CERN-ACC-2014-0303

HiLumi LHC

FP7 High Luminosity Large Hadron Collider Design Study

Milestone Report

Definition of New IR Collimation Solutions

Bruce, Roderick (CERN) *et al*

01 December 2014

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.

This work is part of HiLumi LHC Work Package **5: Collimation**.

CERN-ACC-2014-0303

Grant Agreement No: 284404

HILUMI LHC

FP7 High Luminosity Large Hadron Collider Design Study

Seventh Framework Programme, Capacities Specific Programme, Research Infrastructures, Collaborative Project, Design Study

MILESTONE REPORT

DEFINITION OF NEW IR COLLIMATION SOLUTIONS

MILESTONE: MS51

Document identifier:	HILUMILHC-Mil-MS51
Due date of deliverable:	End of Month 36 (October 2014)
Report release date:	01/12/2014
Work package:	WP5 Collimation
Lead beneficiary:	CERN
Document status:	Final

Abstract:

Definition of new IR collimation solution: this document describes the collimation layouts in the different LHC insertions. In addition to the experimental insertions that are the focus of the FP7 HiLumi-WP5, a global overview of the upgrade layouts in other LHC insertions is also given.

The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404. HiLumi LHC began in November 2011 and will run for 4 years.

Delivery Slip

	Name	Partner	Date
Authored by	R. Bruce, A. Lechner, S. Redaelli	CERN	07/11/2014
Edited by	S. Redaelli, C. Noels	CERN	07/11/2014
Reviewed by	R. Appleby, WP5 deputy coordinator L. Rossi, Project coordinator	UNIMAN CERN	16/11/2014
Approved by	Steering Committee		17/11/2014

TABLE OF CONTENTS

Executive summary

Layouts for conceptual (and for some IRs technical) collimation solutions are defined and available for all IRs. In particular, the layouts for incoming and outgoing beam collimation in IR1 and IR5 are defined and part of the LHC optics version HL-LHCV1.1. This is the main focus of the EU part of the WP5 studies. In addition, WP5 provided layouts for dispersion suppressor collimator solutions based on 11T dipoles and TCLD collimators. This covers the cases of IR2 (1 TCLD per beam) and IR7 (2 TCLD) and a layout for ion cleaning in IR1/5 is also available. The outcome of this work, and the scripts to install collimators and new dipoles in the lattice, were made available for the teams concerned: integration team, WP11 (11T dipole), WP2 (lattice and impedance), WP10 (energy deposition teams).

1. INTRODUCTION

The definition of new collimation layouts in the different LHC insertions is one of the main responsibilities of the WP5 study. The definition of layouts is performed through the preparation of machine sequences that include the collimator positions and geometrical properties (length, materials, aperture interfaces, etc.). At this stage, the definition of conceptual collimation solutions is essentially completed for all LHC insertions.

New layouts are used as input not only for the collimation studies carried out by all WP5 partner institutes, but also for steering the work of supporting teams (integration, optics, energy deposition, …).

This core activity is carried out primarily by the CERN collimation team responsible for the definitions of the new collimation solutions. This activity has been performed since the beginning of the HiLumi-WP5 as a part of the studies for the HL-LHC collimation. Layouts are passed for detailed validation to the other simulations teams within and outside WP5.

2. COLLIMATION LAYOUT IN ALL LHC INSERTIONS

2.1. WEB REPOSITORIES

The collimation layouts and the relevant information for collimation simulations, e.g. inputs and outputs defined as interfaces between the different simulation codes, are consistently collected on the web page of the LHC Collimation Upgrade Specification working group:

http://lhc-collimation-upgrade-spec.web.cern.ch/LHC-Collimation-Upgrade-Spec/

This site contains also relevant information for the collimation studies within EuCARD2. All the collimation upgrade studies for HL–LHC are consistently collected.

Since 2014, the information of the collimation layouts under validation is also part of the standard optics version HL-LHCV1.1. This is available at a page under the responsibility of the WP2 teams:

https://espace.cern.ch/HiLumi/WP2/task2/SitePages/Home.aspx

In the following section, the key layout changes put in place for the collimation upgrade are summarized for the different interaction points. More details can be found also in the extensive list of collimation conceptual functional specifications that cover the relevant aspects of collimation upgrade [http://lhc-collimation-upgrade-spec.web.cern.ch/lhc-collimation-upgrade-spec/Documents.php]. Note that here the focus is put on the upgrade studies that are relevant for the EU FP7 study.

2.2. IR1/5 (ATLAS/CMS)

The high-luminosity points are among the most challenging from the collimation point of view because the smallest β^* implies the tightest aperture, and the highest peak luminosity causes the largest losses from collision products. The collimation layouts of IR1/5 required a complete revision for HL-LHC in order to follow the magnet layout changes.

The conceptual collimation solutions for IR1/5 for **proton operation** that meet the collimation requirements for the optics version HL-LHCV1.1 are described in detail in the WP5 deliverable document D5.5. This solution relies on:

- Two pairs of horizontal and vertical tertiary collimators installed on the incoming beams and located in front of the Q5 and between D2 and TAXN;
- Three horizontal physics debris absorbers installed on the outgoing beam and located on the IP-side of D2, Q5 and Q6;
- Up to 4 fixed masks for the physics debris cleaning, mounted on the IP-side of D2, Q4, Q5 and Q6.

The detailed number of masks and final positions and number of the movable collimators are being evaluated as a part of the validation of this conceptual solution. This conceptual solution is described in detail in the WP5 deliverable report 5.5.

At this stage, it is concluded that for proton operation there is no need for local dispersion suppressor collimators if all the physics debris collimators are installed as described. This conclusions will be reviewed when the final optics layout is finalized and during the LHC Run II, from beam-based evaluation of the assumed quench limits.

For **ion operation**, layouts for dispersion suppressor collimation, based on 11T dipoles and TCLD collimators, have been studied and defined. In a similar way as done for IR2, 1 TCLD collimator might be sufficient to solve the cleaning issue during ion operation. The position is being optimized to help also the cleaning of physics debris for proton operation.

2.3. IR2 (ALICE)

The IR2 layout changes for HL-LHC are steered by the requirements for the ion luminosity upgrade. The proposed solution to the ion cleaning issue is based on one TCLD collimator per beam installed in the dispersion suppressors at each side of IP2. This lay-out requires 11T dipoles to be installed, replacing standard 15 m long dipoles (one per side of the IP. This solution was described in detail in the HiLumi-WP5 deliverable document D5.4.

2.4. IR8 (LHCB)

No collimation layout upgrades are foreseen within the HiLumi-WP5 in IR8. The possibility to add one physics debris absorber on each outgoing beam in being considered, in collaboration with WP10. No layouts are available at this preliminary stage.

2.5. IR7 (BETATRON CLEANING)

The main upgrade scenarios for the betatron cleaning insertion foresee:

- New secondary collimators based on novel high-robustness and low-impedance materials; the layouts were already defined as a part of the design of the present collimation system: new secondary collimator slots are available adjacent to each present secondary collimators for an easy upgrade of the system.
- 2 new dispersion suppressor collimators per side of the P7, to cure potential issues of collimation cleaning both for ion and proton beams; layouts and performance for this solution are described in detail in the HiLumi-WP5 deliverable document D5.4.

It is noted that the possibility to improve the design of the present IR7 movable collimators (primary and secondary collimators made of CFC and shower debris absorbers made of heavy tungsten alloys) and passive absorbers is also considered within HL-LHC. This has no implication on the machine layouts: at this stage, we only envisage the possibility to replace the present collimators.

2.6. IR3 (MOMENTUM CLEANING)

The only upgrade of IR3 considered at this stage is the possibility to improve the materials of the secondary collimators. As for the IR7 case, layout slots are already available for this purpose. As commented already for IR7, as part of HL-LHC we are also considering the possibility to improve the design of present collimators that might be replaced without machine layout changes.

3. CONCLUSION / RELATION TO HL-LHC WORK

Collimator layouts for HL-LHC collimation solutions are available for the baseline optics version. They have been used for detailed performance studies by the collimation teams within WP5 and by supporting teams like WP10 for energy deposition. Lattices and optics for collimation studies were in particular provided to the Merlin and BDSIM collimation study teams. Reports presented recently in IPAC2013 and IPAC2014 (see for example [1]) showed that these inputs were successfully used for settings up the required WP5 simulations.

Within CERN, layouts are also used by other HL-LHC teams, like the integration and the WP11 (11T dipole) teams. They were also taken as an input for the WP2 team responsible for the layout and optics sequence definition.

It is planned that the WP5-provided scripts for the collimation layout implementation into the LHC sequences will be integrated and passed to the WP2 optics team for an implementation into the default sequence repository. This work is basically already completed. The layouts shall be updated after the ongoing validation process that will produce the IR collimation technical definition.

4. REFERENCES

[1] M. Serluca *et al.*, “HiLumi LHC collimation studies with Merlin code,” proc. of IPAC2014, http://accelconf.web.cern.ch/AccelConf/IPAC2014/papers/mopri077.pdf

5. ANNEX: GLOSSARY

Acronym	**Definition**
DS	Dispersion Suppressor
IR	Interaction Region
IP	Interaction Point
LS1, LS2, LS3	Long-shutdown1, 2, 3
TCLD	Target Collimator Long for Dispersion suppressor