

CONCEPTUAL SPECIFICATION

TCLM

Equipment/system description

The HL-LHC baseline in IR1/5 poses new challenges in terms of peak luminosity and total radiation doses that have to be addressed by appropriate layouts for collision products cleaning. The scope of WP5 studies covers that cleaning of physics debris downstream of the TAN. Physics debris collimator, TCLM's (Target Collimator Long Mask) masks are required around LHC high luminosity experiments in the insertion regions IR1 and IR5 to protect the cold magnets in the Matching Sections (MS's) and Dispersion Suppressors (DS's) from products of proton-proton collisions. The masks complement the cleaning role of movable TCL collimators.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V X.X	IR1 and IR5	TBD

RACEABILITY

Project Engineer in charge of the equipment N. Surname [Prepared by]	WP Leader in charge of the equipment Stefano Redaelli	
Committee/Verification Role	Decision	Date
PLC-HLTC/ Performance and technical parameters	Rejected/Accepted	20YY-MM-DD
Configuration-Integration / Configuration, 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

At nominal LHC performance, with a design luminosity of $10^{34}\text{cm}^{-1}\text{s}^{-2}$ at 7 TeV, the products of collision might quench the superconducting magnets in the matching sections (MS's) downstream of the collision points. Three TCL collimators per beam per IP side are sufficient to protect the magnets from quench and radiation damage [1]. The new challenges posed by the high luminosity upgrade of the LHC, foreseeing peak luminosities during proton operation up to $7.5 \times 10^{34}\text{cm}^{-1}\text{s}^{-2}$ [2], require fixed masks in addition to the movable TCL collimators described in [3, 4, 5]. We refer to these masks as TCLM, Target Collimator Long Mask. In the present layout baseline under study, a total of four masks are foreseen in front of D2, Q4, Q5 and Q6 magnets.

1.2 Benefit or objective for the HL-LHC machine performance

The TCLM collimators in interaction regions IR1/5 are needed to keep the MS magnets D2, Q4, Q5 and Q6 in IR1/5 safely below the quench limits and during high-luminosity proton operation and to limit the total integrated doses to the magnets. Without these collimators, the HL-LHC peak and integrated luminosity will be limited.

1.3 Equipment performance objectives

The new physics debris collimator masks must:

- Ensure that the D2, Q4, Q5 and Q6 magnets are below quench limits with peak luminosities up to $7.5 \times 10^{34}\text{cm}^{-1}\text{s}^{-2}$;
- Keep integral doses on these magnets below their radiation damage limits, with appropriate margins.

The need of masks for all the quoted elements (D2, Q4, Q5 and Q6) needs to be addressed after a finalization of the IR layout.

TECHNICAL ANNEXES

2 PRELIMINARY TECHNICAL PARAMETERS

2.1 Assumptions

Key machine parameters that affect the TCL layout requirements are the (1) peak luminosity at the beginning of the fill ($7.5 \times 10^{34} \text{cm}^{-1} \text{s}^{-2}$); (2) total integrated luminosity (3000fb^{-1}) [2].

The masks provide passive shielding of the magnets. The dimension of the mask aperture matches the beam screen design of the adjacent magnet and its orientation [4]. The mask design has therefore to be updated if the magnet aperture changes. The present baseline values are as assumed in this document in Table 1.

2.2 Equipment Technical parameters

At this stage of the studies, we only have an indicative design that assumes a round mask with outer radius chosen to protect the magnet coil and beam aperture matching dimensions and orientation of the beam screen (BS) of the magnet downstream.

The integration length is not defined yet. The masks should be placed as close as possible to the magnet coils. Preliminary integration studies indicate a minimum mask/coils distance of about 750 mm [6].

Table 1: Equipment parameters

Characteristics	Units	Value
Mask length	mm	500-1000
Jaw material	--	W
Flange-to-flange distance	mm	To be determined
Orientation	--	Follow magnet BS
RF damping/transition design	--	Fingers (TBC)
Mask cooling	--	Yes (TBC)
Cooling of the vacuum tank	--	Yes
Inner dimensions – D2 mask	mm	41/36
Inner dimensions – Q4 mask	mm	37/32
Inner dimensions – Q5 mask	mm	30/25
Inner dimensions – Q6 mask	mm	23.25/18.45
Outer radius D2/Q4/Q5/Q6	mm	80/70/50/55

It is also noted that the option to integrate the masks in the cryostat is under investigation. This design of “cold masks” requires however more studies before being considered as a viable baseline.

2.3 Operational parameters and conditions

TCLM’s are fixed mask. Their temperature will have to be monitored and might be interlocked. Otherwise they do not have any active component.

2.4 Technical and Installation services required

Table 2: Technical services

Domain	Requirement
Electricity & Power	YES (temperature monitoring)
Cooling & Ventilation	Active cooling for the mask (demineralized water)
Cryogenics	--
Control and alarms	YES (temperature)
Vacuum	NO
Instrumentation	NO

Table 3: Installation services

Domain	Requirement
Civil Engineering	NO
Handling	YES – special transport
Alignment	YES

2.5 P & I Diagrams

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2.6 Reliability, availability, maintainability

No active moving parts for this passive masks.

2.7 Radiation resistance

The selection of construction materials will take activation properties into account. The design is optimized to allow for fast repair, maintenance and replacement, depending on expected residual dose rate levels. The design also considers dismantling, radioactive waste conditioning and disposal properties at the end of the lifetime of the component.

2.8 List of units to be installed and spares policy

- The total number of new mask is 16 (4 per beam in IR1/5).
- For the moment, these masks require 4 different designs.
- An appropriate spare policy will be established. One spare per design seems appropriate. This might be reviewed in light of the fact that these fully passive elements have limited risk of failure.

3 PRELIMINARY CONFIGURATION AND INSTALLATION CONSTRAINTS

3.1 Longitudinal range

The longitudinal positions for the masks are under study for the present IR baseline. Ideally, the shortest distance between the TCLM and the superconducting coils of the magnets is desirable. Indicatively, a minimum distance of 750 mm is to be expected for the warm/cold transitions and connections. All masks have to be installed at the IP side of each magnet.

3.2 Volume

Outer dimensions and support design to be studies.

It is important to recall that the collimator integration in the region between TAN and D2 magnets must be studies properly, taking into account the constraints coming from the reduced separation between the two beam pipes.

3.3 Installation/Dismantling

New devices to be installed.

4 PRELIMINARY INTERFACE PARAMETERS

4.1 Interfaces with equipment

Standard as present LHC masks.

4.2 Electrical interfaces

No changes for any magnet powering system.

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)

List circuits to be modified/affected by the installation of the new equipment

Table 5: Circuits to be modified/affected

Circuit LHC code name	Action on the circuit

5 COST & SCHEDULE

5.1 Cost evaluation

Cost to be charged on the collimation code 61064.

5.2 Approximated Schedule

The TCLM mask installation is foreseen for LS3 when the full IR upgrade will be put in place. We propose a single production batch in LS3, unless the design can be finalized earlier to start an earlier production.

Table 6: Tentative schedule – Production batch 1

Phase	2014	2015	2016	2017	2018	2019	2020	2021	2022
Funct. Spec.									
Design alternatives									
Production batch 1									

5.3 Schedule and cost dependencies

None.

6 TECHNICAL REFERENCE DOCUMENTS

- [1] 168th meeting of the LHC Collimation Working Group, <https://indico.cern.ch/event/294798/>
- [2] HL-LHC Parameter & Layout Committee page, <https://espace.cern.ch/HiLumi/PLC/default.aspx>
- [3] HL Conceptual Functional Specification, TCL, <https://edms.cern.ch/document/1366522>

[4] L. Esposito *et al.*, “Energy deposition including matching section with latest layout version”, presentation at the 3rd HiLumi Annual meeting, Daresbury, UK (2013), <https://indico.cern.ch/event/257368/>

[5] HiLumi WP5 deliverable document D5.3, <https://cds.cern.ch/record/1557081/files/CERN-ACC-2013-008.pdf>

[6] P. Fessia, private communication.

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 / Configuration, 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