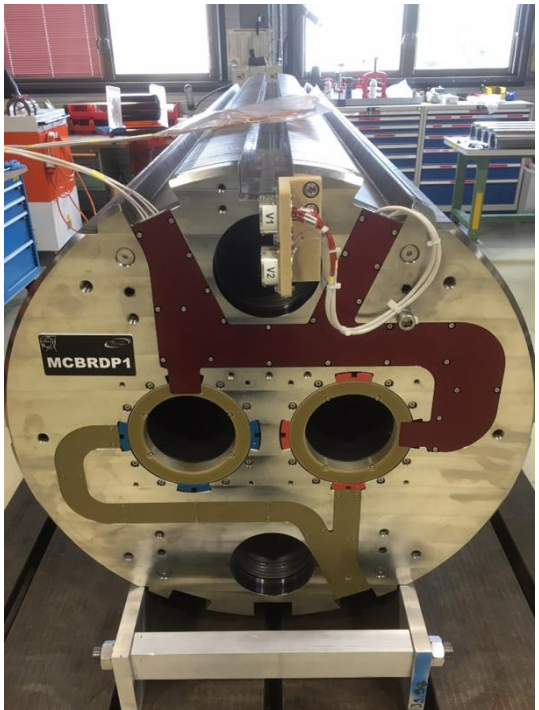
Short model and prototype program of MCBRD at CERN



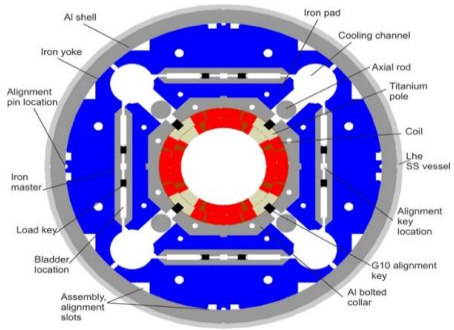
Gijs de Rijk, Glyn Kirby
CERN

17th October 2018

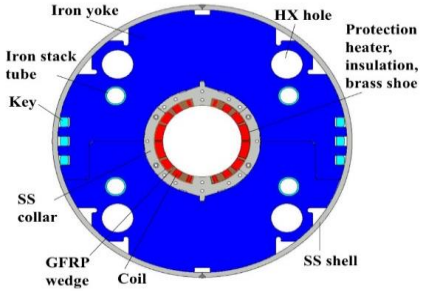
Talk Overview

- MCBRD for HL-LHC
- CCT principles
- Short model results
- Prototype construction
- Conclusions

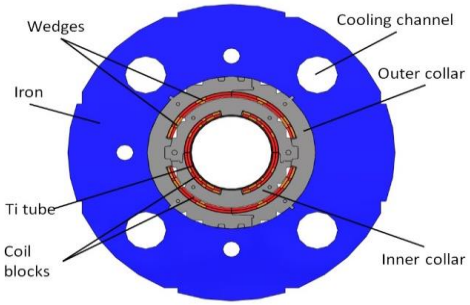
THE MAGNET ZOO



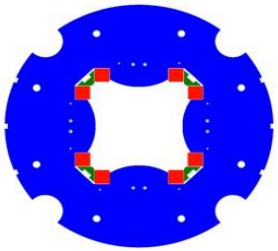
Triplet [G. Ambrosio, S. Feher, P. Ferracin et al.]



D1[T. Nakamoto, et al.]

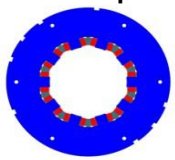


MCBXF [F. Toral, et al.]

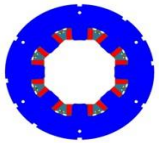


Skew quad [M. Sorbi, M. Statera, et al.]

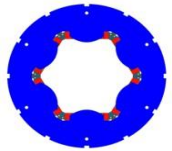
Dodecapole



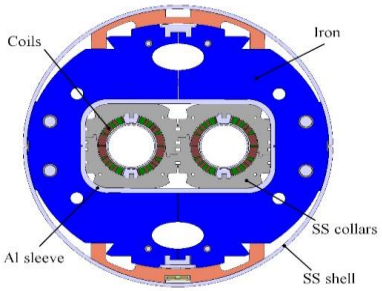
Decapole



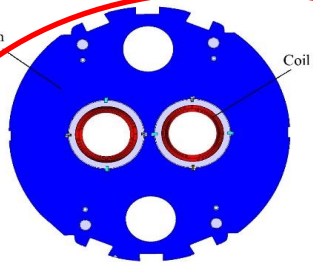
Octupole



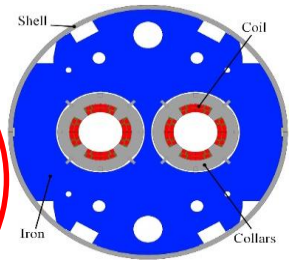
Sextupole



D2 [P. Fabbricatore, S. Farinon, et al.]



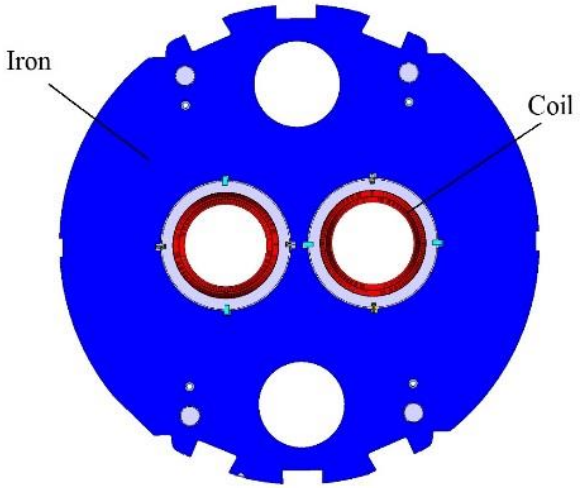
D2 correctors [G. Kirby, Q. Xu, et al.]

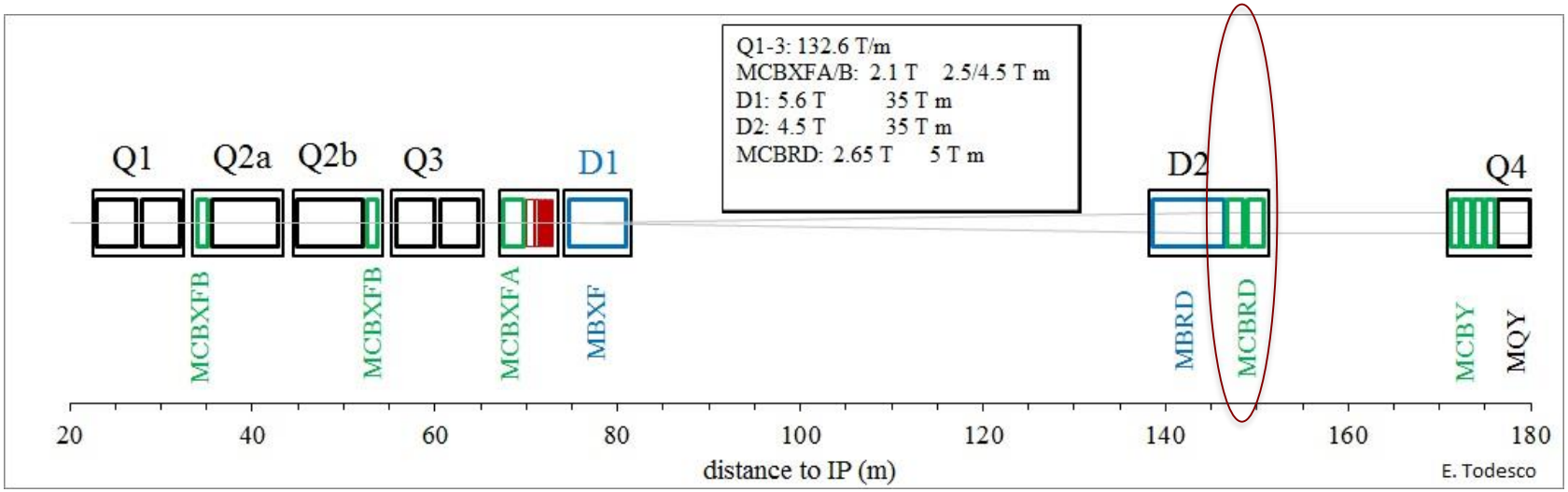


MQYY [H. Felice, et al.]

Courtesy E. Todesco

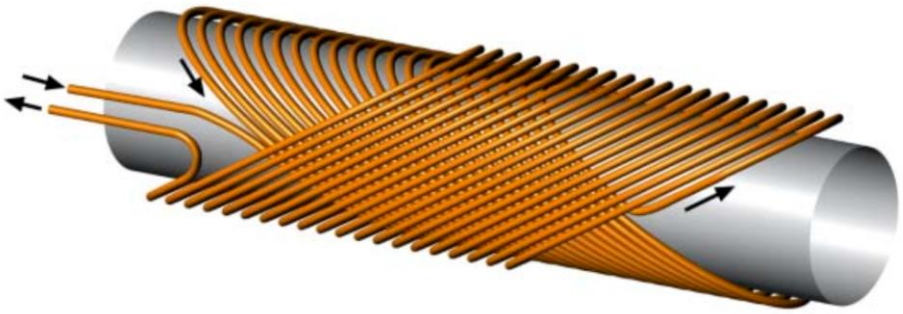
MCBRD (CCT CORRECTOR)





Courtesy E. Todesco

CCT

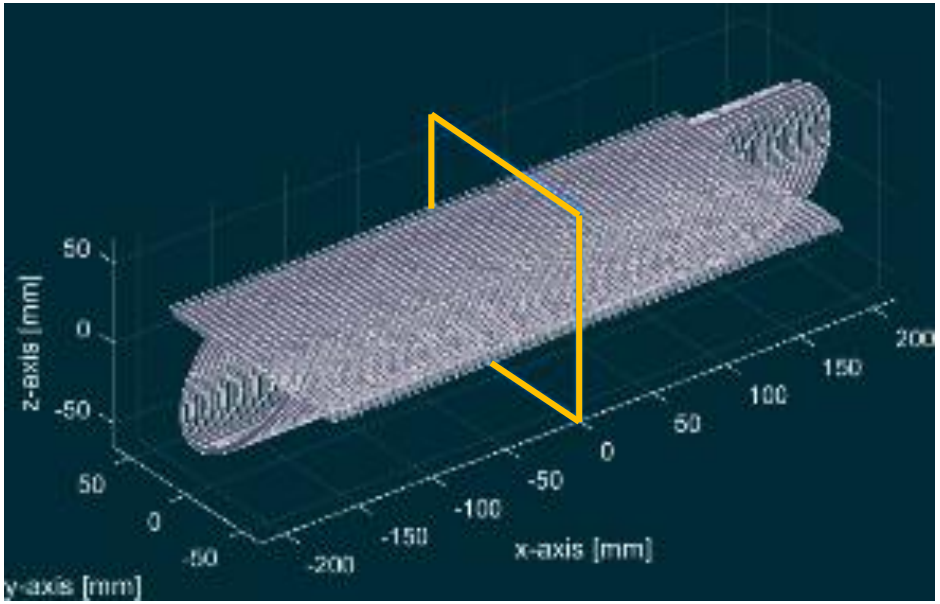


From: R. Meinke, et al., "Superconducting Double Helix Accelerator Magnets", Proc. PAC 2003, 1996-1998, 2003.

Two inclined solenoids, powered such that the axial fields are equal strength but opposite sign and the transverse fields are equal strength but the same sign and thus adding up.

Horizontal bending dipole (V field)

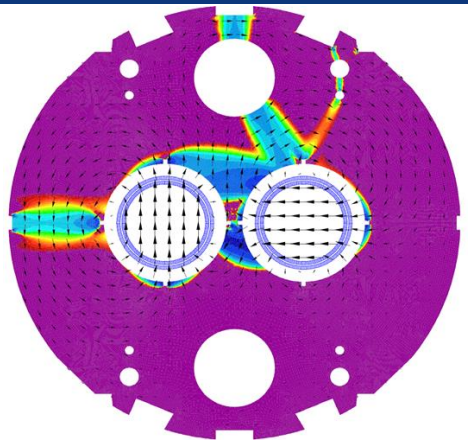
- On the top and bottom the sideward forces are supported by the groove walls
- On the central plane the horizontal outward forces are supported the the next cylinder

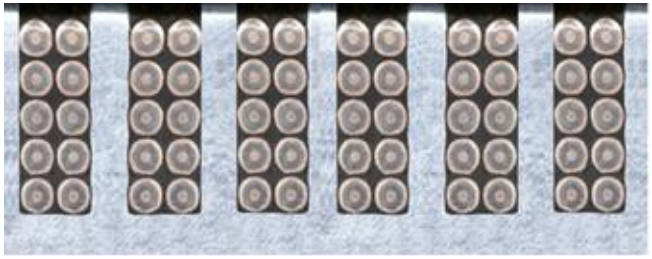


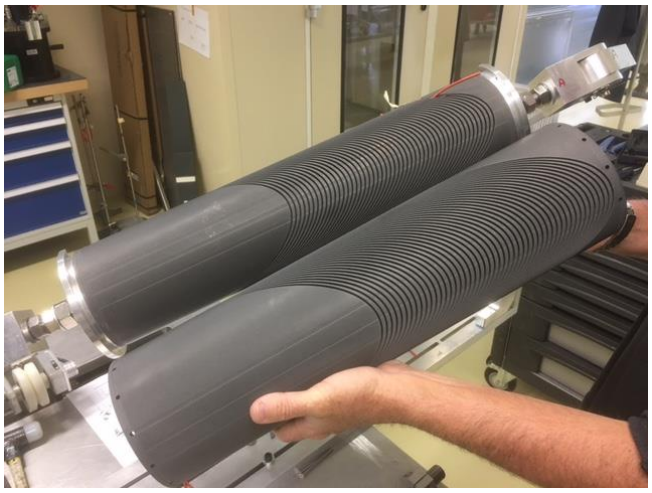
But, the reference to the original paper is:
Meyer D.I. and R. Flasck, Nucl. Instr. and Methods 80, pp. 339-341, 1970.

MCBRD basics

- 10 wires in a groove all in series (not a cable !)
- Anodised Al formers
- Kapton insulated wires
- Connection box in the ends
- Outer Al cylinder to hold the outward forces
- Impregnated together with insulation layers in between the 3 cylinders that also function as slip planes
- The 3 cylinder construction ‘eats’ less space in the yoke and reduces saturation effects wrt other type of magnets



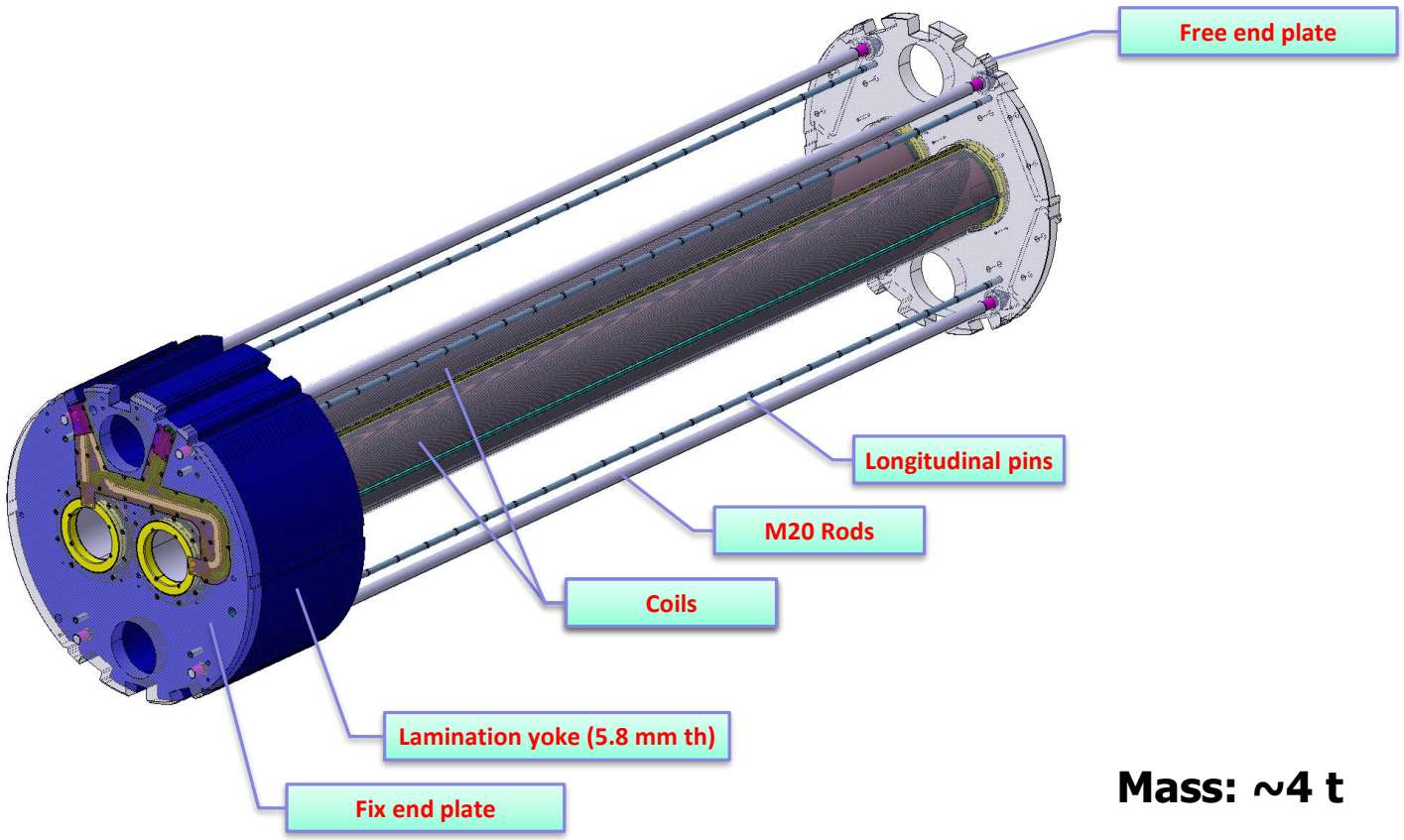




Basic mechanical design

CCT ASSEMBLY

DWG:LHCMCBRD0050

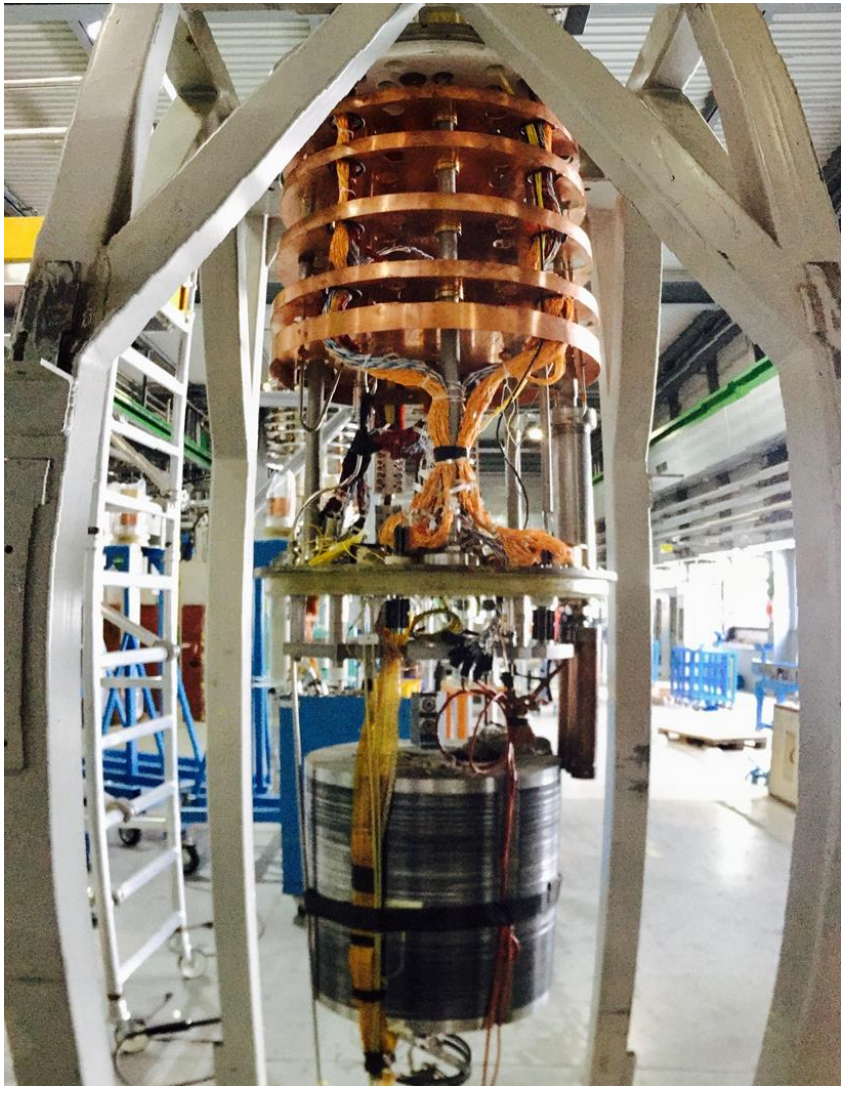


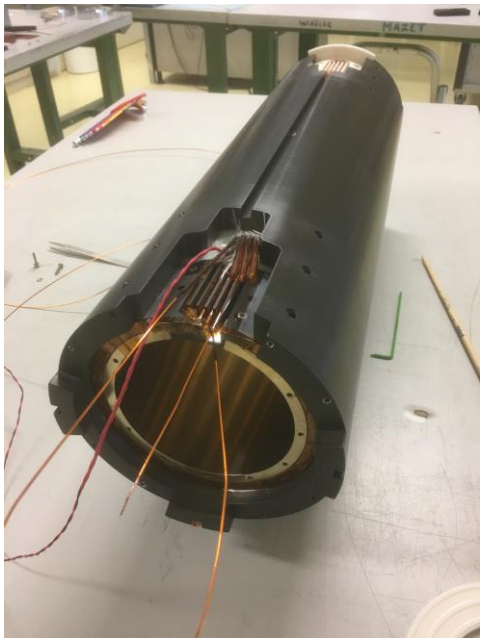
Mass: ~4 t

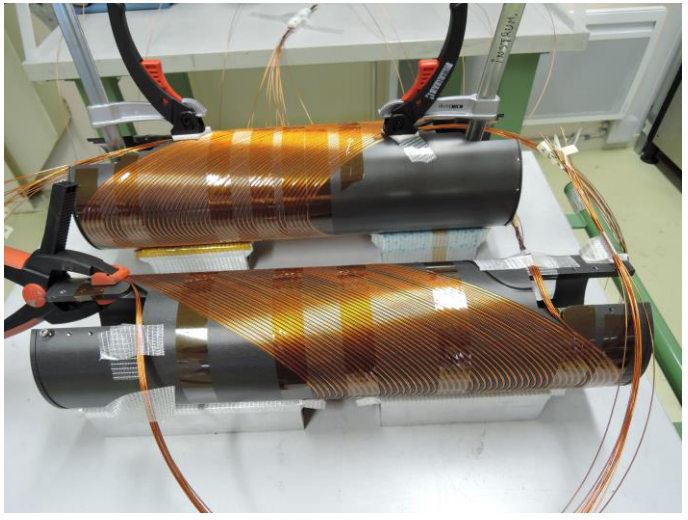
Courtesy L. Gentile

2 Single apertures tested

First test in 2017

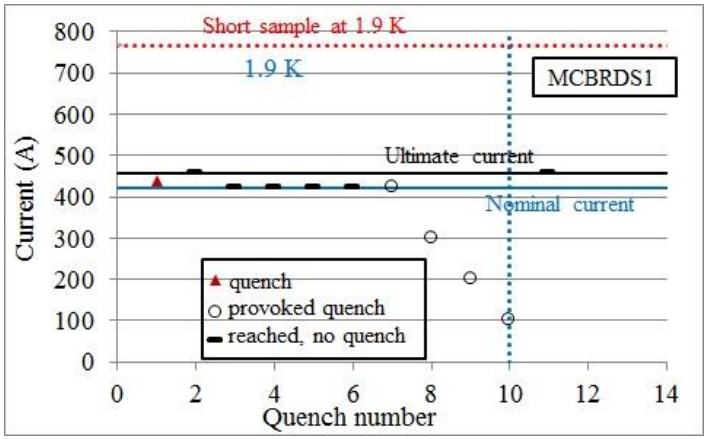


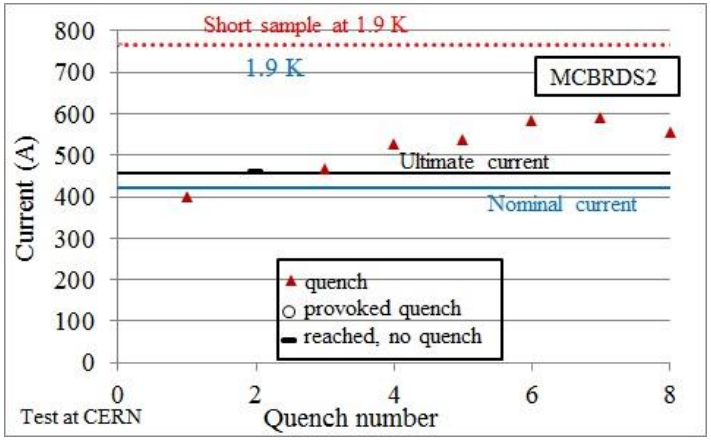




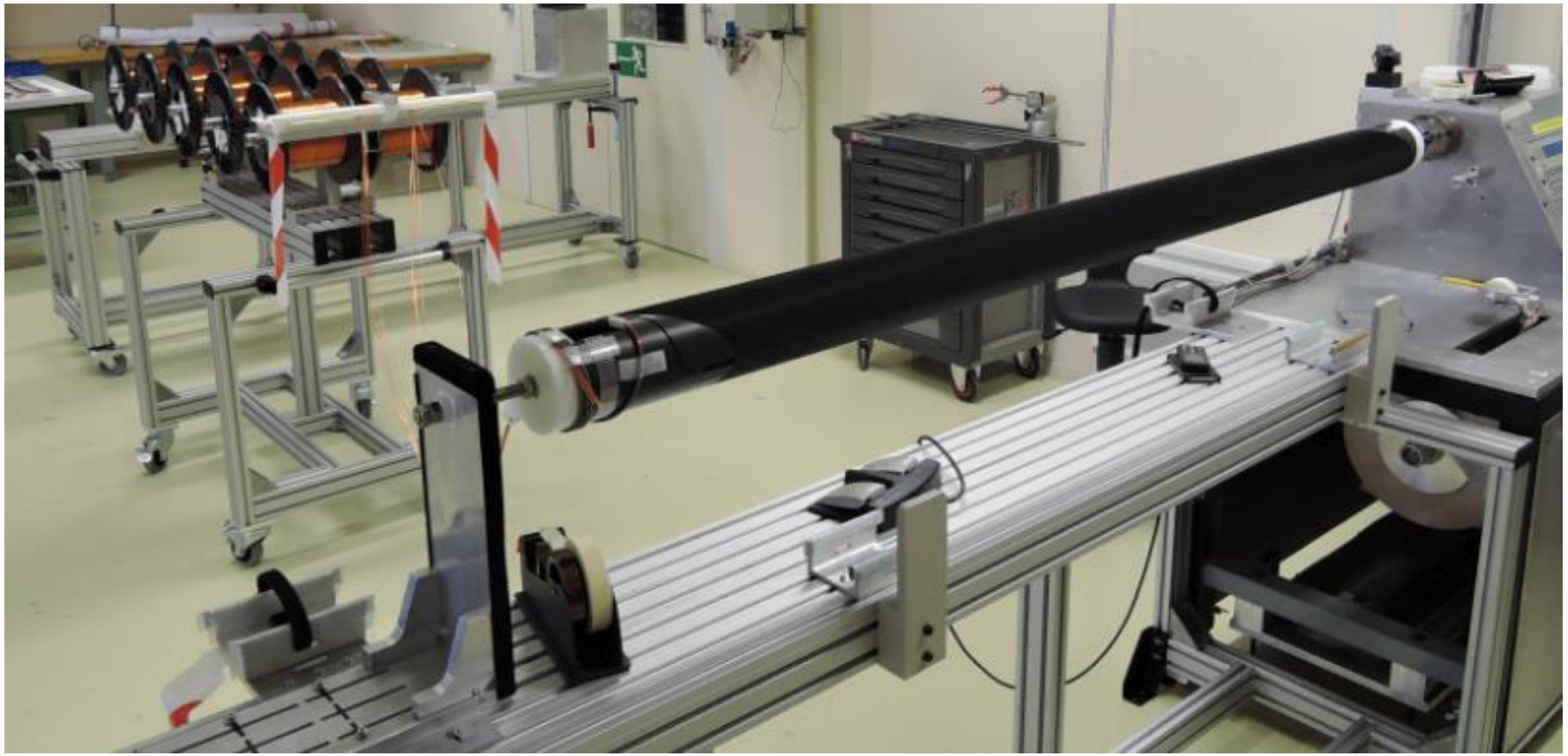
MCBRD (CCT CORRECTOR)

- two short models (single aperture) manufactured and successfully tested
  - Reached performance, no retraining
  - Reached 80% of short sample with limited training





Prototype manufacturing: Coil winding

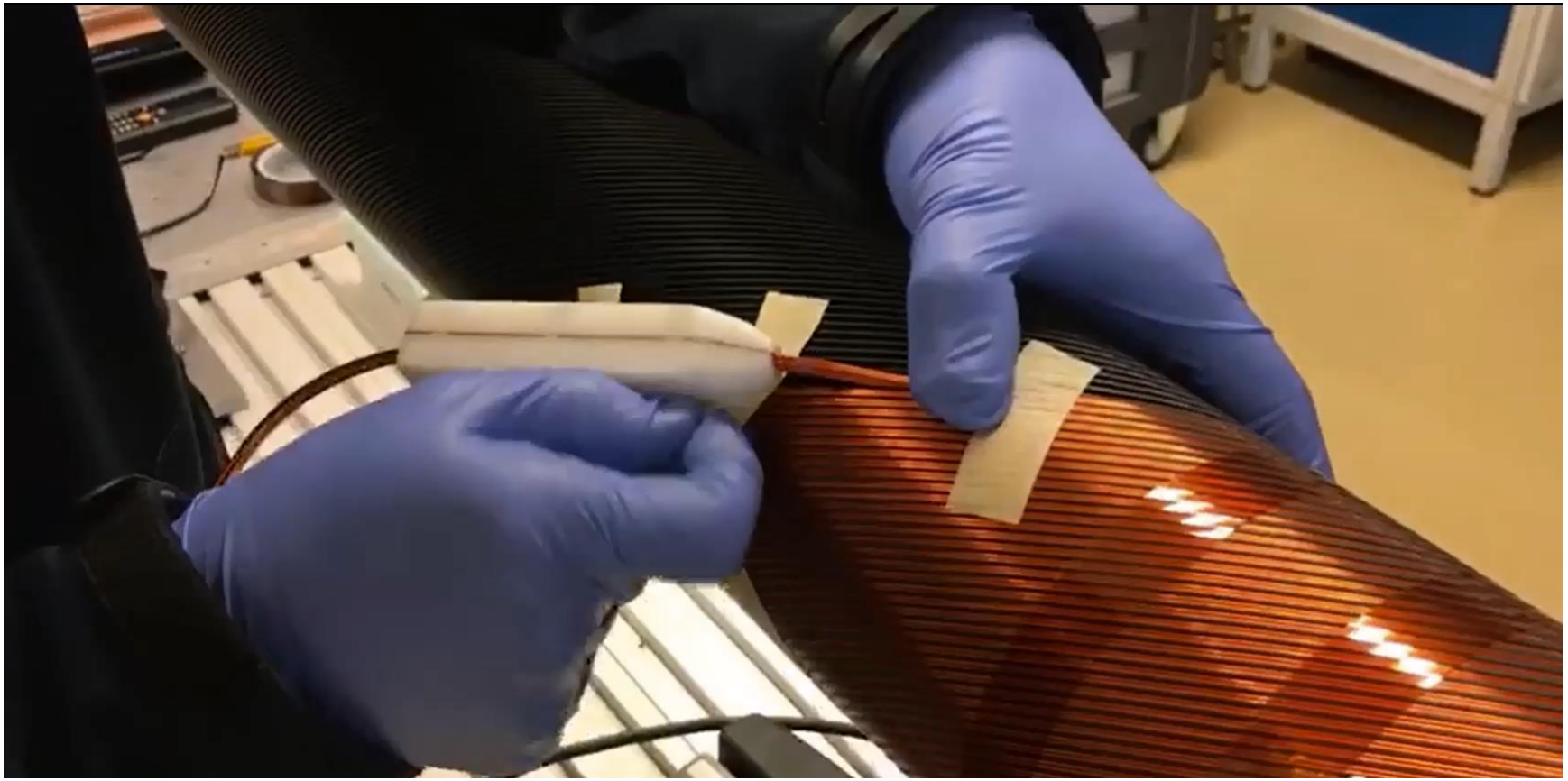


Courtesy: J Mazet and the 927 winding pole

Coil winding

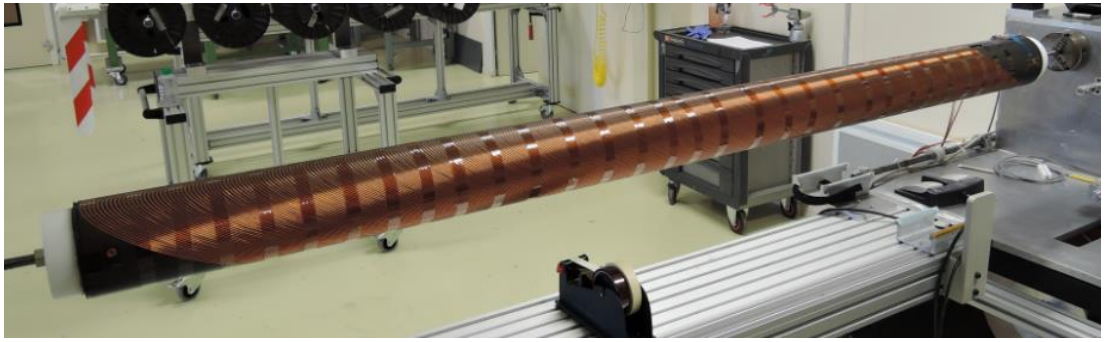
Winding : a modified manual solenoid winding machine

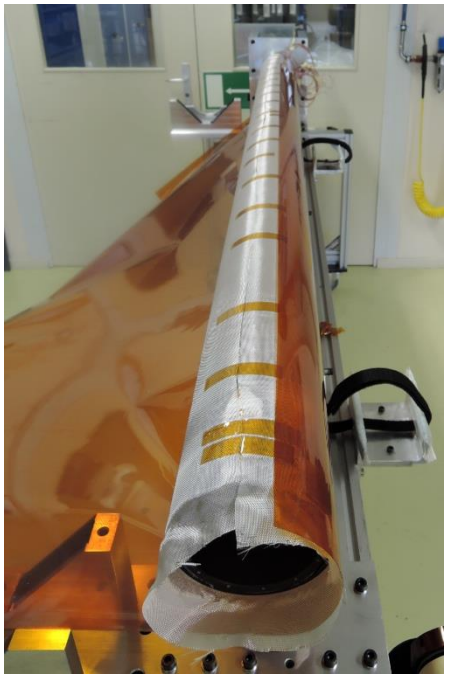
- First: winding the INNER layer
- Using a guide tool

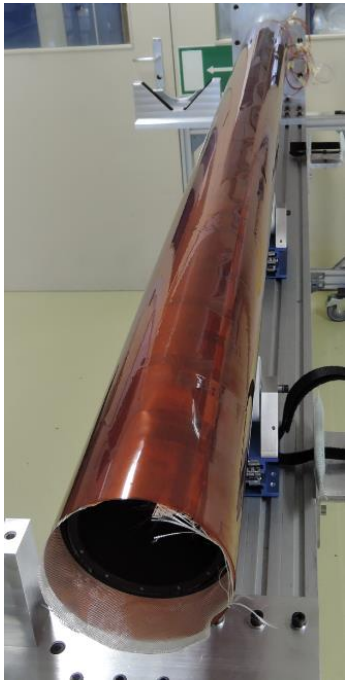


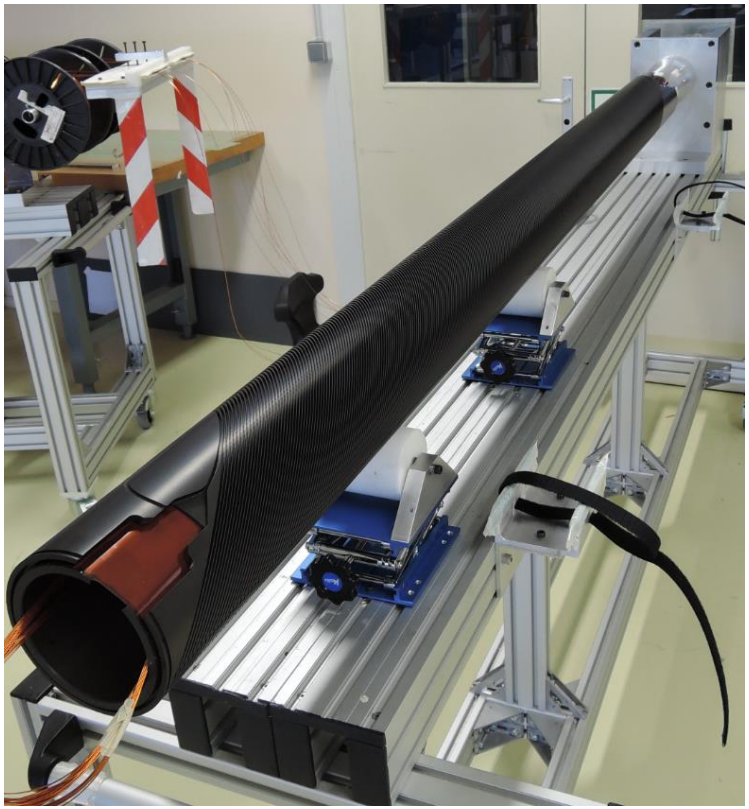
Coil winding

- Winding fixed by Kapton tape
- Electrical check
- Isolation Eglass + Kapton
- Slide on outer former tube



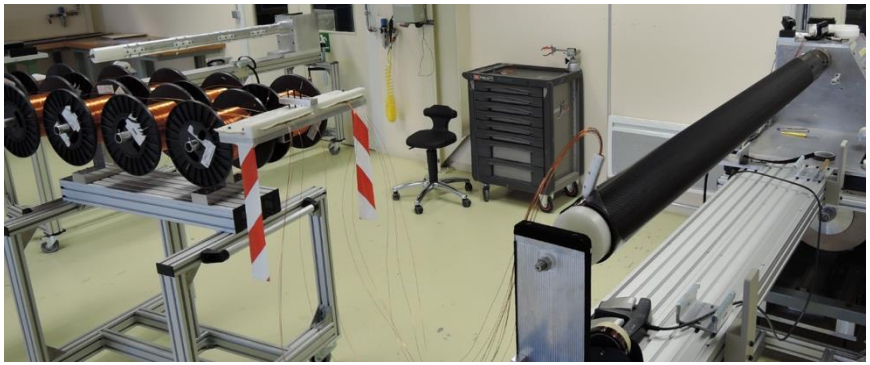


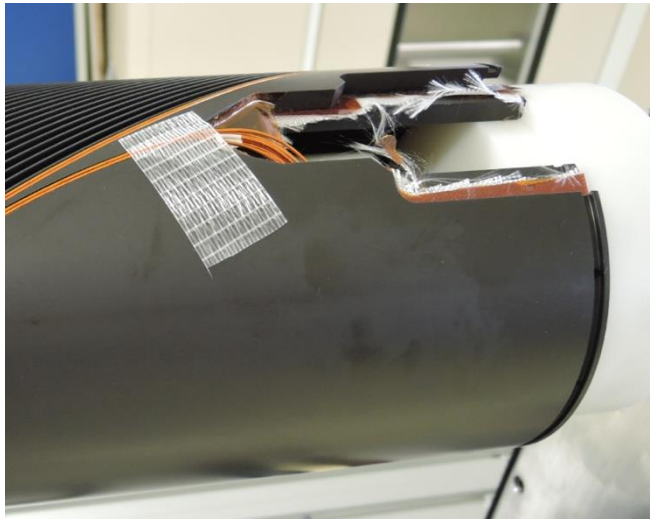


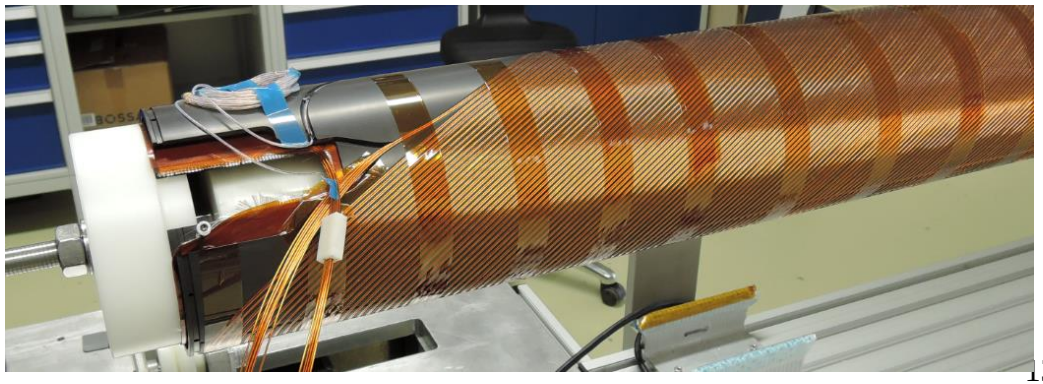


Copil winding

- Winding OUTER layer
- Note the layer jump (no splices)



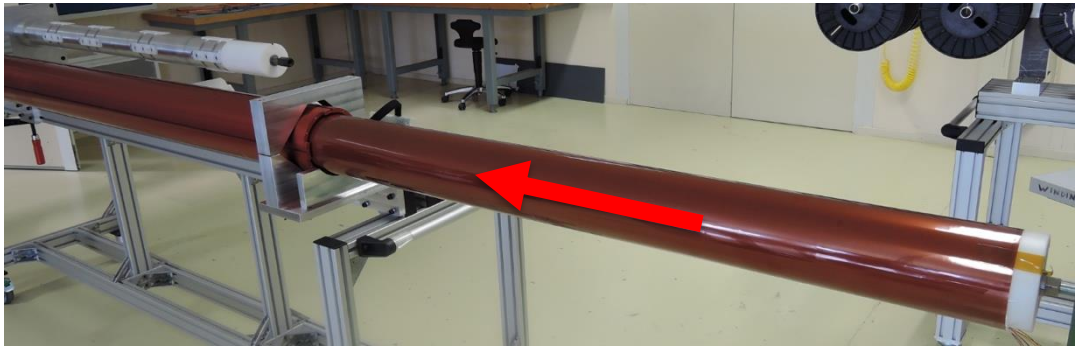


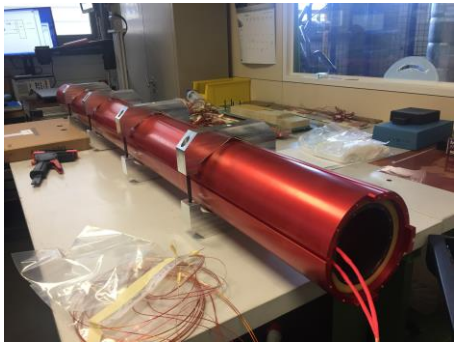


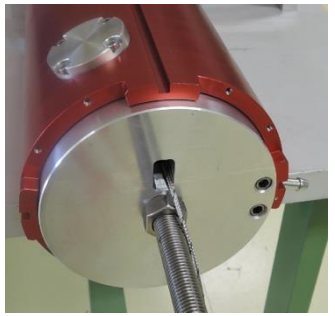
Coil winding

Assembly EXTERNAL tube :

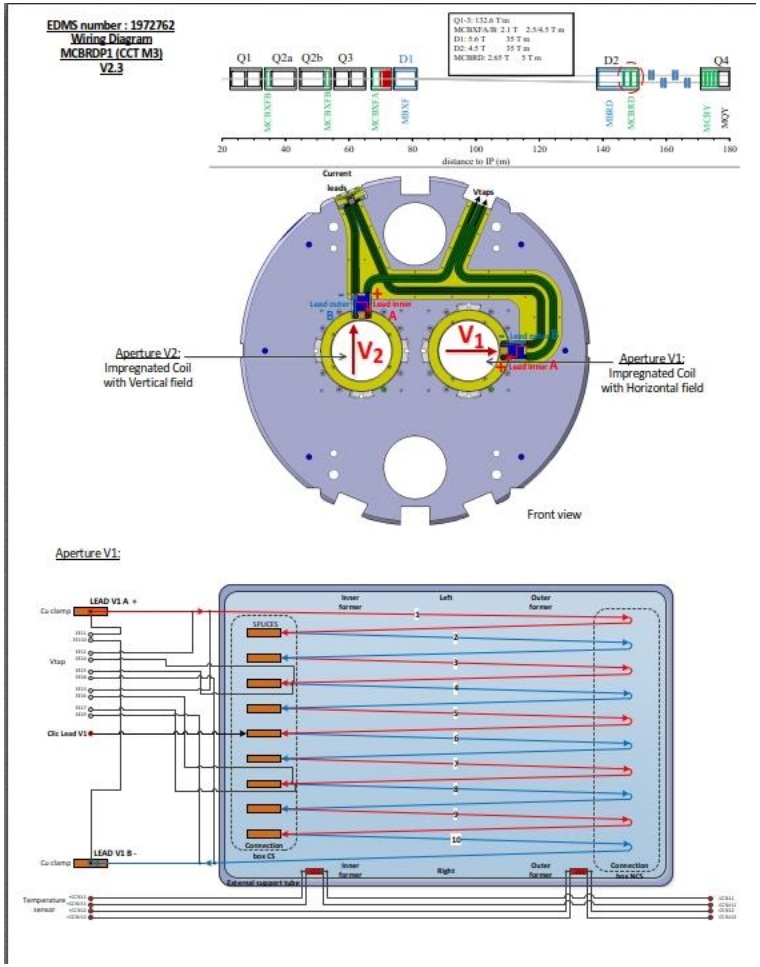
- E-glass sheet 1 x 0.2 mm
- Kapton 2 x 0.125 mm sheets
- OUTER layer tube is fixed
- INNER layer goes in





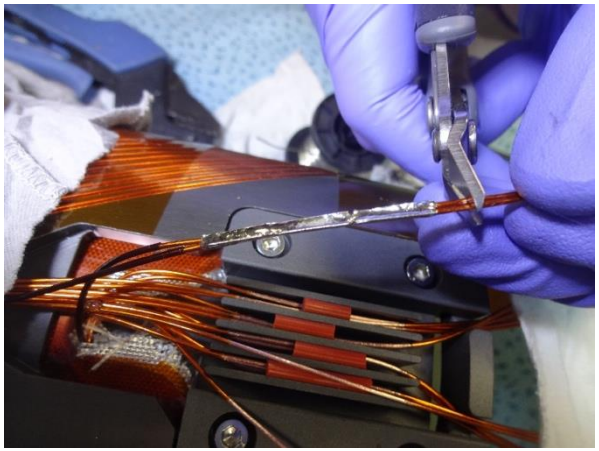


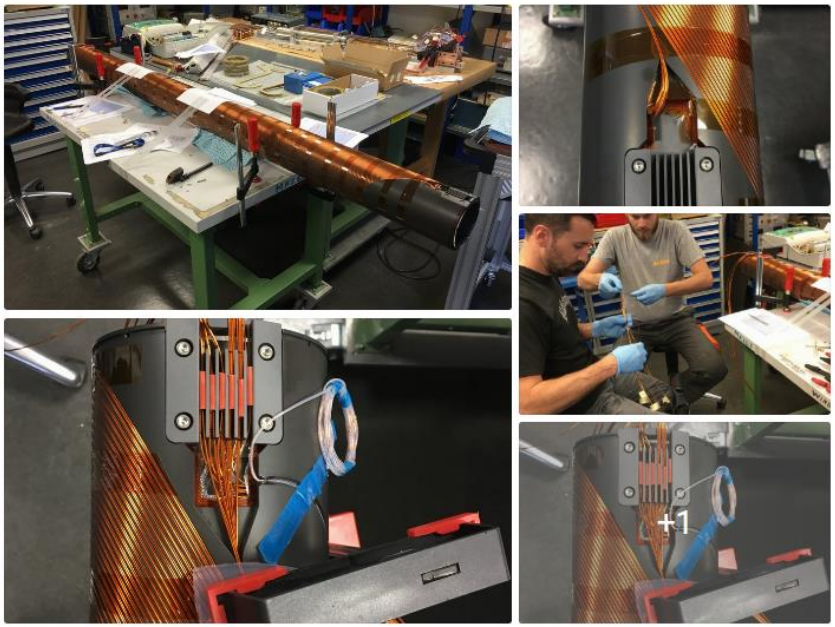
Final Wiring diagram for one of the two prototype magnet aperture.



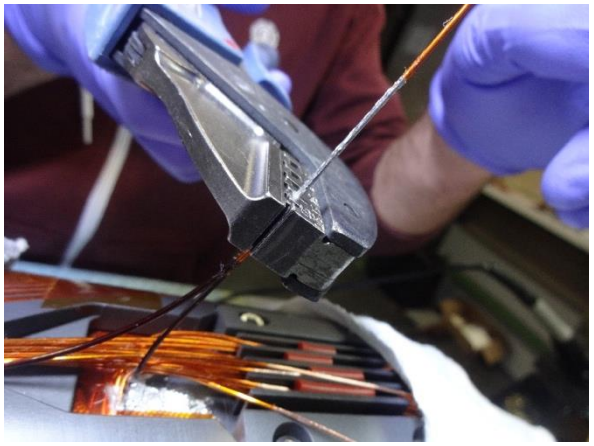
Splicing / Jointing

- Short MCBRDS : 21 splices per aperture
- Prototype MCBRDP : 9 splices
- 45 mm long
- Crimping with “non insulated end-sleeve “ (= tube)
- Sn96Ag4 welding alloy
- Flux MOB39
- Poly-imide sleeve for protection
- Connexion box

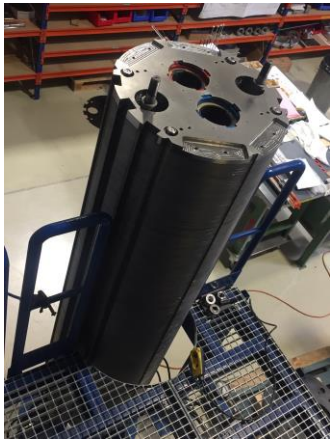


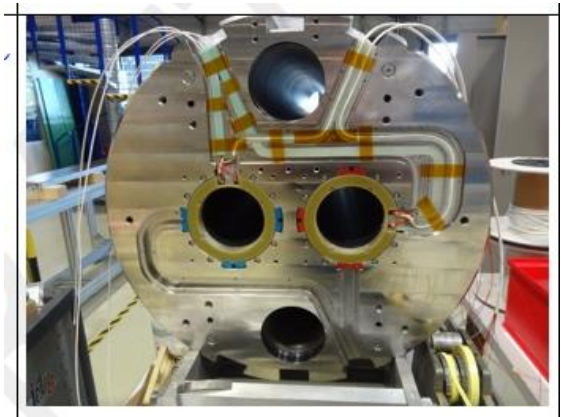


Jointing Aperture One Starts.

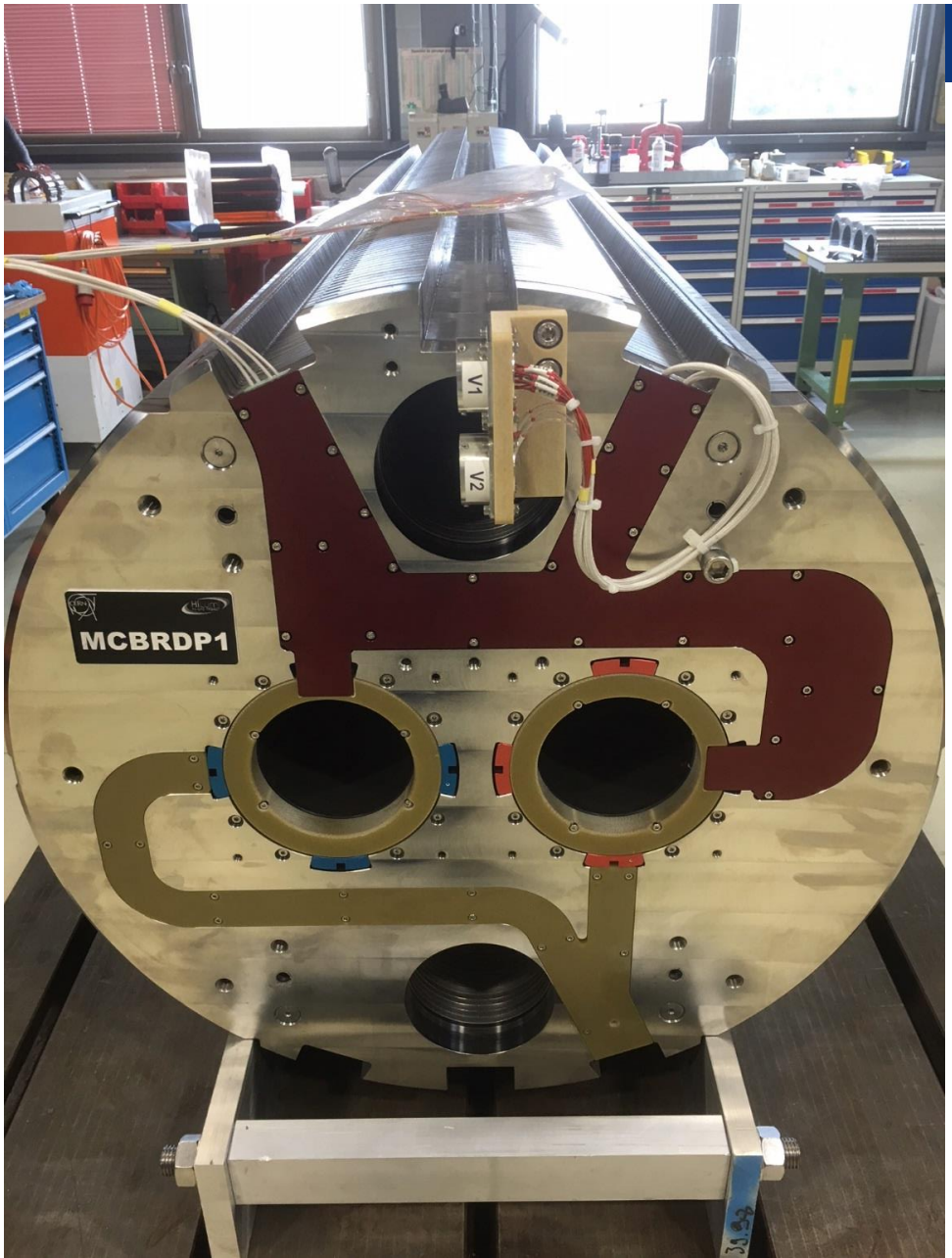


Yoke assembly and connections

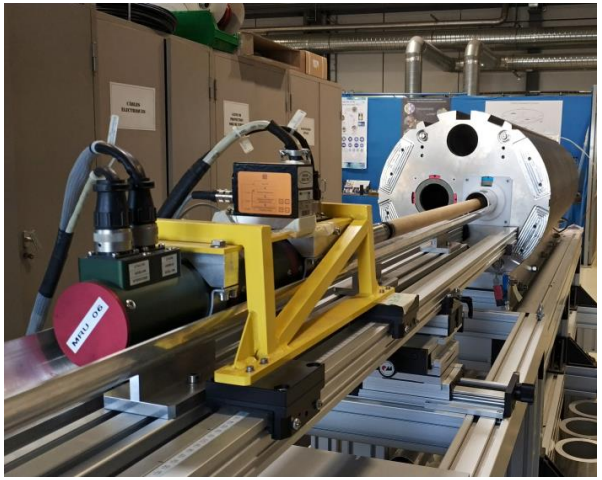




Finished magnet

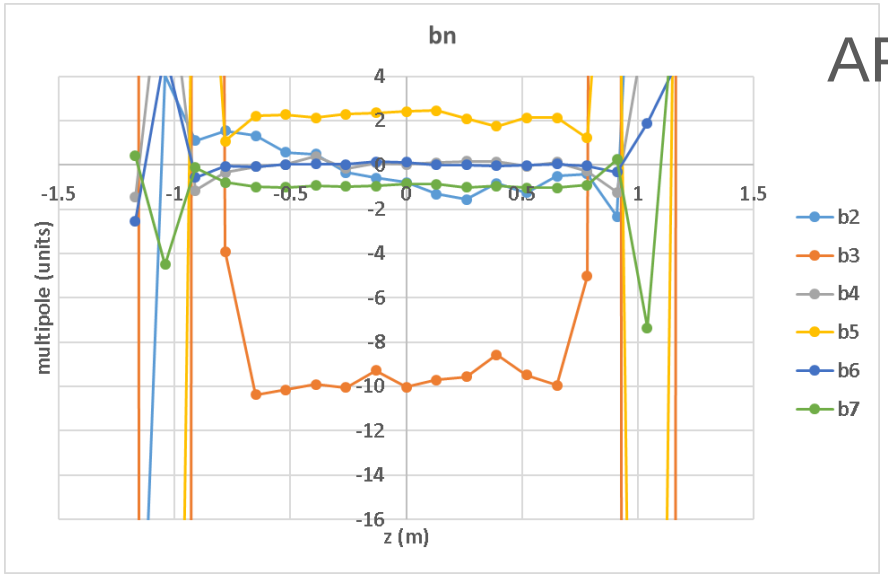


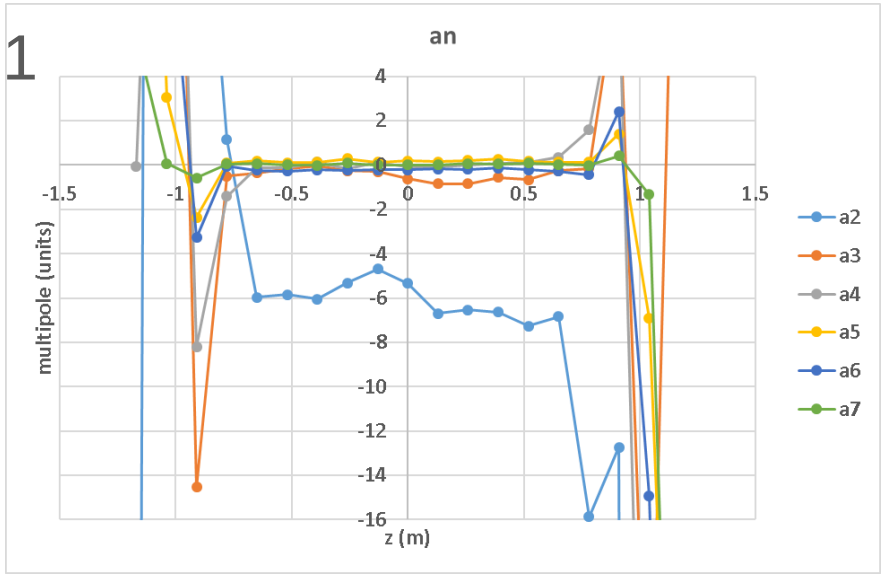
Warm magnetic measurements



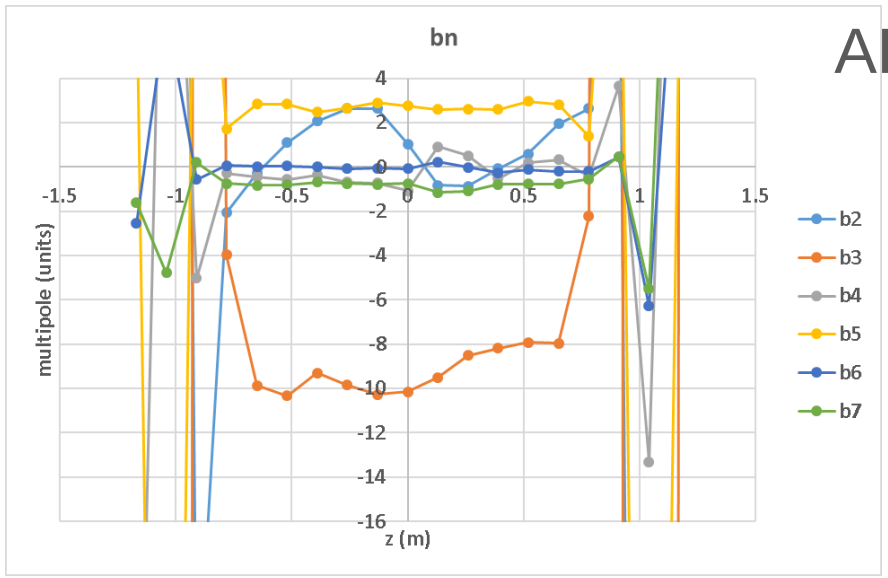
MCBRDP1 at room temperature 3

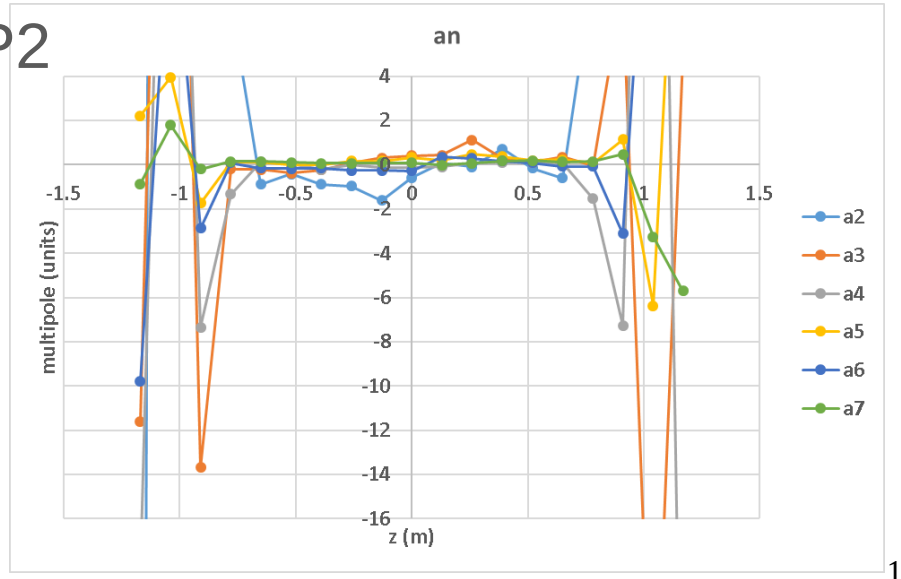
AP1





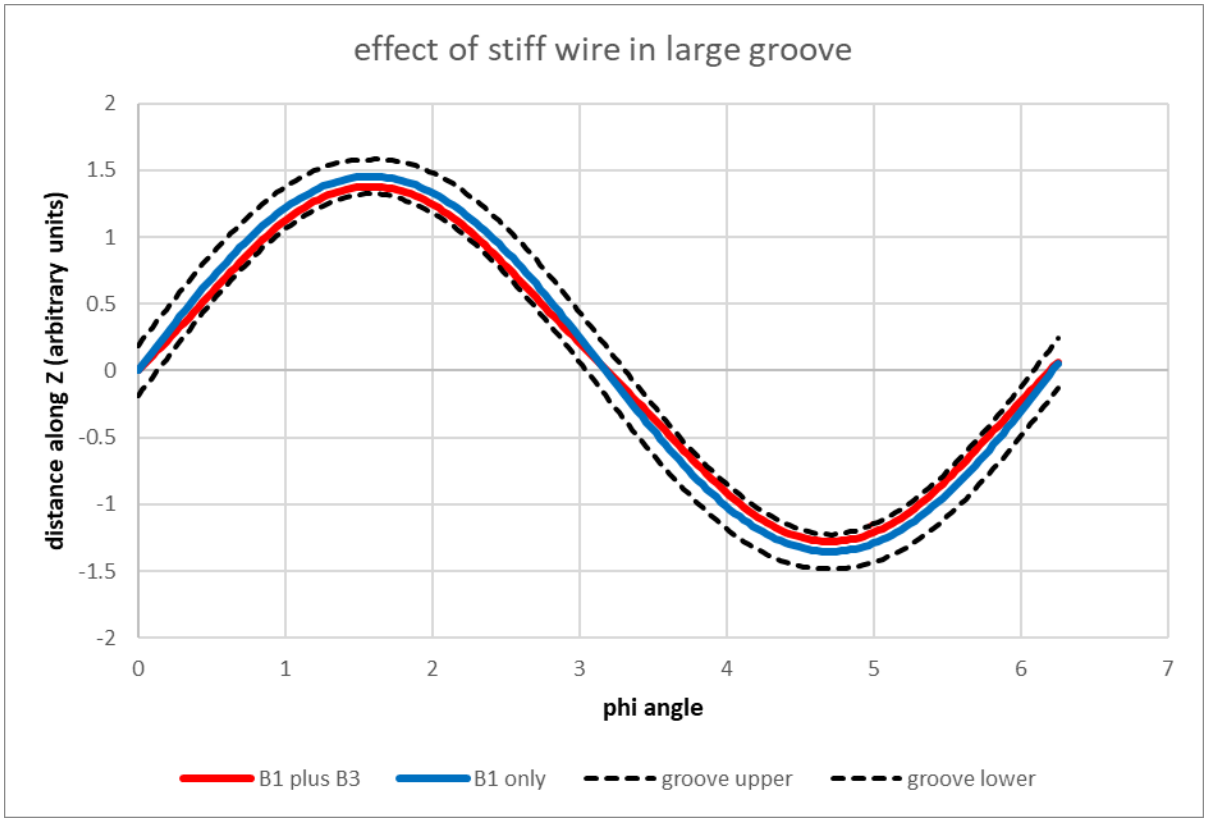
AP2





b_3 hypothesis (M. Koratzinos)

A sideways displacement of the wires by 50μm in the groove on the top and bottom of the loops generates a b_3 of about 10 units.



Ongoing investigation to see if it is this effect that causes the b_3

MCBRD (CCT CORRECTOR)

The first full length prototype is in the SM18 test station (Cluster D) and cooling down.

To report test results we should have postponed this talk to next week…

Conclusions

- The design is finalised
- (nearly) All drawings are complete
- All material choices made
- Short models (2 apertures) made and tested : performance good (in-spec)
- We have done the technology transfer to the Chinese institutes for series production
- First prototype (2 apertures) made
- 10 units b_3 field anomaly found at T_{room} : hypothesis exist to explain this, being investigated (NB. 10 units is just in-spec)
- First prototype is now in the test station cooling down

Let's see in a few days whether it performs as well as the short model !

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