



## Status of nested corrector activities

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13<sup>th</sup> HL-LHC Collaboration Meeting – 25<sup>th</sup> Sept 2023



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# One year ago: executive summary

- Magnet **series** fabrication was ongoing at **Elytt Energy** facilities.
- The second prototype MCBXFBP2 was reassembled at CERN with inner dipole coils produced by Elytt (MCBXFBP2c). Powering tests **validated** the fine-tuning of the design and Elytt coil production.
- The components of the **long prototype** MCBXFAP1 were being manufactured at CIEMAT. The magnet assembly was expected at CERN in November 2022.

# MCBXFA prototype

- This is the **longest** magnet ever produced at CIEMAT.
- The coil production **tooling** was modified to produce inner coils with shorter pole window, like B-type magnets (fine-tuning of the design).
- We used the same **fabrication techniques** that are being used for the B-type coils.
- Same production strategy than followed in previous prototypes:
  - The **components** were produced at CIEMAT.
  - **Assembly** was done at 927 laboratory (CERN) in November 2022.
  - Tests were done at SM-18 test station (CERN) in December 2022.

# MCBXFA prototype: inner dipole coils (I)



*Inner layer winding*

- No significant difficulties for winding.
- Assembly of binder mould in one day is challenging.

*Binder mould assembly*



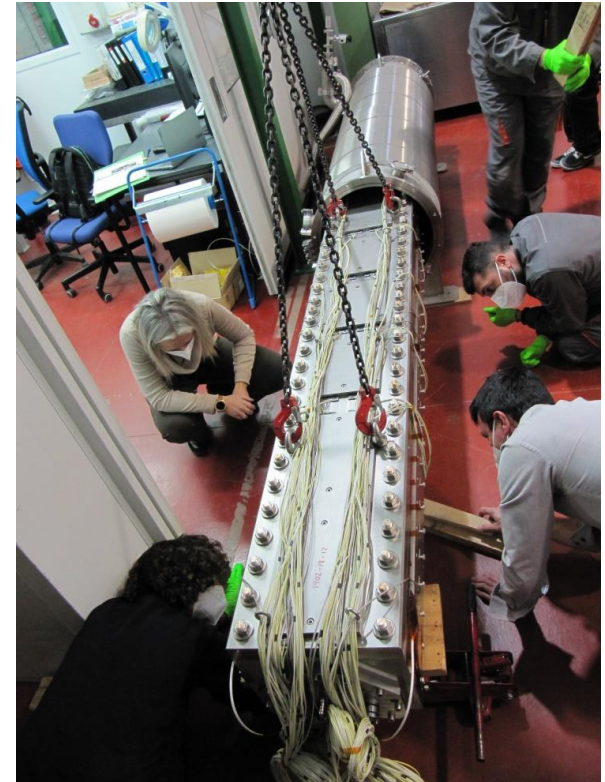


# MCBXFA prototype: inner dipole coils (II)



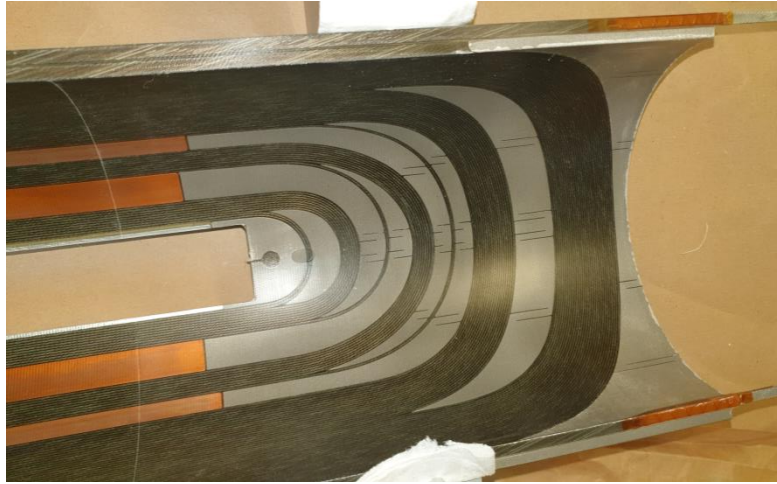
*Inner coil impregnation*

- Assembly of impregnation mould is delicate because of the tight tolerances for such a long coil.
- Long time for resin injection.



*Introduction of impregnation mould into vacuum chamber*

# MCBXFA prototype: inner dipole coils (III)



*First finished inner coil*





# MCBXFA prototype: outer dipole coils



*First layer winding*

*Impregnation mould assembly*



- Difficult winding of inner layer (105 turns).
- Challenging assembly of impregnation mould.
- Very slow injection of resin.



# MCBXFA prototype: assembly at 927 laboratory

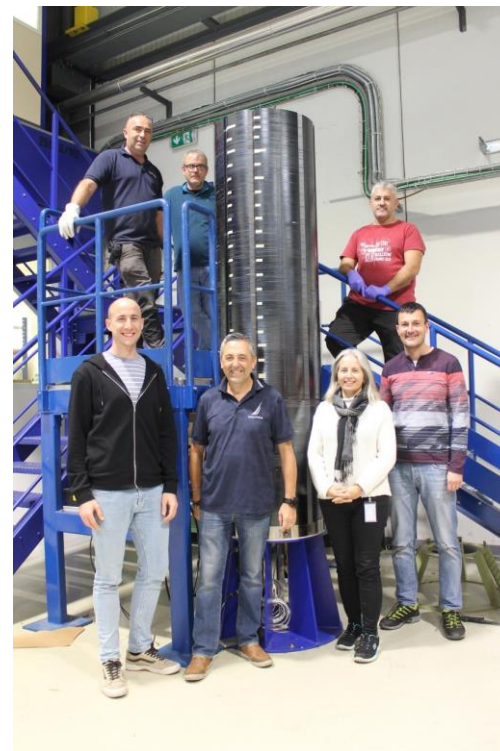


*Assembly of inner collared dipole*



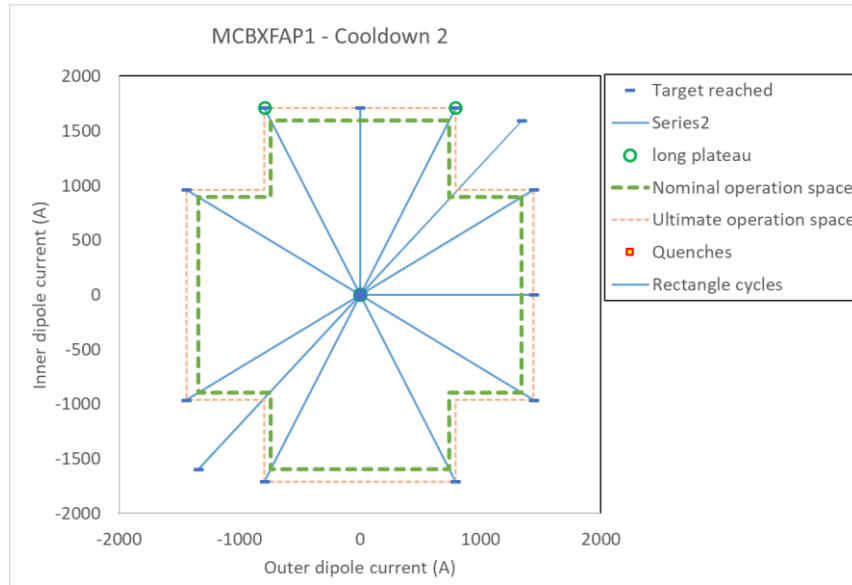
*Inner dipole at collaring press*

- Challenging assembly but...
- No major incidents due to the gained experience on short magnets and the excellent team.



*Assembly of iron yoke*

# MCBXFA prototype: powering test at SM18 facility at CERN



- **Excellent results:** all requirements were fulfilled.
- Only one quench in the first cool down.
- Nice field quality.



Long prototype magnet at insert

# MCBXF prototypes: assembly in cold mass at CERN



*Assembly of long nested corrector into the cold mass*



*Cryostat including long nested and high order correctors*

- The long corrector prototype is being assembled with the high order correctors into a cold mass for the **HL-LHC string**.

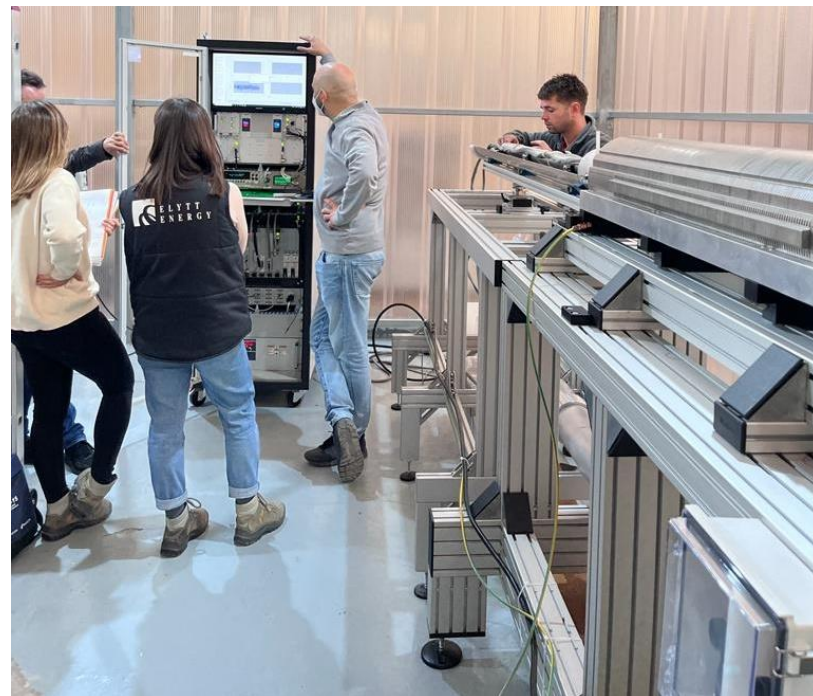
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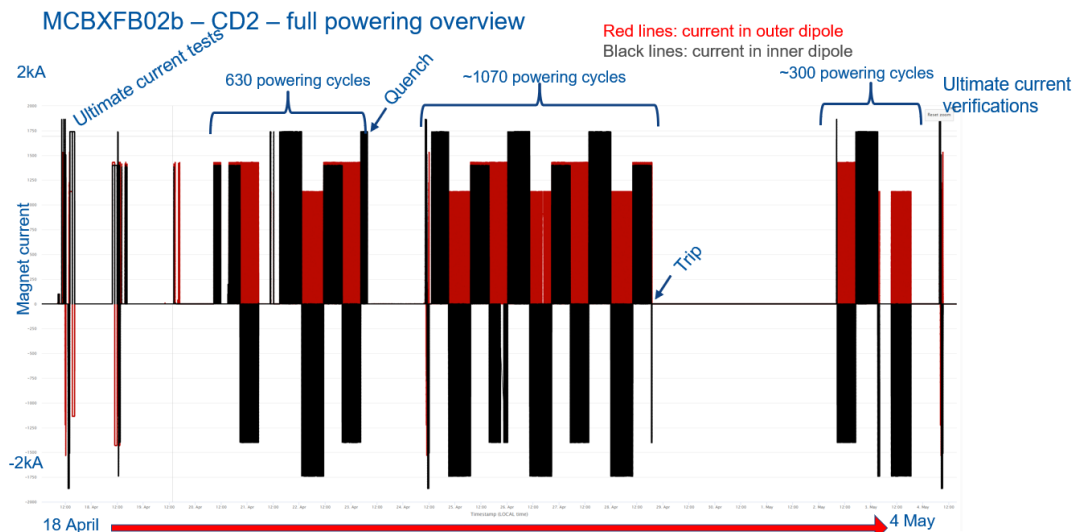
# Summary: short magnet series production

- About two thirds of the coils are already produced.
- Two short magnets (B02 and B03) are delivered to CERN and accepted after power tests, ready for cold mass assembly.
- The assembly of the short magnet B04 is being finished.



*Magnetic measurement bench*

# Summary: power test of short series magnets



- **Weak electrical insulation** in outer dipole B02. The origin of the problem was the **collaring press** at Elytt. It was successfully reassembled (B02b).
- Successful **endurance test** during the second cool down of B02b.
- No significant problems during **B03** tests, only the training was a bit longer.

# Summary: long magnet series production

- **Inner coils and one outer coil** are ready for the first magnet.
- Second **outer coil** is impregnated.
- Part of the **tooling** is shared between inner and outer coils: coil production must be sequential.



*First long inner coil produced at Elytt*  
13<sup>th</sup> HL-LHC Coll. Meeting – F. Toral - 25<sup>th</sup> Sept 2023

# MCBXF magnet series: quality assurance

- **Quality controls** of each step of production are defined in the manufacturing and inspection plan (MIP), both for coils and magnets. Elytt is not uploading these reports in time.
- There is a high number of **non-conformity reports**. Some of them are repetitive. The main cause is that the technicians are not following the established procedures.
- **A third-party inspector (Cualicontrol)** is following up the production hired by Ciemat. He visits the production plant two half-days per week. He is doing a very good work.
- The **internal organization** of the company should be improved to solve the aforementioned quality problems.
- The dedication of **CIEMAT and CERN staff** to support series fabrication is well beyond the expectations.



# Quality assurance: collaring press

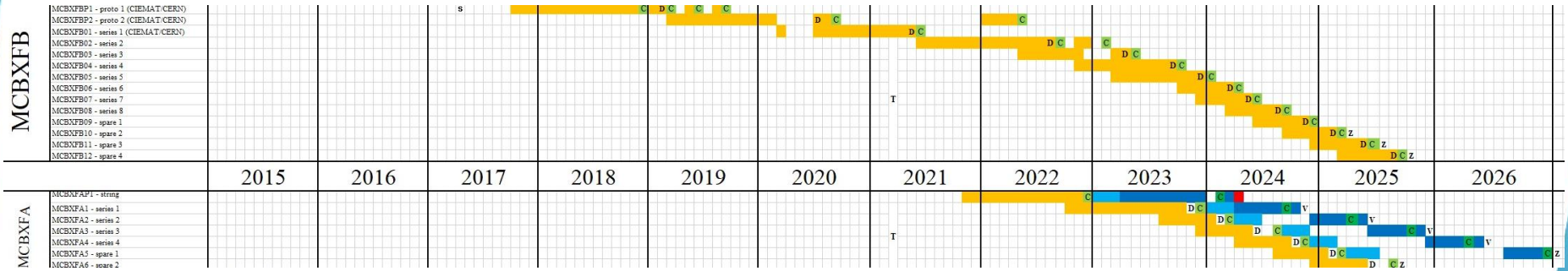
- The parallelism of the upper and lower plates of the **collaring press** is not good.
- The collaring shoes (protections sheets) are **collapsing** inwards, damaging the electrical insulation of the coils.
- The collaring press is being **refurbished**. It is expected to be ready by mid-October. Magnet assembly is stopped till then.



*Collaring sheets are collapsing inwards*

# MCBXF series: schedule

- The present delivery rate needs to be improved to comply with the schedule.
- There is a **continuous shifting** of the schedule due to quality assurance and collaring press problems.



# Conclusions

- The **fine-tuning** of the inner dipole design was also implemented in long orbit corrector magnet.
- The components of the **long prototype** MCBXFAP1 were manufactured at CIEMAT. The magnet assembly and power tests were successfully done at CERN. It is being assembled into the **cold mass** for the HL-LHC string.
- The series magnets are in production at **Elytt Energy**.
- The **first two short series magnets** have been accepted for cold mass assembly. The third one is being finished.
- **Important difficulties with the series production** related with quality assurance and schedule of the production at Elytt Energy. Magnet assembly delayed because a **major need of collaring press refurbishment**. A significant effort of CIEMAT to facilitate solutions. Contingencies under consideration, to be consolidated in the next months, depending on the evolution of the corrections implemented by ELYTT.



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# Reminder: design fine-tuning (MCBXFB01)

- Torque locking is only possible along the OD pole window (828 mm long). ID pole window of magnet prototypes was 946 mm long => 59 mm at each side **without torque locking**.
- MCBXFB01 inner coil length was **shortened by 118 mm** to **reduce the unlocked length** at coil ends.
- In addition, **endspacers** legs were enlarged to increase the rigidity at the transition from the straight section to the coil heads.
- This feature is implemented in **long coils** as well.

Torque locking

