Assembly & tests results on MCBXFB prototypes at CERN

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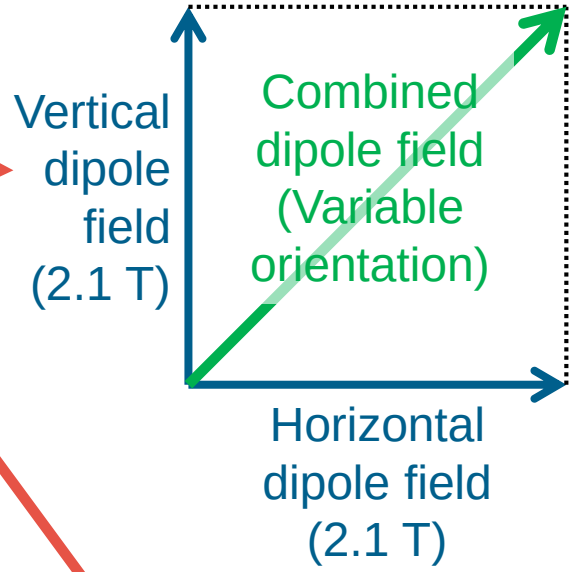
On behalf of MCBXF CERN-CIEMAT team

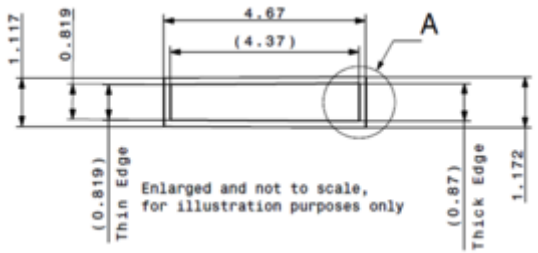
Kick-off meeting for MCBXF series production – CERN 23rd April 2021

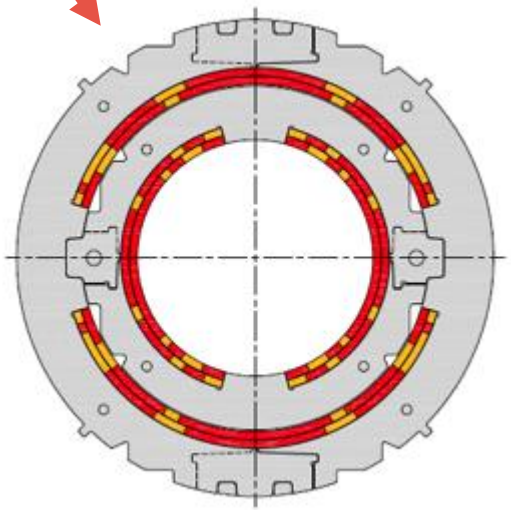
Magnet and cable specifications

MCBXFB Technical specifications	
Magnet configuration	Combined dipole (Operation in X-Y square)
Integrated field	2.5 Tm
Minimum free aperture	150 mm
Nominal current	< 2500 A
Radiation resistance	35 MGy
Physical length	< 1.505 m
Working temperature	1.9 K
Iron geometry	MQXF iron holes
Field quality	< 5 units (1E-4) (b_3<20)
Fringe field	< 40 mT (Out of the Cryostat)



Cable Parameters	
No. of strands	18
Strand diameter	0.48 mm
Cable thickness	0.845 mm
Cable width	4.37 mm
Key-stone angle	0.67º
Cu:Sc	1.75

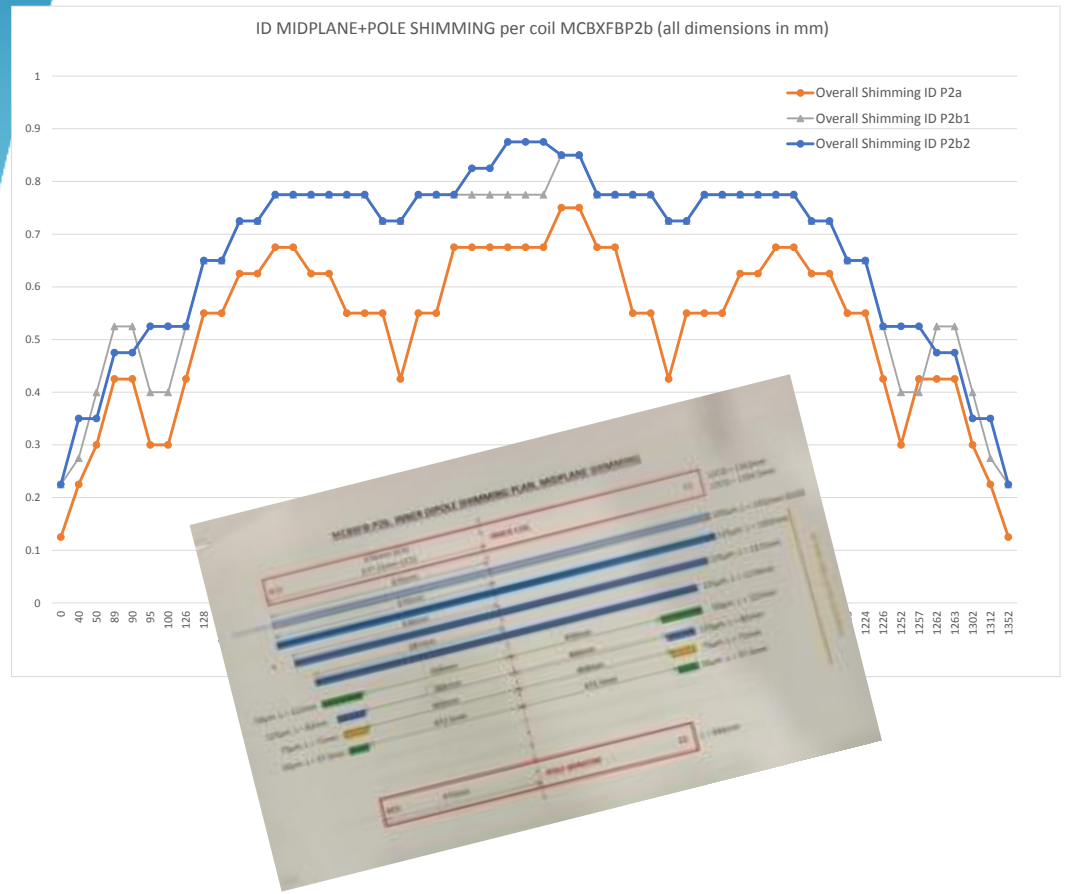


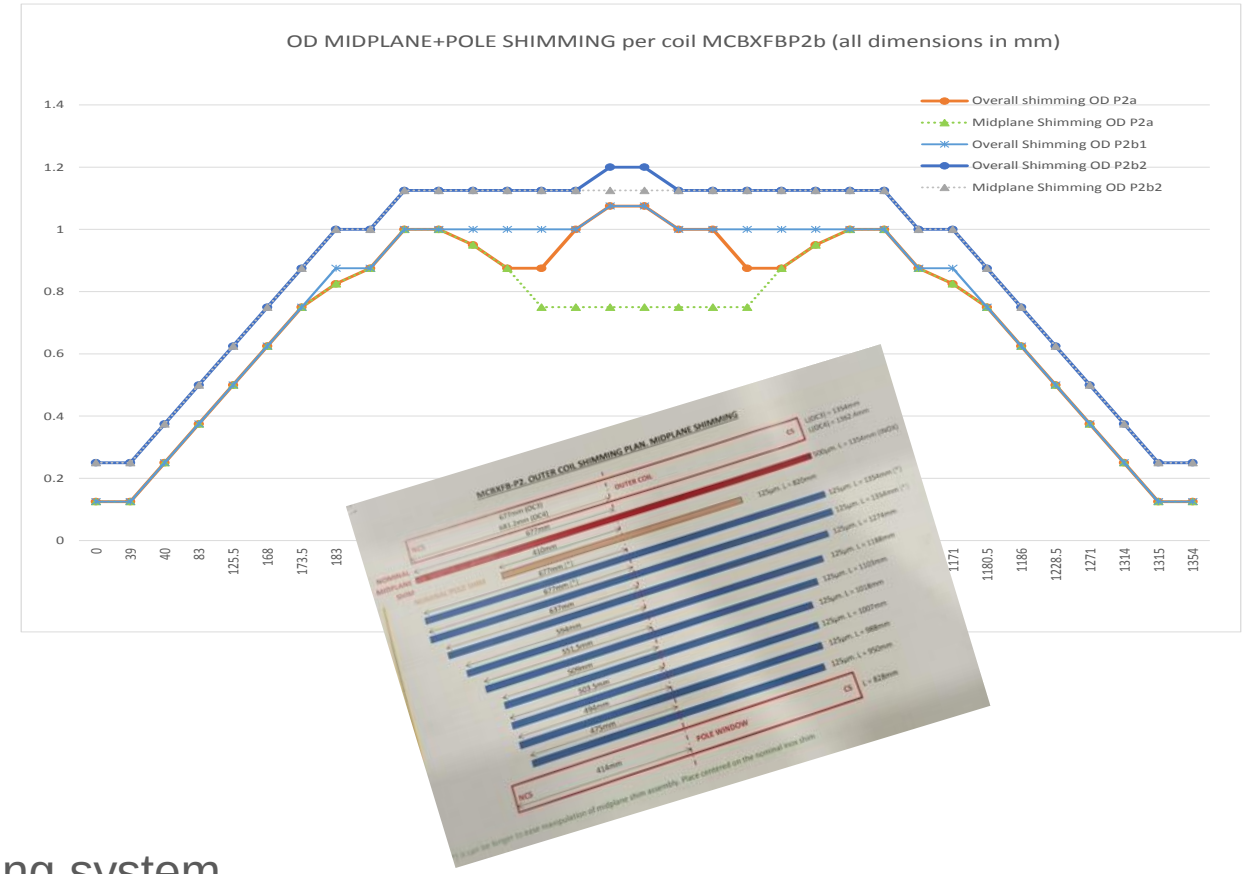


Magnet coils & components delivery to CERN

- The coils are wound at CEDEX (see Carla's presentation)
- All magnet components are delivered by CIEMAT

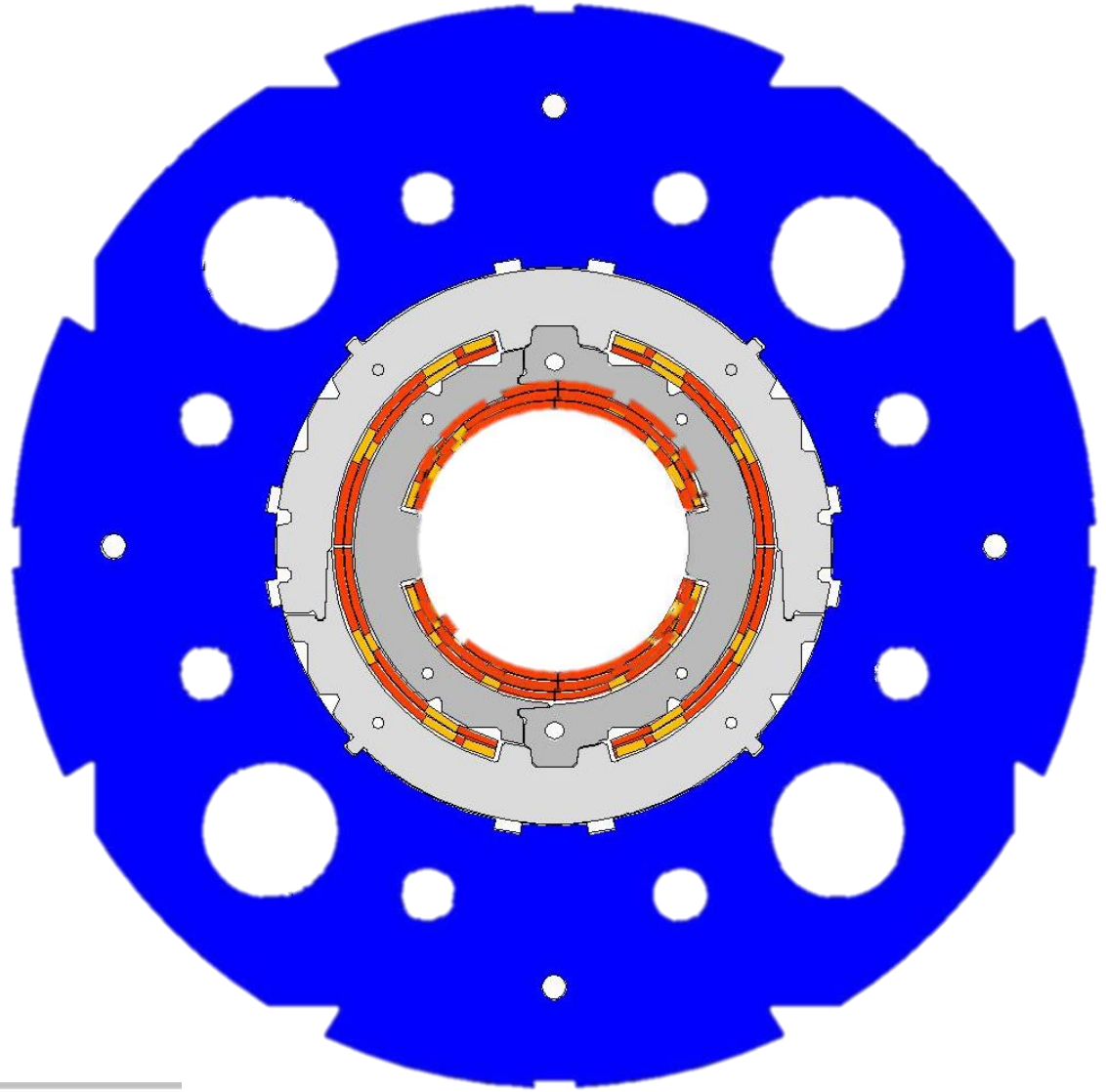
Coils geometry and shimming plan





- Each coil is measured using a CMM measuring system.
- A shimming plan is defined by CIEMAT's crew to compensate the cross-section deviation from nomimal design value and to achive the required coil compression values during magnet operation.

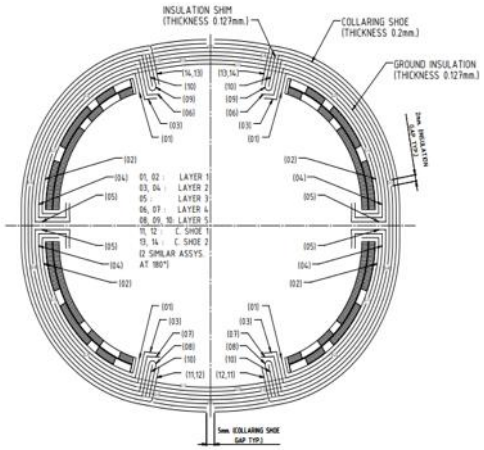
MCBXF magnet assembly sequence



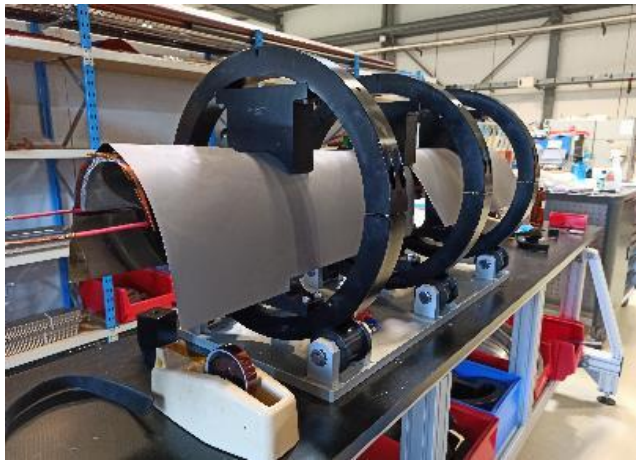
Inner dipole assembly

Ground insulation assembly

Stepped shimming preparation

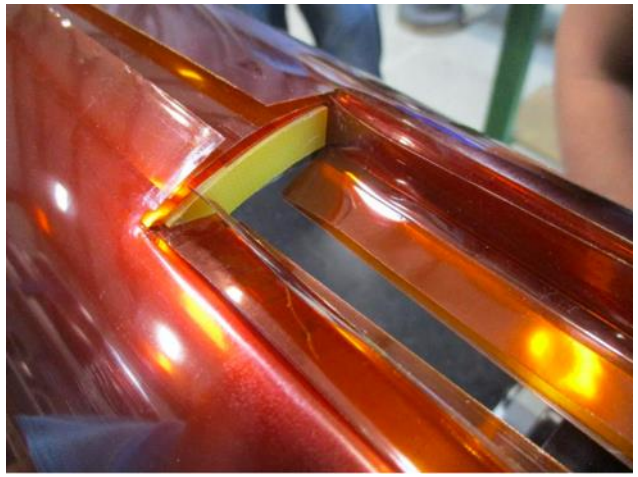


Ground insulation scheme

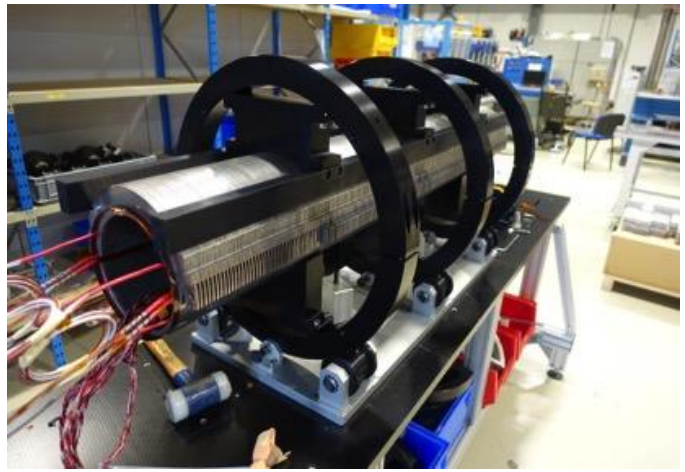


Collaring shoe assembly

Transfer of second inner coil



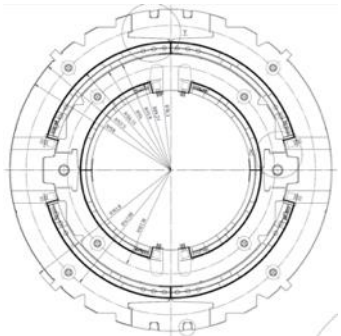
Ground insulation

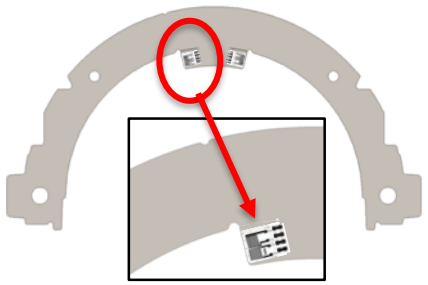


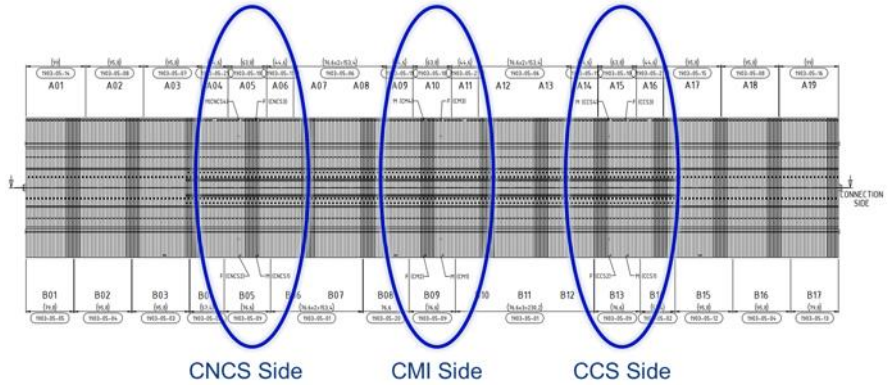
Collar pack assembly

Mechanical measurements during assembly process

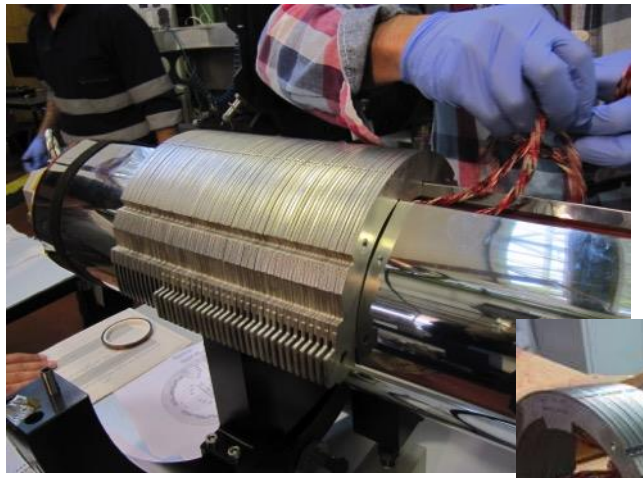
- Collar packs equipped with strain gauges are used during the assembly process for azimuthal strain measurements
  - 12 instrumented collars
  - 3 magnet sections equipped
  - Instrumented collars equipped for temperature and magnetic field compensation for the prototypes





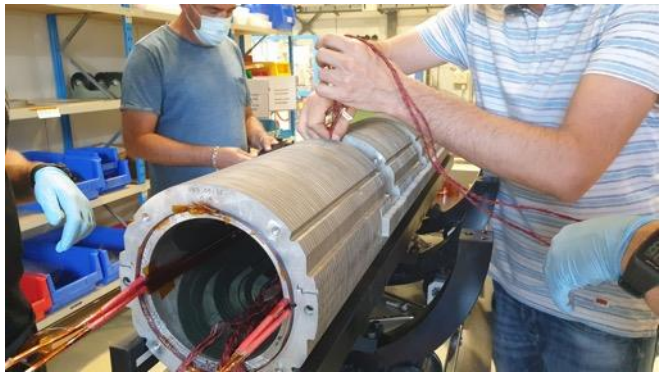


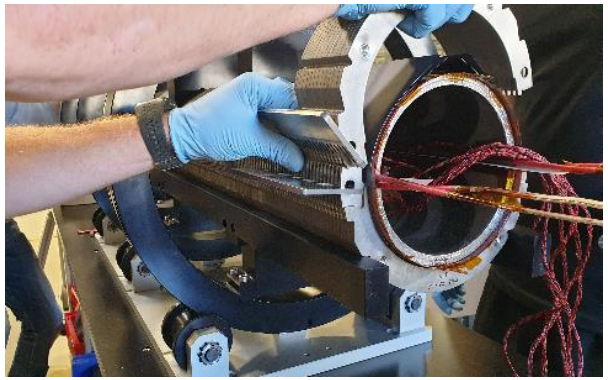
Collars Location



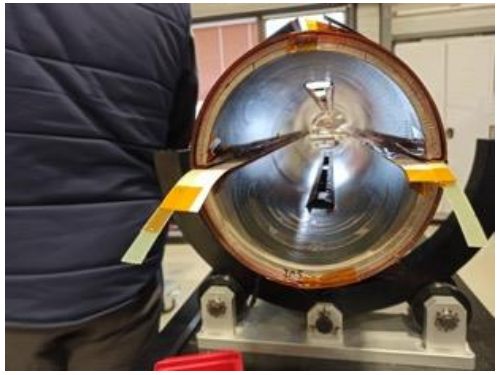
The targeted strain will be validated under the collaring press and the instrumented collars will be removed during series production

Inner dipole collars assembly



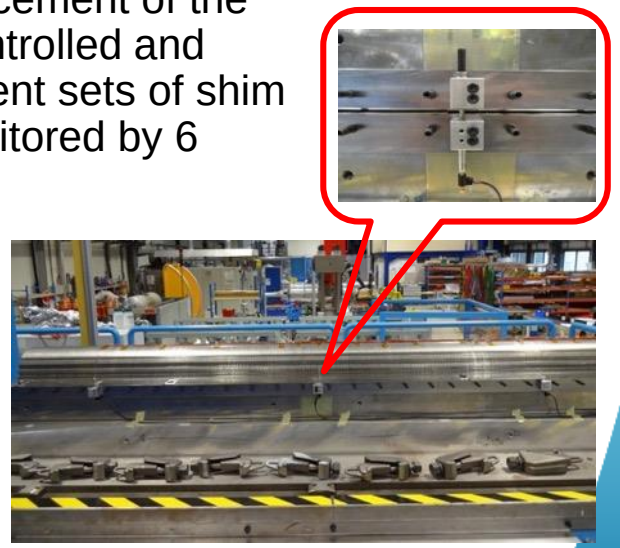


The inner dipole is assembled using temporary instrumented collar- packs



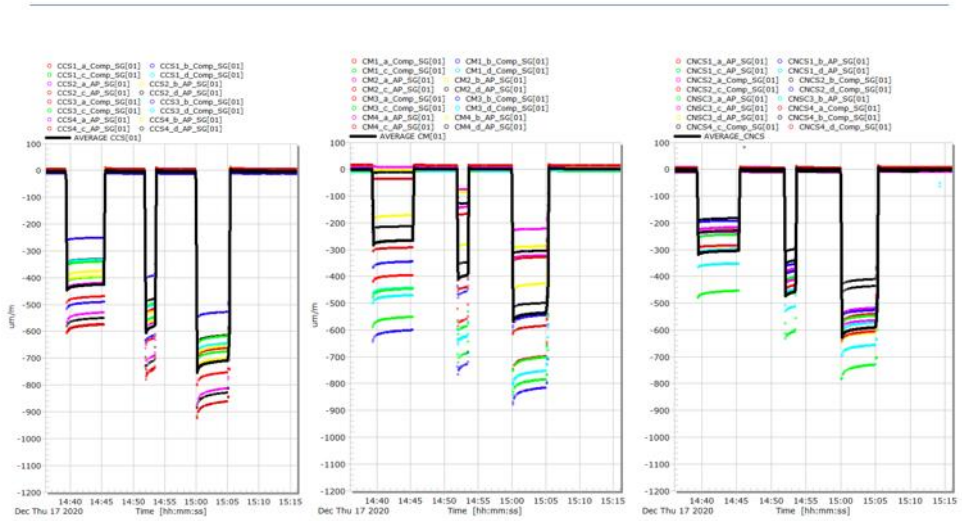
Strain sensitive Fuji paper is inserted in the mid-plane to confirm a homogenous contact over the full coil length.

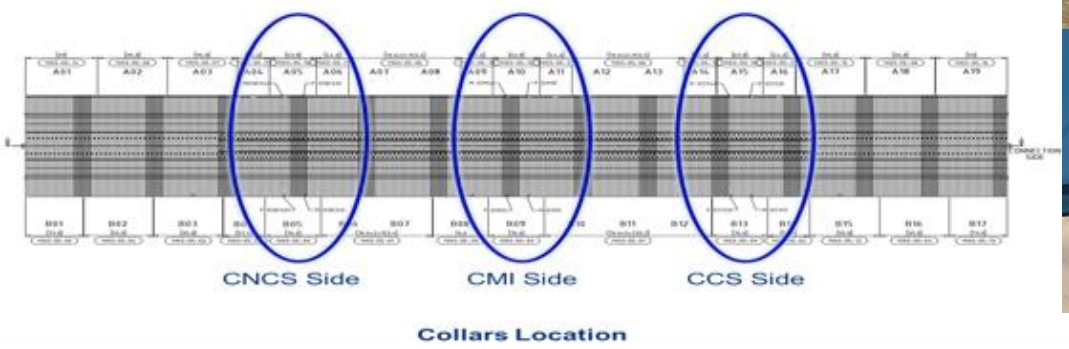
The relative displacement of the collaring tool is controlled and limited using different sets of shim thickness and monitored by 6 LVDTs.



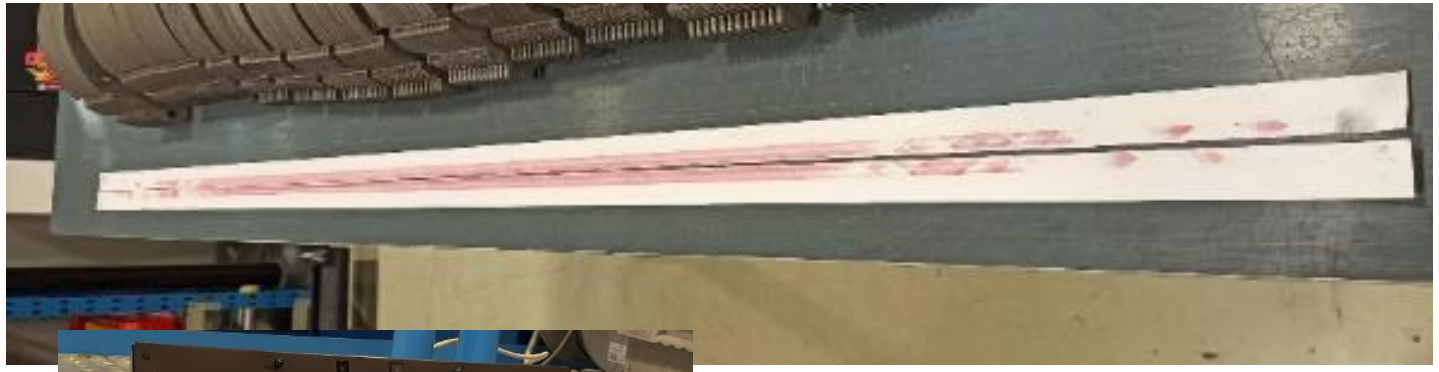
The inner dipole is mounted into the collaring tool and inserted in the collaring press

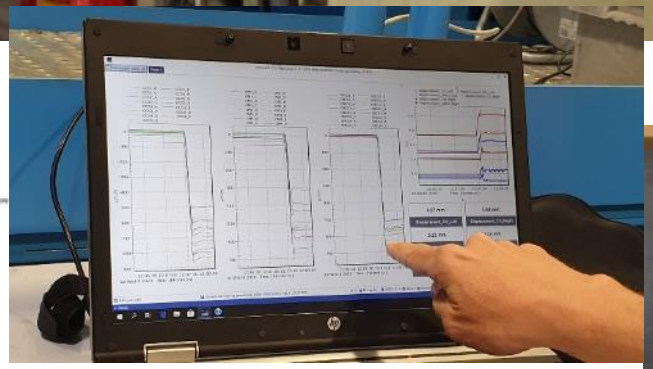
Inner dipole pre-collaring

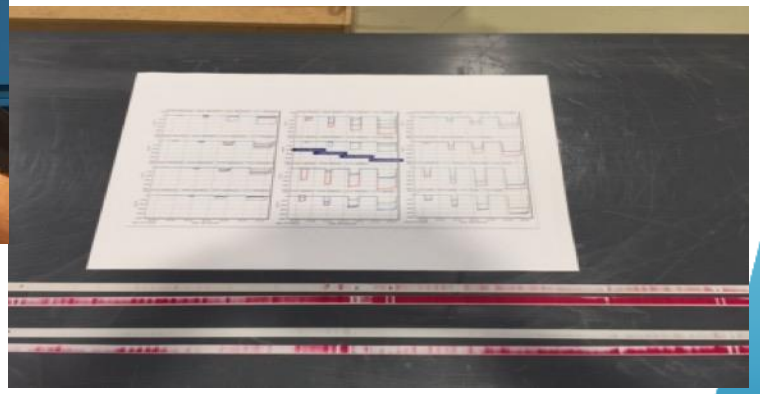




Gap	cs	cm	cncs	mean	prediction	max	min
1	85	53	53	64		119	2
0.8	114	78	82	91	98	145	15
0.6	139	105	108	117	133	168	43

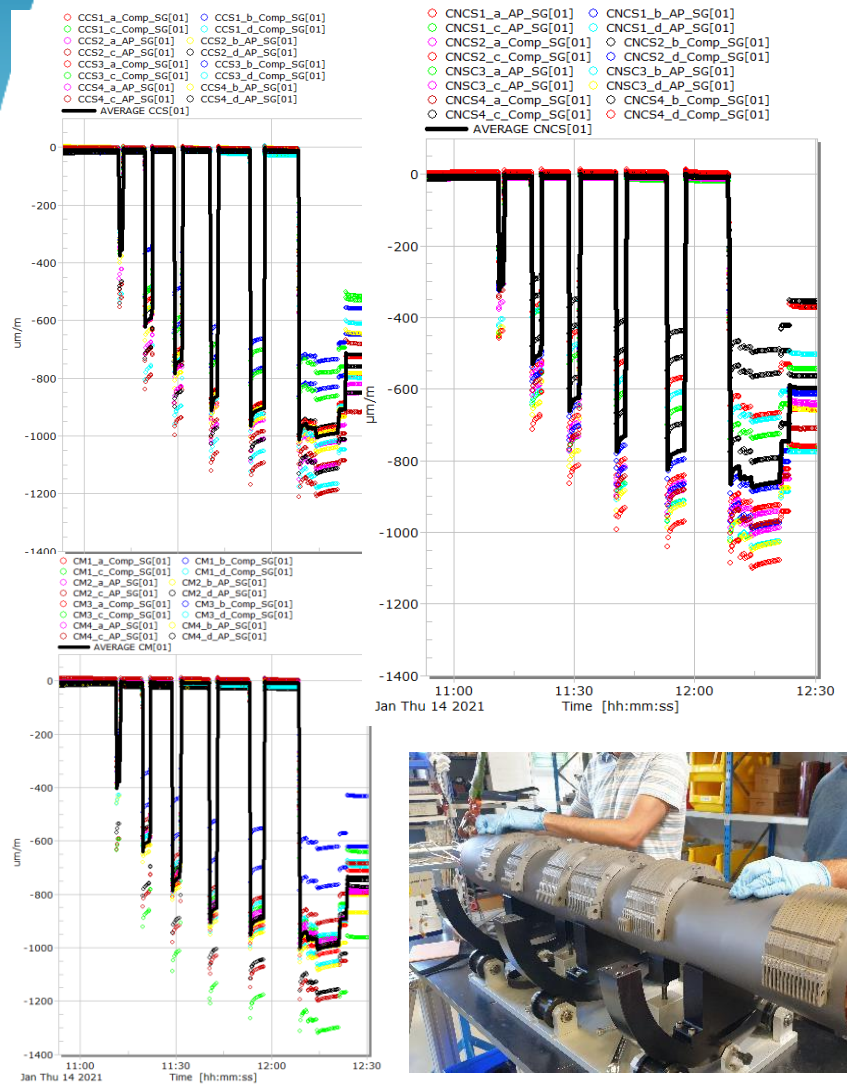




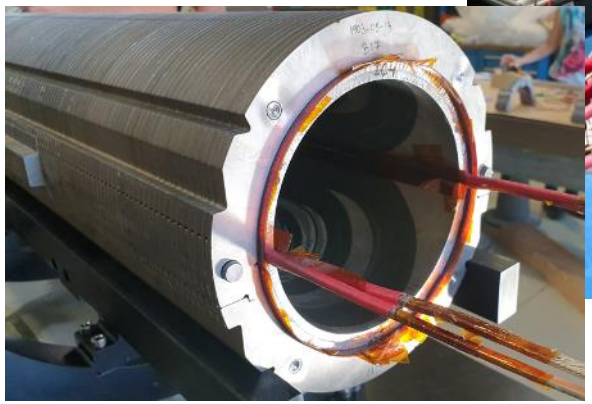


The strain values are monitored and compared with expected values. The coils contact at mid-plane is validated before proceeding with final collaring operation.

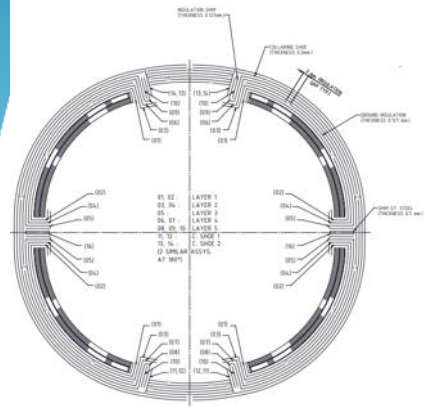
Inner dipole final collaring operation

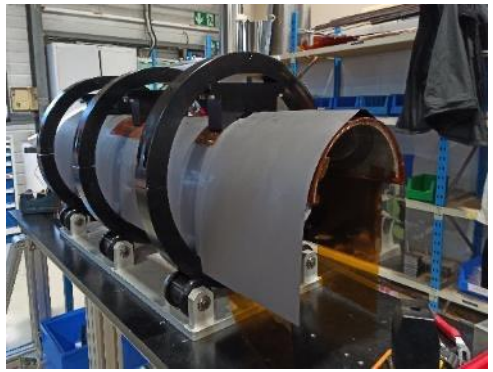
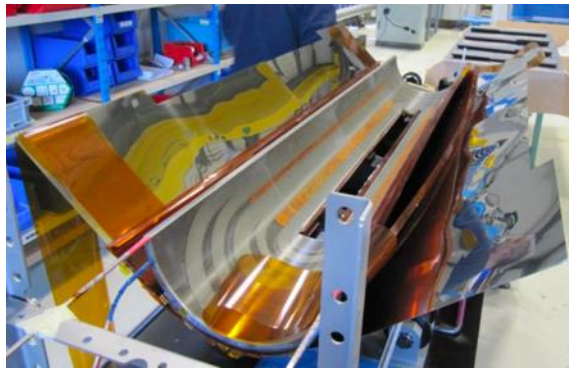


Gap	CS	CM	CNCS	Mean	Prediction	Max	Min
1	69	74	60	68	92	116	30
0.7	116	118	99	111	125	169	57
0.5	144	144	122	137	147	198	68
0.3	168	166	143	159	158	221	80
0.2	177	174	150	167	169	230	85
0.1	192	188	163	181	180	246	93

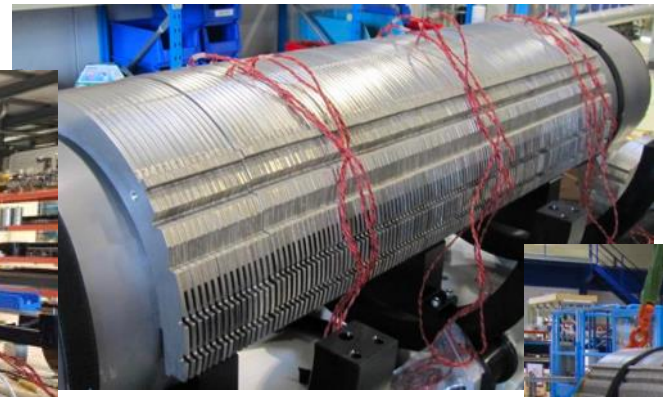


Outer dipole assembly



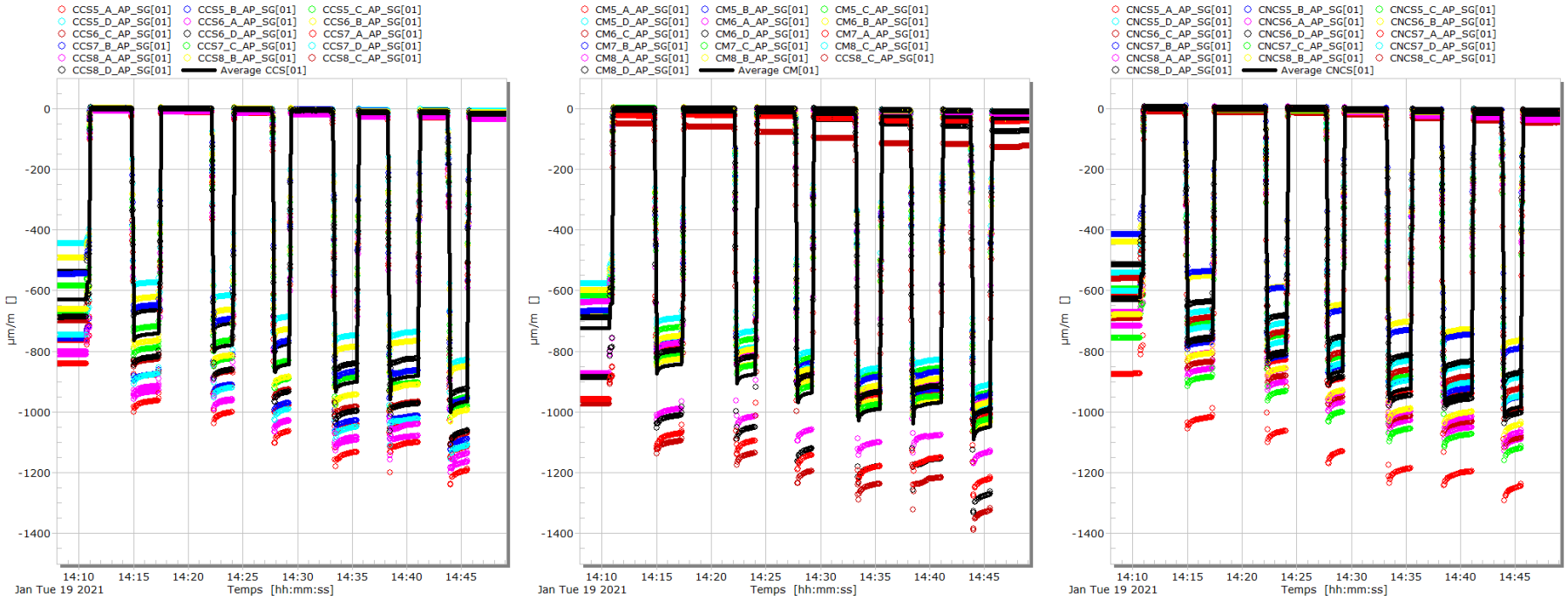





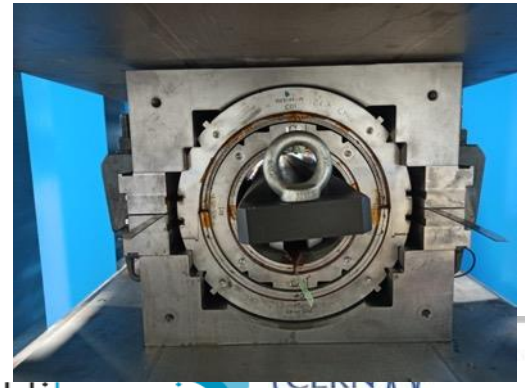


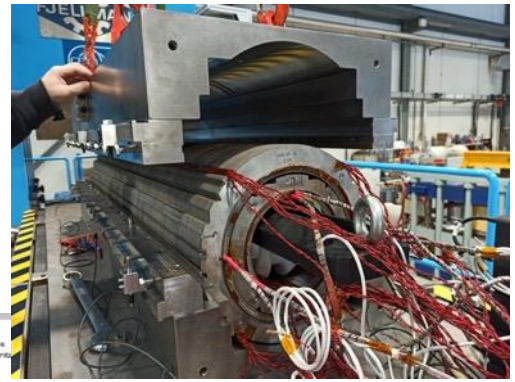
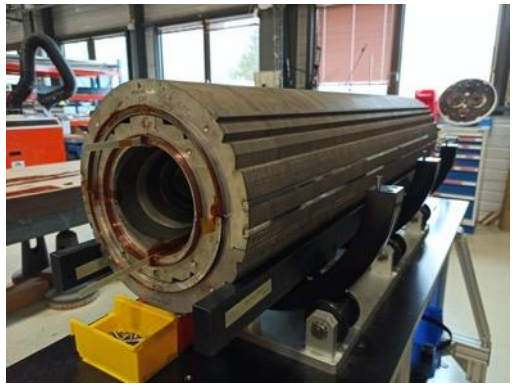
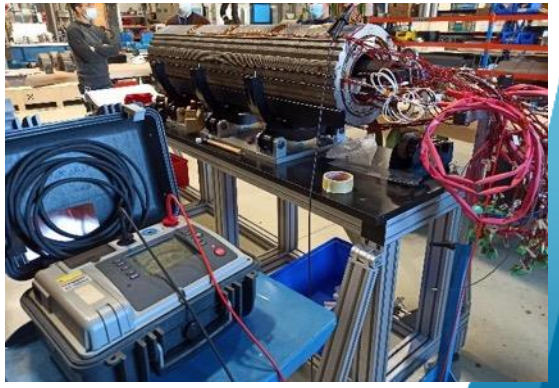

The same assembly sequence used for the inner dipole is applied while assembling the outer dipole

Outer dipole collaring



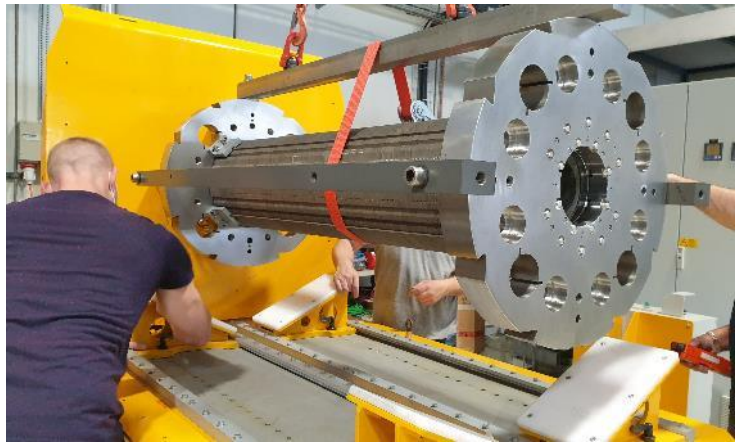
The instrumented outer collars were removed before the final collaring operation



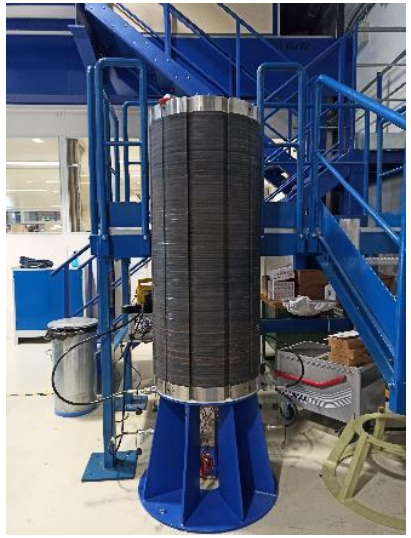




Magnetic yoke assembly

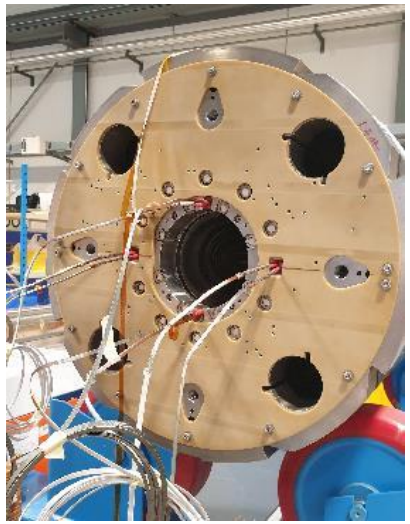
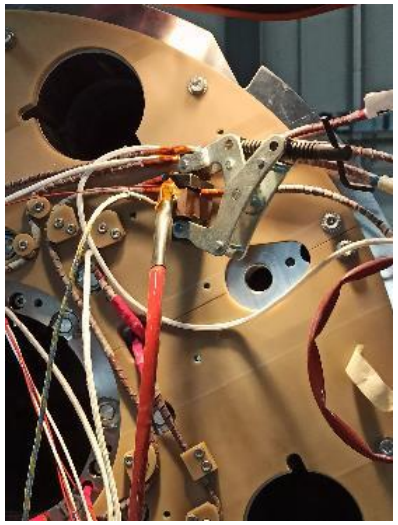
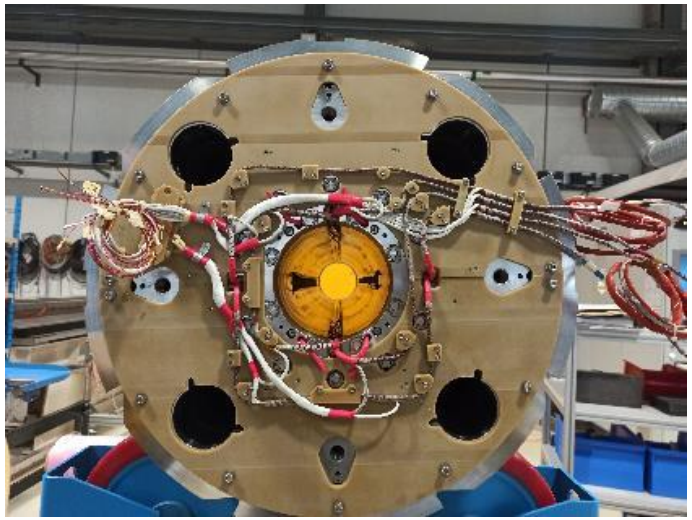
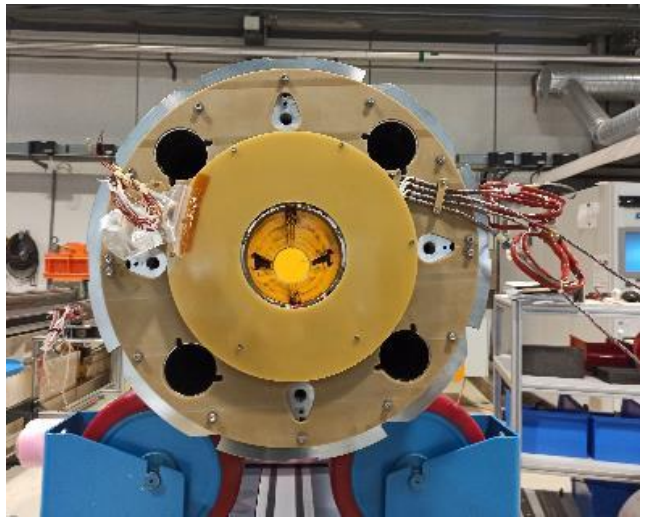




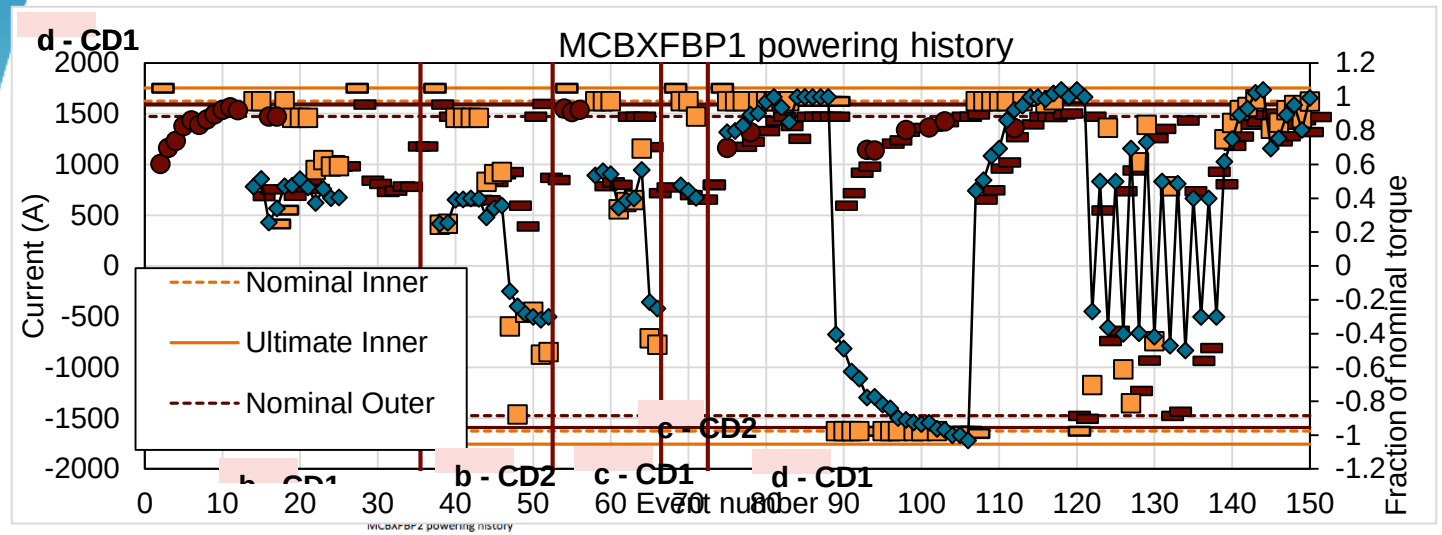




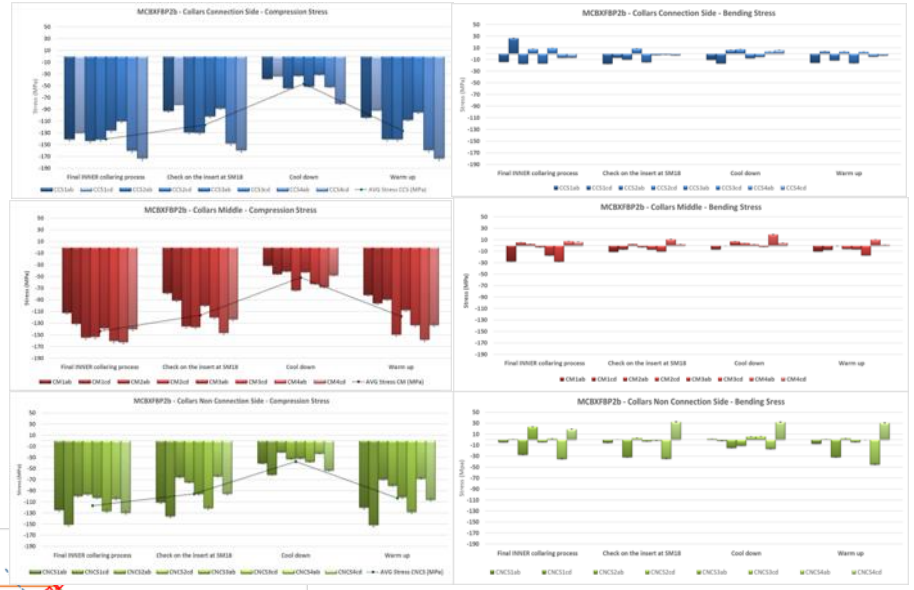

Electrical Connections & Warm Magnetic Measurements

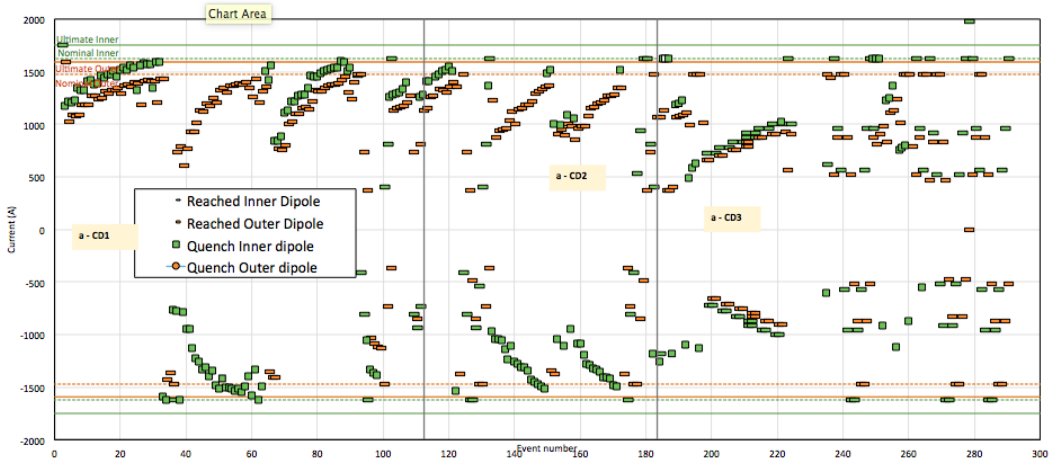





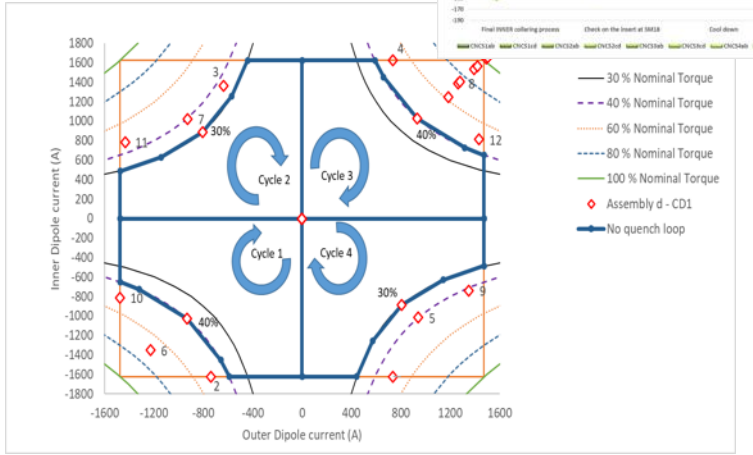

MCBXFBs prototypes powering campaign

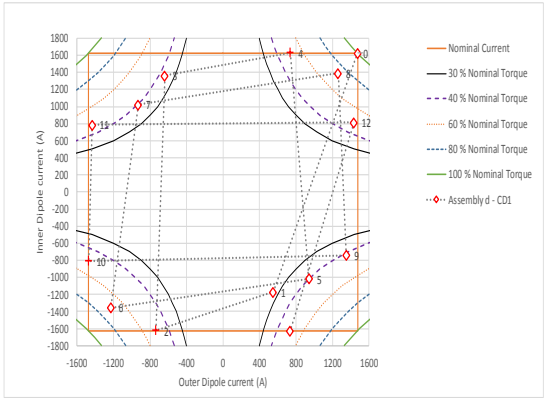


Mechanical measurements



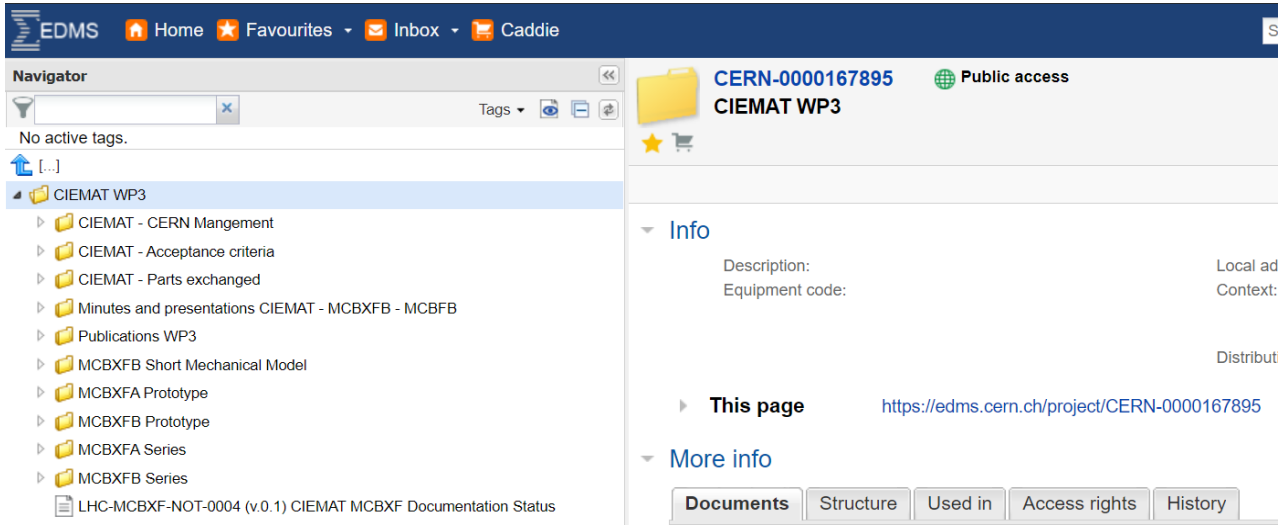


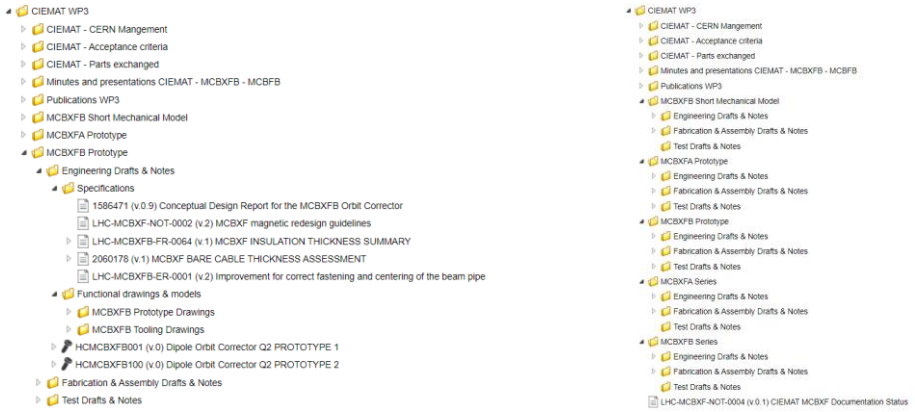


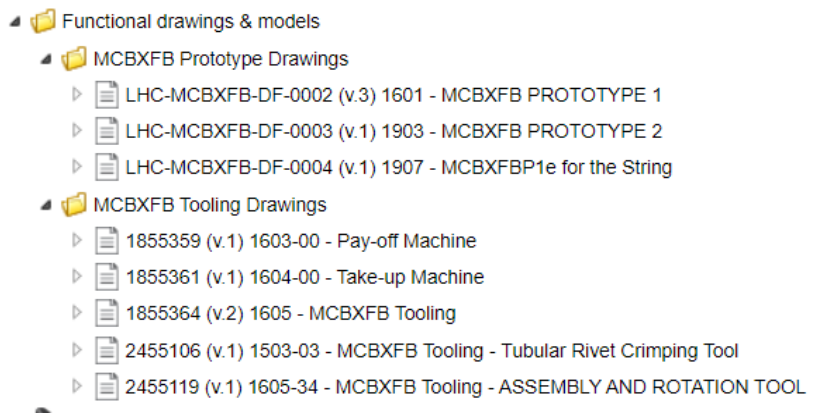


Intensive powering tests campaign: several thermal cycles, around 600 events and more than 300 quenches.

Documentation







- QA/QC structure is ready in EDMS. All drawings and fabrication records from the prototypes are accessible
- Detailed assembly procedures optimised during the prototype construction phase as well as hundreds of pictures are available
- MIP document ready

Lessons learned and Conclusion

- The final coil geometry needs to be precisely measured to provide the required inputs for shimming calculation.
- The fabrication quality and accuracy of the shims is a key point for final magnet performance and field quality.
- The validation of the contact surface between coils using FUJI sensitive paper is a crucial step during assembly.
- Coil preload at room temperature needs to be validated by strain gauge measurements.
- The fabrication and test of 2 MCBXFB prototypes has proved a reproducibility of the magnet performance.
- Both prototypes were assembled several times to optimise their performance.
- Field quality is under control and does not pose significant challenges.
- Both prototypes went through more than 150 quenches each, proving the robustness of the magnet design.
- A fine tuning of the inner coils geometry will be implemented on the next assembly to try to improve magnet performance when changing the torque orientation (see Ezio's presentation).
- QA/QC, MOP, MIP documentation ready.
- Many pictures illustrating each fabrication step are available.
- The assembly of the next MCBXFB01 at CERN will be an unique occasion for ELYTT crew to get trained with a real magnet.
- I encourage ELYTT management to organise a visit to our laboratory for one of their technical staff during the assembly of the next magnet foreseen from last week of May onwards.

Acknowledgements to:

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Beatriz Almeida, Marta Bajko, Isabel Bejar, Nicolas Bourcey, Raphael Bouvier, Cristina Castro, Ruth Diaz, Hugues Dupont, Nicolas Eyraud, Elena Fernandez, Salvador Ferradas, Paolo Fessia, Bertrand Fornes, Jean-Luc Guyon, Hector Garcia, Michael Guinchard, Lucio Fiscarelli. Gregory Maury, Jacky Mazet, Sylvain Mugnier, Francois-Olivier Pincot, Ezio Todesco, Gerard Willering from CERN ….. & many others

Thank you for your attention.