UNIVERSITY OF LIVERPOOL

Local Interaction Region Coupling Correction for the LHC and High Luminosity LHC

Author:
Felix SOUBELET

Supervisors:
Dr. Tobias PERSSON
Dr. Rogelio TOMÁS
Prof. Carsten WELSCH

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For/Dedicated to/To my...

UNIVERSITY OF LIVERPOOL

Abstract

CERN
School of Physical Sciences

Doctor of Philosophy

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by Felix SOUBELET

Lorem ipsum.

Acknowledgements

First and foremost,

"*Just don't forget to eat and sleep.*"

Lee Robert Carver.

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List of Abbreviations

ABP	CERN's **A**ccelerators and **B**eam **P**hysics group
AD	**A**ntiproton **D**ecelerator
ALICE	**A** **L**arge **I**on **C**ollider **E**xperiment
ATLAS	**A** **T**oroidal **L**HC **A**pparatu**S**
AWAKE	**A**dvanced **WAK**efield **E**xperiment
BE	CERN's **BE**ams department
BPM	**B**eam **P**osition **M**onitor
CERN	**E**uropean **O**rganization for **N**uclear **R**esearch
CMS	**C**ompact **M**uon **S**olenoid
DA	**D**ynamic **A**perture
ELENA	**E**xtra **L**ow **EN**ergy **A**ntiproton ring
HERA	**H**adron-**E**lectron **R**ing **A**ccelerator
HiRadMat	**H**igh **Rad**iation to **Mat**erials
HL-LHC	**H**igh **L**uminosity **L**arge **H**adron **C**ollider
HSS	CERN's **H**adron **S**ynchrotron **S**ingle particle effects section
IP	**I**nteraction **P**oint
IR	**I**nteraction **R**egion
ISOLDE	**I**sotope **S**eparator **O**n **L**ine **DE**tector
LEIR	**L**ow **E**nergy **I**on **R**ing
LHC	**L**arge **H**adron **C**ollider
LHCb	**L**arge **H**adron **C**ollider **b**eauty
MAD	**M**ethodical **A**ccelerator **D**esign
n-TOF	**N**eutron **T**ime **O**f **F**light
OMC	**O**ptics **M**easurements and **C**orrections
PS	**P**roton **S**ynchrotron
PTC	**P**olymorphic **T**racking **C**ode
RDT	**R**esonance **D**riving **T**erm
SPS	**S**uper **P**roton **S**ynchrotron

Introduction

Some paragraph of text here. Figures to include:

FIGURE 1: The CERN Accelerator Complex as of 2020. This graphic indicates the first year of operation for each accelerator, as well as its circumference. Not to scale.

FIGURE 2: Cross-section of an LHC superconducting dipole magnet (see https://cds.cern.ch/record/40524).

FIGURE 3: The LHC ring with the purpose of the main sections. Not to scale.

As mentioned, each Insertion Region is separated from the previous one by an arc and has its own purpose:

1. IR1 houses the ATLAS experiment
2. IR2 houses the ALICE experiment and the injection of Beam1
3. IR3 houses the off-momentum collimation cleaning (ref https://accelconf.web.cern.ch/ipac2016/doi/
   IPAC2016-WEPMW007.html)
4. IR4 houses the RF cavities to accelerate the beams
5. IR5 houses the CMS experiment
6. IR6 houses the beams extraction to the dumps (ref https://cds.cern.ch/record/1392619)
7. IR7 houses the betatronic collimation cleaning (ref https://cds.cern.ch/record/1056681)
8. IR8 houses the LHCb experiment and the injection of Beam2

FIGURE 4: Integrated luminosity in the four experiments of the LHC during the 2017-2018 LHC Run 2.

FIGURE 5: Beam positions around the two high luminosity Interaction Points during the 2018 LHC Run. The dipoles are represented by blue rectangles while the quadrupoles by red ones.

0.1 The CERN Accelerator Complex and its Upgrade

0.1.1 An Overview of CERN History

0.1.2 The Large Hadron Collider and its Injectors

0.1.3 The Concept of Luminosity

0.1.4 The LHC Performance and the HL-LHC Upgrade

0.2 Optics Measurements and Corrections in the LHC

0.2.1 The need

0.2.2 The practice

0.2.3 ETC

Chapter 1

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Some paragraph before the first section.

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1.2 Non-Linear Magnetic Multipoles

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1.4 Phenomenology of Non-Linear Beam Dynamics

1.4.1 Chromaticity

1.4.2 Detuning with Amplitude

1.4.3 Decoherence

1.4.4 Resonances and RDTs / CRDTs

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1.5 Luminosity

1.6 Notions of Machine Learning Here?

Chapter 2

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Some paragraph before the first section.

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2.1.1 The LHC Arcs

2.1.2 The LHC Insertion Regions

2.1.3 Error Estimates for the LHC Lattice

2.2 The LHC Experimental Interaction Regions (EIR)

2.2.1 Interaction Point

2.2.2 The LHC Triplet

2.2.3 Separation Dipoles

2.2.4 Matching Section

2.2.5 Dispersion Supressor

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2.4 Beam Instrumentation in the LHC

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Some paragraph before the first section.

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3.2 Proof of Principle: Measurement and Correction of Local Coupling in the LHC Interaction Regions

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3.2.2 Beam-Based Study of IRs Local Coupling

3.2.3 Simulations of IRs Local Coupling

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3.3.2 Impact on Dynamic Aperture (hopefully none)?

3.3.3 Impact on Luminosity (hopefully yayyy)?

3.4 Operational Correction Procedure

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3.4.2 Developped Software

3.5 Conclusions

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5.1.1 Measurement of Local Coupling in the IRs at $\beta^*_{IP} = 0.3m$

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5.2 LHC Run III Commissioning Experience

5.3 Conclusions

Conclusions

Talk about stuff.

Bibliography

Appendix A

Appendix A Title

Some content.

Appendix B

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