EDMS NO.	REV.	VALIDITY
1366547	**1.0**	**DRAFT**

REFERENCE : LHC-EQCOD-ES-XXXX

CONCEPTUAL SPECIFICATION

INNER TRIPLET Q2 COLD MASS

MQXFB

Equipment/system description

The inner triplet quadrupoles are the magnetic system used to steer the beta functions around the interaction point, allowing to reach values in the IP of the order of 10 cm. The triplet is made of three magnets Q1, Q2 and Q3. Here we deal with the Q2 case, which has many features in common with Q1 and Q3 given in a separate document.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V X.X	S1-2, S4-5, S5-6, S8-1	TBD

TRACEABILITY

Project Engineer in charge of the equipment	WP Leader in charge of the equipment
P. Ferracin	E. Todesco, G. L. Sabbi

Committee/Verification Role	Decision	Date
PLC-HLTC/ Performance and technical parameters	Rejected/Accepted	20YY-MM-DD
Configuration-Integration / Configuraration, installation and interface parameters	Rejected/Accepted	20YY-MM-DD
TC / Cost and schedule	Rejected/Accepted	20YY-MM-DD
Final decision by PL	Rejected/Accepted/Accepted pending (integration studies, …)	20YY-MM-DD

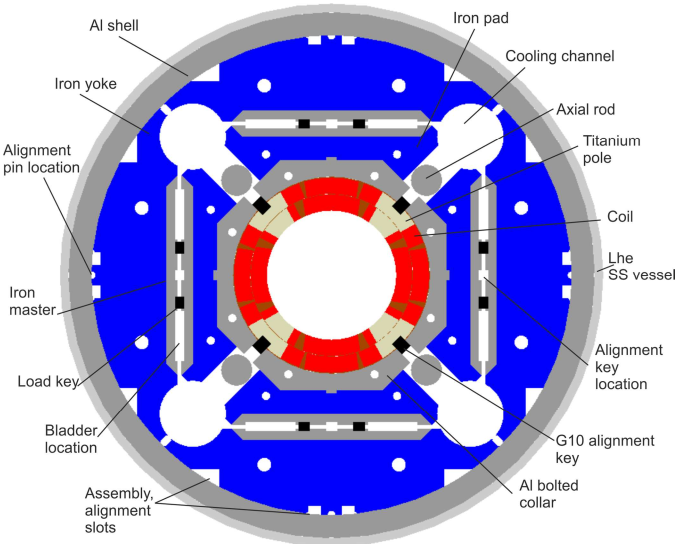
Distribution: N. Surname (DEP/GRP) *(in alphabetical order) can also include reference to committees*

Rev. No.	***Date***	***Description of Changes*** *(major changes only, minor changes in EDMS)*
X.0	20YY-MM-DD	Description of changes

1 CONCEPTUAL DESCRIPTION

1.1 Scope

The inner triplet quadrupoles are the magnetic system used to steer the beta functions around the interaction point, allowing to reach values in the IP of the order of 10 cm. The triplet is made of three magnets Q1, Q2 and Q3. Here we deal with the Q2 case, which has many features in common with Q1 and Q3 given in a separate document.



1.2 Benefit or objective for the HL-LHC machine performance

The large aperture of these magnets (150 mm) allows reaching a beta function in the IP of the order of 10 cm.

1.3 Equipment performance objectives

These magnets will provide 140 T/m in the transverse plane, with operational temperature of 1.9 K.

TECHNICAL ANNEXES

2 PRELIMINARY TECHNICAL PARAMETERS

2.1 Equipment Technical parameters

The following parameters are for Q2 cold masses.

Table 1: Equipment parameters

Characteristics	Units	Value
Aperture	mm	150
Number of apertures		1
Distance between apertures		NA
Cold mass outer diameter	mm	630
Magnetic length	m	6.8
Approximated weight	t	18.5
Gradient	T/m	140
Peak field	T	12.1
Current	kA	17.5
Temperature	K	1.9
Loadline margin	(%)	20
Overall current density	A/mm^2	490
Stored energy per meter	MJ/m	1.32
Differential inductance per meter	mH/m	8.2
Stored energy	MJ	9.0
Differential inductance	mH	56
Superconductor		Nb3Sn
Strand diameter	mm	0.85
Cu/No Cu		1.2
RRR		>150
Superconductor current density at 15 T, 4.2 K	A/mm^2	1400
Number of strands per cable		40
Cable bare width before reaction	mm	18.15
Cable bare mid thickness before reaction	mm	1.525
Keystone angle	degrees	0.55
Insulation thickness per side at 5 MPa	mm	0.15
Number of layers		2
Number of turns inner layer		17+5
Number of turns outer layer		16+12
Cable unit length	m	710
Coil physical length	m	7.1
Magnet physical length	m	7.5
Cold mass weigth	t	11.5
Heat exchanger hole diameter	mm	77
Heat exchanger angle	degrees	45
Heat exchanger distance from centre	mm	227.5
Fx / Fy (per octant)	MN/m	+2.65 / -3.87
Fz (whole magnet)	MN	1.4
Stress on the mid-plane	MNP	160
Cold bore thickness	mm	4
Gap cold bore to coil	mm	1.5
Fringe field on the cryostat outer surface	mT	40

2.2 Operational parameters and conditions

They will operate under a peak heat load due to the debris shower of 2.5 mW/cm^3, withstand 25 MGy of radiation dose, and have a cooling power of 105/130 W on Q2a/Q2b and 50/70 W on the beam screen.

2.3 Technical and Installation services required

Table 2: Technical services

Domain	Requirement
Electricity & Power	20 kA circuit
Cooling & Ventilation	350 W cooling power (235 operational plus 50% margin)
Cryogenics	1.9 K cooling through heat exchangers
Control and alarms	
Vacuum	
Instrumentation	Voltage taps for quench detection

Table 3: Installation services

Domain	Requirement
Civil Engineering	
Handling	
Alignment	Cold mass alignment in the cryostat within 0.1 mm (TBC) and 1 mrad (TBC)

2.4 P & I Diagrams

2.5 Reliability, availability, maintainability

If the magnet is not providing the gradient, in any one of the magnets, the machine cannot operate. A lower than specified cooling power can limit the peak luminosity to values lower than nominal. A lower than specified radiation resistance can break the magnet before the expected end of HL-LHC.

2.6 Radiation resistance

The equipment is designed to withstand 25 MGy.

2.7 List of units to be installed and spares policy

8 cold masses to be installed, 2 per side at IP1 and IP5.

2 spare cold masses.

3 PRELIMINARY CONFIGURATION AND INSTALLATION CONSTRAINTS

3.1 Longitudinal range

Q2a: from 35.2 to 42.0 m from the IP.

Q2b: from 44.0 to 50.8 m from the IP.

3.2 Volume

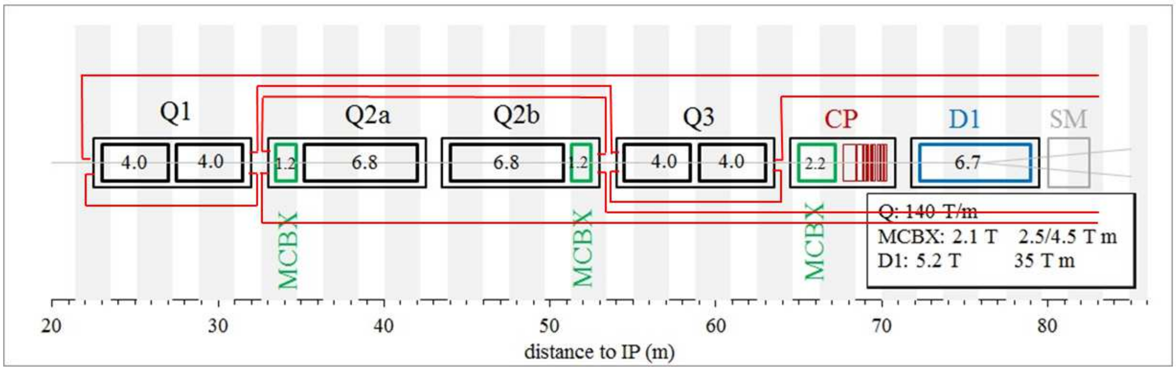
630 mm diameter and 7.5 m length: 2.3 m^3. Approximate weight of 18.5 t.

3.3 Installation/Dismantling

The present triplet, orbit correctors, non-linear correctors, and D1 need to be dismantled.

4 PRELIMINARY INTERFACE PARAMETERS

4.1 Interfaces with equipment



4.2 Electrical interfaces

Table 4: Circuits to be generated

New circuit description	Circuit LHC code name (if known)	Approx. current rating (if known)	Approx. voltage rating (if known)
RQXFB.L1		20 kA	
RQXFB.R1		20 kA	
RQXFB.L5		20 kA	
RQXFB.R5		20 kA	

5 COST & SCHEDULE

5.1 Cost evaluation

Project code 91114

5.2 Approximated Schedule

Table 5: Schedule

Phase	2012		2013		2014		2015		2016		2017		2018	2019	2020	2021	2022
Conceptual design	■	■	■														
Engineering design (short)				■	■												
Short model						■	■	■	■	■							
Engineering design (long)						■	■	■									
Prototype									■	■	■	■	■				
Production													■	■	■	■	
Installation																	■

Note the following definitions:

- Conceptual design: choice of aperture, gradient, cable, cross-section and coil heads design
- Engineering design: CAD design of components and tooling
- Short model: first coil winding, assembly and test of short model
- Prototype: first coil winding, assembly and test
- Production: including test

6 TECHNICAL REFERENCE DOCUMENTS

- Future magnet report

7 APPROVAL PROCESS COMMENTS FOR VERSION X.0 OF THE CONCEPTUAL SPECIFICATION

7.1 PLC-HLTC / Performance and technical parameters Verification

Comments or references to approval notes. In case of rejection detailed reasoning

7.2 Configuration-Integration / Configuraration, installation and interface parameters Verification

Comments or references to approval notes. In case of rejection detailed reasoning

7.3 TC / Cost and schedule Verification

Comments or references to approval notes. In case of rejection detailed reasoning

7.4 Final decision by PL

Comments or references to approval notes. In case of rejection detailed reasoning