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WINDABILITY TESTS OF Nb_3Sn RUTHERFORD CABLES FOR HL-LHC AND FCC

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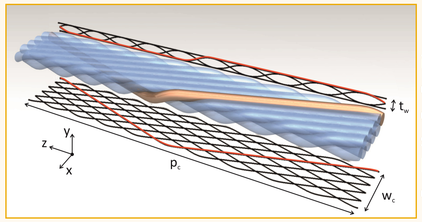
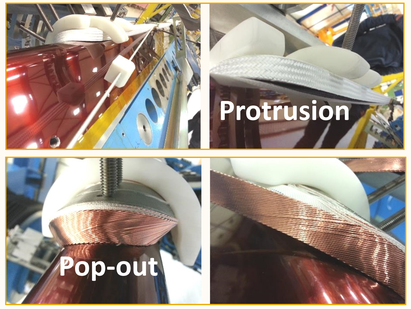
INTRODUCTION



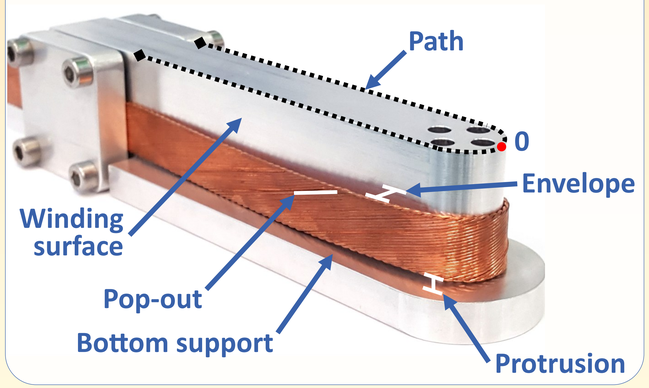
The Nb_3Sn is formed in so-called Rutherford cable, allowing for a dense compaction of strands benefiting in high engineering critical current densities.



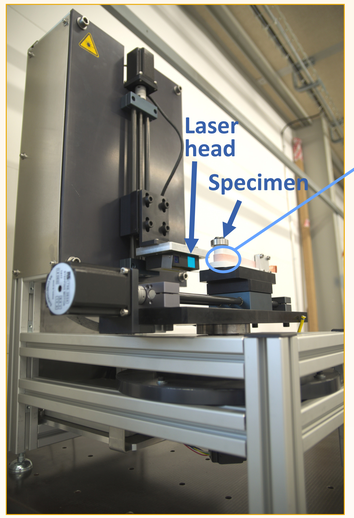
The instability was observed during the prototype winding of the 11 T dipole, most frequently occurring at the coil extremities.

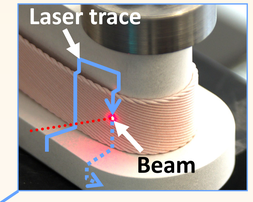
Three observed deformation types, i.e. winding instabilities:

- **Envelope** – a distance between the winding surface and the cable;
- **Pop-out** – a local change in the cable thickness caused by at least one strand coming out of the cable side plane;
- **Protrusion** – a distance from the bottom support to the bottom of the cable.



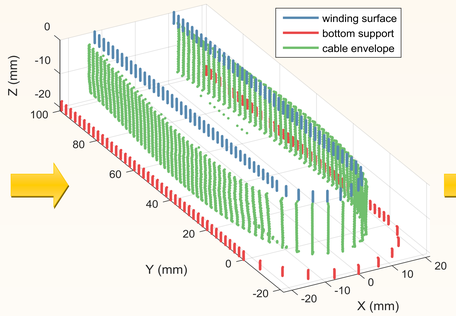
SCANNING METHODOLOGY

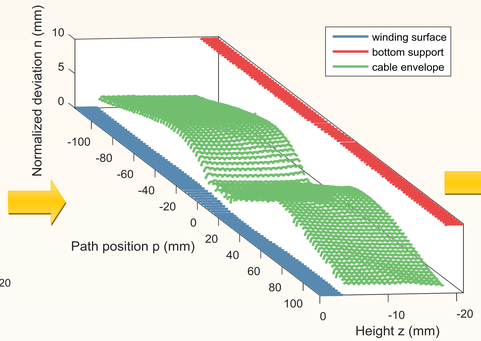




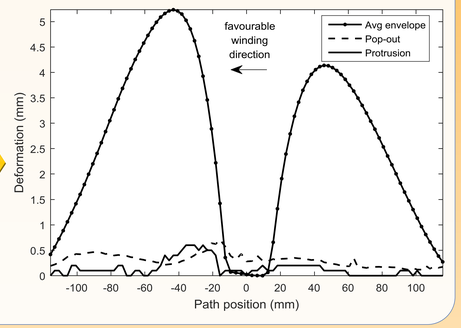
In order to automate the scanning process, a winding scanner was designed allowing obtaining a high accurate 3D scan of the outer surface of the specimen. The winding scanner is a three Degrees Of Freedom (DOF) device, which allows scanning the winding specimen with use of a triangulation laser head.

A dedicated scan analysis algorithm was developed which allows the extraction of functions describing different types of instabilities. Afterwards, the deformation functions are integrated with respect to *p* – the path position. Consequently, the observed cable deformations of a winding specimen are described with three values, allowing for a relative qualification of the performance and the stability.





Three deformation functions:



WINDING CAMPAIGN AND RESULTS

Winding campaign parameters:

Description	Value	Unit
Guide angle	0	(deg)
Winding mass	{5, 20, 30}	(kg)
Pole diameter	20	(mm)
Winding direction	{favorable, unfavorable}	-

Parameters of tested cables:

Cable name	11 T Cu	11 T RRP	NbTi	MQXF	FRESCA2
Strand Material	Annealed copper	Nb_3Sn RRP	Nb-Ti	Nb_3Sn RRP	Nb_3Sn RRP
Number of strands	40	40	28	40	40
Strand Diameter	0.7 mm	0.7 mm	1.07 mm	0.85 mm	1 mm

The winding campaign was conducted, in order to investigate the influence of a winding mass and a winding direction on the winding quality based on:

- **Performance** – an average deformation indicator value of three specimens wound with the same set of parameters; demonstrating the amount of a deformation;
- **Stability** – a standard deviation of indicator values of three specimens wound with the same set of parameters; demonstrating the reproducibility of the observed deformation.

Performance: **Stability:**