

CONCEPTUAL SPECIFICATION

TARGET COLLIMATOR LONG DISPERSION SUPPRESSOR P7 [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 bypass between two 5.5 m-long 11 T dipoles that shall replace one standard LHC dipole. Around IR7, 2 TCLD collimators per side are necessary to adequately improve the collimation cleaning by removing loss spikes in the DS. These losses appear in 2 clusters at different dispersion values and are primarily caused by protons that have lost energy in the collimation insertion due to single diffractive interactions with the collimators. The TCLD collimators installation is tentatively scheduled for LS3 (long shutdown 3), but in case of severe limitations from quench behaviour or collimation cleaning, revealed by the operation in 2015, this schedule might be revisited.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V 1.0	S1-2 and S2-3	HLCTCLD to be created by S. Chemli

TRACEABILITY

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

Protons and ions interacting with the collimators in IR7 emerge from the IR with a changed magnetic rigidity. This represents a source of local heat deposition in the cold dispersion suppressor (DS) magnets downstream of IR7 (see [1] and references): these losses are the limiting locations for collimation cleaning, i.e. they are the highest cold losses around the ring. This may pose a certain risk for inducing magnet quenches, in particular in view of the higher intensities expected for HL-LHC.

A strategy to eliminate any risk of quench is the installation of DS collimators (TCLDs, Target Collimator Long Dispersion suppressor). Two collimators per side of IR7 would be sufficient to effectively intercept the protons or ions that would otherwise hit the DS magnets. Extensive tracking and energy deposition simulations, based on the assumption that the dipoles MB.B8R7 and MB.B10R7 are substituted with a pair of 11 T magnets and a TCLD collimator, indicate that this solution can greatly improve the collimation cleaning, reducing losses by a factor of 10 [1, 2, 3]. TCLD collimators also make the cleaning performance more robust against various error models of the LHC collimation and of the optics [4], as they remove at the first high dispersion location downstream of IR7 the off-momentum particles. This is of particular concern for the ATS optics that requires modified optics in the cold arcs. Should the LHC total intensity be limited by collimation cleaning, the factor 10 quoted above would translate into the same gain factor for the total stored beam energy.

1.2 Benefit or objective for the HL-LHC machine performance

DS collimation in IR7 can improve the cleaning by reducing by about a factor 10 the power density in cold magnets. For the HL baseline optics, this solution reduces significantly losses around the ring coming from the telescopic squeeze and lowers the sensitivity to losses from collimation, orbit and optics imperfections [4]. It should be noted that the DS collimation solution reduces also the radiation damage to the cold magnets protected by the TCLD collimators and the activation of nearby components.

Furthermore, the improvement in cleaning could be very beneficial for the LHC operation even if not limited by the collimation losses. For example, a better cleaning performance might allow to relax the opening of some secondary collimators with a subsequent reduction of the machine impedance.

The real need for this gain can only be addressed after having accumulated beam experience at higher energies during the post-LS1 operation (including beam tests of quench limits at energies close to 7 TeV). On the other hand, a recent collimation project review recommended to pursue with high priority the preparation of DS collimation in IR7 [5].

Even if the full performance improvement provided by the DS collimation solution in IR7 relies on 2 TCLD collimators per side, alternative solutions based on one single unit are being considered as possible “staged” deployment in IR7, in case of performance limitations during high intensity proton operation were made apparent by the post-LS1 operation experience.

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 losses caused by drops of beam lifetime during operation. Their design must ensure a correct functioning of the basic mechanical and beam cleaning functionalities (e.g., mechanical stability and flatness constraint, to be specified in detail).

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 key machine parameters affecting the design requirements are, amongst others, (1) total intensity and single bunch charge (determining requirements for cleaning and impedance); (2) assumed beam lifetime and tail population (cleaning); (3) injection and top energy failure scenarios (material robustness); (4) total design loss rates on the collimators.

As recommended by an external collimation project review [5], the design baseline assumes a 0.2 h lifetime during about 10 s. This defines, for a given collimator cleaning, the heat loads expected at these collimators. Different jaw lengths and materials have been comparatively addressed in terms of provided cleaning [3]. The baseline length adopted for the TCLD is 80 cm for IR7. Jaw are made of a W-based heavy alloys. The detailed TCLD integration studies are ongoing.

The cleaning constraints in IR7 are the most challenging and call for the longest collimator jaw design. The parameter above are used also as baselining for the implementation in other IRs [6, 7].

2.2 Equipment Technical parameters

Table 1: Equipment parameters

Characteristics	Units	Value
Jaw active length	mm	80
Jaw material	--	W
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
Transverse jaw movement (5 th axis)	--	No

2.3 Operational parameters and conditions

The TCLD collimators shall be used during proton and ion operation to improve the collimator betatron cleaning in all machine phases. As a minimum requirement, they will be moved to settings of 10-20 local beam sizes at top energy. But they can improve the cleaning at injection energy if needed.

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 [8]. 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
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 the TCLD' around IR7 the radiation constraints are significantly relaxed due to the limited beam loss loads at the DS locations.

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.
- Four units, i.e. 11 T dipoles, are needed in IR7 and will be installed in the dipole slots MB.B8R7 and MB.B10R7 (a symmetrical locations on the opposite side of the IP).

3 PRELIMINARY CONFIGURATION AND INSTALLATION CONSTRAINTS

3.1 Longitudinal range

The TCLD / 11 T dipole units around IR7 will replace the dipoles MB.B8R7 and MB.B10R7 at either side of the IR.

3.2 Volume

Smaller than a standard collimators. Latest design available in [8].

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.

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

The construction of 4 TCLD collimators and 1 spare for installation in LS3 is assumed here. 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.

In the present baseline, as recommended by the 2013 Collimation Project Review [5], it is planned to prepare for a deployment of DS collimation in IR2 during LS2. The priority for the deployment of TCLD/11 T dipole units in LS2 is however subject to the cleaning performance evaluation in 2015 with high-intensity proton beams. A (partial) installation in IR7 might be favoured in case of limitations during high intensity proton operation.

5.3 Schedule and cost dependencies

The possibility to install the TCLD's depends on the availability of new 11 T dipoles. It is expected that this technology and the possibility to produce the required units will be at hand by LS3 .

In case of problems with the 11 T dipoles, alternative solutions, e.g. based on moving the cryo magnets to free space for the TCLD collimators, will have to be considered.

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] R. Bruce, A. Marsili, S. Redaelli, "Cleaning performance with 11 T dipoles and local dispersion suppressor collimation at the LHC", IPAC2014, Dresden, GE (2014).
<http://accelconf.web.cern.ch/AccelConf/IPAC2014/papers/mopro042.pdf>
- [3] A. Lechner *et al.*, "Power deposition in LHC magnets with and without dispersion suppressor collimators downstream of the betatron cleaning insertion", IPAC2014, Dresden, GE (2014).
<http://accelconf.web.cern.ch/AccelConf/IPAC2014/papers/mopro021.pdf>
- [4] A. Marsili, R. Bruce, S. Redaelli, "Collimation cleaning for HL-LHC optics with error models," IPAC2014, Dresden, GE (2014).
<http://accelconf.web.cern.ch/AccelConf/IPAC2014/papers/mopro040.pdf>
- [5] Recommendation of the external review panel of the 2013 Collimation Project review, available at
<http://indico.cern.ch/event/251588>
- [6] HL Conceptual Functional specification, TCLD in IR2, <https://edms.cern.ch/document/1366517>
- [7] HL Conceptual Functional specification, TCLD in IR1/5, <https://edms.cern.ch/document/1366520>
- [8] 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