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LIV.



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



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for the degree of Doctor of Philosophy at the*
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For/Dedicated to/To my...

UNIVERSITY OF LIVERPOOL

Abstract

CERN
School of Physical Sciences

Doctor of Philosophy

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

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 Large Ion Collider Experiment
ATLAS	A Toroidal LHC Apparatu S
AWAKE	Advanced W AKefield Experiment
BE	CERN's B Eams department
BPM	B eam P osition M onitor
CERN	E uropean O rganization for Nuclear R esearch
CMS	C ompact M uon S olenoid
DA	D ynamic A perture
ELENA	E xtra L ow E NErgy A ntiproton ring
HERA	H adron- E lectron R ing A ccelerator
HiRadMat	H igh R adiation to M aterials
HL-LHC	H igh L uminosity L arge H adron Collider
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 D Etector
LEIR	L ow E nergy I on R ing
LHC	L arge H adron Collider
LHCb	L arge H adron Collider 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

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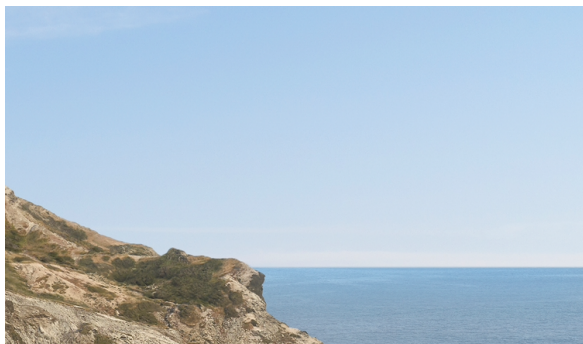


FIGURE 1: The CERN Accelerator Complex as of 2020. This graphic indicates the first year of operation for each accelerator, as well as its circumference. Not to scale.

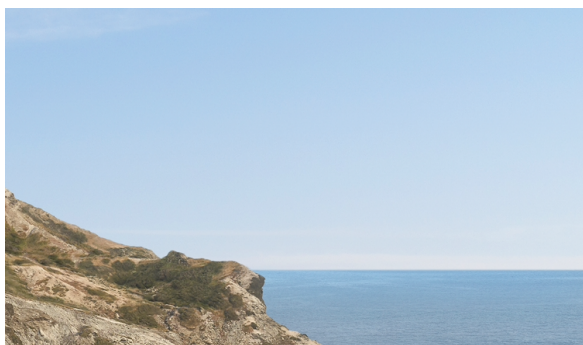


FIGURE 2: Cross-section of an LHC superconducting dipole magnet (see <https://cds.cern.ch/record/40524>).

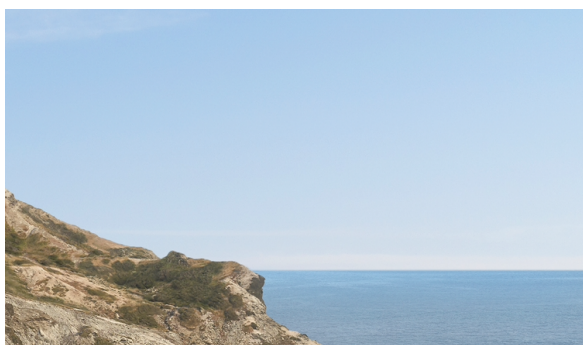


FIGURE 3: The LHC ring with the purpose of the main sections. Not to scale.

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/JAIPAC2016-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

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Chapter 1

Theory of Beam Dynamics Pertaining to Transverse Single-Particle Motion in the Large Hadron Collider

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1.1 Linear Beam Dynamics

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2.1 The LHC Lattice

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Chapter 3

Modelling and Correction of the Linear Optics

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3.1 Measurement and Correction of the Linear Optics

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4.4.2 Software

4.5 Conclusions

Chapter 5

Machine Learning for Interaction Region Local Coupling

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- 5.1 The influence of various sources to local coupling**
- 5.2 Identification of Sources with Machine Learning**
- 5.3 Prediction of Corrections for Local Coupling**
- 5.4 Conclusions**

Chapter 6

Experimental Measurement and Correction of Interaction Region Local Coupling in the LHC Run III

Some paragraph before the first section.

6.1 Dedicated Measurement and Correction of Local Coupling in IR1 and IR5

6.1.1 Measurement of Local Coupling in IR1 at $\beta_{IP1}^* = 0.3m$

6.1.2 Correction of Local Coupling in IR1 at $\beta_{IP1}^* = 0.3m$

6.1.3 Correction of Local Coupling in IR5 at $\beta_{IP5}^* = 0.3m$

6.2 LHC Run III Commissioning Experience

6.3 Conclusions

Conclusions

Talk about stuff.

Bibliography

Appendix A

Appendix A Title

Some content.

Appendix B

Appendix B Title

Some content.

Appendix C

Appendix C Title

Some content.