

# Nb<sub>3</sub>Sn Wind & React conductors and joints for the low field grades of a layer wound DEMO TF coil

L. Muzzi, R. Righetti, L. Affinito, A. Anemona, M. Arabi, S. Chiarelli, V. Corato, A. della Corte, A. Di Zenobio, C. Fiamozzi Zignani, R. Freda, L. Morici: **ENEA, Centro Ricerche Frascati (Rome), Italy**  
A. Bragagni, M. Seri, S. Boncompagni, A. Formichetti: **TRATOS Cavi S.p.A., Pieve Santo Stefano (AR), Italy**; G. Roveta, S. Galignano, L. Merli: **CRIOTEC Impianti S.p.A., Chivasso (TO), Italy**

## BACKGROUND:

Feasibility studies for a **layer-wound TF** coil in **EU-DEMO**.

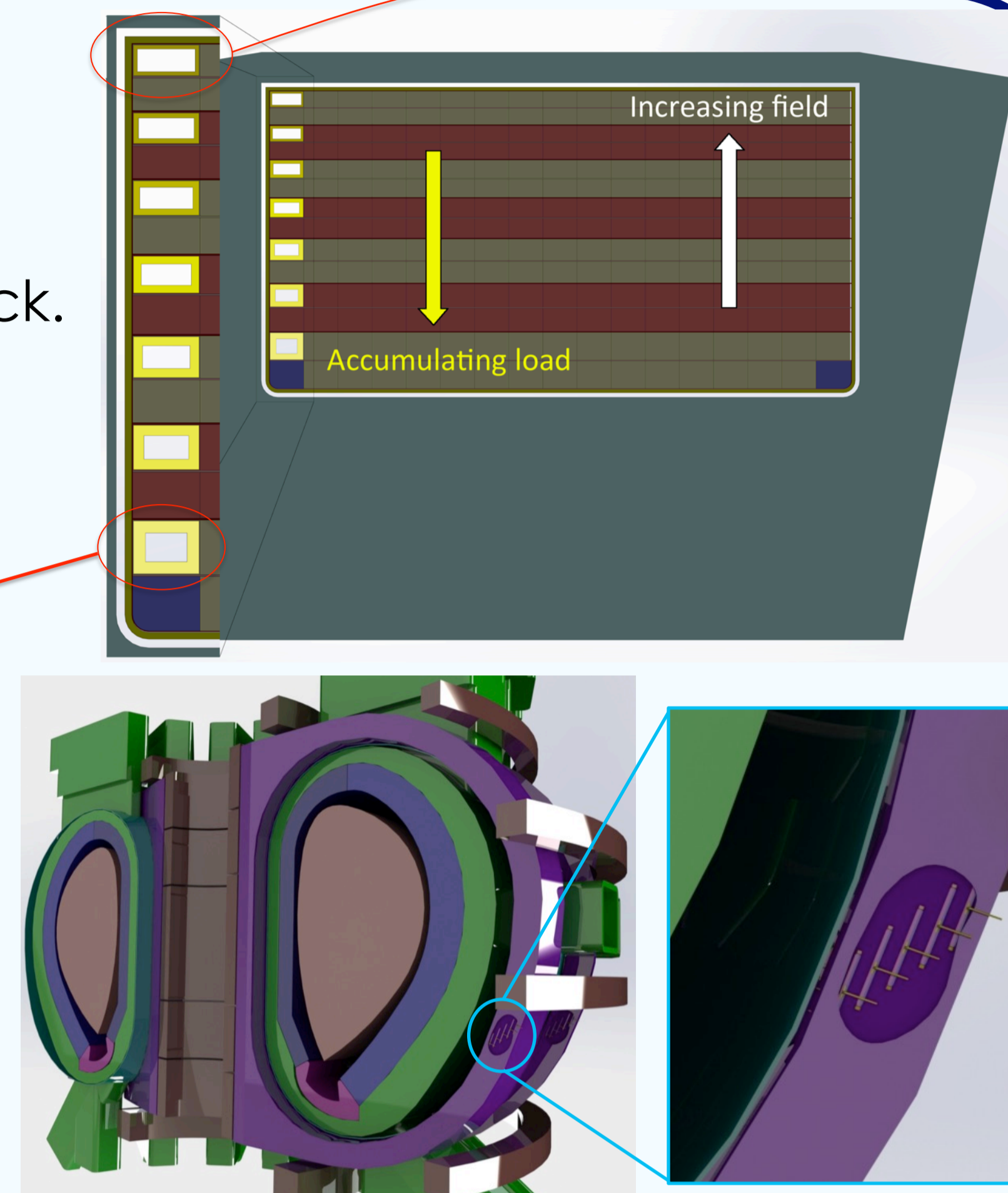
**Advantage:** optimized distribution of **steel** and **superconductor** in winding pack.

**Approach:** **Wind & React** coil; **rectangular CICC** Concept with **distributed** pressure relief **channels**.

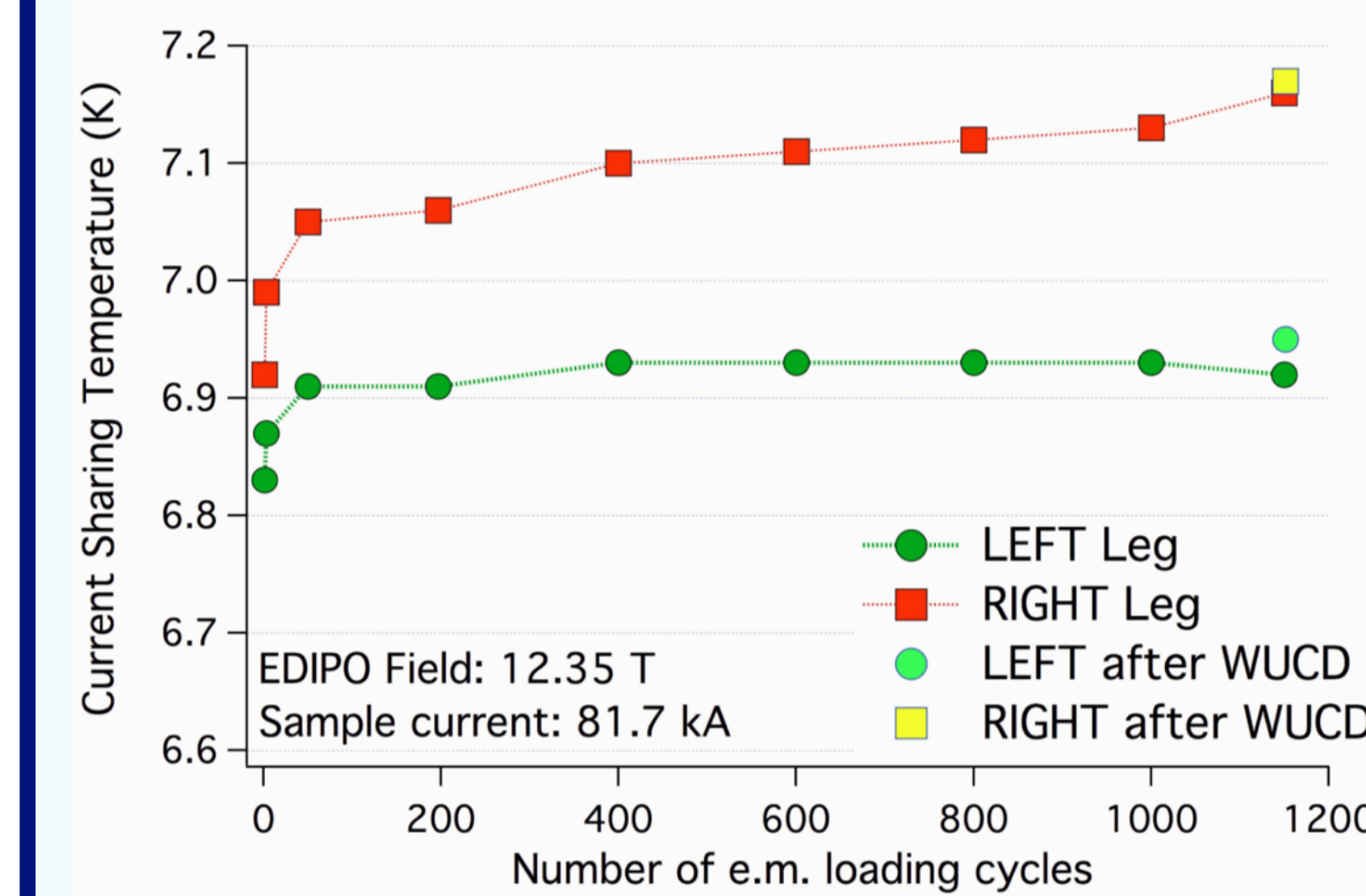
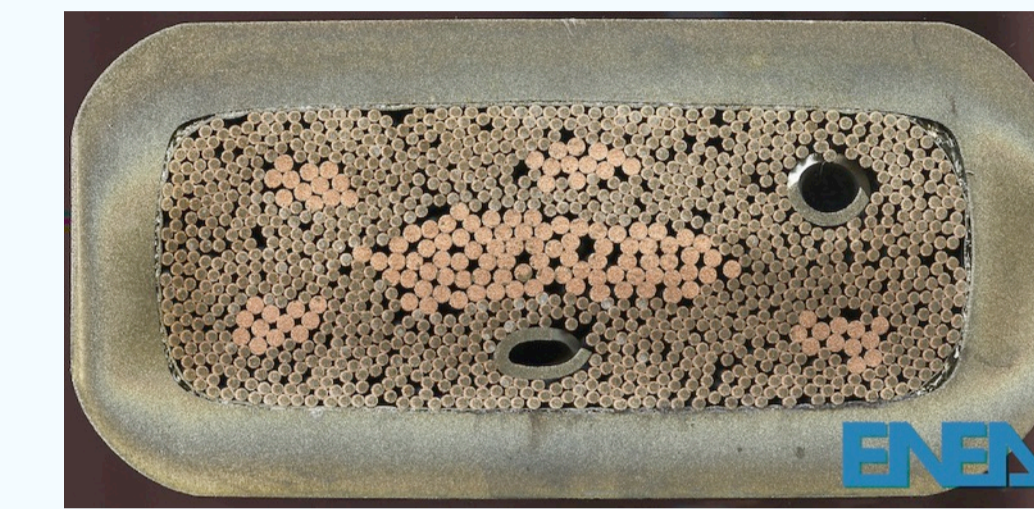
## Object of the present work:

**1: Low Field Conductor:** how to distribute a **small number of superconducting strands** and **large amount of Cu wires**? Round-to-rectangular compaction of **thick steel jacket** feasible? What is the performance of such CICC, with **large electromagnetic load per s.c. strand**?

**2: Inter-layer "invisible" Joint:**



## In 2015: High Field Conductor prototype



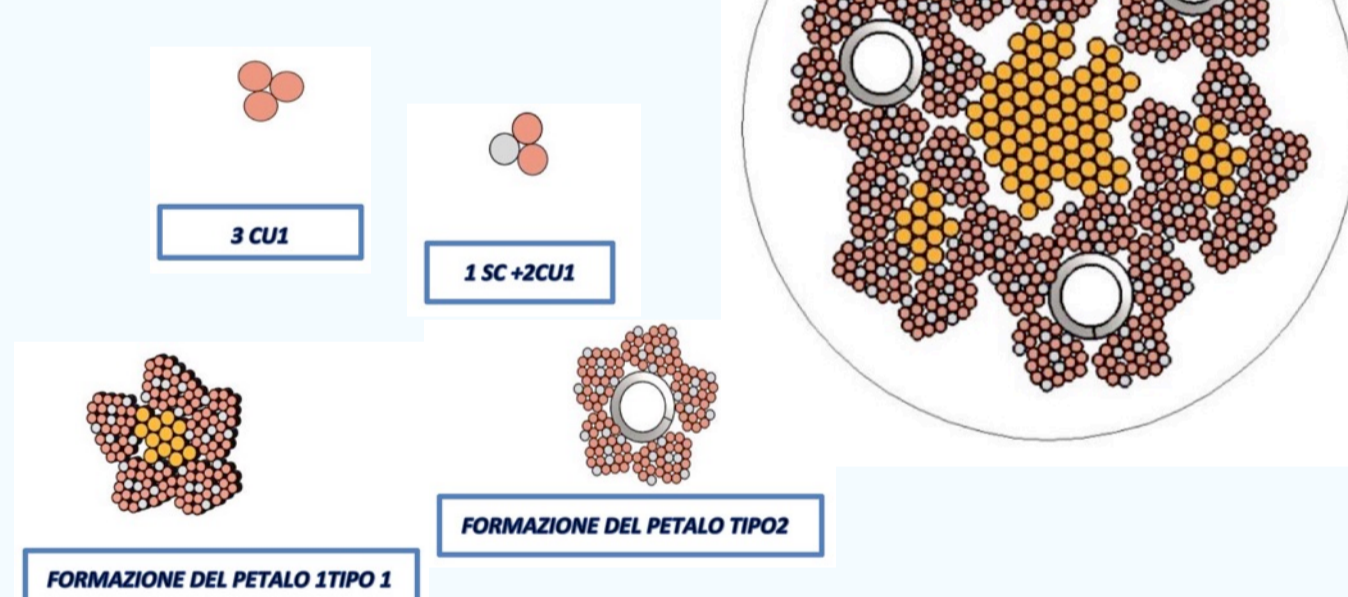
Parameter	Value
Op. conditions (2015 DEMO version)	81.7 kA – 13 T
# S.C. strands (1 mm)	1080
J <sub>nonCu</sub> (A/mm <sup>2</sup> )	192.6
Cable Layout	3x3x4x(5+C1)x(6+C2)
Twist Pitch Sequence (mm)	103/135/175/227/690
V.F. in cable bundle	24.6%
Jacket Thickness	6.9 mm
Outer dimensions	38.8 x 80.6 mm <sup>2</sup>

Nb<sub>3</sub>Sn Strand by WST (China)

In this CICC the Nb<sub>3</sub>Sn operates with  $-0.55\% < \epsilon_{eff} < -0.50\%$

## Low Field Conductor manufacturing trials

### Cable Layout:



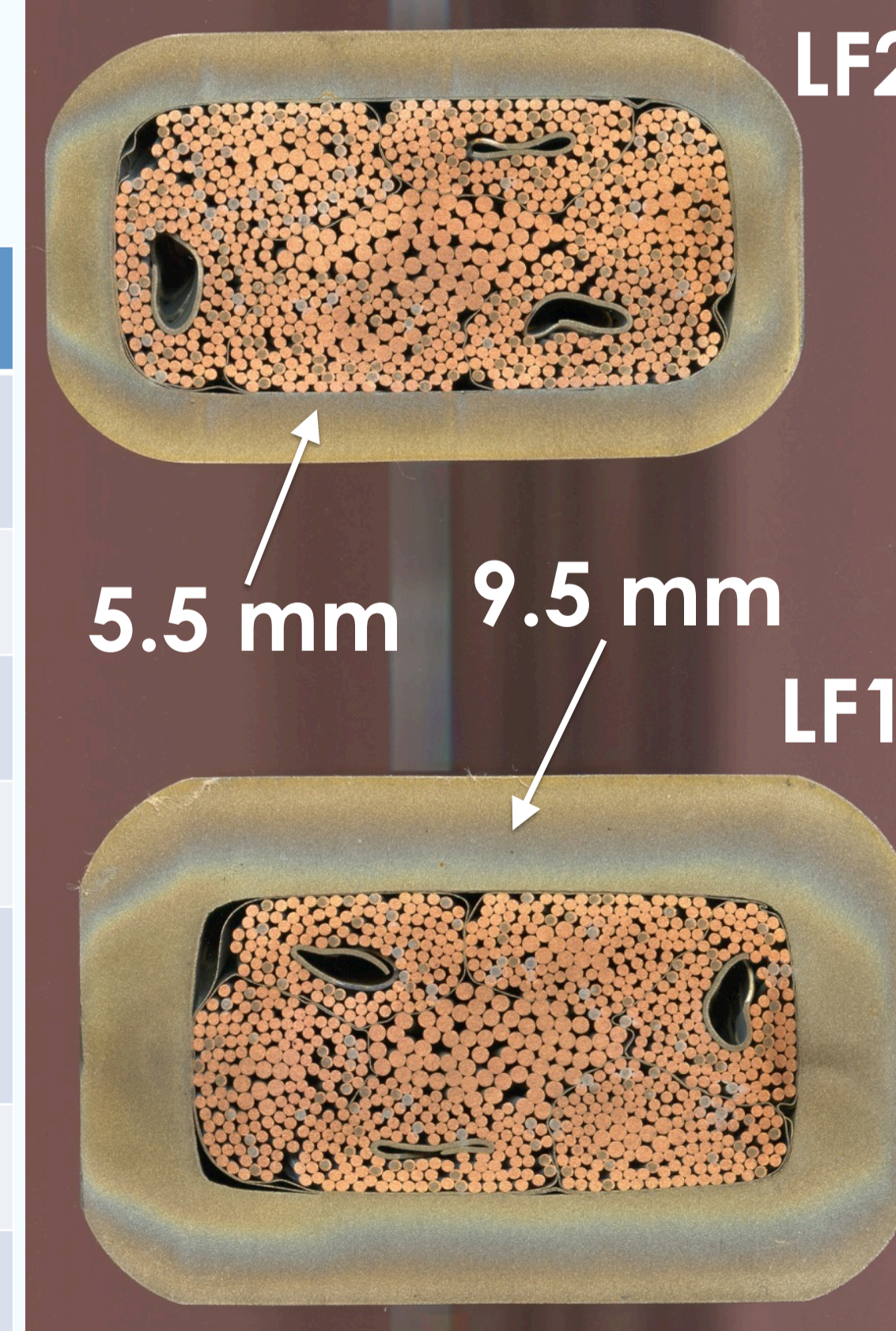
**Thin spiral (0.5 mm thick strip):** too large deformations during CICC compaction. It was **1 mm** in 2015 High Field prototype.

Nb<sub>3</sub>Sn Strand by WST (China)



Different aspect ratios explored.

Parameter	LF1	LF2
Op. conditions (2016 DEMO version)	70.8 kA – 7.1 T	70.8 kA – 6.0 T
# S.C. strands (1 mm)	120	180
# Cu strands (1.0/1.5 mm)	690 / 120	630 / 120
J <sub>nonCu</sub> (A/mm <sup>2</sup> )	1500	1000
Cable Layout	$[(2x(2x(1sc+2Cu)+3Cu)+3x3Cu)]x(5+C1)x(6+C2)$	$(2x(1sc+2Cu)+3Cu)x3x(5+C1)x(6+C2)$
Twist Pitch Sequence	110/125/145/175/500 mm	
Target V.F. in cable bundle	26%	

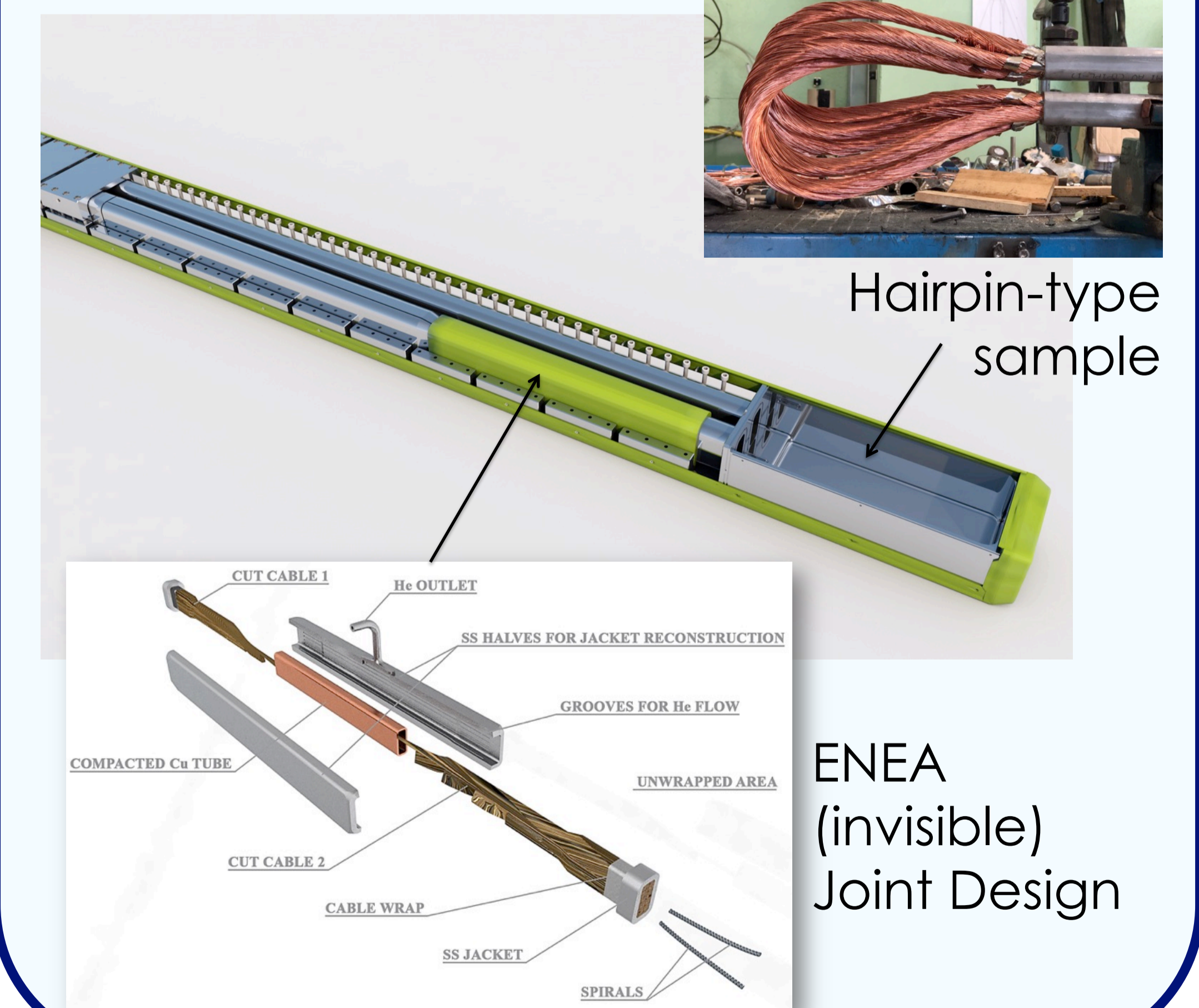


## Feed-back on design:

- **Thick spiral** OR not at the center of petals;
- Large copper cores distributed between petals;
- Round-to-Rectangular compaction with **thick jacket** OK.

## LF1 – LF2 Joint sample

A sample of the **joint** between LF1 and LF2 for the **SULTAN** facility is under preparation for qualification tests.



Hairpin-type sample

ENEA (invisible) Joint Design

## Next steps

- **Joint sample manufacture** being finalized, to be tested in the next months;
- **Change to thicker spiral**; to be agreed: DC / AC performance test.