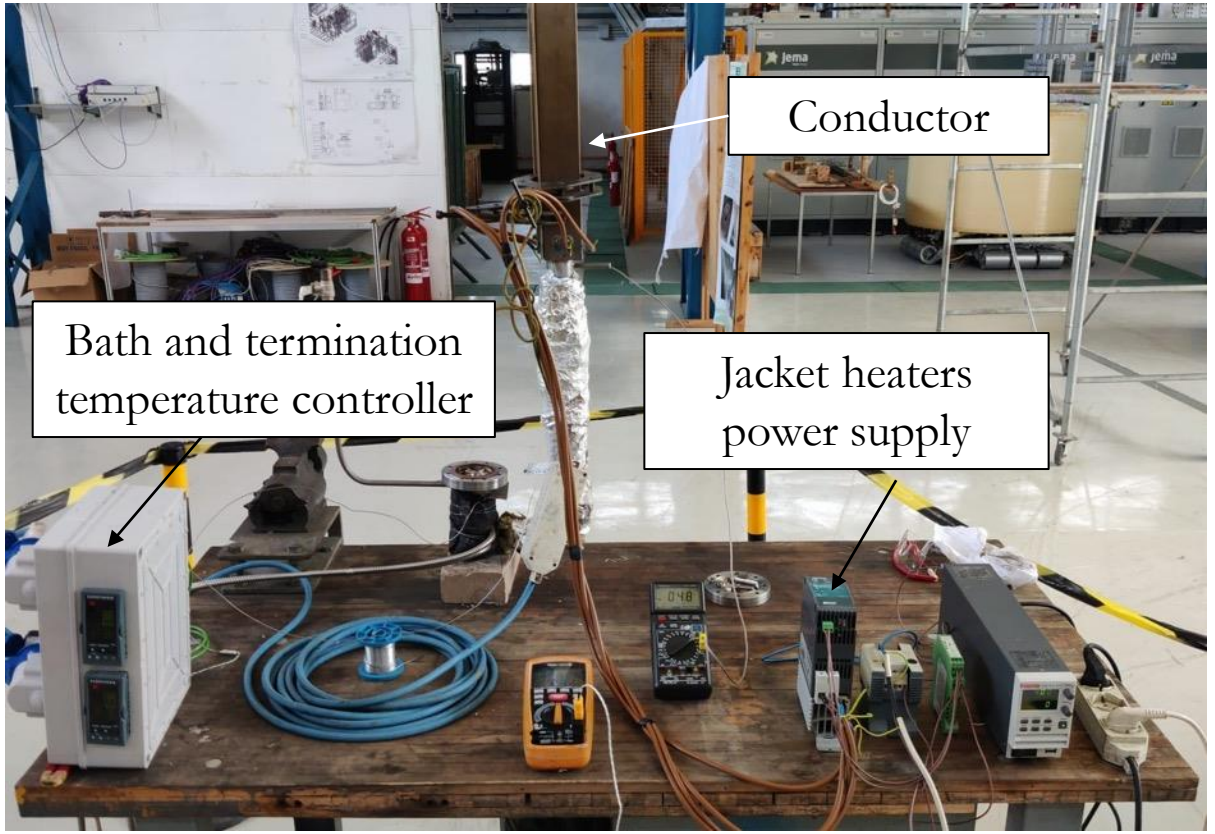
1 FBG array



Leaking problems at fibers feedthroughs →
DFOS no more adopted in this cable
It will be implemented for the **third SULTAN leg** (currently in preparation)

SECAS - SULTAN termination manufacturing

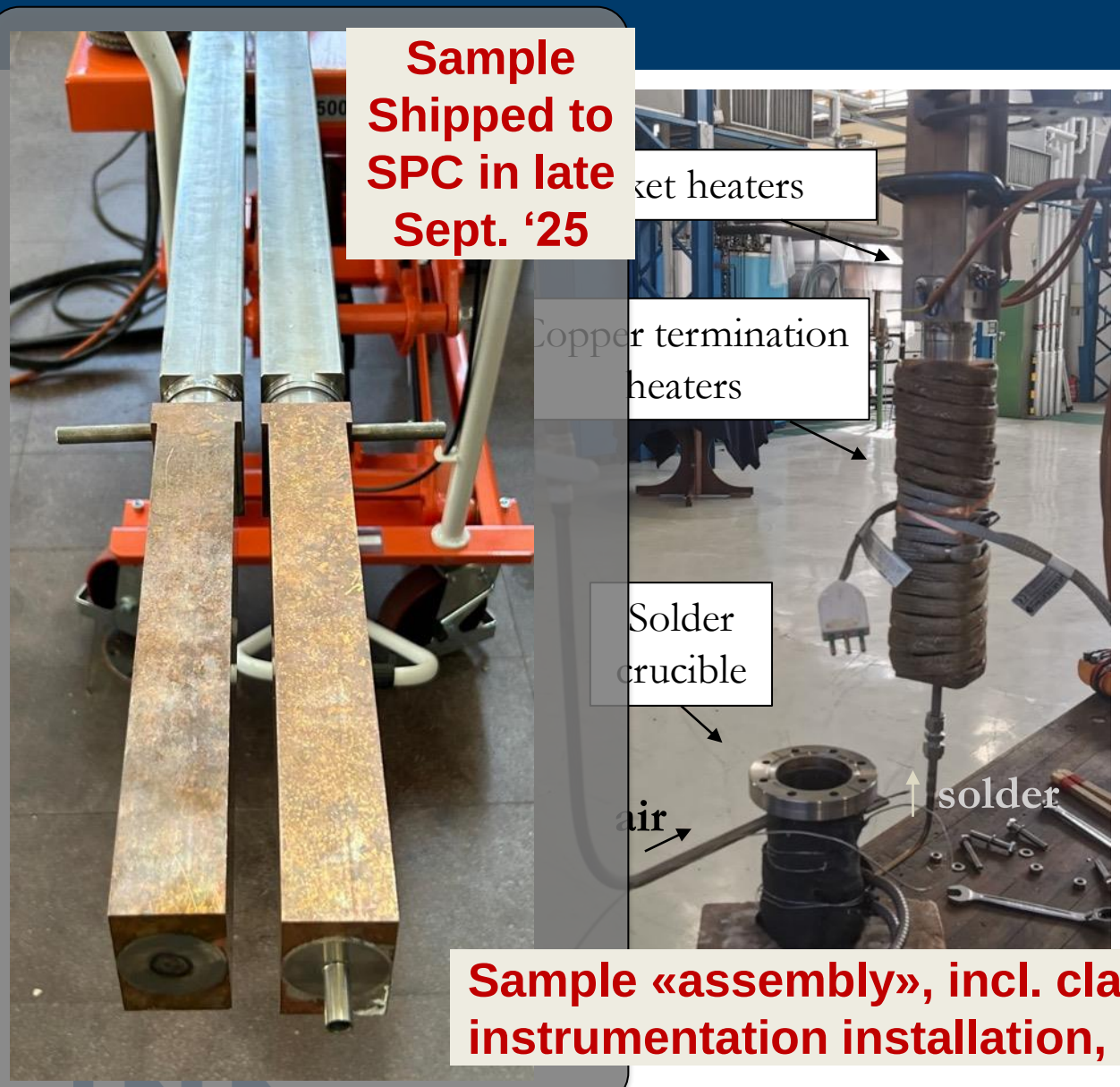


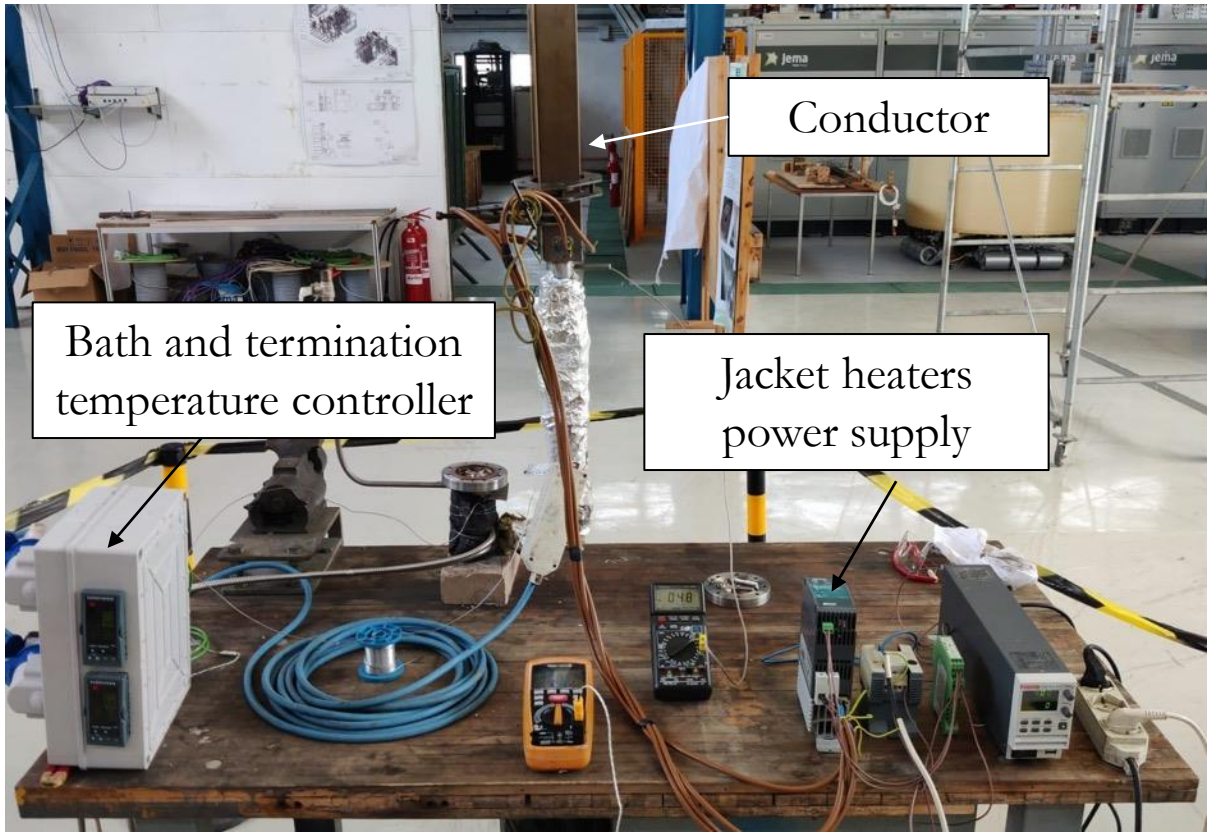


The termination is soldered via impregnation while heated stably at 200 °C

SECAS - SULTAN termination manufacturing

Sample Shipped to SPC in late Sept. '25

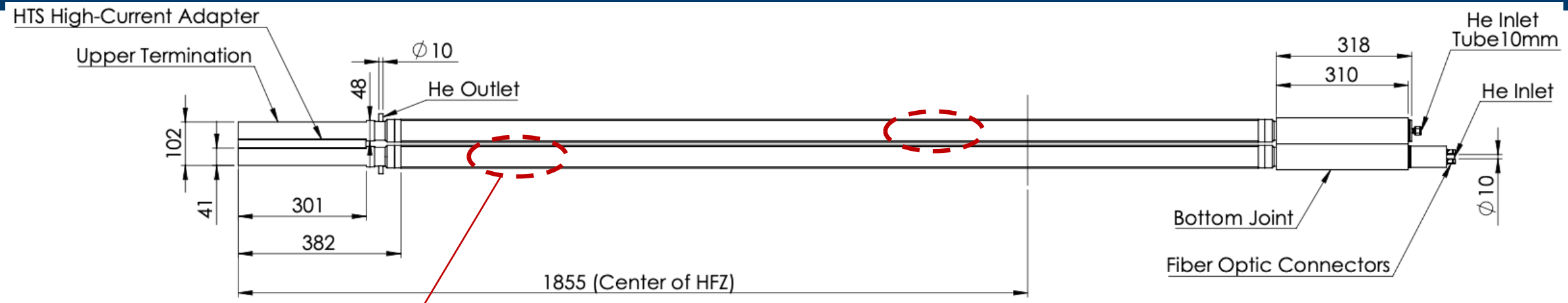




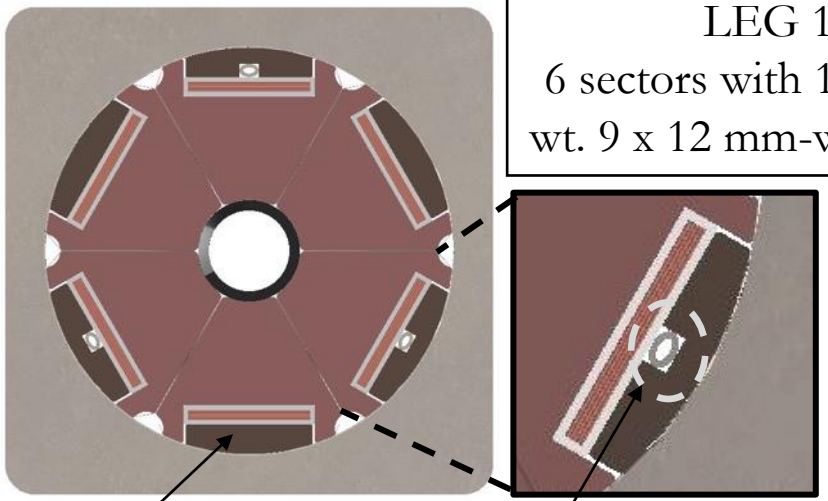
The termination is soldered via impregnation while at 200 °C

Sample «assembly», incl. clamps and instrumentation installation, by SPC

SECAS - SULTAN sample



LEG 1
6 sectors with 1 BRAST
wt. 9 x 12 mm-wide tapes



Now in preparation:

LEG 3
6 sectors with 1 BRAST
wt. 9 x 12 mm-wide tapes

BUT with sector twisting applied before insertion of tape stacks, simulating a very different possible processing approach.

CICC length is ready; terminations still to be manufactured.
→ Ready by the end of February 2026.

Next Steps

- manufacture of a **third SECAS** prototype **length** is on-going**.**

- assembly of the full-size sample → **SPC**

- test of the full-size sample.

- a new sample for KIT FBI facility is also under preparation.

- modelling activities are also on-going, to help clarify the observed effects of current re-distribution among tapes occurring at terminations in short samples.