Cable Options for Eucard 2

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From presentation given on 14th June 2013

Cables for accelerator magnets

High Jc conductor
High **I** cables
High **Je**
Field quality
- precise and controlled **dimensions** of cables
- controlled **inter-strand resistance** (coupling currents)
- low **magnetization** – also at low field (injection current)
- **twisted** filaments and strands
- **transposed** cable configuration

Mechanical strength, mechanical stability, windability (bending radius)
Stability
Protection
Radiation resistance characteristics
Cost (conductor + cabling (yield, assembly, stabilization,…))

Specification derived experience with LTS cables

CERN Eucard 2 Program

Target performance for HTS cables

parameter	units	targets
J_E (20 T, 4.2 K)	(A/mm^2)	600
J_E (15 T, 4.2 K)	(A/mm^2)	675
J_E (12 T, 4.2 K)	(A/mm^2)	800
σ (I_C) within a unit length	(%)	10
M(1.5 T, 10 mT/s)	(mT)	300
Range of $\sigma_{transverse}$	(MPa)	100
Range of $\varepsilon_{longitudinal}$	(%)	±0.3
Unit length	(m)	100

5 T Dipole Insert (40 mm bore) in a 15 T dipole magnet

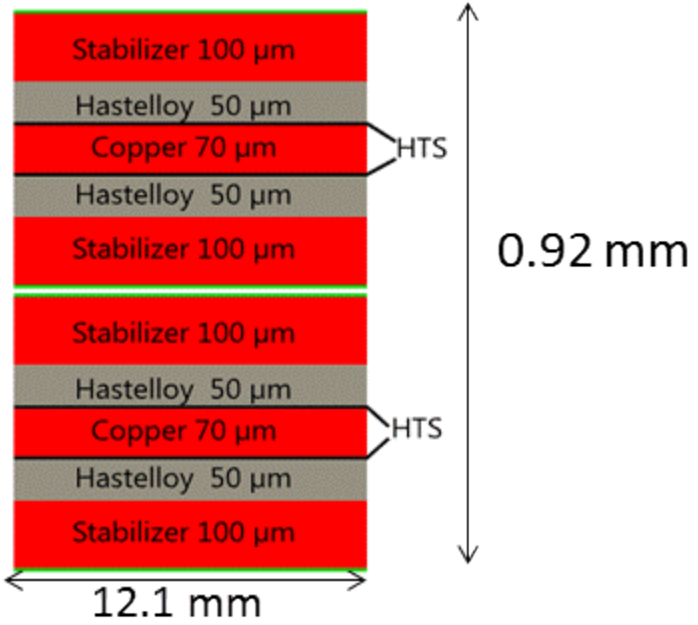
HTS Cables developed for High Field magnets

A

Strands wrapped around a core to make a multi-layer cable

D. Van der Laan et al.

B



Stacked-tape conductor

Eucard stack-cable
(Race-track HTS Insert-Fresca 2
6 T in a 13 T dipole field)

C

Twisted-stacked tape conductor

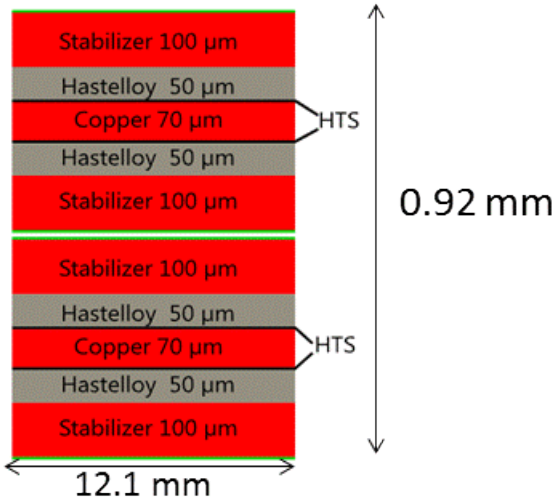
Takayasu, Chiesa, Minervini et al.

All not fully-transposed Cables

72 Tapes, 4 mm width
17 Layers
Φ = 7.5 mm
Je (4.2 K, 19 T)= 114 A/mm²
Bending radius > 8 cm
Requires dog-bone ends
Not practical for accelerator magnets

D. Van der Laan et al.

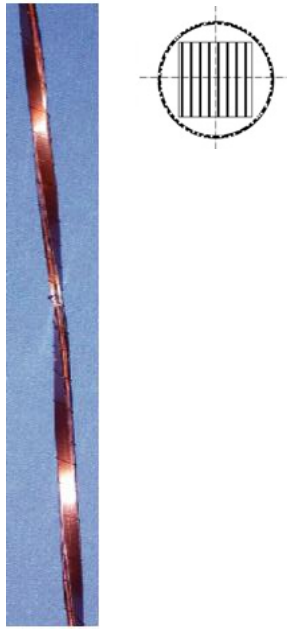
B



4 Tapes, 12 mm width
Je-op(4.2 K, 19 T)= 250 A/mm²
Can/will be wound

Eucard stack-cable
(HTS Insert-Fresca 2)

C



40 Tapes, 4 mm width
Φ=7 mm
Je (4.2 K, 15 T)= 160 A/mm²
Requires dog-bone ends
Not practical for accelerator magnets

Takayasu, Chiesa, Minervini et al.

HTS Cables developed for High Field magnets

c

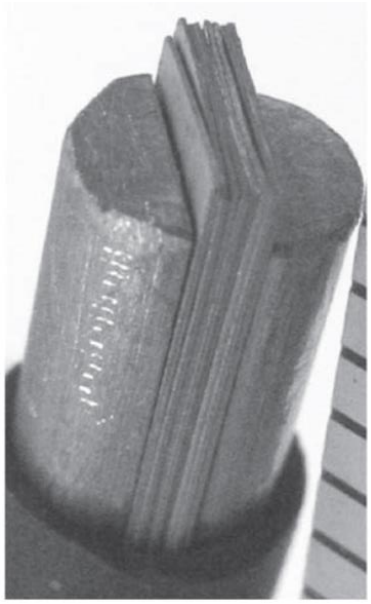
12 mm x 12 mm CICC
(copper diameter 9.5 mm)

40 YBCO tapes in a copper diameter 9.5 mm.

20 YBCO tapes in each helical groove in a copper diameter 9.5 mm.

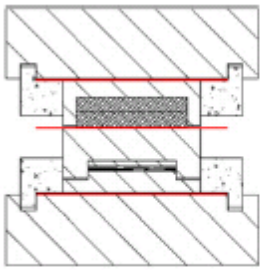
Takayasu, Chiesa, Minervini et al.

C

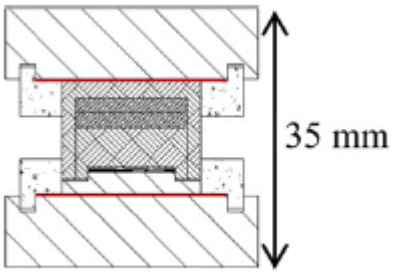


Uglietti, Bruzzone, et al.

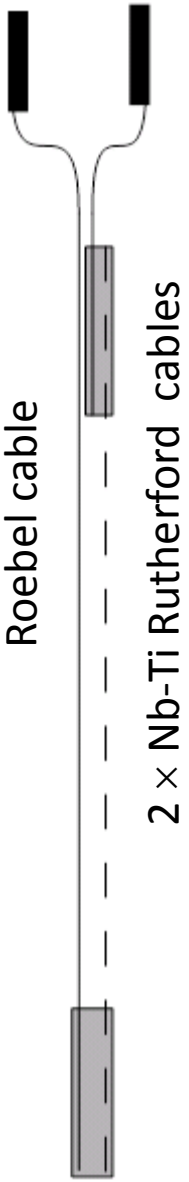
Roebel cables measured @ 4.2 K

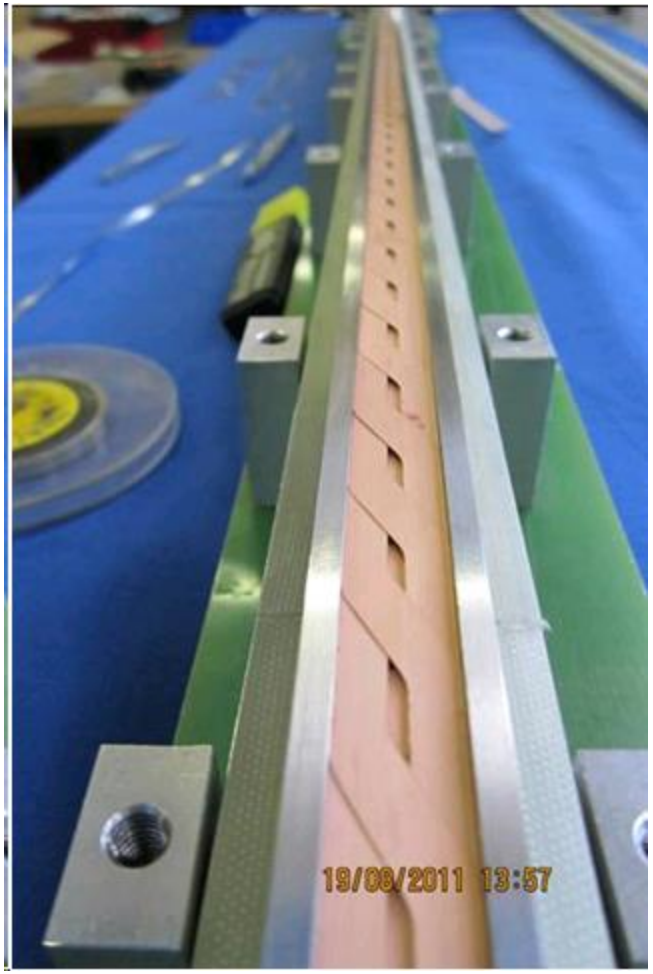


Main part



Bottom joint





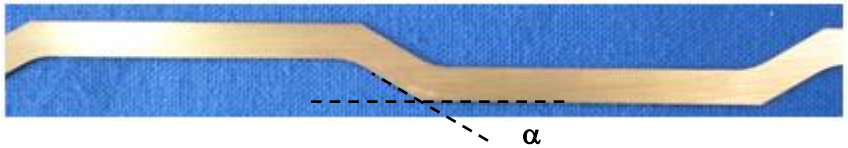
CERN, Superconducting Lab

J. Fleiter, PhD thesis, CERN and Univ. of Grenoble

Roebel cables measured @ 4.2 K

Measurements @ CERN in the FRESCA Test Station

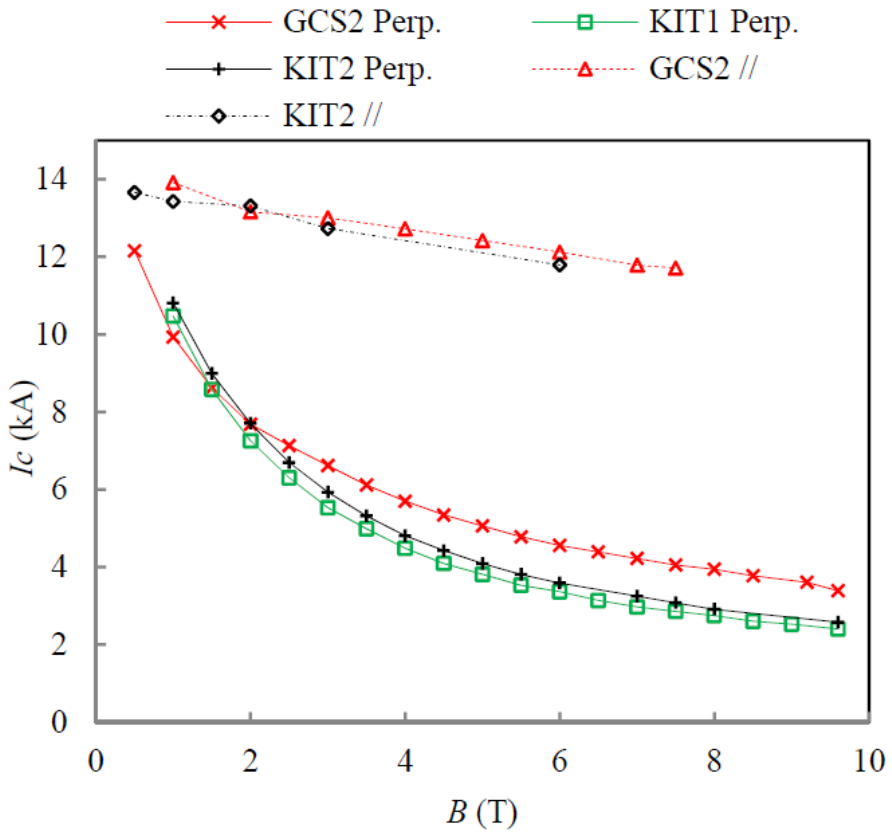
		Cable CGS	Cables KIT
Number of tapes	**-**	15	10
Transposition length	**mm**	300	126
Width	**mm**	12	12
Thickness	**mm**	0.85	0.79

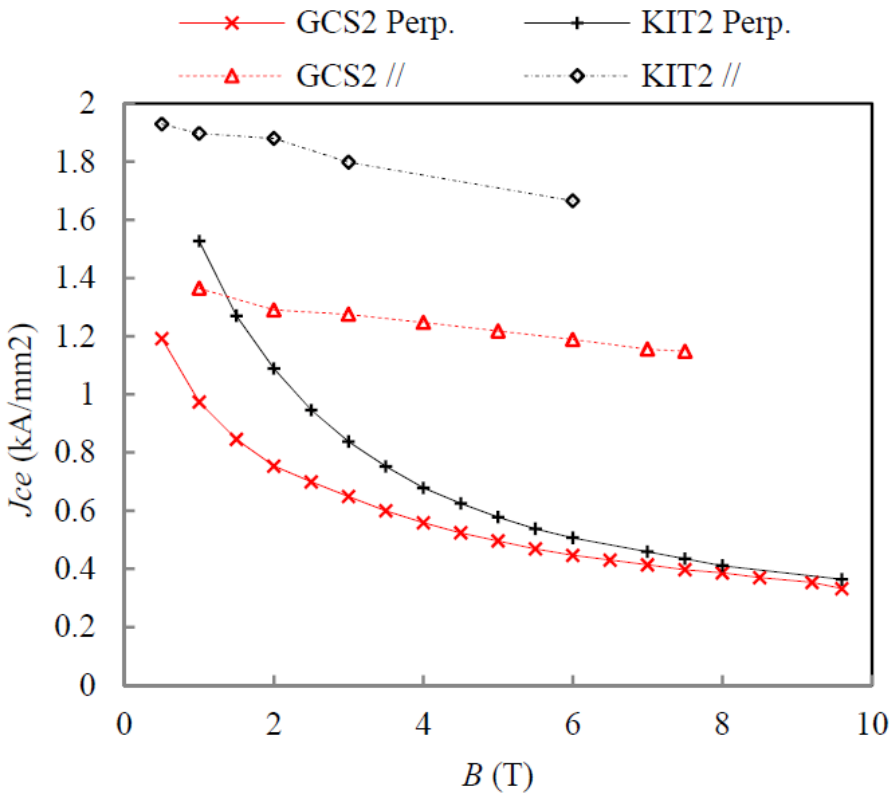


Width = 5 mm
Ic (77 K, s.f.) = 165 A

Roebel cables

Measurements @ CERN in FRESCA Test Station





Ic (B⊥=9.6 T, 4.2 K) = 3.4 kA

Je (B⊥=9.6 T, 4.2 K) = 400 A/mm²

CERN, Superconductors Laboratory

JFleiter, PhD thesis, CERN and Univ. of Grenoble

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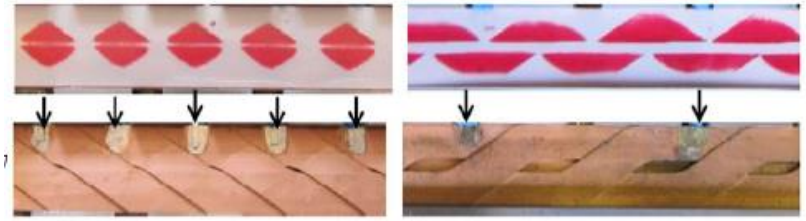
Roebel cables

- Non homogeneous stress distribution across the length and across the section
  Measured no Ic reduction up to 45 MPa of average transverse stress (188 MPa peak)



J. Fleiter, CERN

- Tensile axial strength of YBCO tape in a Roebel cable (~ 0.3 %) about half of that of a straight tape
- Internal delamination is an issue that must be addressed, as well as possibility of doing impregnation
- Using tape conductor has an implication on field quality. Striation will help but the cable will not be fully transposed – it would be like a Rutherford cable with un-twisted filaments
- Unit length of cable that can be produced ?

Thanks for your attention !