

CONCEPTUAL SPECIFICATION

TARGET COLLIMATOR LONG DISPERSION SUPPRESSOR P2 [LHC-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 IR2, 1 TCLD collimator per side is necessary to allow high ion beam luminosity operation for ALICE, while remaining safely below the quench limits of the superconducting magnets. The TCLD collimators installation is scheduled for LS2 (long shut-down 2), i.e. in conjunction with the ALICE detector upgrade for higher lead-ion luminosities.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V 2.0	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 Stefano Redaelli	
Committee/Verification Role	Decision	Date
PLC-HLTC/ Performance and technical parameters	Rejected/Accepted	2014-07-01
Configuration-Integration / Configurartion, 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

Secondary ion beams emerging from heavy ion collisions with a changed magnetic rigidity represent a source of local heat deposition in dispersion suppressor (DS) magnets downstream of IR2 (see [1] and references therein). These ion beams may pose a certain risk of inducing magnet quenches. For the ALICE upgrade that requests an instantaneous luminosity 6 times higher than the nominal one, losses are expected to be about a factor 2 above the quench limit. Similar risk during ion operation occurs in IR1 and IR5 [2]. A strategy to eliminate any risk of quench is the installation of DS collimators to catch ions beams before they reach the magnets. These collimators are referred to as TCLDs (Target Collimator Long Dispersion suppressor). One collimator per side of the experiment would be sufficient to effectively intercept the secondary beams from the most dominant processes in a location where these ions are well separated from the main beam. Energy deposition simulations were extensively carried out, based on the assumption that MB.A10 is substituted with a pair of 11 T magnets and a TCLD collimator, to confirm this assumption [1, 3].

1.2 Benefit or objective for the HL-LHC machine performance

DS collimation in IR2 is considered necessary for the ALICE detector upgrade taking place in LS2, aiming at a peak luminosity of $6 \times 10^{27} \text{cm}^{-2} \text{s}^{-1}$, corresponding to a loss in the MB.B10 dipole of about 50 mW/cm^3 . The proposed TCLD collimator installation, with a jaw based on 80 cm of a tungsten heavy alloy, is expected to reduce by more than a factor 100 the losses in the new 11 T dipoles compared to the losses in cold dipoles with the present layout with old dipoles and no TCLD collimators [3].

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 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 proposed DS collimation solution to the issue of ion luminosity debris depends on the assumed peak luminosity and on the quench limits of superconducting magnet (DS dipoles in this case). For the IR2 case discussed in this note, a peak luminosity of $6 \times 10^{27} \text{cm}^{-2}\text{s}^{-1}$ (ALICE upgrade) and a quench limit of about 30mW/cm^3 are assumed (see [4] for the conclusion on the quench limits).

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 [5, 6].

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 IR2 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 IR2 implementation.

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
Transverse jaw movement (5 th axis)	--	No

2.3 Operational parameters and conditions

The TCLD collimators around IR2 are expected to be used during heavy ion operation only. They will be moved to settings of 10-20 local beam sizes before – or while – bringing the beams in collision. The TCLD collimators should contribute in a negligible way to the machine impedance (note that they will only be needed with beam in collision, so beams will be stabilized by beam-beam effects).

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

Not applicable

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 IP2 TCLD's radiation constraints are significantly relaxed due to the limited beam loss loads (usage during ion operation only).

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.
- For IR2 only (2 TCLD units) one spare seems sufficient considering the production times.

3 PRELIMINARY CONFIGURATION AND INSTALLATION CONSTRAINTS

3.1 Longitudinal range

The TCLD / 11 T dipole units in point two will replace the MB.B10 dipoles at either side of the IR.

3.2 Volume

Smaller than a standard collimators. Latest design to date was presented in [7].

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

It is assumed that the construction of 2 TCLD collimators and 1 spare for installation in LS2 is required, following the ALICE upgrade program.

A TCLD prototype should also be built as soon as possible after having frozen the design (including integration of the cryogenics components) in order to gain experience with the new design.

Note that this preliminary schedule assumes that at most 2 TCLD/11 T dipole units will be feasible by LS2, limited by the timeline of 11 T dipole production. More TCLD collimator units might be needed for other alternative scenarios (e.g., need to consider alternative solutions based on moving magnets in IR7) or in case more 11 T dipole units were available.

Also note that the priority for the deployment of TCLD/11 T dipole units in LS2 is subject to the performance evaluation in 2015. In case the post-LS1 operation showed cleaning issues with high intensity proton beams, a (partial) installation in IR7, if proved effective, might be favoured compared to the IR2 installation for ion operation only.

Table 4: Tentative schedule

Phase	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Length definition from cleaning										
Functional specification										
Engineering specification										
Prototyping and tests										
Acquisition Process										
Production and validation										
Installation – Commissioning										
Beam operation										

5.3 Schedule and cost dependencies

The possibility to install the TCLD's depends 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, also available on the HiLumi web page:
<http://hilumilhc.web.cern.ch/HiLumiLHC/results/deliverables/>
- [2] EDMS document 1366520, <https://edms.cern.ch/document/1366520>
- [3] 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>
- [4] A. Verweij, "Quench limits: extrapolation of quench tests to 7 TeV", presentation at the 2013 LHC Collimation Project review, <http://indico.cern.ch/event/251588>
- [5] 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>
- [6] 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>
- [7] 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