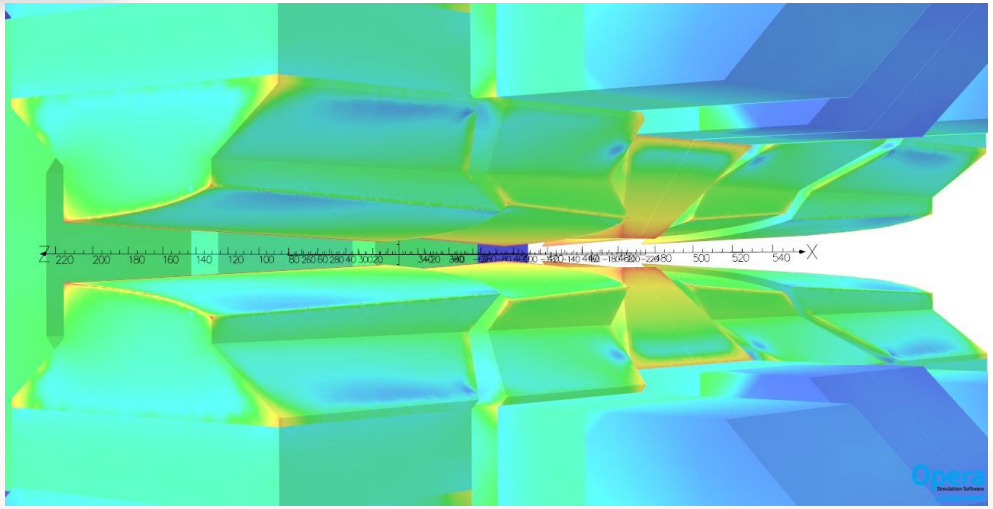
# High-field longitudinal gradient dipole: Assembly and Magnetic Measurements



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CLIC Project meeting 41

# Outline

1. Magnet overview
2. Assembly
3. Magnetic Measurements
4. Conclusions

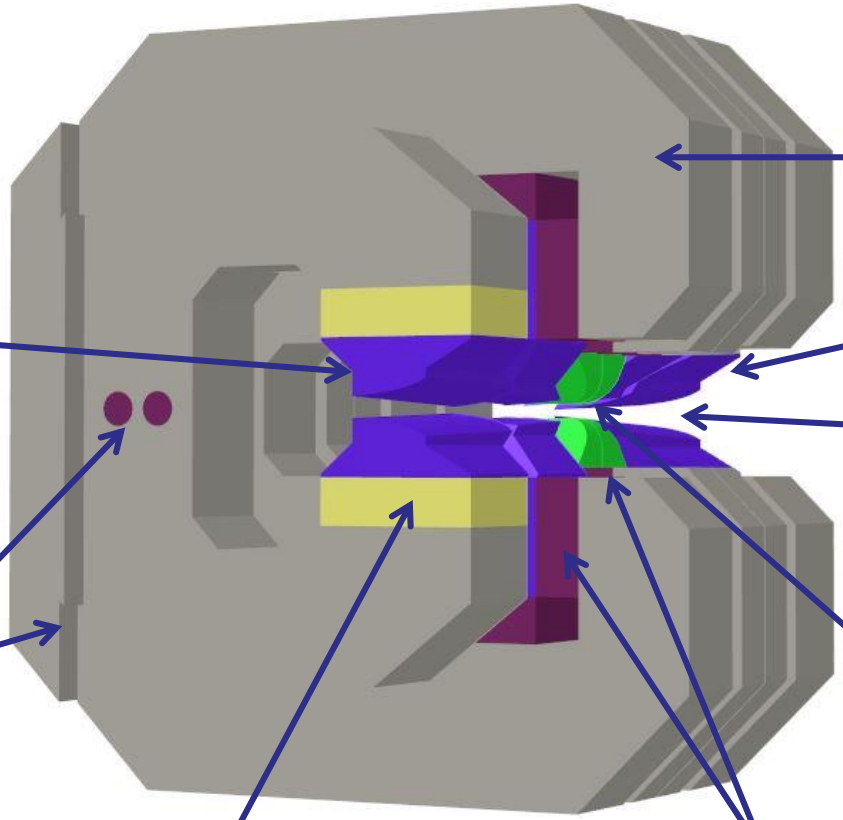
# Magnet Overview

CLIC DRs Main Bending Magnet (Prototype)

Combined Function:
Longitudinal gradient with trapezoidal shape (2.3 T Peak)
Transverse gradient 11 Tm

Dimensions:
0.65 x 0.68 x 0.56 m

Weight: 1.2 T



Steel 1010

Flux concentration

Armco

Hyperbolic pole tips profile

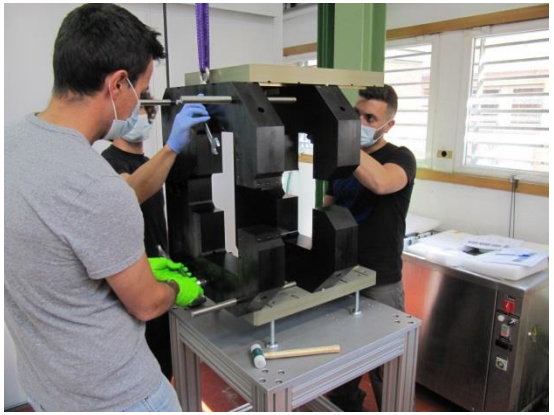
Field trimming

Fe-Co (Vacoflux)
Flat pole tip profile

SmCo in LF

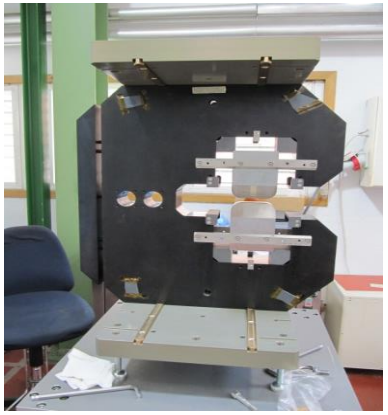
NdFeB in MF and HF

# Preliminary Assembly without Permanent Magnets (PM)

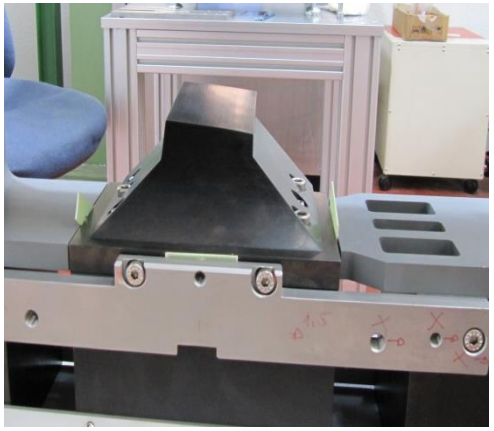


The modules' aproach method was tested

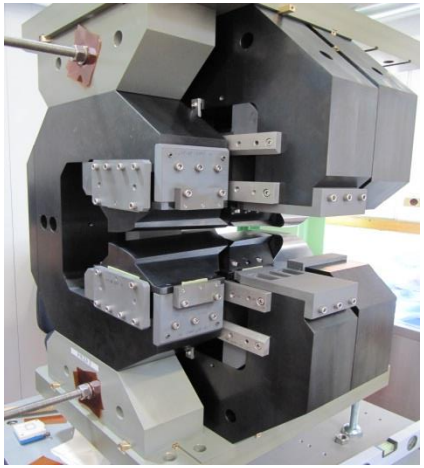
Each module was mounted separately, with all the parts except the PM



Then introduced following the bronze guides fixed to the plates

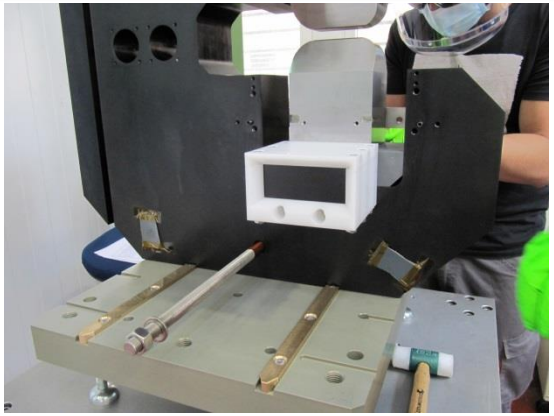


All the poles were fixed in their nominal position using gauges

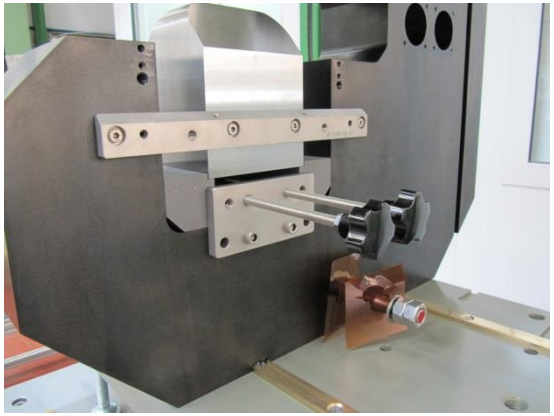


No major issues were found during this part of the process

# Assembly (with PM)



The PM blocks were introduced using a POM box attached to the yoke



The insertion was controlled using these rods and plate…

…that have to be redesigned due to the huge forces involved


Magnetic measurements were done manually after each PM was inserted. Results were very close to simulations.

Once each module had all the magnets in, the controlled aproach started

The process was repeated in each module until the assembly was completed

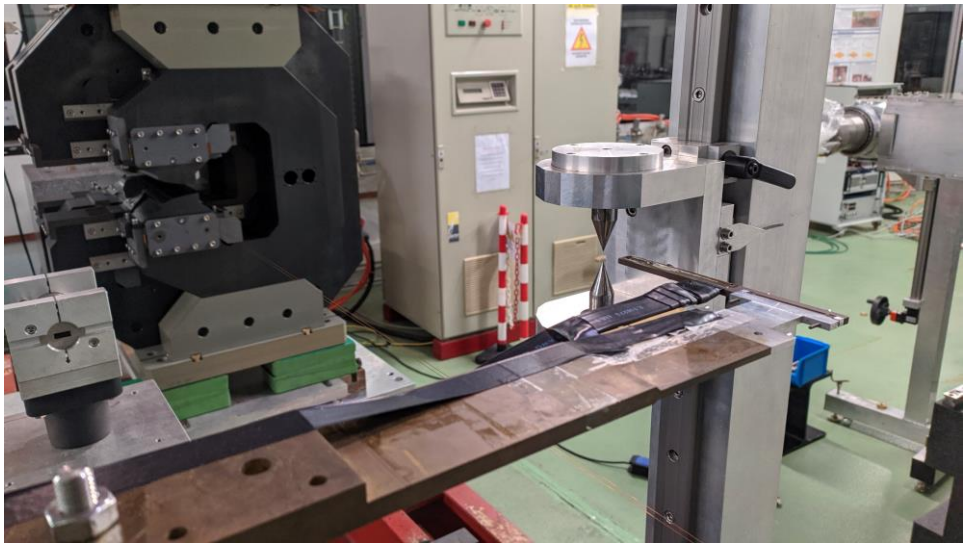
# Assembly: Lessons learned

- Huge magnetic forces involved: always think twice in advance and wear proper protection
- We had to redesign the insertion rods (8mm to 12mm diameter) and their support plates (steel to bronze to reduce friction with the rods), to avoid a possible seize. It stopped the assembly during one month
- The order in which the permanent magnet blocks are inserted is highly important. Simulating all the alternatives we were able to find the optimal order and lower the maximum force seen when inserting them
- The most risky moment is when you are manipulating the PM blocks to insert them in the POM box. An error there can lead to serious personal and material damage
- Everything went smoothly in our assembly!

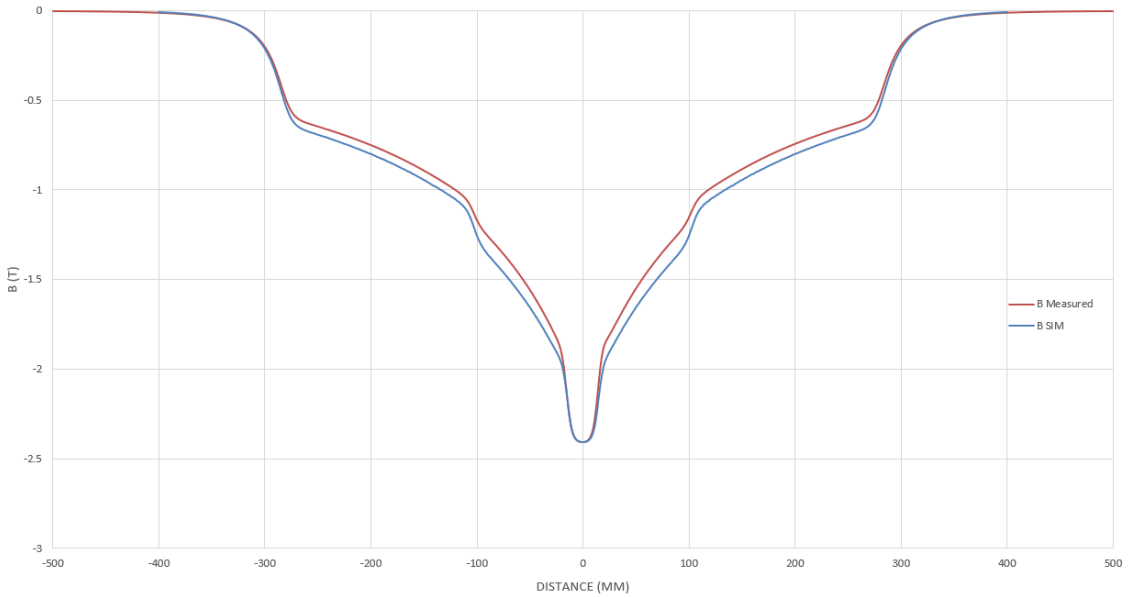
# Magnetic measurements at ALBA

Flip Coil

Hall Probe

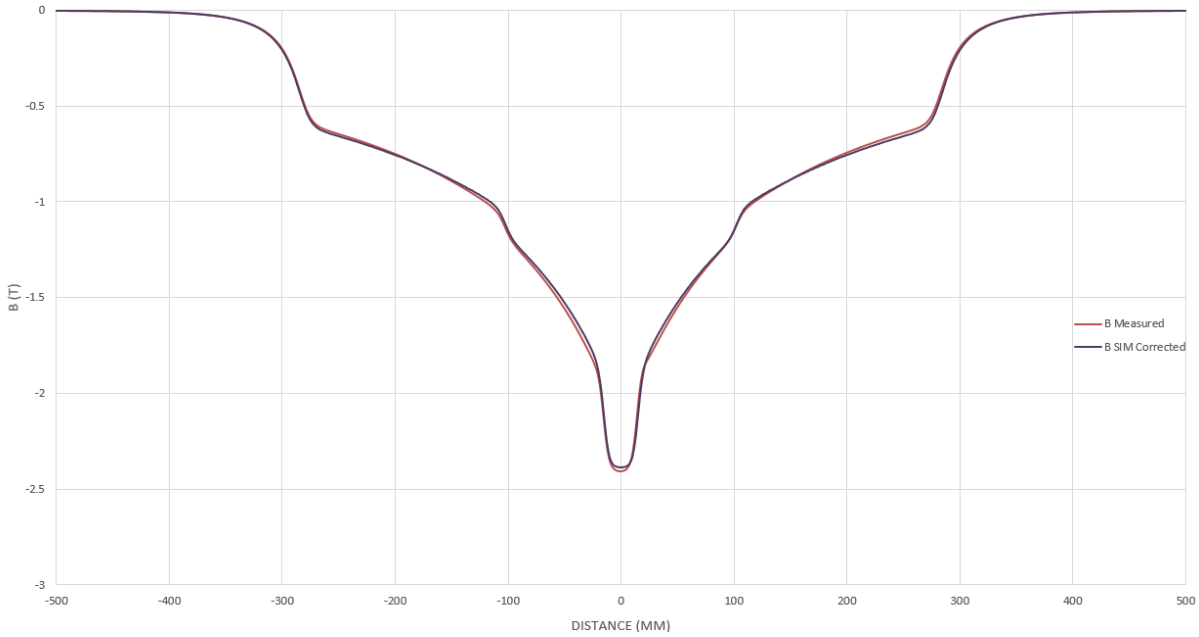


# Measurement Vs Simulation




- First measurements showed some discrepancies with the simulations
- Localised in the medium and low field regions
- Discrepancies around 5-6 % below the expected values
- High field region matches perfectly
- Suspected origin: ARMCO poles (present in the mid and low field regions, not in the high field part)
- Probable cause: ARMCO fabrication (forged) and/or excessive machining

# Measurement Vs Simulation (II)




- New simulations: trying to reproduce the lower ARMCO B-H curve
- Almost perfect agreement with the measurements
- Confirmation: retrieve a block of the same ARMCO batch to characterize and reproduce the behaviour

# Conclusions

- First accelerator magnet with longitudinal trapezoidal gradient!

- The field quality (up to B5, waiting for the full measurements report) is really good and complies with the requirements (Rref=2.5mm):

| B1 | B2 | B3 | B4 | B5 |
|---|---|---|---|---|
| 10000 | 283.0257896 | 1.875867866 | 0.076584498 | 0 |

- The integrated dipolar field is slightly lower than expected: 0.638 vs 0.667 T

- The problem is now understood and corrections are being evaluated:
  - Adjustable poles: can be approximated up to 2mm
  - Insert the trimming cylindrical PM
  - Displace 4mm the vacuum chamber

# *Thanks to all the team…*

# *And thank you for your attention!*