



MCBXF Magnet production at CIEMAT

Carla Martins (CIEMAT)

On behalf of MCBXF CERN-CIEMAT Collaboration

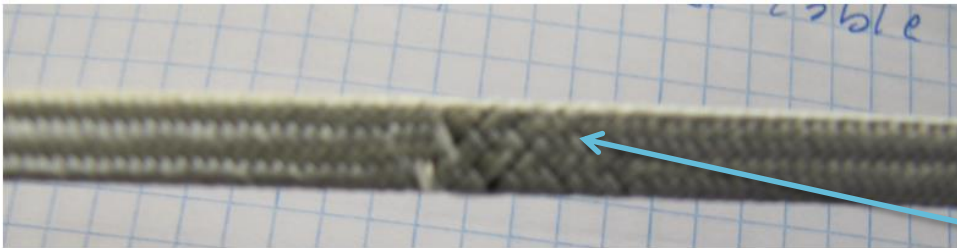
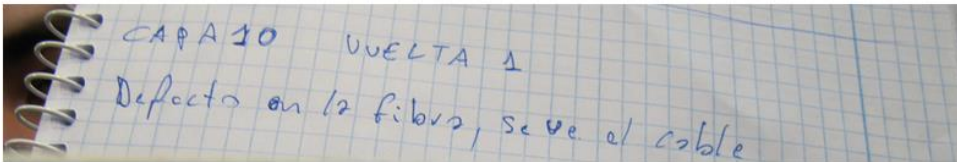
Series Production kick-off meeting – 23rd April 2021



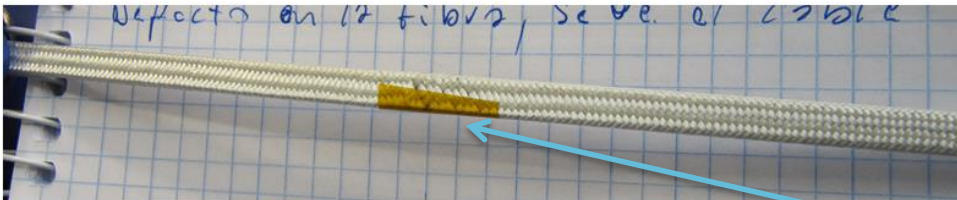
MCBXF Cable Revision

Position

1. Defect in fiberglass insulation. Strand visible at 342-343m approx. (Layer 10, Turn 1):



Visible strand repaired with adhesive kapton (without overlapping).



Defect

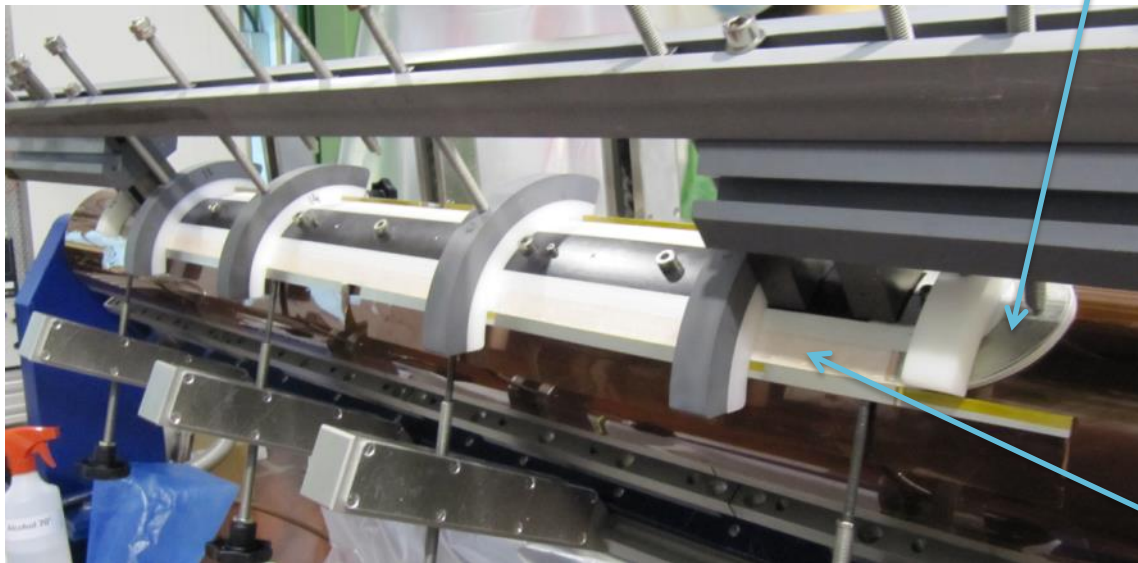
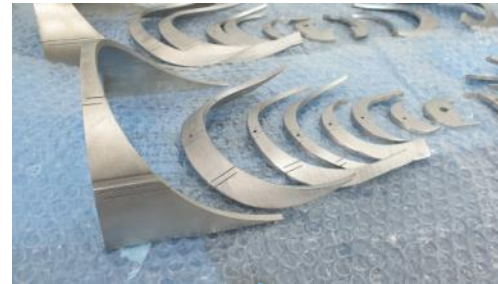
Reparation

MCBXF Coil Winding



Split cable for Inner and Outer Layer

End spacers: 3D printing in stainless steel. Insulated with glass fiber tape impregnated with binder (acetone as solvent)



Winding tension is decreasing while the turns are increasing (from 4.5 kg to 3.5 kg). Measurement of last cable at both ends on every turn registered.

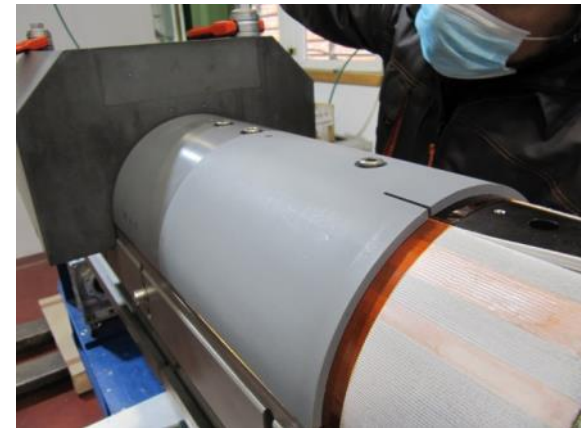
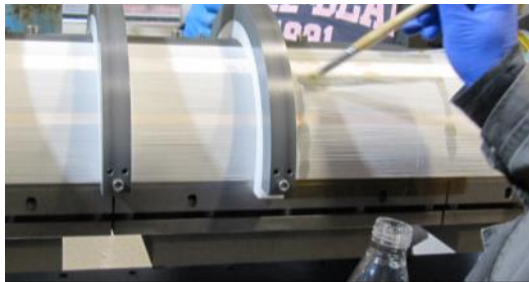
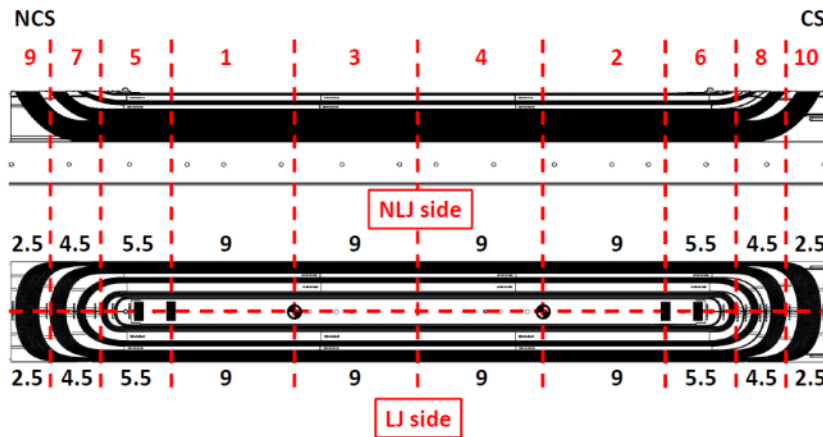
Copper wedges: insulated with glass fiber sleeves glued with binder at both ends

MCBXFB Coil Binding (I)

- We use **binder** (CTD 1.1) with butanone as solvent. Curing at 120°C during 18 hours with slow cooling.

Binder is applied with a **brush**, controlling applied weight by zones.

It is necessary to apply binder on **both layers** (inner and outer). For the inner layer, we use the same mould with **fillers** replacing the outer layer.



Binding mould is assembled at the winding machine. Delicate process to avoid cables loosening

MCBXFB Coil Binding (II)

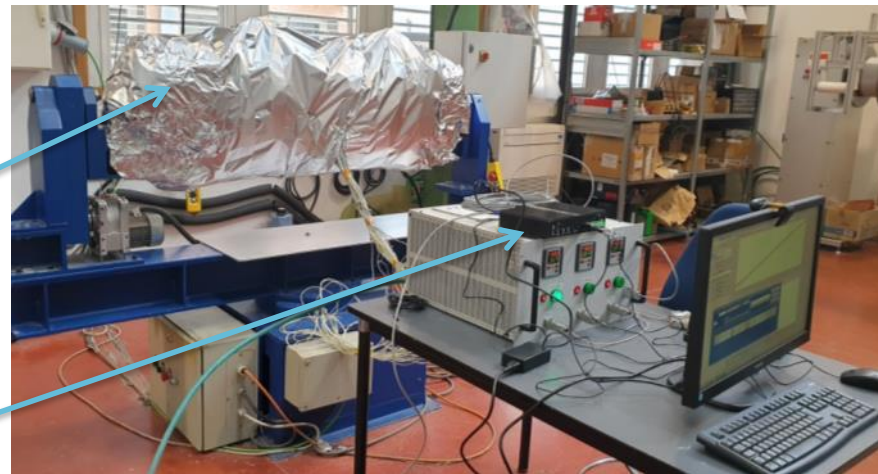
- **Heating** using resistors. The complete mould is thermally insulated with several layers of aluminium foil.



Resistors (4 at each side of the mould and up)

Aluminium
foil insulation

Temperature
control system

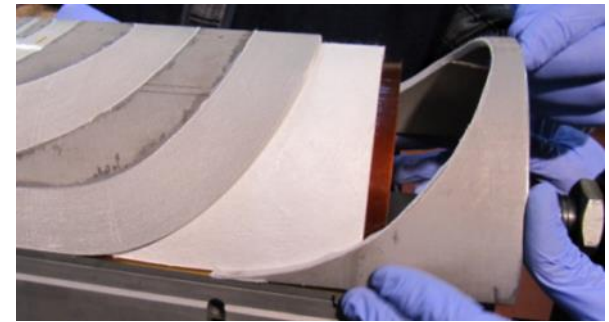


MCBXFB Coil Binding (III)

Important to **avoid wrinkles** in kapton protective sheets during mould assembly. During the curing cycle, more and bigger wrinkles could appear and the cable insulation could be damaged.



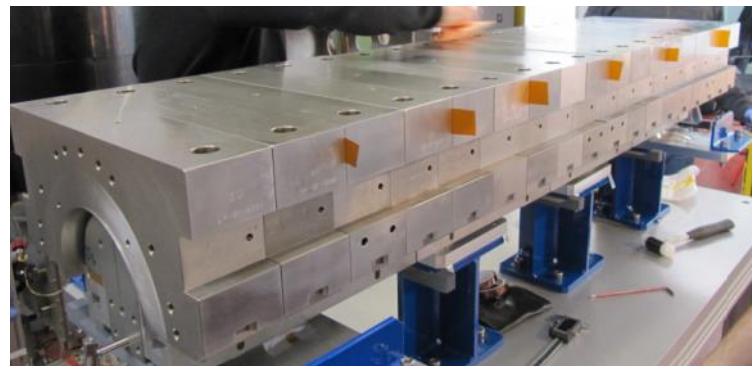
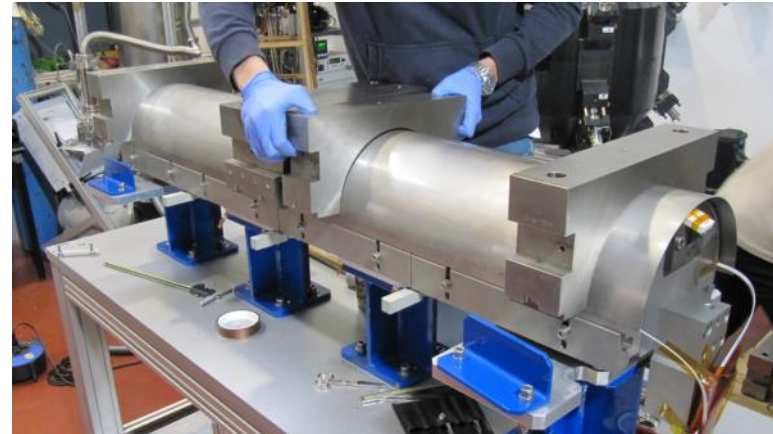
After the binding of each layer, the **final end spacers** must be adapted to the last cable block at each end of the coil.



- The coil length **increases** due to the pressure applied by the mould. Elongation usually is larger in the inner layer (winding over kapton foil) than in the outer one (winding over Nomex, less smooth).
- The coil is now **rigid** enough to be manipulated during the next steps of the fabrication.

MCBXFB Coil Impregnation (I)

- The tasks needed to prepare the coil for impregnation take place in a custom table



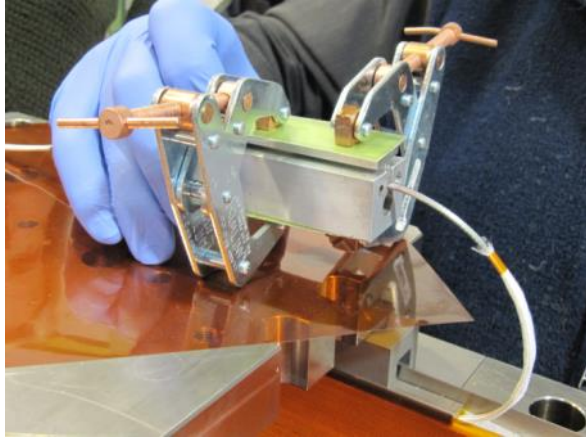
MCBXFB Coil Impregnation (II)

- Lifting of the winding mandrel is very delicate operation. It is important to be very careful with the previous steps to avoid damaging the coil



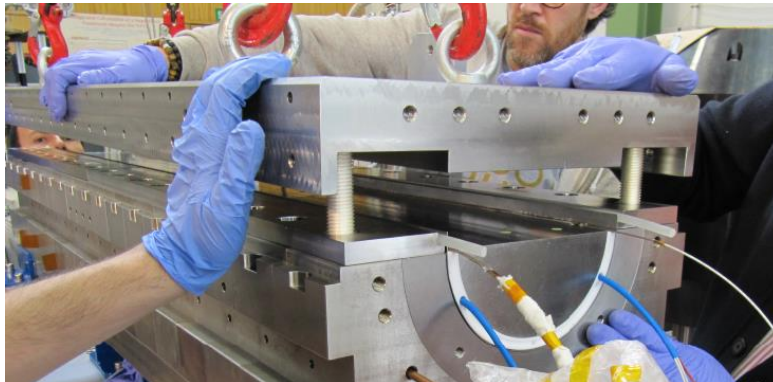
MCBXFB Coil Impregnation (III)

- **Tinning mould** used to stabilize the current leads of the coil



Stabilized and insulated
current lead

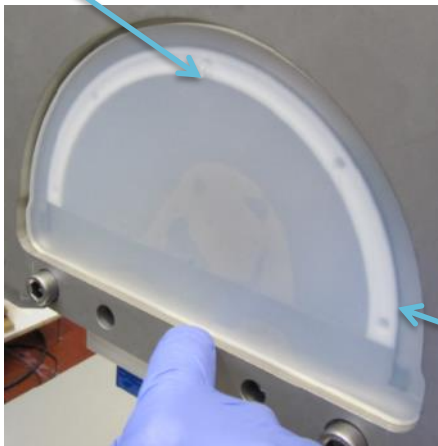
- Intermediate measurements between impregnation mould parts and adjustments needed to ensure that everything is in place (to avoid/minimize leaks).



MCBXFB Coil Impregnation (IV)

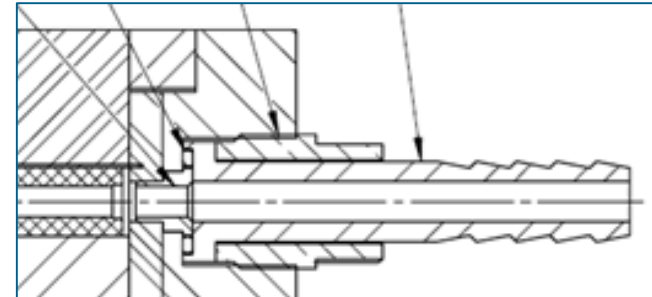
- Transversal mould closing with silicone seals is also very delicate. To avoid the expansion of the resin entrance (& exit) holes, a new design has been implemented.

Hole



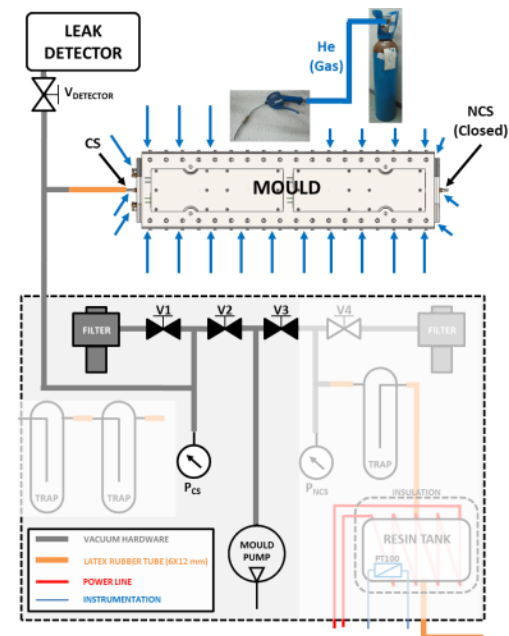
The hole in the silicone seal must be placed far from the closing sheet (to avoid ripping)

Closing sheet



A first **leak test** of the mould with He gas take place outside the vacuum chamber

A second leak test at **warm conditions** before starting each impregnation process is established to check that the mould is properly sealed



MCBXFB Coil Impregnation (V)

- The mould is introduced in a custom **vacuum chamber** to ease vacuum processing. The heating of the mould is also made by resistors (up & down the mould).
- The coils are impregnated with **CTD-101K** resin at 60°C (mould and resin). Curing for 16 hours at 125°C.

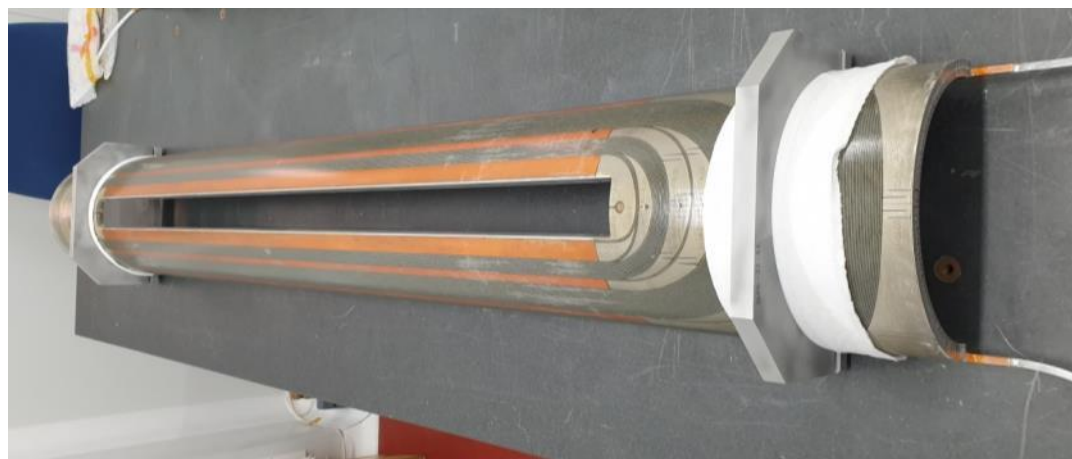
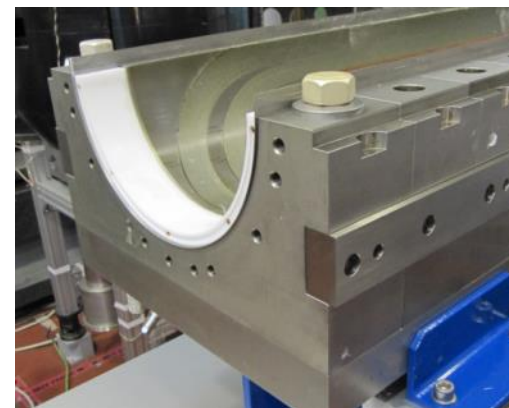


Vacuum chamber



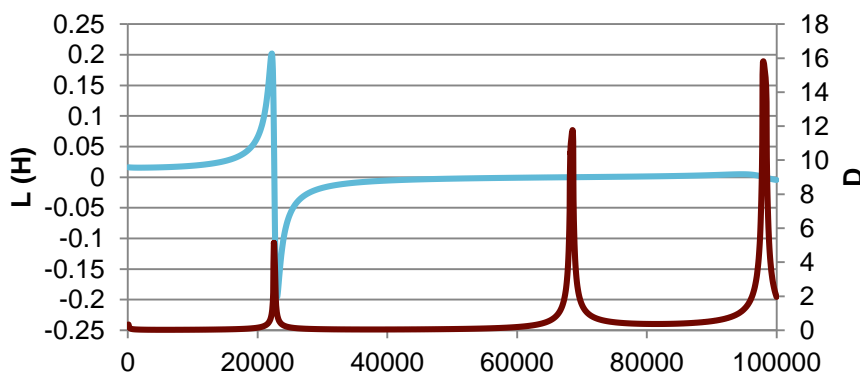
MCBXFB Coil Impregnation (VI)

- Impregnation mould opening



MCBXFB Coil Quality Control

- Dimensional measurements with CMM to control principal dimensions of the coil (length, pole window, midplane). The coil is measured clamped onto the winding mandrel.
- Electrical measurements: resistance, self-inductance and insulation. The self-inductance is measured with a frequency sweep to detect short-circuits, due to the large number of turns



MCBXF Components: Collaring Shoes & GI

Collaring shoes are laser-cut and pre-formed with a custom tooling (0,5mm stainless steel sheet).



Ground insulation (kapton foils) pre-formed at 140°C heating during 6 hours.

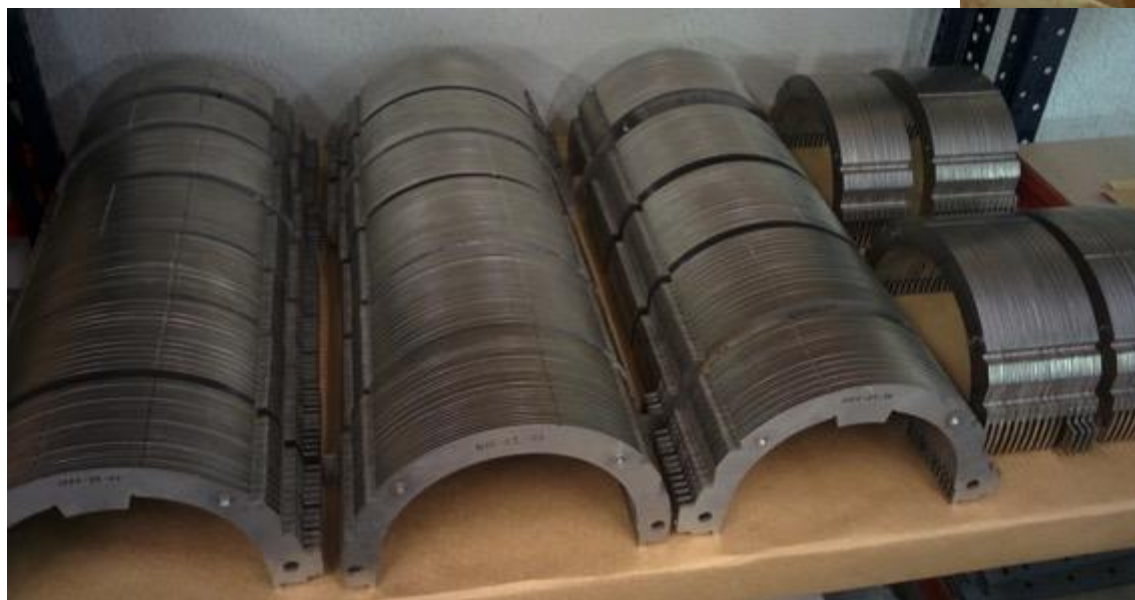


MCBXF Components: Collars

Prototype collars manufactured
by EDM wire-cut

Collar sets assembled using a
custom tooling

Instrumentation done at CERN



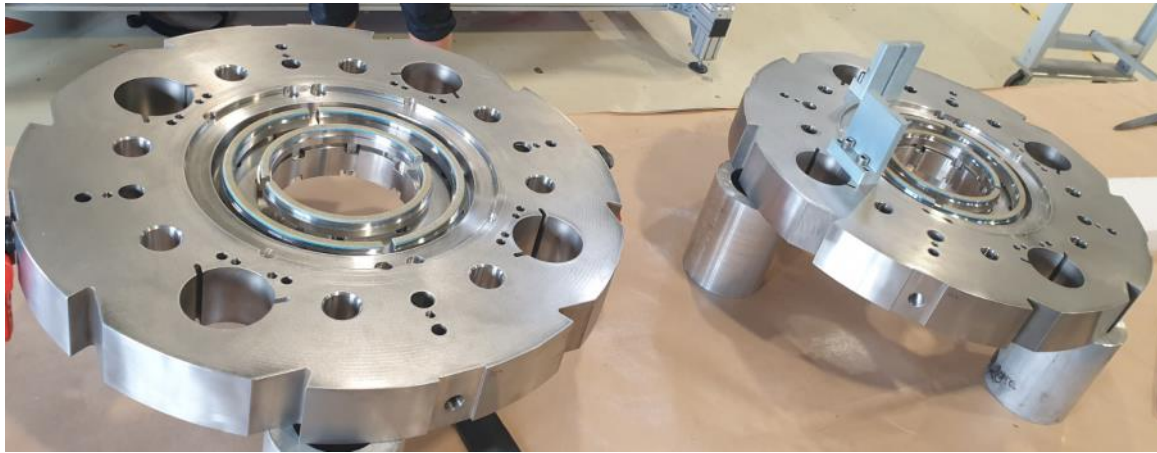
MCBXF Components: Iron Yoke laminations

- Iron laminations for the prototypes manufacturing process:
 - Laser cut
 - EDM wire cut
 - Black oxide for surface protection



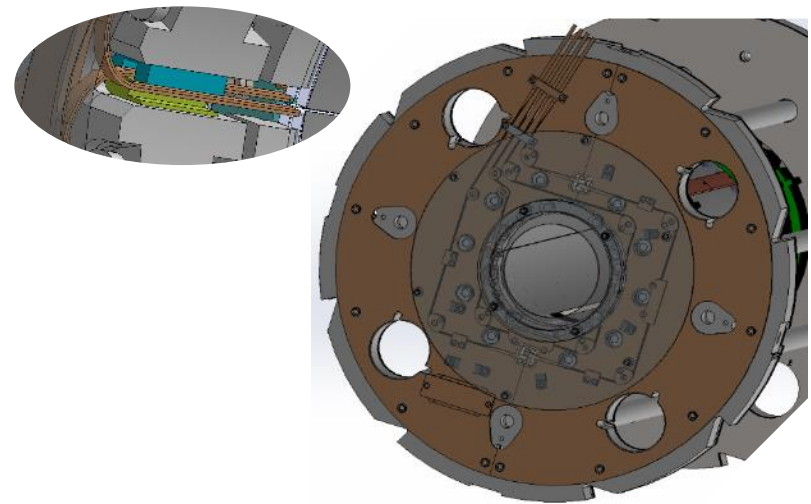
MCBXF Components: End Plates & Rods

Two 70mm thickness endplates (stainless steel), with eight rods (also stainless steel) compress the iron laminations



MCBXF Components: Connection Plate

Duratron and G10 parts (radiation resistant)



Summary (I)

- Cable revision (and reparation of insulation defects if any).
- Coil winding:
 - Decreasing tension (from 4,5kg to 3,5kg). Cable position at both heads monitoring (compare with nominal values, and other coil data).
 - Insulate (glass fiber tape) all components in touch with cable.
- Coil binding:
 - CTD 1.1 with butanone. Control quantity applied by weight.
 - Avoid kapton wrinkles.
- Coil impregnation:
 - CTD 101K resin.
 - Lifting of the winding mandrel and closing of the impregnation mould is a delicate operation.
 - Leak test of the mould at room temperature + leak test (in vacuum chamber) at warm temperature.

Summary (II)

- Coil quality control:
 - Dimensional measurements with CMM.
 - Electrical measurements (resistance, self-inductance and insulation).
- Other magnet components:
 - Ground insulation (GI).
 - Collaring shoes.
 - Collars.
 - Iron Yoke laminations.
 - End Plates and Rods.
 - Connection Plate.

Thanks for your attention