

CONCEPTUAL SPECIFICATION

TARGET COLLIMATOR LONG DISPERSION SUPPRESSOR P1-P5 [TCLD]

Equipment/system description

Dispersion suppressor collimators (Target Collimator Long Dispersion suppressor, TCLD) inserted in the cold dispersion suppressor (DS) regions are used to clean local losses that would otherwise occur in the cold dipoles and quadrupoles. These collimators work at room temperature and are installed in a dedicated cryogenics by-pass between two 5.5 m-long 11 T dipoles that shall replace one standard LHC dipole. Around IR1 and IR5, up to 2 TCLD collimators per side might be necessary to allow high luminosity operation in ATLAS and CMS while remaining safely below quench limits of the superconducting magnets. One collimator per side might instead be sufficient for the heavy ion beam cleaning. The TCLD collimator installation around IR1/5, if needed, is scheduled for LS3 (long shutdown 3), i.e. in conjunction with the full HL-LHC upgrade.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V 1.0	S8-1 and S1-2; S4-5 and S5-6	HLCTCLD to be created by S. Chemli

TRACEABILITY

Project Engineer in charge of the equipment	WP Leader in charge of the equipment	
tbd	S. Redaelli	
Committee/Verification Role	Decision	Date
PLC-HLTC/ Performance and technical parameters	Rejected/Accepted	2014-07-01
Configuration-Integration / Configuraton, 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: HL-TC

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

Collision products emerging from the interaction points might be lost in the matching sections and the dispersion suppressors (DSs) around the experiments. In particular, protons that changed their magnetic rigidity represent a source of local heat deposition in the first DS cells where the dispersion function starts rising. A similar mechanism occurs for ion operations (see [1] and references). These physics debris losses may pose a certain risk of inducing magnet quenches. A strategy to eliminate any risk of quench is the installation of DS collimators (TCLDs, Target Collimator Long Dispersion suppressor). The solution proposed for IR2 for ion operation, to be implemented in LS2, is described in [2]. This note addresses the case of IR1 and IR5 in view of the HL-LHC upgrade that will take place in LS3. The peaks observed around these IRs during proton operation at high intensity can be reduced with 2 TCLD collimators per IR side. The need for such implementation depends on the dipole quench limits and on the effectiveness of the physics debris collimation with TCL collimators [3, 4]. For ion operation, 1 TCLD collimator per IR side is expected to be sufficient [5].

1.2 Benefit or objective for the HL-LHC machine performance

DS collimation is considered necessary for the operation with lead ion beams, for luminosities above few $10^{27} \text{cm}^{-2} \text{s}^{-1}$. For the ALICE luminosity upgrade scenario aiming at a peak luminosity of $6 \times 10^{27} \text{cm}^{-2} \text{s}^{-1}$, the estimated peak power density in magnet coils is about 50mW/cm^3 [1, 6]. Similar figures are expected in IR1 and IR5 [5], however detailed simulations are yet to be done. Also for these IRs, the proposed installation of one single TCLD collimator per beam is expected to reduce by more than a factor 50 the peak power density in the new 11 T dipoles compared to the peak power density at the cold dipoles with the present layout (with old dipoles and no TCLD collimators). This estimate assumes 80 cm jaws made of tungsten.

One or two TCLD units per beam would also greatly reduce the losses in cold magnets for the high luminosity proton operations in IR1/5. According to present estimates, the proposed physics debris collimation with 3 TCL collimators per beam [3] and TCLM masks [4] should be sufficient to operate the machine safely below quench limits for peak luminosities up to $7.5 \times 10^{34} \text{cm}^{-2} \text{s}^{-1}$ at 7 TeV. This preliminary conclusion must be confirmed by detailed simulations with the final layout and by an update estimate of quench limits of SC dipoles at energies close to 7 TeV, before finalizing the TCLD strategy for IR1/5. Also note that the efficiency of the TCL collimators during ion operation needs to be assessed.

1.3 Equipment performance objectives

The new collimators are to be installed in warm insertions between two cold 11 T dipoles. They are designed to withstand the losses from proton and ion luminosity debris while ensuring their basic mechanical and beam cleaning functionalities (e.g., mechanical stability and flatness constraint, to be specified in detail). Total losses in the collimator jaws up to about 100 W are expected [3].

In addition, the design is based on the state-of-the-art collimator design used in the rest of the machine. It features all the latest design improvements, including in-jaw BPMs for fast alignment and orbit monitoring.

TECHNICAL ANNEXES

2 PRELIMINARY TECHNICAL PARAMETERS

2.1 Assumptions

The need of TCLD collimation in IR1 and IR5 depends on the peak luminosity values in these insertion. We assumed peak luminosities of $6 \times 10^{27} \text{cm}^{-2}\text{s}^{-1}$ for ions and of $7.5 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$ for protons. It is noted that the proposed solution also have the advantage of mitigating total doses on the superconducting magnets. Detailed estimates are being worked out assuming a total HL-LHC integrated luminosity of 3000fb^{-1} with proton beams.

The collimator design is based on the same concepts adopted for other DS in other LHC insertion regions. The IR7 case is the most challenging one for the hardware integration because it requires the longest jaw length for an efficient proton halo cleaning [7, 8].

Different jaw lengths and materials have been comparatively addressed for the specific case of IR2 by using as a figure of merit the reduction factor of losses in the DS dipoles [3]. Simulations show that 50 cm of Copper would suffice. However, in order to minimize design effort and production works both for the collimator and for the design of the cryo by-pass, the same length of 80 cm adopted for the TCLD in IR7 is also used as a baseline for the IR1/5 TCLD collimators. For the jaw material, W is used as baseline for IR7. Should the Cu design be easier/less costly, it could be considered for the IR1/5 implementation.

Simulations for IR1 and IR5 have not been performed yet. However, it is expected that the conclusions drawn from IR2 simulations for the ion case hold true. It is therefore assumed that per beam and per IR: (1) 1 TCLD made of 80 cm of Tungsten is adequate for ion operations; (2) 2 TCLD units are sufficient for proton operation. At this stage of the conceptual specification for the HL project, we consider a pessimistic scenario based on 2 TCLD collimators per beam per IR, knowing that this baseline will be reviewed in 2015.

2.2 Equipment Technical parameters

Table 1: Equipment parameters

Characteristics	Units	Value
Jaw active length	mm	800
Jaw material	--	W or Cu
Flange-to-flange distance	mm	TBD
Number of jaws	--	2
Orientation	--	Horizontal
Dipole replaced by 11 T dipole/TCLD	--	MB.B10
Number of BPMs per jaw	--	2
RF damping	--	Fingers or ferrite
Cooling of the jaw	--	Yes
Cooling of the vacuum tank	--	No
Minimum gap	mm	< 2
Maximum gap	mm	> 45
Stroke across zero	mm	> 4
Number of motors per jaw	--	1
Angular adjustment	--	No

2.3 Operational parameters and conditions

The TCLD collimators in IR1 and IR5 shall be used during proton and ion operation. They will be moved to settings of 10-20 local beam sizes before – or while – bringing the beams into collision. They can remain at parking levels in the other operational phases.

These new collimators should be designed to have a negligible contribution to the total machine impedance.

2.4 Technical and Installation services required

The TCLD collimators feature a simplified design compared to the one of the standard LHC collimators. They require a reduced set of controls cables (less motors), cooling water and baking equipment.

Table 2: Technical services

Domain	Requirement
Electricity & Power	YES
Cooling & Ventilation	Active cooling for the jaws (demineralized water)
Cryogenics	--
Control and alarms	YES
Vacuum	YES. The vacuum team encourages the usage of Conflat gaskets for all future designs.
Instrumentation	YES

Table 3: Installation services

Domain	Requirement
Civil Engineering	NO
Handling	YES – special transport. Independent of 11 T dipole / QTC assembly.
Alignment	YES

2.5 P & I Diagrams

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2.6 Reliability, availability, maintainability

Same standards as the other collimators.

2.7 Radiation resistance

All collimator components are optimized for operation in high radiation environments. For the case of IR1/5 TCLD's, radiation constraints are significantly relaxed compared to the IR7 collimators but detailed dose calculations have to be done for the nominal HL target integrated luminosity.

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

- It is planned to adopt the same design in all points requiring TCLD collimators. An appropriate space policy will be established when the total number of installed units will be known. Figures of 10-25 % seem appropriate at this stage.
- For IR1/5, the maximum number of TCLD units is 16 if this solutions is need for proton operation and 8 if it is only required for protons.

3 PRELIMINARY CONFIGURATION AND INSTALLATION CONSTRAINTS

3.1 Longitudinal range

The TCLD / 11 T dipole units location for IR1/5 needs to be studies in details. Preliminary layouts can be found in [5].

3.2 Volume

Smaller than a standard collimators. Latest design to date was presented in [9].

Detailed integration with the cryo by-pass is followed up in collaboration with WP11.

3.3 Installation/Dismantling

Present 15 m long dipoles in the cells concerned must be removed.

4 PRELIMINARY INTERFACE PARAMETERS

4.1 Interfaces with equipment

Vacuum and dipole cryostats through a dedicated cryo by-pass (QTC).

4.2 Electrical interfaces

New circuits are to be described in the document for the 11 T dipoles.

5 COST & SCHEDULE

5.1 Cost evaluation

Cost to be charged on the collimation code 61064.

5.2 Approximated Schedule

All the units for IR1 and IR5 need to be produced in time for an installation during LS3. The detailed planning depends obviously on the schedule of the 11 T dipole production. Note that the development for IR2, targeting an installation in LS2, will determine the design phase and first production line. This is presented in detail in [2], (including prototyping phase). The production for the LS3 implementation will build on the experience acquired for the LS2 implementation. We assume that an iteration on the design will be done following the first production line.

The possibility to install the TCLD's depend on the availability of new 11 T dipoles. In case of issues to deliver the required dipole units in LS2, alternative solutions must be studied. This will have an impact on the TCLD design. Therefore, alternatives should be defined in due time.

6 TECHNICAL REFERENCE DOCUMENTS

- [1] HiLumi-WP5 deliverable document 5.4, available on the HiLumi web page:
<http://hilumilhc.web.cern.ch/HiLumiLHC/results/deliverables/>
- [2] HL Conceptual Functional specification, TCLD in IR2, <https://edms.cern.ch/document/1366517>
- [3] HL Conceptual Functional specification, TCL in IR1/5, <https://edms.cern.ch/document/1366522>
- [4] HL Conceptual Functional specification, TCLM in IR1/5,
- [5] J. Jowett and M. Schaumann, "DS collimation for heavy-ion operation", presentation at the 2013 LHC Collimation Project review, <http://indico.cern.ch/event/251588>
- [6] G. Steel *et al.*, "Heat load scenarios and protection levels for ions", presentation at the 2013 LHC Collimation Project review, <http://indico.cern.ch/event/251588>
- [7] R. Bruce, A. Marsili, S. Redaelli, "Cleaning performance with 11 T dipoles and local dispersion suppressor collimation at the LHC", IPAC2014,
<http://accelconf.web.cern.ch/AccelConf/IPAC2014/papers/mopro042.pdf>
- [8] A. Lechner *et al.*, "Power deposition in LHC magnets with and without dispersion suppressor collimators downstream of the betatron cleaning insertion", IPAC2014,
<http://accelconf.web.cern.ch/AccelConf/IPAC2014/papers/mopro021.pdf>
- [9] L. Gentini, presentation at the 30th meeting of the Collimation Upgrade Specification working group, <http://indico.cern.ch/event/278104/>

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