CONCEPTUAL SPECIFICATION

TCP – LHC PRIMARY COLLIMATORS

WP5

Equipment/system description

Carbon-based primary collimators (TCP, Target Collimator Primary) are used in the LHC to define the primary beam halo cut in the momentum (IR3) and betatron (IR7) cleaning insertion. One TCP collimator per beam is used in IR3 (horizontal orientation) whereas 3 collimators are used in IR7 (horizontal, vertical and skew orientations) for a total of 8 primary collimators in the LHC. Since these collimators are the closest ones to the circulating beams, their jaws are built with a robust Carbon-Fibre Composite (CFC) that is designed to withstand the design LHC failure scenarios at injection (full injection train of 288 bunches impacting on one jaw) and at 7 TeV (up to 8 bunches impacting on one jaw in case of an asynchronous dump). The need to improve the TCP collimator design in view of the updated beam parameters for the HL-LHC design is being assessed.

Layout Versions	LHC sectors concerned	CDD Drawings root names (drawing storage):
V 1.1	IR7	HLHEB to be created by S. Chemli

TRACEABILITY

Project Engineer in charge of the equipment	WP Leader in charge of the equipment
O. Aberle	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

Carbon-based primary collimators (TCP, Target Collimator Primary) are used in the LHC to define the primary beam halo cut in the momentum (IR3) and betatron (IR7) cleaning insertion. One TCP collimator per beam is used in IR3 (horizontal orientation) whereas 3 collimators are used in IR7 (horizontal, vertical and skew orientations) for a total of 8 primary collimators in the LHC. Since these collimators are the closest ones to the circulating beams, their jaws are built with a robust Carbon-Fibre Composite (CFC) that is designed to withstand the design LHC failure scenarios at injection (full injection train of 288 bunches impacting on one jaw) and at 7 TeV (up to 8 bunches impacting on one jaw in case of an asynchronous dump) [1]. The need to improve the TCP collimator design in view of the updated beam parameters for the HL-LHC design is being assessed.

1.2   Benefit or objective for the HL-LHC machine performance

The upgrade of the LHC primary collimators might be needed for HL-LHC if the present design:
-    proved not to be adequate to cope with the design LHC failure scenarios updated for the upgraded HL-LHC beam parameters (larger bunch intensity and smaller emittances);
-    proved not to be adequate for the standard operational losses with a larger stored beam energy in HL-LHC: for the same assumed minimum beam lifetime in operation, the total loss rates expected on the collimators might be up to a factor 2 larger for HL-LHC than for LHC;
-    can be improved in a way that HL-LHC could profit from; e.g. improved materials or improved alignment features (integrated BPMs) for a more efficient operation.

Present work is on-going to understand if the present design is adequate for the HL-LHC parameters.

1.3   Equipment performance objectives

The primary collimators are a fundamental element of the LHC multi-stage collimation hierarchy and are required in all operational conditions with beam in the machine. These are therefore high-reliability devices that must be compatible with operation in very high radiation environments and withstand standard operational losses and relevant failure cases without permanent damage that can jeopardize their functionality. In particular, the present design is robust against [1]:
-    injection failure scenario: 1 injected train of up to 288 bunches at 450 GeV impacting on one jaw;
-    asynchronous beam dump at top energy: up to 8-10 bunches at 7 Tev impacting on one jaw;
-    continuous loss rates during standard operation: 0.2 h beam lifetime at 7 TeV during up to 10 s (equivalent to peak losses of 500 kW during 10 s for the LHC nominal case) and 1 h beam lifetime for an indefinite amount of time.

TECHNICAL ANNEXES

2 PRELIMINARY TECHNICAL PARAMETERS

2.1 Assumptions

Assuming for the moment the same failure scenarios as for the LHC design [1] to be updated with the HL-LHC parameters. Relevant parameters are

- bunch intensity;
- bunch emittance (injected value and top-energy value);
- maximum number of bunches per injection train;
- minimum allowed beam lifetime at top energy with maximum intensity in the machine.

2.2 Equipment Technical parameters

The key design parameters are given in the following table.

Table 1: Equipment parameters

Characteristics	Units	Value
Jaw active length	mm	600
Jaw material	--	CFC
Flange-to-flange distance	mm	1480 (to be reviewed)
Number of jaws	--	2
Orientation	--	Horiz., vert., skew
Number of motors per jaw	--	2
Number of BPMs per jaw	--	2
RF damping	--	Fingers
Cooling of the jaw	--	Yes
Cooling of the vacuum tank	--	Yes
Minimum gap	mm	< 1
Maximum gap	mm	> 60 (to be reviewed)
Stroke across zero	mm	> 5
Angular adjustment	--	Yes
Jaw coating	--	No
Transverse jaw movement (5th axis)	mm	+/- 10 mm (at least)

2.3 Operational parameters and conditions

Same as the present system.

2.4 Technical and Installation services required

Same as the present system.

Template EDMS No.: 1311290

2.5   P & I Diagrams

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2.6   Reliability, availability, maintainability

The LHC cannot operate above safe intensities without primary collimators.

2.7   Radiation resistance

Same as the present system.

2.8   List of units to be installed and spares policy

Eight primary collimators are installed in the LHC. Adequate spare policy for HL-LHC to be defined.

3   PRELIMINARY CONFIGURATION AND INSTALLATION CONSTRAINTS

3.1   Longitudinal range

Same as the present system, see [1].

3.2   Volume

Same as the present system, see [1].

3.3   Installation/Dismantling

Present primary collimators will have to be dismounted to allow the installation of upgraded TCPs.

4   PRELIMINARY INTERFACE PARAMETERS

4.1   Interfaces with equipment

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4.2   Electrical interfaces

No changes for the powering.

5   COST & SCHEDULE

5.1   Cost evaluation

The indicative figure of 500 kCHF per collimator unit is assumed.

5.2   Approximated Schedule

The needs for upgrading the primary collimators must be addressed in time for an upgrade in LS3.

5.3   Schedule and cost dependencies

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6　TECHNICAL REFERENCE DOCUMENTS

[1] R. Assmann *et al.*, Collimation chapter of the LHC Design Report, edited by O. Brüning *et al.*, http://ab-div.web.cern.ch/ab-div/Publications/LHC-DesignReport.html

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