CONCEPTUAL SPECIFICATION

RECOMBINATION DIPOLE D2 COLD MASS

MBRD

Equipment/system description

The recombination dipole is the magnetic system used to bring the divergining beams coming out of D1 (separation dipole) to parallel orbits with the nominal distance of 192 mm, with a 35 T·m kick.

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

TRACEABILITY

Project Engineer in charge of the equipment	**WP Leader in charge of the equipment**
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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

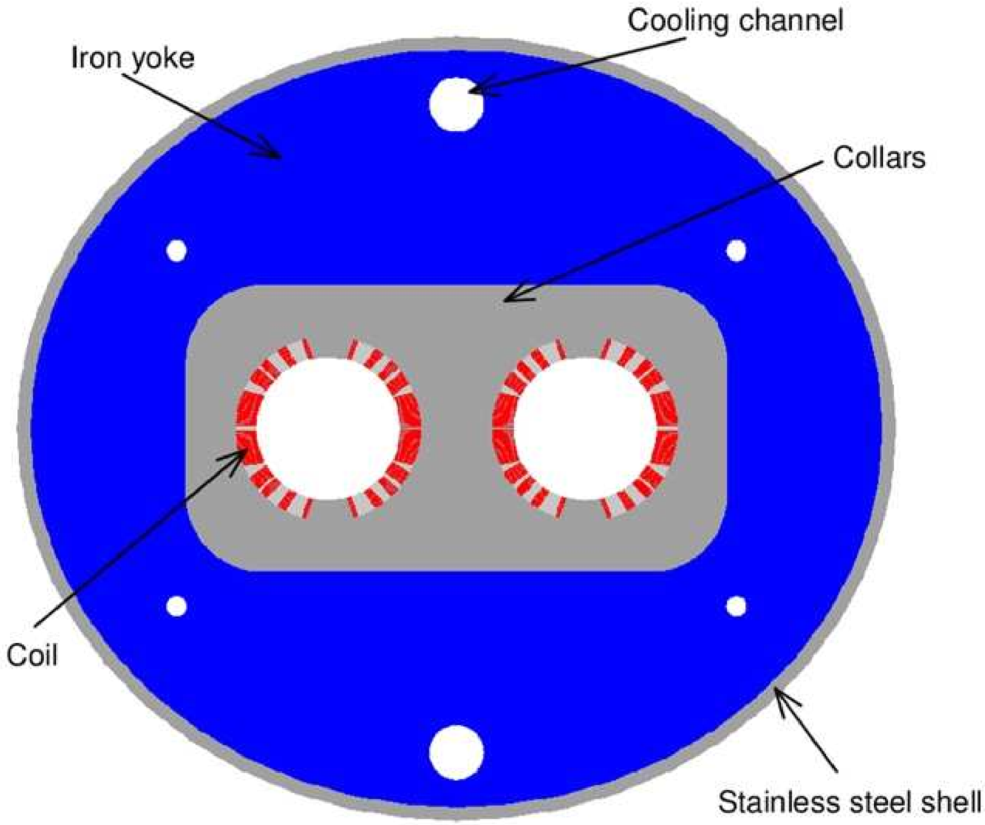
Distribution: N. Surname (DEP/GRP) *(in alphabetical order) can also include reference to committees*

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 recombination dipole is the magnetic system used to bring the diverginging beams coming out of D1 (separation dipole) to parallel orbits with the nominal distance of 192 mm, with a 35 T·m kick.



1.2 Benefit or objective for the HL-LHC machine performance

The large aperture of this magnet (105 mm) allows reaching a beta function in the IP of the order of 10 cm. The larger kick (35 T·m w.r.t. 26 T·m of the LHC) allows reducing the distance D1-D2 baricentres from ~85 m to ~65 m, i.e. saving about 20 m longitudinal space in the straight section.

1.3 Equipment performance objectives

These magnets will provide 35 T m integrated field, 5.6 T bore field in the transverse plane, with operational temperature of 1.9 K.

TECHNICAL ANNEXES

2 PRELIMINARY TECHNICAL PARAMETERS

2.1 Equipment Technical parameters

Table 1: Equipment parameters

Characteristics	Units	Value
Aperture	mm	105
Number of apertures		2
Distance between apertures		188
Cold mass outer diameter	mm	570/630
Magnetic length	m	7.78
Bore field	T	4.5
Peak field	T	5.2
Current	kA	12.0
Temperature	K	1.9
Loadline margin	(%)	35
Overall current density	A/mm^2	461
Stored energy per meter	MJ/m	0.284
Differential inductance per meter	mH/m	3.51
Stored energy	MJ	2.21
Differential inductance	mH	27.3
Superconductor		Nb-Ti
Strand diameter	mm	0.825
Cu/No Cu		1.95
RRR		>150
Superconductor current density at 10 T, 1.9 K	A/mm^2	2100
Number of strands per cable		36
Cable bare width	mm	15.1
Cable bare mid thickness	mm	1.480
Keystone angle	degrees	0.90
Insulation thickness per side radial	mm	0.160
Insulation thickness per side azimuthal	mm	0.145
Number of layers		1
Number of turns		31=15+6+4+4+2
Cable unit length	m	520
Coil physical length	m	8.2
Magnet physical length	m	8.5
Cold mass weigth	t	17
Heat exchanger hole diameter	mm	40
Heat exchanger angle	degrees	90
Heat exchanger distance from centre	mm	237
Fx (per quarter, per aperture) [left right]	MN/m	0.60/0.68
Fy (per quarter, per aperture)	MN/m	-0.40

Fz (whole magnet)	MN	0.2
Stress on the mid-plane	MPa	50
Cold bore thickness	mm	4
Gap cold bore to coil	mm	1.5
Fringe field on the cryostat outer surface	mT	60 to 90

Please note that fringe field in present version is larger than target (40 mT).

2.2 Operational parameters and conditions

It will operate under a peak heat load due to the debris shower of 1.8 mW/cm^3, 25 MGy of radiation dose, and it will need a cooling power of 65 W on the magnet at nominal luminosity.

2.3 Technical and Installation services required

Table 2: Technical services

Domain	Requirement
Electricity & Power	13 kA circuit
Cooling & Ventilation	100 W cooling power per magnet (65 W 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 Reliability, availability, maintainability

If the magnet is not providing the integrated field, the machine cannot operate. Lower field will correspond to lower collision energy. 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 gathering 3000 fb^{-1} in HL-LHC.

2.5 Radiation resistance

The equipment is designed to withstand 25 MGy.

2.6 List of units to be installed and spares policy

Four cold masses to be installed, one per side at IP1 and IP5.

Two spare cold masses.

3 PRELIMINARY CONFIGURATION AND INSTALLATION CONSTRAINTS

3.1 Longitudinal range

From 138.5 m to 146.3 m from the IP

3.2 Volume

570/630 mm diameter (vertical/horizontal) and 8 m length: 2.3 m^3.

3.3 Installation/Dismantling

The present D2 needs 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)
	RD2.L1	13 kA	
	RD2.R1	13 kA	
	RD2.L5	13 kA	
	RD2.R1	13 kA	

5 COST & SCHEDULE

5.1 Cost evaluation

Project code 91115

5.2 Conceptual schedule

Table 5: Conceptual 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 – 1 unit foreseen
- Prototype: first coil winding, assembly and test – 1 unit foreseen
- 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