Barcelona, Spain – 7th November 2016

Conductor Activity within EuroCirCol

B. Bordini

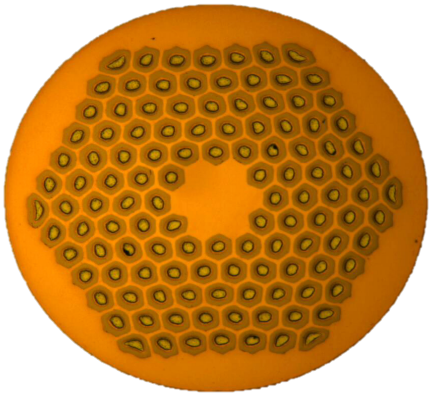
EuroCirCol WP5 Workshop

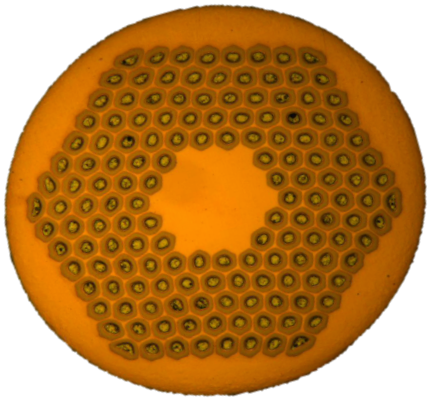
Outline

- Procurement
  - Wire Ordered and Received in 2016
  - Plan for next year
- Characterization of Nb_3Sn Under Transversal Stress
  - CERN Sample holder for cable to test in FRESCA
  - TWENTE set-up for cable tests
  - UNIGE set-up for wire tests
- Conclusions

Wire procured in 2016

- Received 53 km of 1 mm RRP wire
- Wire from 4 billets 120/127 and 5 billets 150/169



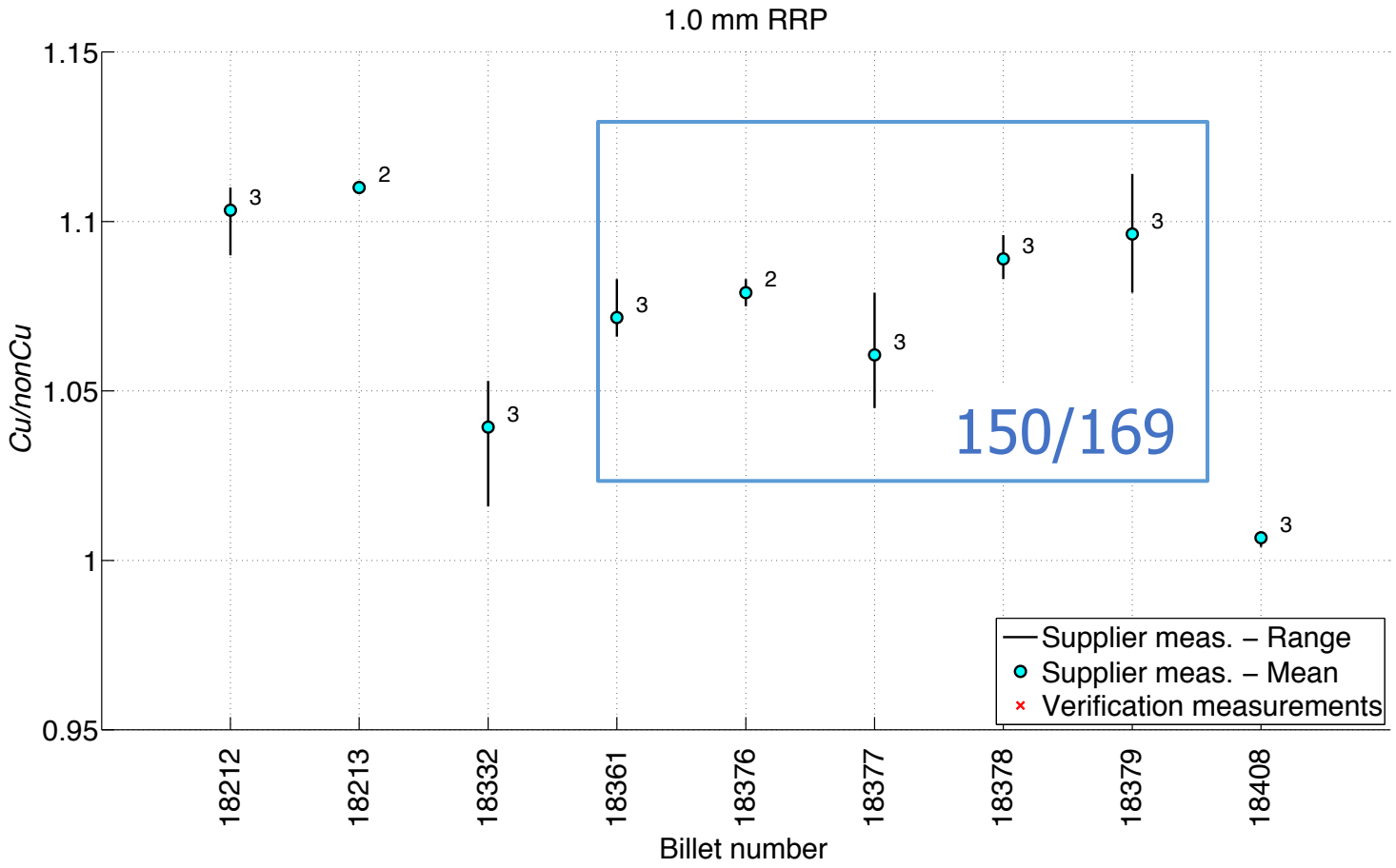


- The sub-element size is about: 62-64 μm for the 120/127; and and 54-55 μm for the 150/169

Wire procured in 2016

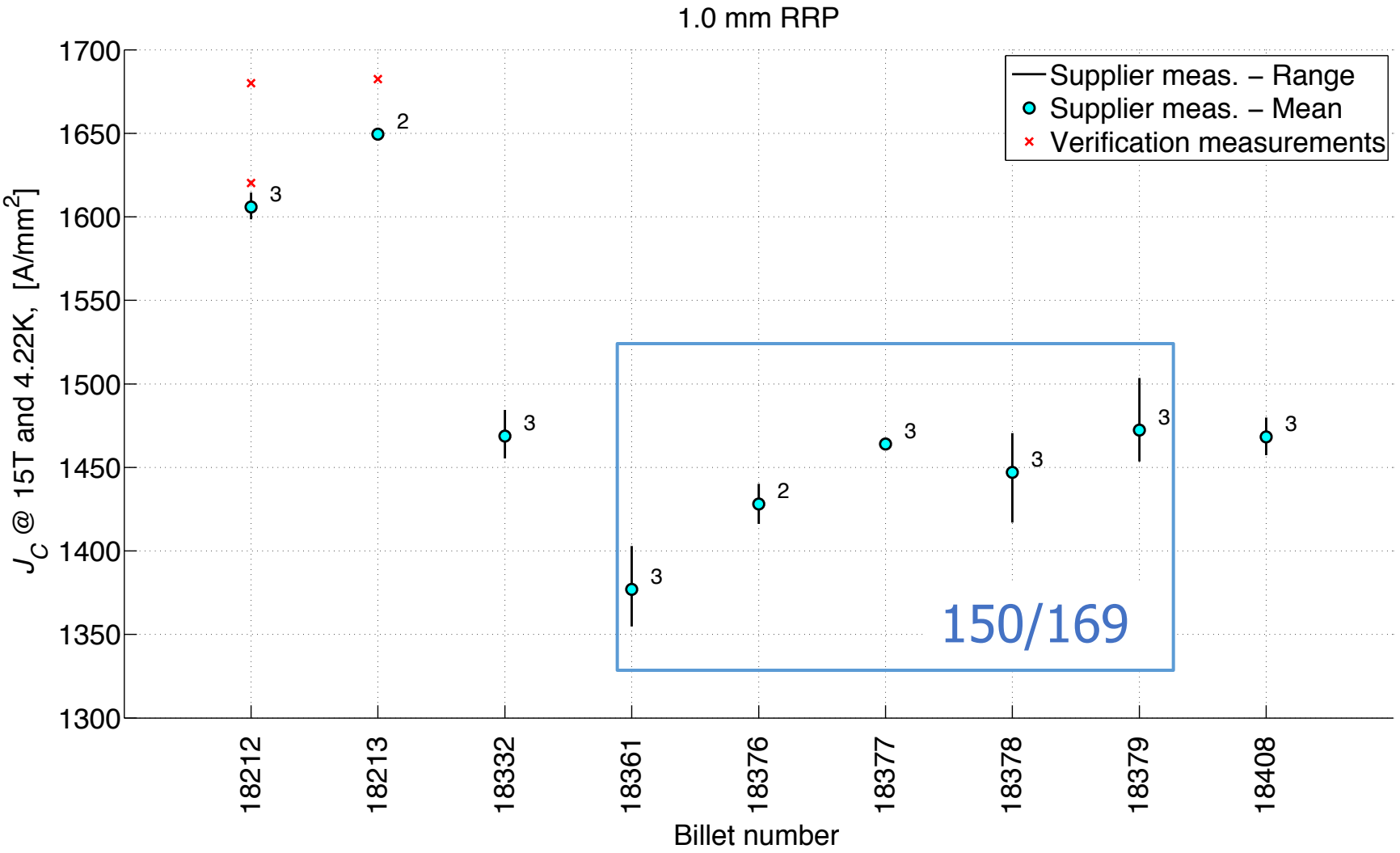
Copper to Non Copper Ratio

- Required Target value → 1



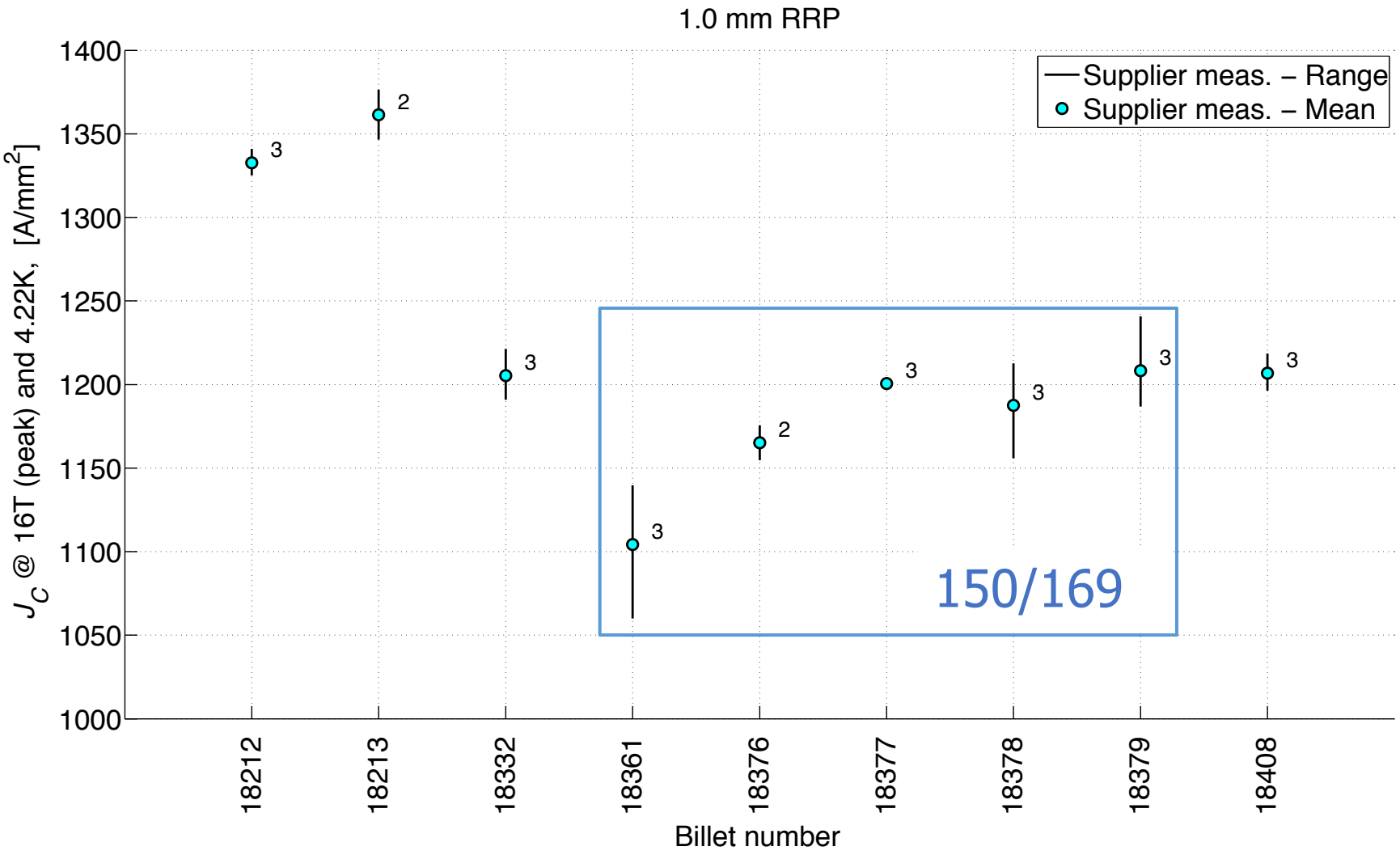
Wire procured in 2016

Critical Current Density at 15 T (background field)



Wire procured in 2016

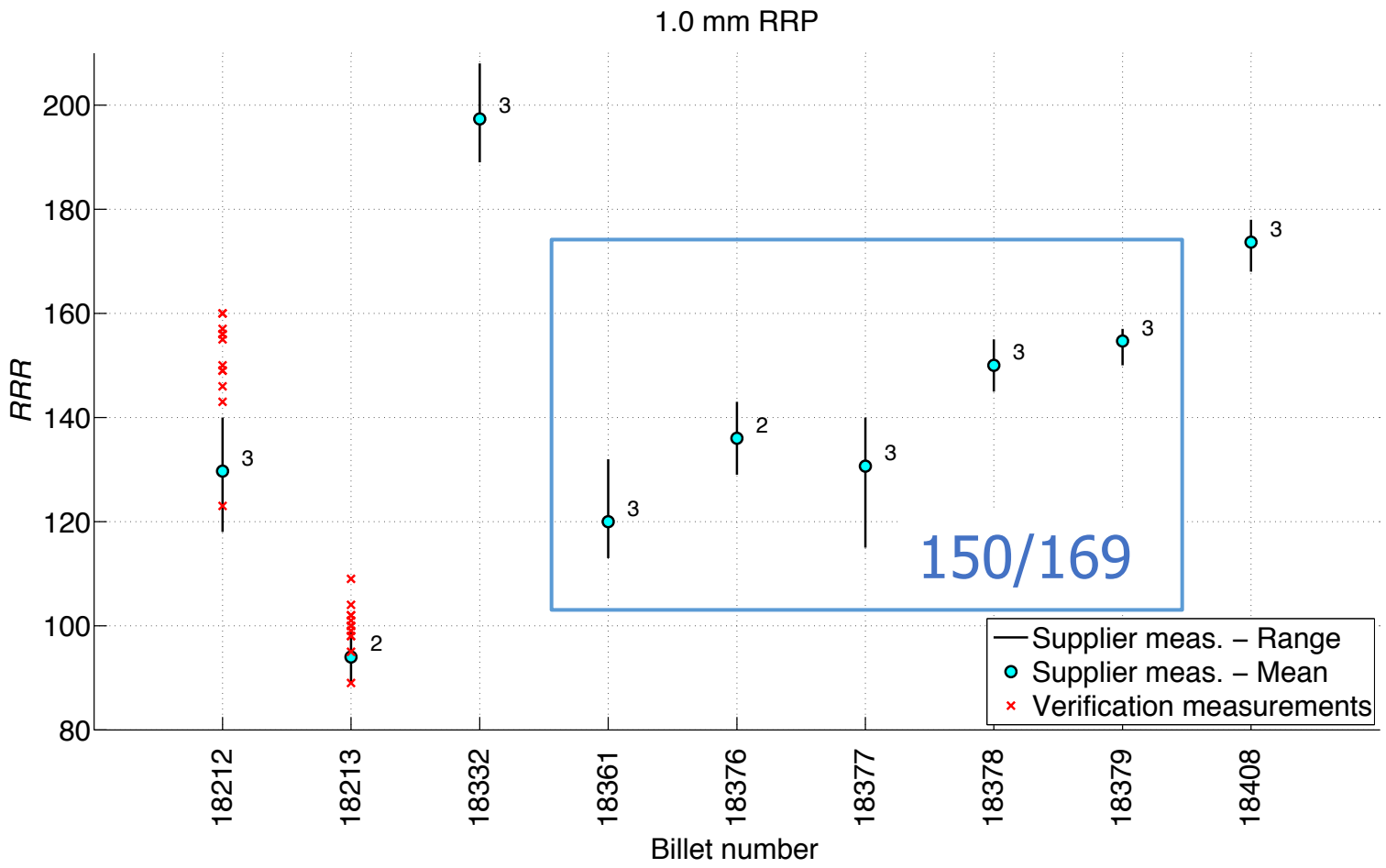
Critical Current Density at 16 T (peak field)



Wire procured in 2016

Residual Resistivity Ratio

- Required Target value > 80 (used diffusion barrier with inclusions)



Plan for Next Year

- 30 km of the 1 mm wire Cu-non Cu 1
- 120 km of the 0.7 mm wire Cu-non Cu 1.15

2 Graded ERMC

2 Graded RMM

- 30 km of the 1 mm wire Cu-non Cu 1

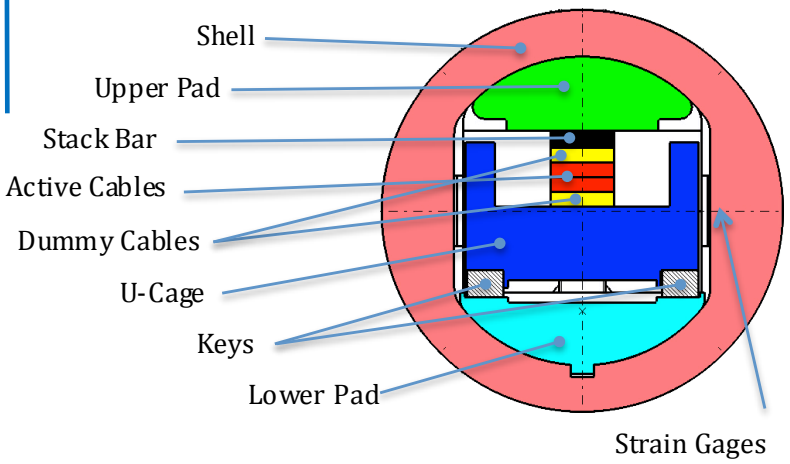
3 ERMC - CIEMAT

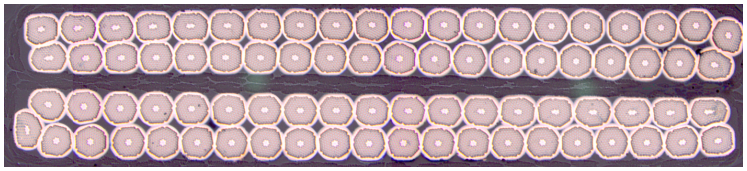
Cable I_c vs. Transversal Load

CERN Sample Holder Conceptual Design

- Sample holder for testing superconducting Rutherford cables under transverse load of up to 250 MPa on a 10 mm wide cable in the existing FRESCA test station.

- The high pressure region of the sample holder will extend over the entire 700 mm field uniformity length in FRESCA





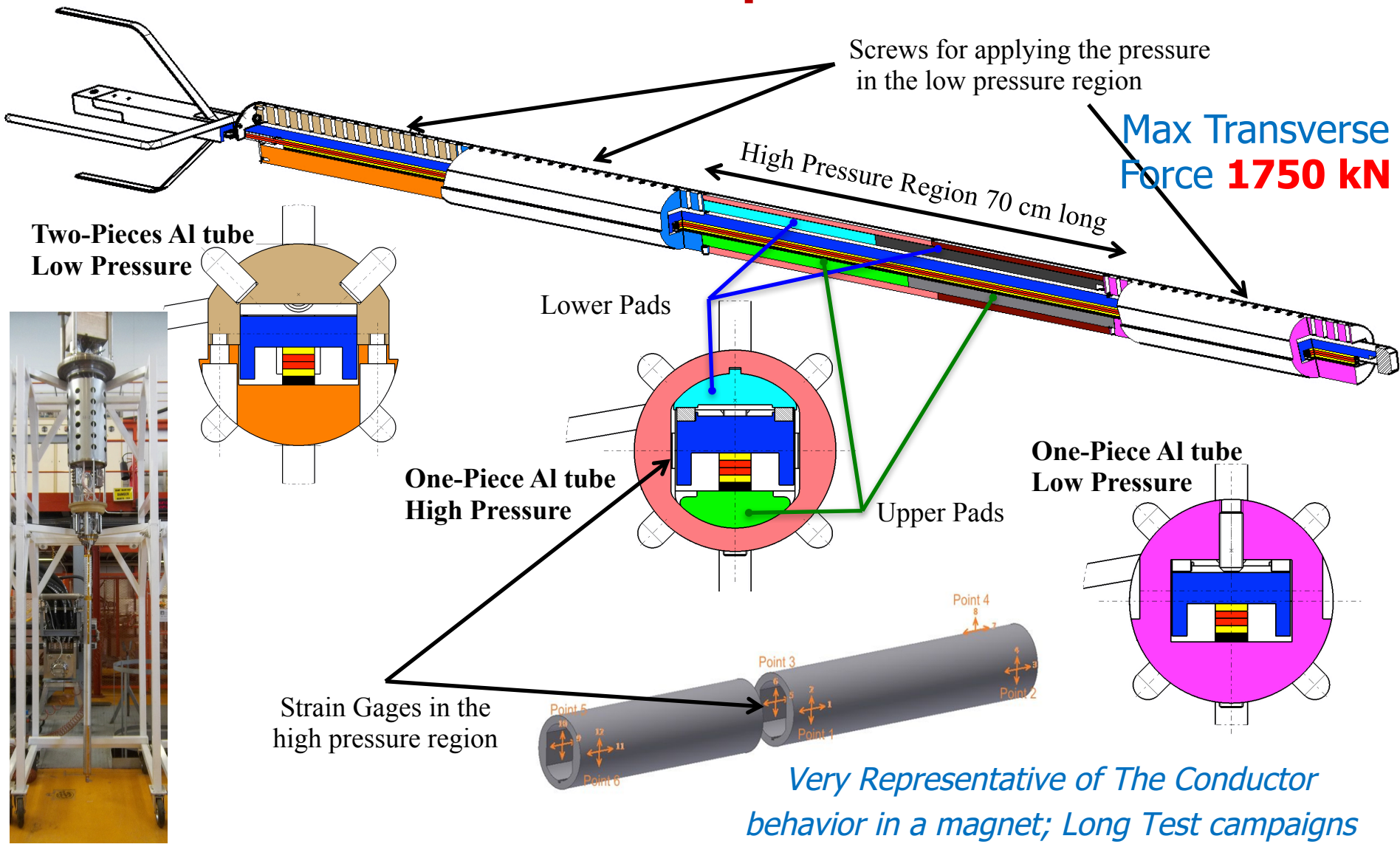
- The transverse pressure is provided by using the bladder and key method to create pre-stresses at room temperature.

- The final pressure is reached due to difference in thermal contraction in the different materials in the sample holder

Item	Material	E Young (GPa)		$R_{p,0.2}$ (MPa)		$\alpha\Delta T$
		293 K	4.2 K	293 K	4.2 K	(mm/m)
Shell	Al 7075	73	80	480	690	4.0
U-cage	Ti6Al4V	110	130	700	1000	1.7
Pads	Ti6Al4V	110	130	700	1000	1.7
Cable	Nb_3Sn	30	42	-	-	3.9

Cable I_c vs. Transversal Load

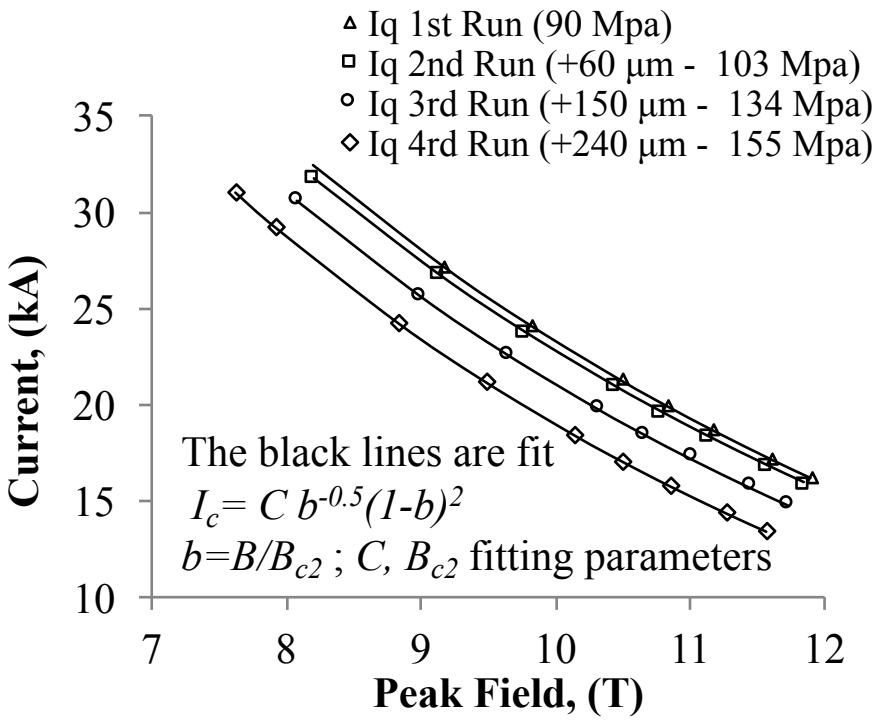
CERN Sample Holder

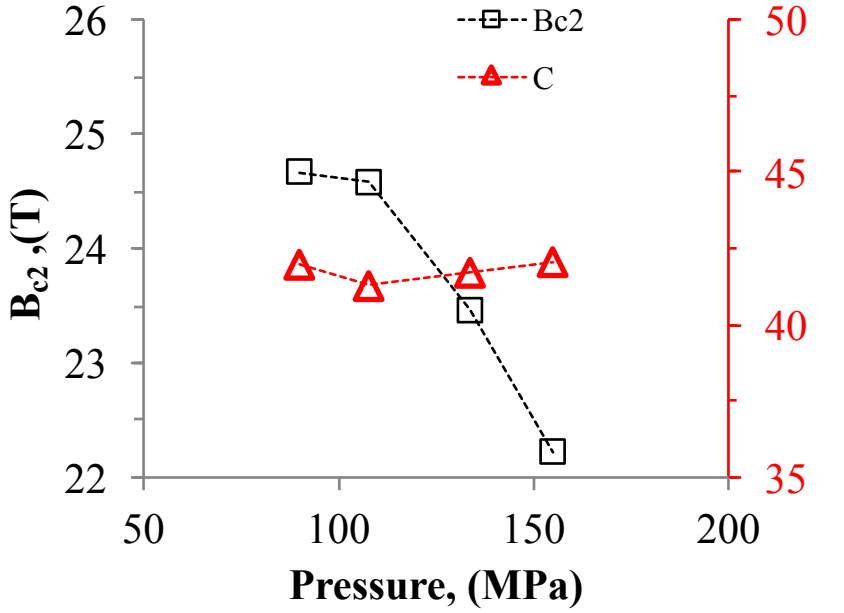


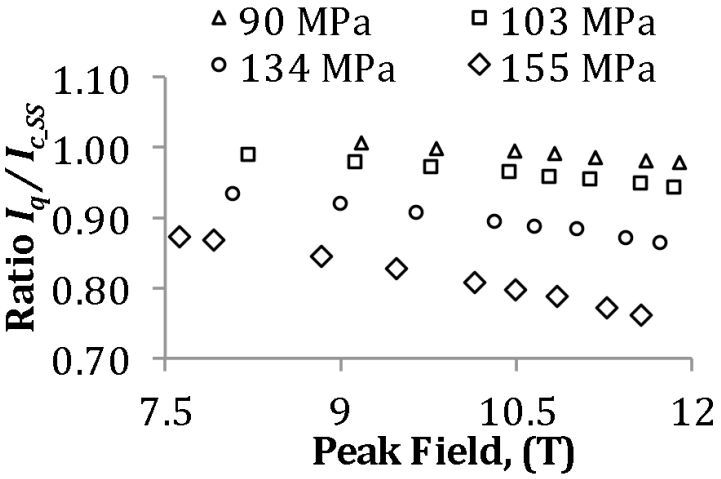
Very Representative of The Conductor behavior in a magnet; Long Test campaigns

Cable I_c vs. Transversal Load

Test at CERN on a PIT cable







- B_{c2} significantly reduces when increasing the transversal pressure while C is practically constant.
- The critical current reduction seems to be dominated by the reversible effects on the superconductor

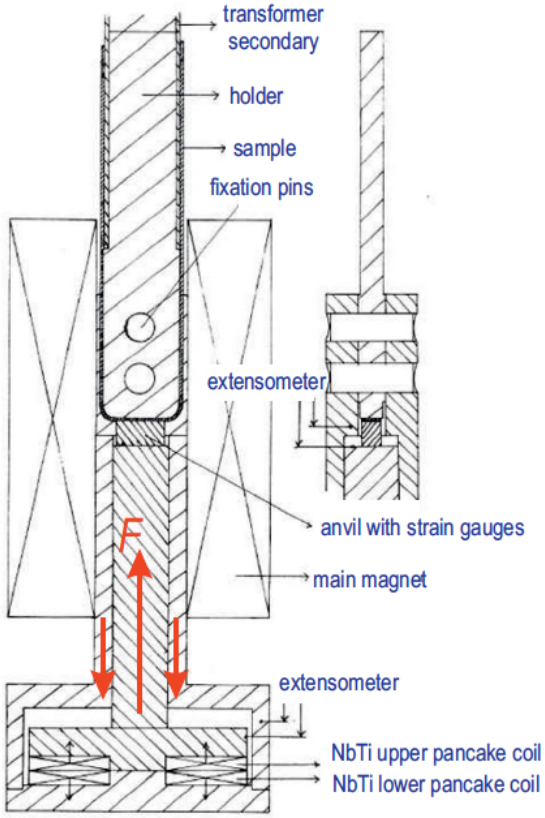
Cable I_c vs. Transversal Load

TWENTE Sample Holder

Electromagnetic press

- Double NbTi pancake;
  F_{max} = 260 kN
- Steel + 50 μm kapton anvil;
  (45×15.2) mm^2 , σ_{max} = 340 MPa

H.H.J. ten Kate et al,
IEEE Trans. Appl.
Supercond. 1993

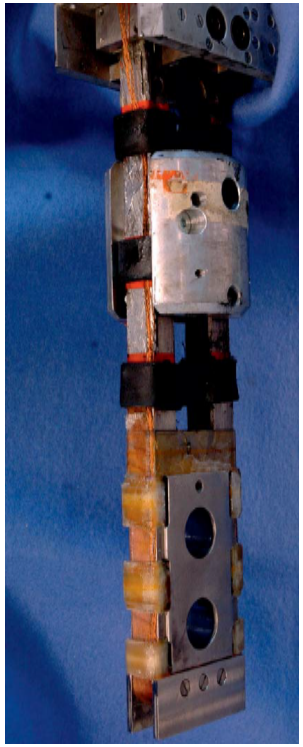


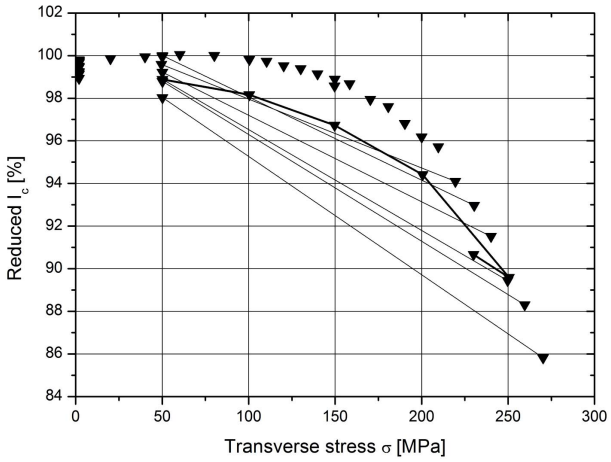
University of Twente
Enschede - The Netherlands

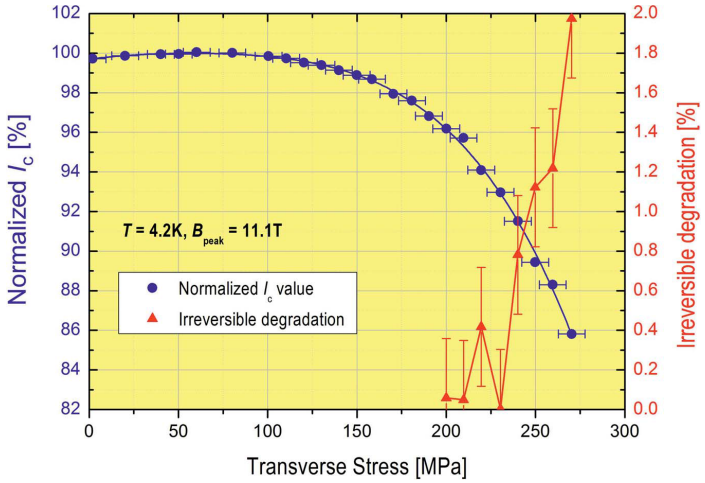
Courtesy of Mark Dhalle

Cable I_c vs. Transversal Load

Test at TWENTE on a RRP cable (11 T project)







1% fully reversible reduction at 150 MPa

No irreversible Degradation until 220 MPa

Powerful and Rapid Test Set-Up for Cables;
Relatively Short Samples; Significant field gradients

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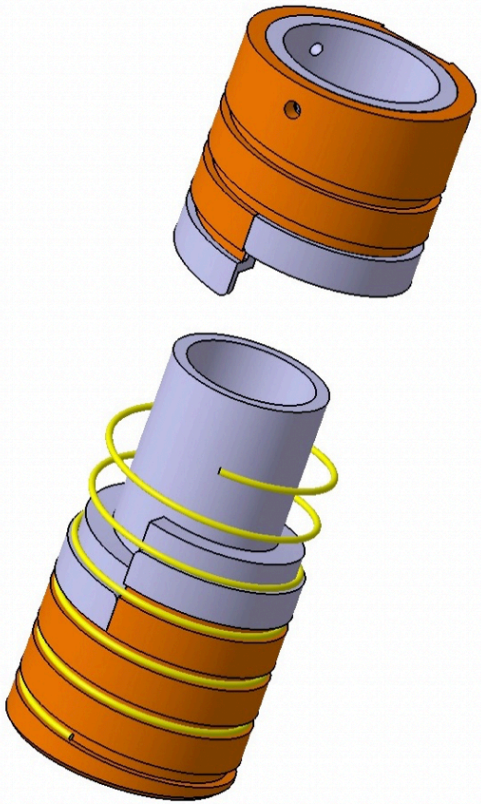
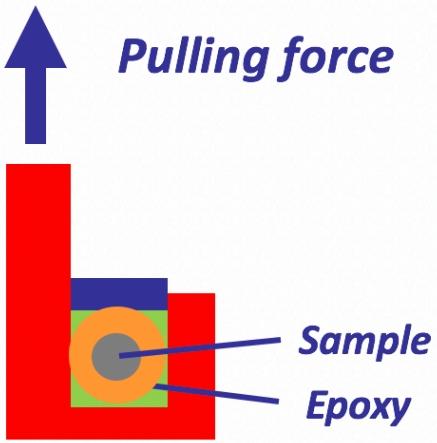
Courtesy of Mark Dhalle

Wire I_c vs. Transversal Load

UNIGE sample holder



4-WALL + impregnation



3 groove widths — ***1.30 mm*** / ***1.15 mm*** / ***1.00 mm***

Wire impregnated with epoxy applied stress uniformly distributed

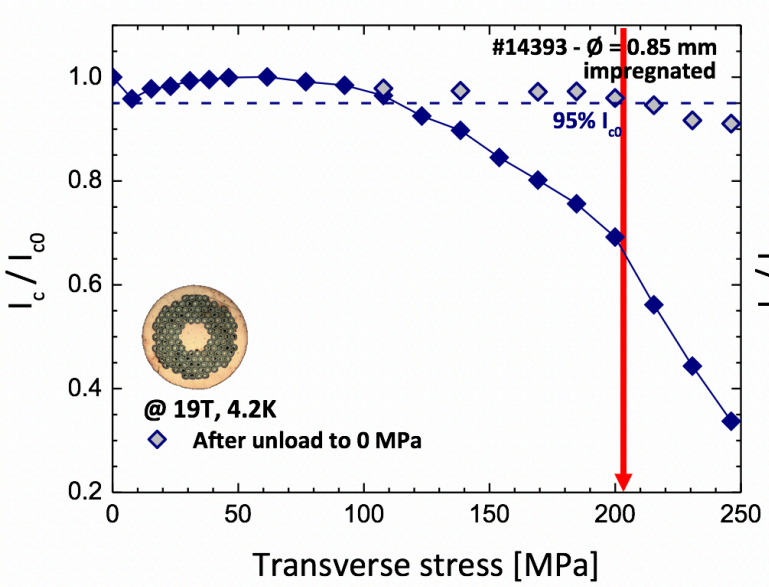
Extremely Rapid and Versatile Test Set-Up for Superconducting Wires

Courtesy of Carmine Senatore

UNIVERSITÉ DE GENÈVE

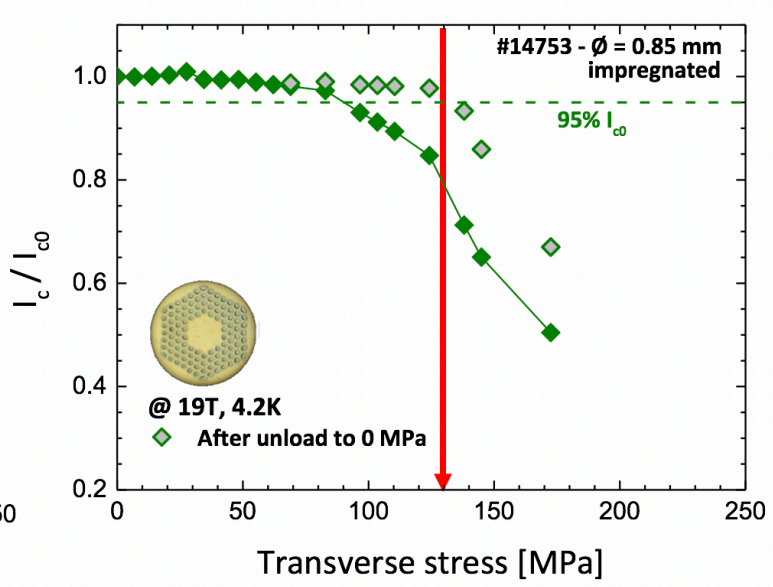
Wire I_c vs. Transversal Load

Results on 0.85 mm RRP wires



RRP 132/169

Irreversible stress limit above 200 MPa



RRP 108/127

Irreversible stress limit at the same level as PIT wires, ~130 MPa

Extremely Rapid and Versatile Test Set-Up for Superconducting Wires

Courtesy of Carmine Senatore

UNIVERSITÉ DE GENÈVE

Characterization of Nb_3Sn Under Transversal Stress – on going activity 1/2

- To get more independent and efficient, the superconductor laboratory at CERN has bought and commissioned:
  - A DAQ system to read the strain gages of the cable sample holder
  - A pump to pressurize the bladder
- AT CERN a 10 mm wide cable based on 18 PIT wires (1 mm in diameter) was tested
  - The critical current values are similar to what already published*
  - It was also found that the PIT cable was in reversible regime at least till 135 MPa
- At CERN four 10 mm wide cable samples are in preparation:
  - 2 samples based on a 1 mm RRP wire (FRESCA2 wire)
  - 2 samples based on 1 mm PIT wire (FRESCA2 wire)

*IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, VOL. 24, NO. 3, JUNE 2014

Characterization of Nb_3Sn Under Transversal Stress – on going activity 2/2

- The same cables in preparation at CERN, will be shipped at TWENTE
  - Starting from January TWENTE will start working on the sample preparation and testing → comparison CERN/TWENTE results
- In July UNIGE has received 40 m of PIT wire:
  - 1 mm FRESCA2 wire: 10 m round; 10 m 15% rolled
  - 0.85 mm High-Lumi wire (old, no bundle barrier): 10 m round; 10 m 15% rolled
- UNIGE has reacted the 1 mm wire and started the critical current measurements on the round wire

Conclusions

- CERN has procured 53 km of the 1 mm RRP wire for the ERMC and RMM program
- Started the study of the performance of Nb_3Sn as a function of the transversal load
  - CERN has upgraded its set-up and tested a 10 mm wide PIT cable
  - Four cable samples (two RRP and two PIT) are in preparation at CERN;
    1. 10 mm wide cables based on 18 FRESCA2 wires (1 mm in diameter)
  - Starting from January 2017, TWENTE will start the preparation of samples of the same 10 mm wide cables
  - UNIGE started the preparation and test of the 1 mm PIT wire: both the round and the 15% rolled wire