13th European Conference on Applied Superconductivity

Electro-mechanical performance of 18-strand MgB_2 cables for the Superconducting Link project at CERN

K. Konstantopoulou[1], J. Hurte[1], L. Muzzi[2], A. della Corte[2], P. W. Retz[1], A. Ballarino[1]

[1]European Organization for Nuclear Research, CERN, Switzerland
[2]ENEA, Frascati, Italy

Introduction

In the framework of the High Luminosity LHC project, high-current superconducting links (cables) are under development at CERN for the powering of the superconducting magnets. The superconducting link is a MgB_2 multi-cable assembly composed of superconducting cables with different configurations and current capacity up to 18 kA. The assembly of the cables is carried out with reacted MgB_2 wire, thus the cable geometry and the cabling processes has to take into account the mechanical performance of the wire to ensure its electrical integrity. One of the main sub-unit cables of the superconducting link is the Composite strand cable: made with a Cu core and 18 MgB_2 strands.

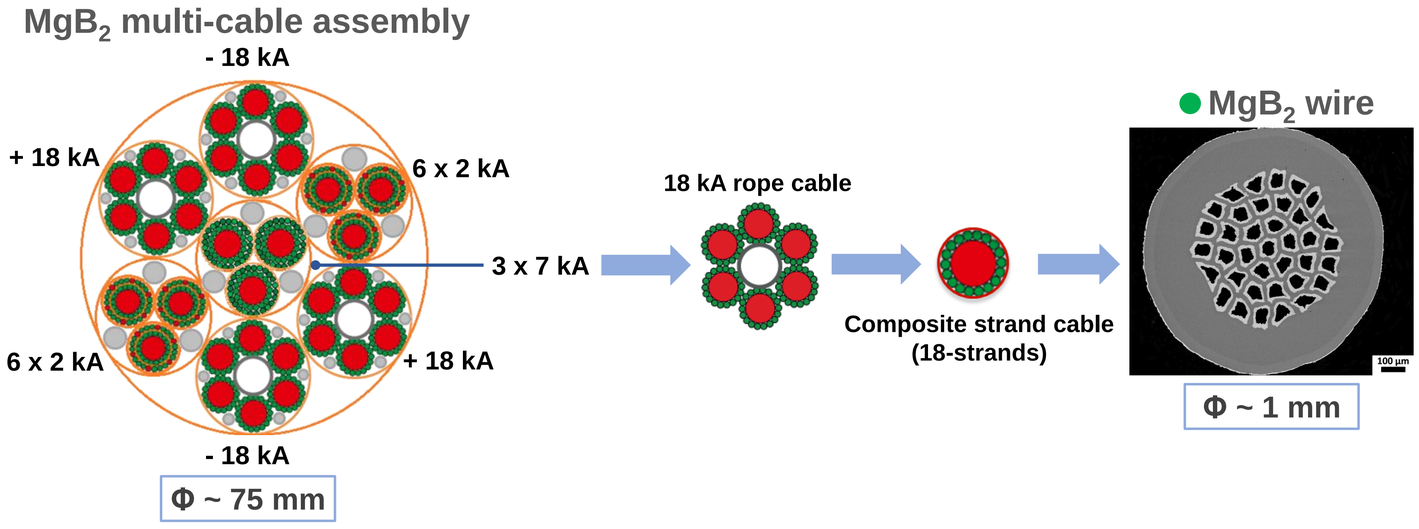
During the last year, an intense R&D effort has been carried out at CERN to define and validate the main cabling parameters of the Composite strand cable: tensile load, twist pitch (T_p) and bending radius (R_b). In order to achieve this, several short length cables were prepared and tested at CERN and additionally, longer lengths have been industrially manufactured by TRATOS Cavi in Italy.

In the present work we report on the electro-mechanical characterization of 18-strand MgB_2 cables manufactured at CERN and in collaboration with TRATOS Cavi. The tests were carried out by means of I_C measurements of either extracted strands or short length cables in FRESCA test facility. Additional mechanical characterization of the MgB_2 wire is reported and numerical simulations show the strain distribution on the superconducting strands during mechanical loading.

Cabling parameters for the 25 m long "Composite strand" cable

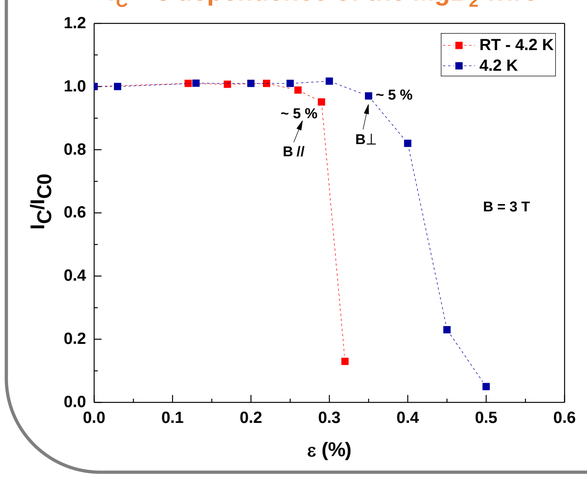
Tensile load per wire (kg)	Twist pitch (mm)	R of curvature of the wire (mm)	ε (%) in the outer MgB_2 filaments	$R_{b,\ cable}$ (mm)
1.5	180	281	~ 0.1 < 0.2	300

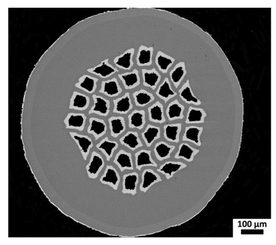
MgB_2 multi-cable assembly



Electro-mechanical performance of the MgB_2 wire

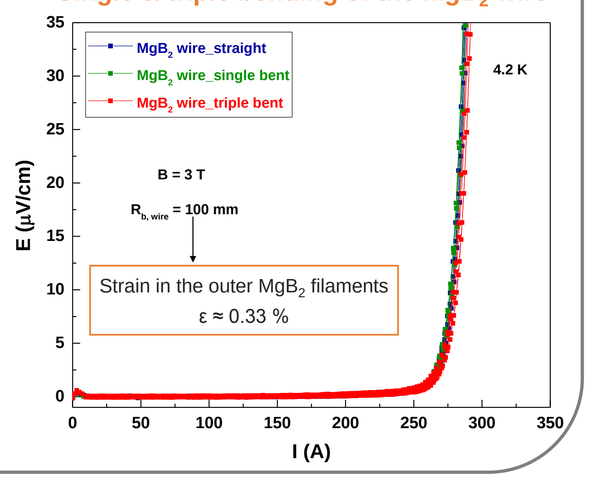
I_C – ε dependence of the MgB_2 wire





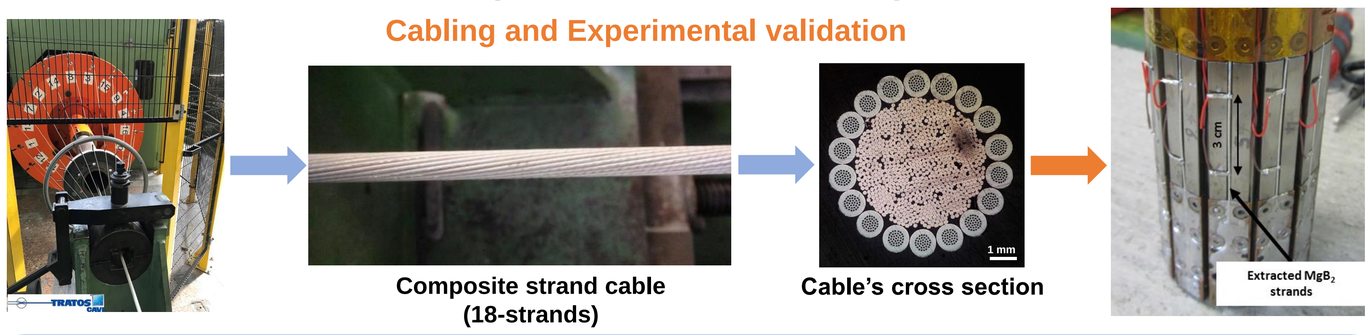
MgB_2 wire's cross section

Single & triple bending of the MgB_2 wire

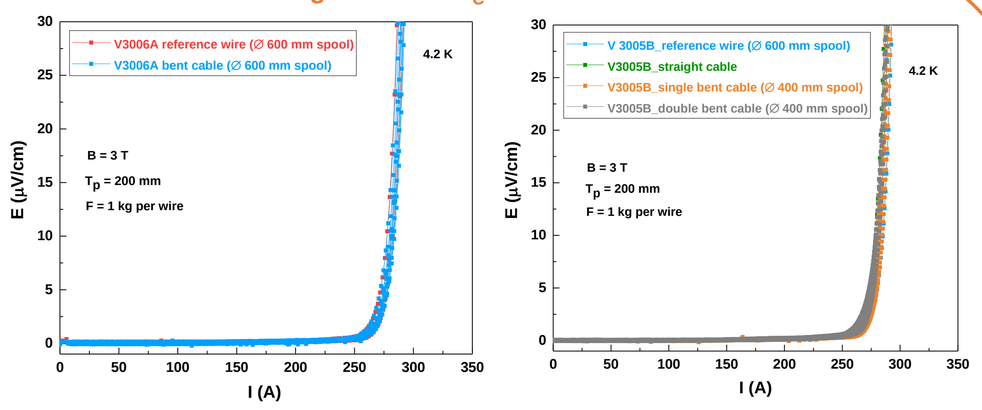


Electro-mechanical performance of the Composite strand cable

Cabling and Experimental validation

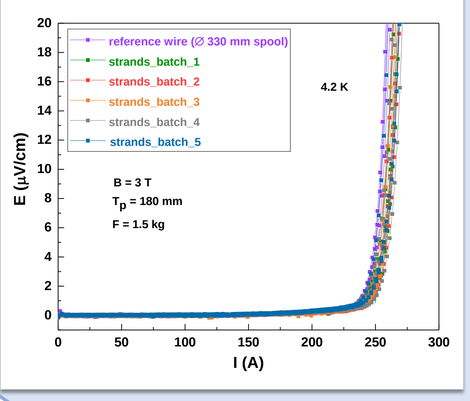


Cabling at CERN – I_C of extracted strands

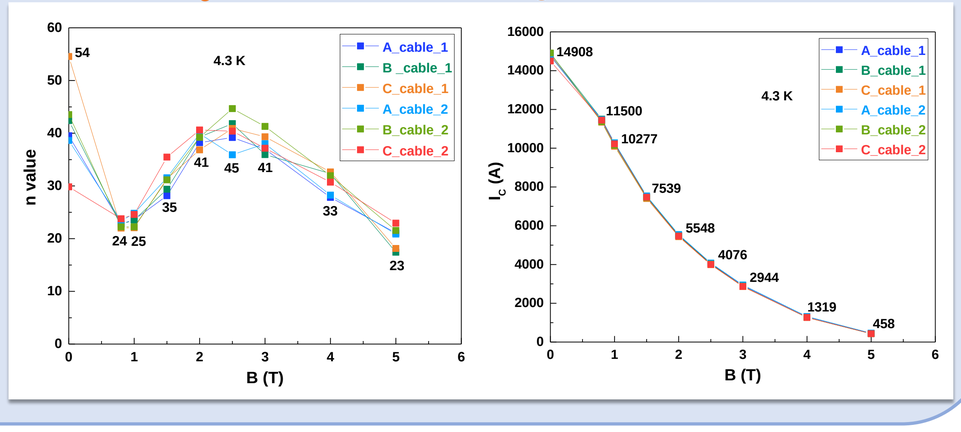


25 m long "Composite strand" cable (18-strands)

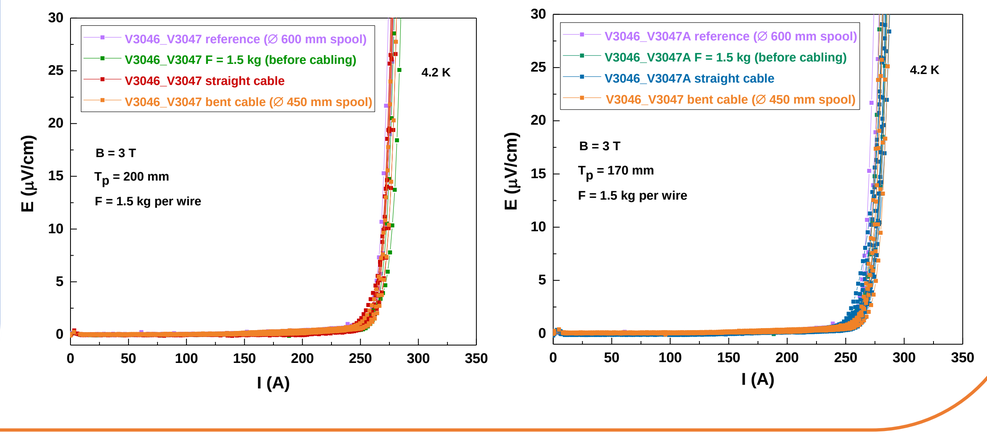
I_C of extracted strands



I_C and n value of 2 x 2 m long cable – FRESCA



Cabling at TRATOS Cavi – I_C of extracted strands

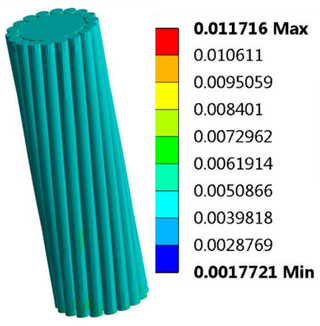


Numerical Simulation

Tensile test

The FE simulation of the tensile test of a Composite strand cable show an homogeneous strain distribution in the Cu core and in the MgB_2 strands.

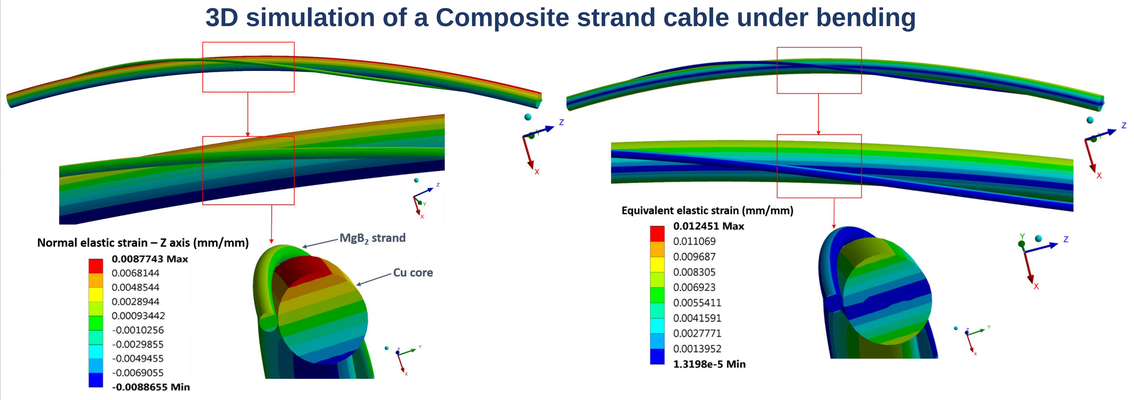
Elastic strain – Z axis (mm/mm)



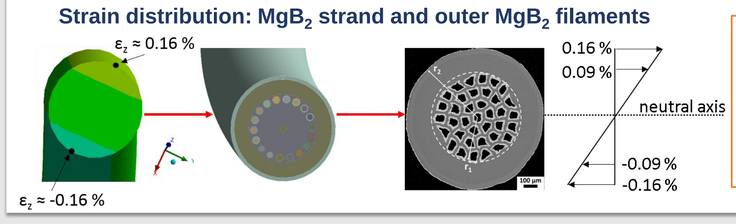
Applied strain
ε_z = 0.5 %

Bending test

3D simulation of a Composite strand cable under bending



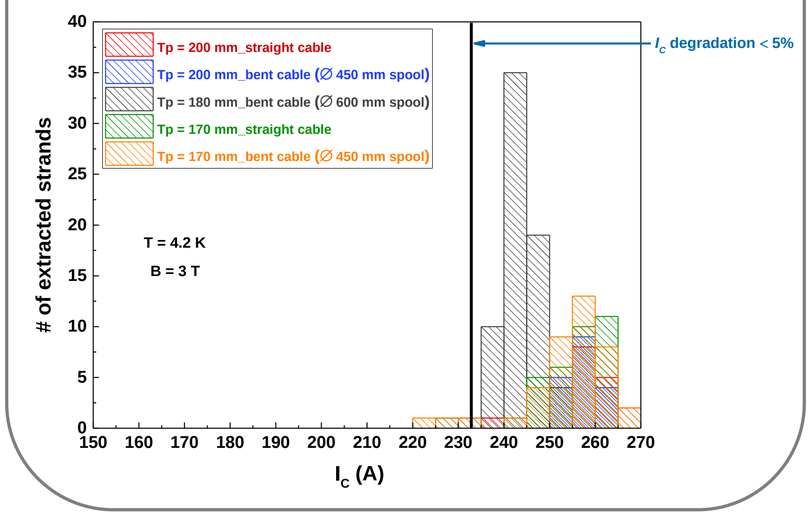
Strain distribution: MgB_2 strand and outer MgB_2 filaments



Parameters for the simulation

- L_{cable} = 180 mm
- T_p = 180 mm
- $R_{b,\ cable}$ = 300 mm

Overview of the electrical performance of extracted strands from three Composite strand cables



Conclusions

- A thorough electro-mechanical characterization of 1 mm MgB_2 wire has been carried out at CERN to determine the optimal cabling parameters of the MgB_2 cables in the framework of the SC Link project. The 1 mm MgB_2 wire was developed in a collaboration between CERN and Columbus Superconductors SpA.
- Several "Composite strand" cables up to 3 m long were prepared at CERN. The maximum tensile load on the MgB_2 wire, the minimum twist pitch of the MgB_2 strands and the minimum bending radius of the "Composite strand" cable have been experimentally validated.
- A 25 m long "Composite strand" cable was industrially manufactured by TRATOS Cavi and shipped to CERN. The main cabling parameters are: T_p = 180 mm, $R_{b,cable}$ = 300 mm and $F_{per\ wire}$ = 1.5 kg. The I_C measurement of 2 x 2 m long cables shows a very good and homogeneous electrical performance at 4.3 K, in self-field and in external perpendicular field up to 5 T.
- Numerical simulations show the strain distribution on the "Composite strand" cable under axial loading and bending. The obtained results support the selection of the proposed cabling parameters: twist pitch and bending radius for the studied MgB_2 cable.
- The studied configuration of the "Composite strand" cable will be used as the base cable for the 18 kA MgB_2 superconducting link.