HFM

High Field Magnets

Overview on High Field Magnet program at CIEMAT

J. García-Matos, C. Martins, F. Toral, CIEMAT
J. C. Pérez, CERN

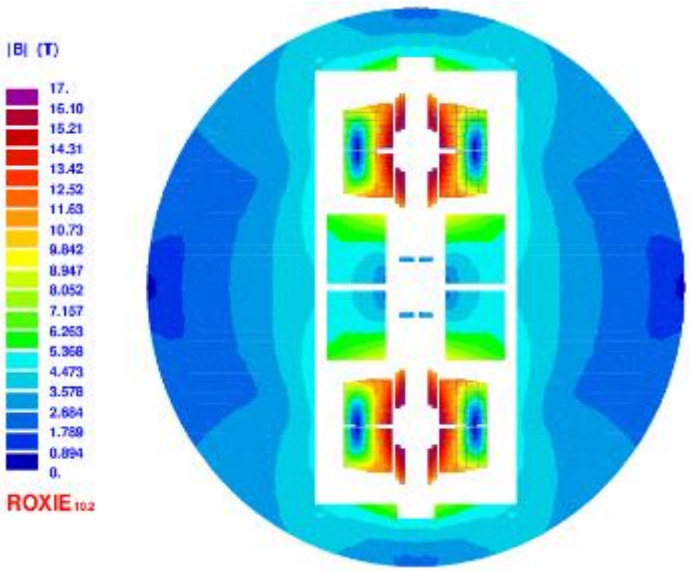
Table of contents

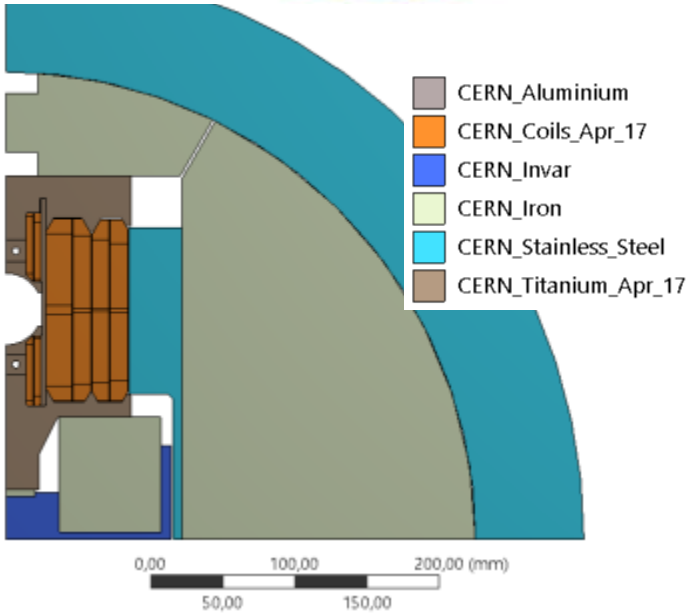
- Background
- High field magnet program at CIEMAT
- Ongoing activities

Background

Parameter	Value	Units
Magnet configuration	Twin-aperture dipole	-
Free aperture	55	mm
Intra-beam distance	320	mm
Nominal bore field	16.0	T
Magnetic length	14.069	m
Working temperature	1.9	K
Nominal current	15880	A
Iron yoke outer diameter	650	mm
Number of cable turns of the main coil (per magnet side)	80	-
Number of cable turns of the secondary coil (per magnet side)	76	-
Number of cable turns of the pole coils (per magnet aperture)	16	-
Number of strands per cable (HF/LF/PC)	28/18/30	-
Strand diameter (HF/LF/PC)	1.2 / 1.2 / 1.2	mm
Cu/non-Cu ratio (HF/LF/PC)	1 / 2.6 / 1	-
Total surface of strands	166.8	cm^2
Total FCC bare cable weight	9502	ton

Parameter	Value	Units
Field peak in cables	16.57	T
Margin on load line in cable type (HF/LF/PC)	14.1 / 14.3 / 14.1	%
b3 / b5 / b7 / b9	-0.2 / -4.5 / 1.6 / -2.3	units
a2 / a4 / a6 / a8	0.4 / -0.9 / -0.9 / -0.3	units
Stored energy	3.24	MJ/m
Static self inductance	25.7	mH/m
L*I	408	HA/m
Sum Fx	14.47	MN/m
Sum Fy	0.37	MN/m





EuroCirCol layout for 16 T common coil magnet

High field magnet program at CIEMAT

- Initial constraints for the research on high field magnets at CIEMAT:
  - Some delay to start the activity due to the workload driven by MCBXF magnets.
  - The new laboratory will not be fully operational till Spring 2024.
  - Previous work was focused on common coil layout.
- Our proposal is based on the following steps:
  1. Model magnet using RMC coils in common coil configuration.
  2. Revisit the existing design of 16T common coil dipole magnet.
  3. Research on fabrication techniques: react-and-wind coils.
  4. Prototype of a high field magnet in common coil configuration.

	HIGH FIELD SC MAGNET MODELS FOR FCC	2022				2023				2024				2025				2026				2027			
UM-IO-1.1	Provision of building and services																								
UM-IO-1.2	Set-up and commissioning of laboratory																								
UM-IO-2.1	Production of tooling and structure for ERMC and RMM																								
UM-IO-2.2	Production of practice coils																								
UM-IO-3.1	High field demonstrator: detailed design																								
UM-IO-3.2	High field demonstrator: design and procurement of the tooling																								
UM-IO-3.3	High field demonstrator: manufacturing of the coils																								
UM-IO-3.4	High field demonstrator: magnets assembly and participation to cold tests & analysis																								

Magnet laboratory at CIEMAT (I)

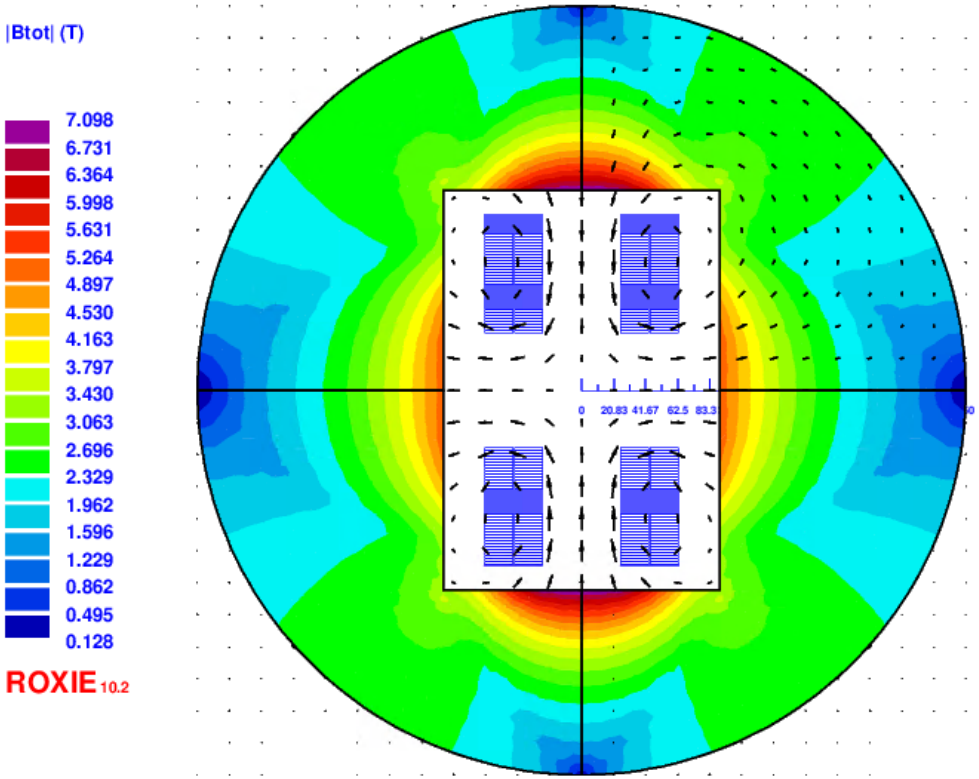
- The building has been finished.
- A new crane is necessary for the hall devoted to magnet assembly.

Magnet laboratory at CIEMAT (II)

- Procurement of large equipment is starting: reaction furnace, press.
- Procurement of the rest of the equipment is more advanced: machines for mechanical workshop, benches, shelves, tooling.

Design of a common coil magnet using existing RMC coils (I)

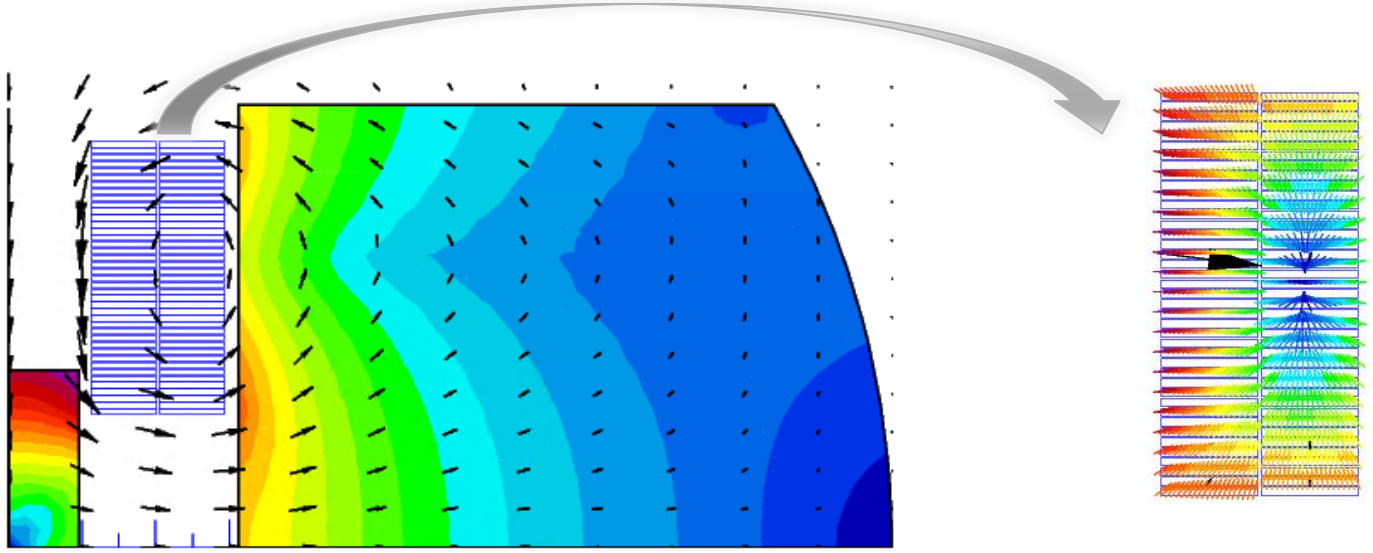
- First design yields about 10 T in a 50 mm aperture.



Design ID	2D_V0_80	Units
Aperture	50	mm
Intra-beam dist.	152	mm
I_nom	16	kA
Yoke inner X	90	mm
Yoke inner Y	130	mm
Yoke outer diam.	500	mm
B	10.25	T
Peak field	11.68	T
Load	80.2	%
Stored energy	855	kJ/m
Static Self Induct.	6.68	mH/m
L*I	106.86	HA/m
Stray field (20 mm)	0.29	T
Sum Fx Q1	4.19	MN/m
Sum Fy Q1	1.54	MN/m
Total F	4.47	MN/m
b3	584.7	units
b5	-2.02	units
b7	-1.32	units
a2	-458.7	units
a4	7.32	units
a6	-0.09	units

Design of a common coil magnet using existing RMC coils (II)

- Sensitivity analysis is ongoing:
  - position of coils vs field aperture
  - iron geometry vs Lorentz forces
- First calculations on magnet protection.



Design of a common coil magnet using existing RMC coils (III)

- Study of previous experiences: visit to BNL and LBNL.
- First mechanical calculations:
  - Conceptual analysis: preload, type of support structure

Design of a CIEMAT FCC-hh short dipole model magnet

- Two strands are available for the model magnet fabrication: MQXF and ERMC-1.
- Electromagnetic calculations of a common coil magnet providing 14 T in the aperture are ongoing (restrained optimization because of available strands).
- The first objective is to evaluate the Lorentz forces.

Conclusions

- The new laboratory building is finished. Procurement of equipment is ongoing.
- Design of a common coil model magnet using existing RMC coils is progressing.
- Electromagnetic calculations of a 14 T common coil magnet have just started.