16 T common coil dipole
status and update

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GOBIERNO DE ESPAÑA
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Overview

- Status
- Electromagnetic design
- Mechanical design
- Quench protection
- Conclusions

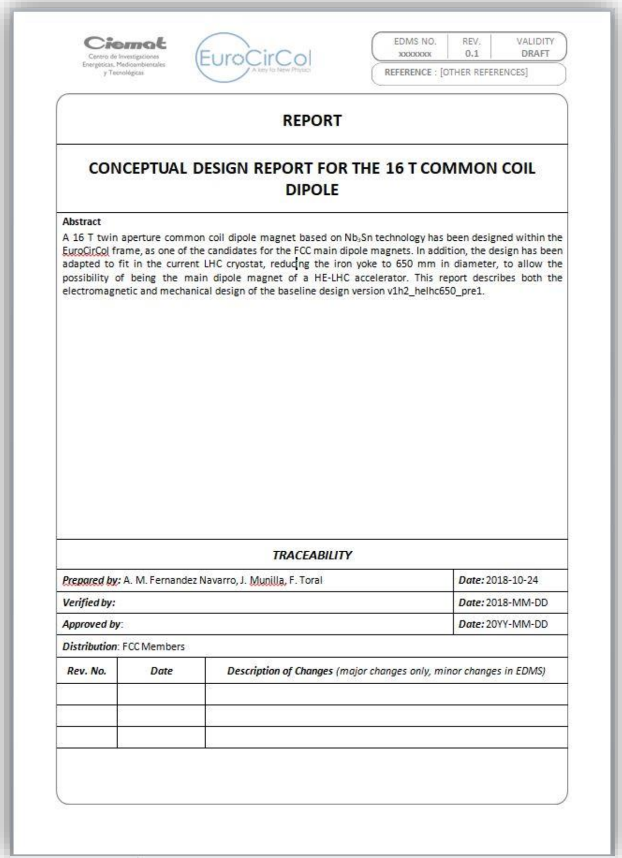
Status

- **Two conceptual options for the mechanical support** have been considered:
  - Closed support, based on a constrained "classical" solution for accelerator magnets regarding prestress levels.
  - Open support, based on a more "innovative" solution for small stresses but higher displacements of the coil.

The closed support option was selected as baseline for the FCC-CDR.

We are working on the signature of a **Collaboration Agreement** to develop and study both support structures for Nb_3Sn racetrack coils produced at CERN.

- The **2D electromagnetic design** of the baseline Common Coil option has been finalized, **the 2D mechanical design** has been updated.
- We are writing the **Common Coil Conceptual Design Report** for the FCC-CDR long contribution.



EDMS NO.	REV.	VALIDITY
xxxxxxx	0.1	DRAFT

REFERENCE : [OTHER REFERENCES]

REPORT

CONCEPTUAL DESIGN REPORT FOR THE 16 T COMMON COIL DIPOLE

Abstract

A 16 T twin aperture common coil dipole magnet based on Nb_3Sn technology has been designed within the EuroCirCol frame, as one of the candidates for the FCC main dipole magnets. In addition, the design has been adapted to fit in the current LHC cryostat, reducing the iron yoke to 650 mm in diameter, to allow the possibility of being the main dipole magnet of a HE-LHC accelerator. This report describes both the electromagnetic and mechanical design of the baseline design version v1h2_helhc650_pre1.

TRACEABILITY

Prepared by: A. M. Fernandez Navarro, J. Munilla, F. Toral	***Date:*** 2018-10-24
Verified by:	***Date:*** 2018-MM-DD
Approved by:	***Date:*** 20YY-MM-DD
Distribution: FCC Members	

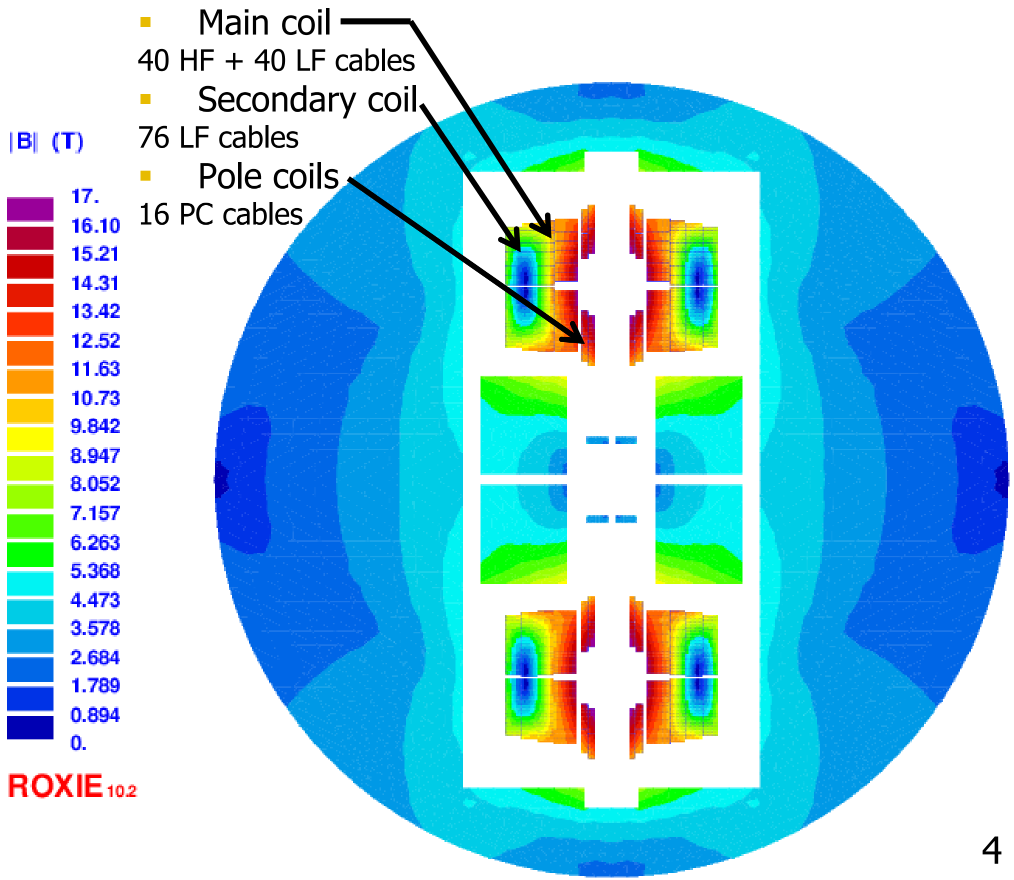
Rev. No.	*Date*	***Description of Changes*** *(major changes only, minor changes in EDMS)*

Electromagnetic design

- **Design parameters**

Optimized: 3 cables, 2 wires.

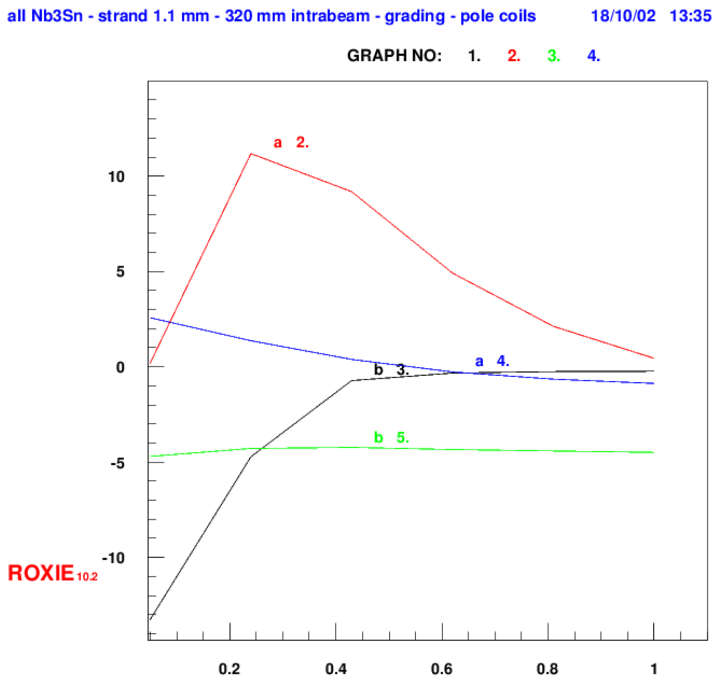
Parameter	Units	V1h2_hllh c650_pre1
Nominal current	kA	15.88
Nominal bore field	T	16.00
Intra-beam distance	mm	320
Aperture	mm	27.5
Iron yoke diameter	mm	650
Number of strands per cable (HF/LF/PC)	-	28/18/30
Strand diameter (HF/LF/PC)	mm	1.2/1.2/1.2
Cu/Sc ratio (HF/LF/PC)	-	1/2.6/1
Total surface of strands	cm^2	166.8
Total FCC bare cable weight	ton	9502



Electromagnetic results

2D magnetic results summary

Parameter	Units	V1h2_hllhc650_pre1
B peak in cables	T	16.57
Margin on load line in cable type (HF/LF/PC)	%	**14.1**/14.3/**14.1**
b3/b5/b7/b9	units	-0.2/**-4.5**/1.6/-2.3
a2/a4/a6/a8	units	0.4/-0.9/-0.9/-0.3
Stored energy	MJ/m	3.24
Static self inductance	mH/m	25.7
L*I	HA/m	408
Sum Fx	MN/m	14.47
Sum Fy	MN/m	0.37



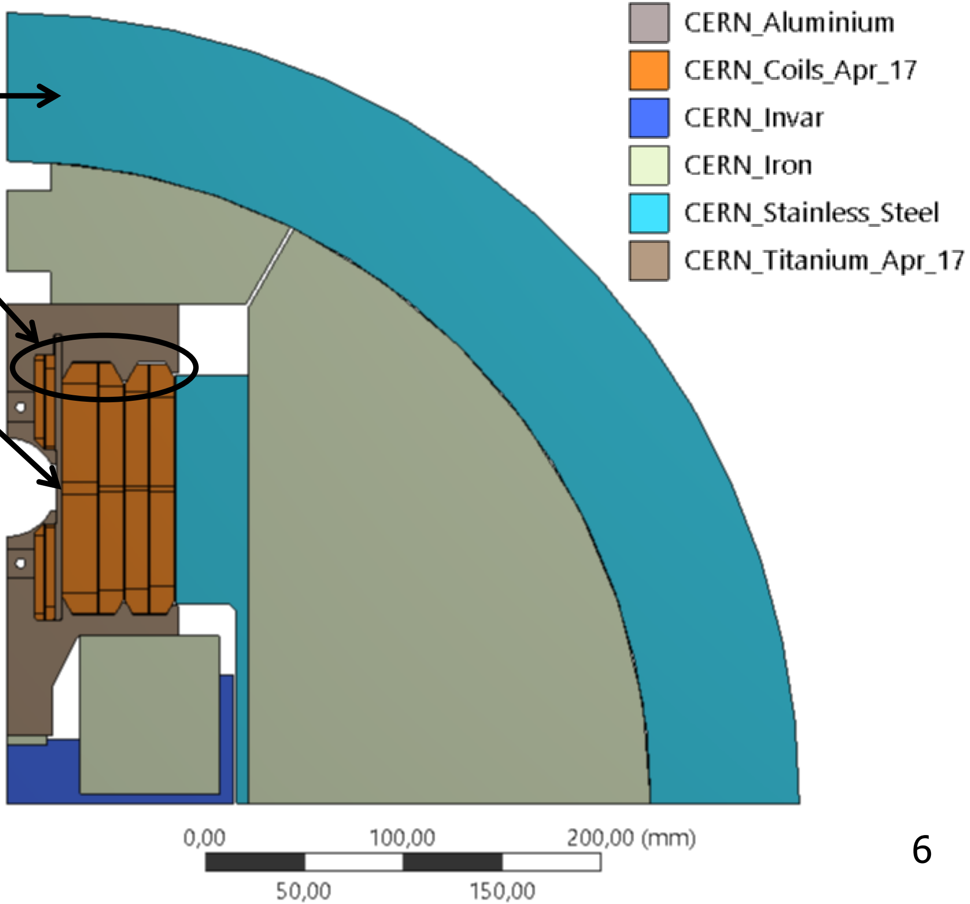
Quench protection results

Calculated in Excel: the adiabatic hot-spot temperature at 105 % of the nominal current is **348 K.**
A collaboration with the TE-MPE-PE section (Michal Maciejewski and Marco Prioli) made possible to check that the stresses in the coils in a quench event after CLIQ firing are under the 200 MPa stress limit (STEAM-COMSOL-ANSYS).

Mechanical design

- **Pre-compression in assembly with a SS shell.**
- **Coil support transfers the stresses to the coil copper wedges.**
- **Titanium closed support separator to minimize the coil displacements.**

MATERIAL	Stress limit [MPa] RT	1.9 K	E [GPa] RT	1.9 K	ν	α RT→1.9K
Coil	150	200			0.3	
Radial dir			30	33		$3.1\ 10^{-3}$
Azimuthal dir			25	27.5		$3.4\ 10^{-3}$
Austenitic steel (316LN)	350	1050	193	210	0.28	$2.8\ 10^{-3}$
Al7075	480	690	70	79	0.3	$4.2\ 10^{-3}$
Ferromagnetic iron	230	720*	213	224	0.28	$2.0\ 10^{-3}$
Ti6Al4V	800	1650	115	126	0.3	$1.7\ 10^{-3}$



Mechanical results

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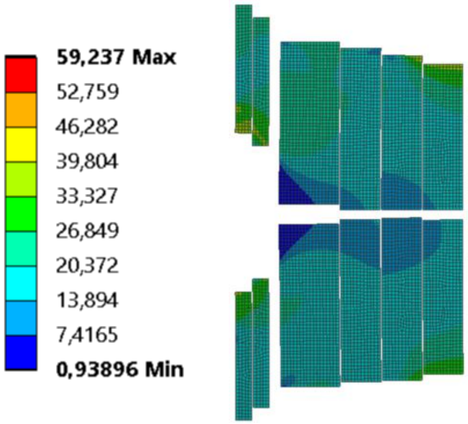
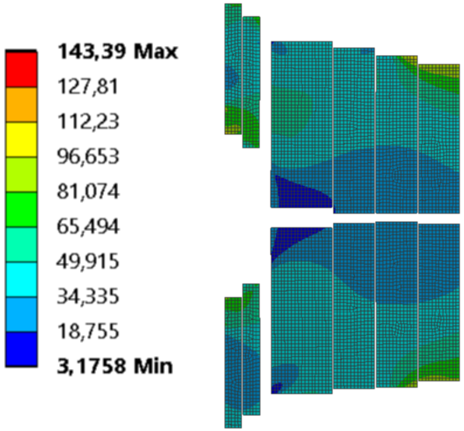
- All the **equivalent stresses in the support**, iron yoke and shell **are under the yield strength** of the materials for the three steps: Assembly, cool down and powering at nominal.

- The **equivalent stress in the coils is under the design limit** for the three steps: Assembly, cool down and powering.

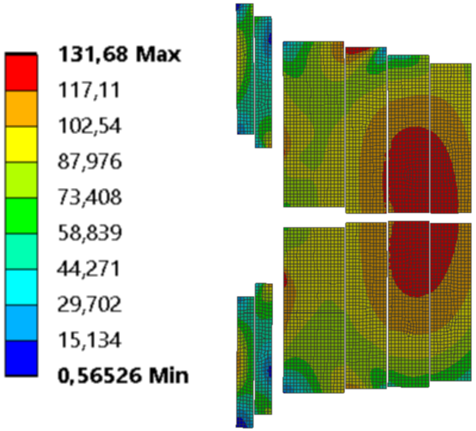
- Assembly coil Von-Mises stress (Mpa)



- Cool down 1.9 K coil Von-Mises stress (Mpa)

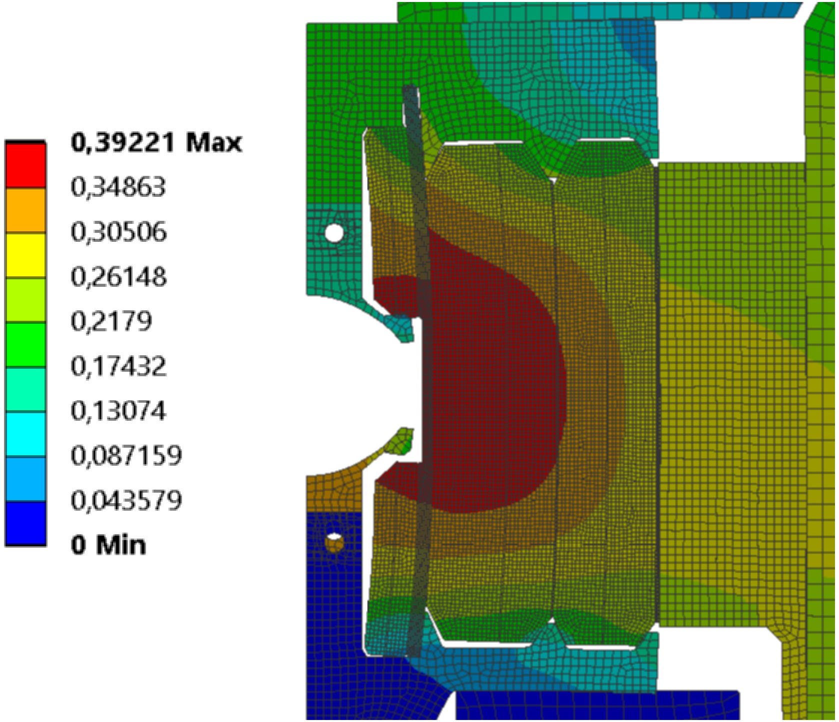


- Powering at nominal coil Von-Mises stress (Mpa)



Mechanical results

- **Total deformation (mm) from cold to powering (deformation amplified x10)**



- Small separations up to 0.39 mm without sliding in some contacts between coils and support or between the wedges and support.

Conclusions

- **The closed support option** was selected as baseline for the FCC-CDR.
- The **2D electromagnetic design** of the baseline Common Coil option has been finalized and fulfills the design requirements.
- **The 2D mechanical design** of the baseline Common Coil option has been updated and fulfills the maximum stress requirements.
- We are writing the **Common Coil Conceptual Design Report** for the FCC-CDR long contribution.
- We are working on the signature of a **Collaboration Agreement** to develop and study both support structures for Nb_3Sn racetrack coils produced at CERN.