Contents

List of Tables

List of Figures

Chapter 1

Introduction

Synchrotron Radiation (SR) emission is the phenomenon product of the change of direction of relativistic-charged particles. Ever since it was observed in 1947 at the G.E. Synchrotron, the interest in its study has increased, even though great part of the theory was developed before that, and it is still being developed at the present (after a hundred years).

In electron storage rings and circular accelerators, the emitted synchrotron radiation reaches high intensities and energies. Although, Nowadays, there are dedicated electron accelerators with the purpose of producing SR with specific characteristics; in many other accelerators, S.R. is considered a secondary product which is nocuous to the operation of the machine.

The power of emitted S.R. depends on the square of the Lorentz factor (γ_r^2). For this reason S.R. was considered negligible in hadron accelerators. It was until the construction of LHC, that hadron S.R. became a problem for protons with a $\gamma_r^2 = 7460$ that the negative effects of S.R. were not negligible. The LHC is the coldest place in the universe, in order to keep the superconductor magnetic coils at 1.9 °K, gigantic cryogenic plants are used because of the arc S.R. heat load of 0.17 W/m/aperture. The vacuum in the LHC is as low as interestellar vacuum 10^{-14} bar, high-energy photons from S.R. can remove molecules and particles from the wall, degrading this vacuum. Yet another problem related to S.R. is the formation of electron clouds. These clouds could grow from seed electrons torn from the wall by incident photons, these electrons are attracted by the proton beam and also follow the magnetic field lines. Electron-cloud problems are the main motivation for these studies.

The main objective of this work is to map the absorption points of S.R. photons in the arcs of the LHC, with the idea that this map could be used in the future to generate a photon distribution function (P.D.F.) to be used as an input for electron-cloud simulations. To make this map we use the code Synrad3D developed at Cornell which generates and tracks synchrotron-radiation photons in an accelerator beam line, including specular and diffuse reflection on the chamber surface. The photons are generated randomly in any bending field, with initial parameters determined by the local beam distribution, the local electromagnetic field, and by the beam energy. When a photon hits the chamber wall its reflection probability depends on the energy and angle of incidence, as well as on the material, including combinations of multiple layers, and on the surface roughness.

The first chapter of this thesis is devoted to the most basic introduction to accelerator design {a lo mejor accelerator design no es la mejor forma de decirlo, basics of accelerators o algo asi, semblance quizá} and then it presents some features a lo mejor en vez de some features, usar the description of the highest-energy circular colliders where our analysis was implemented.

We then present in the second chapter a qualitative description of S.R. {a lo mejor poner explícito synchrotron radiation} for a further understanding of it, the author recommends going through chapters 1, 2 and 3 of "Synchrotron Radiation" by A. A. Sokolov. {aqui no se si debo decir eso o no… en caso de que sí, ver como hacer la referencia de forma correcta}

A description of the code Synrad3D is given in the third chapter. This is the code we use for all simulations described in this thesis. Also, some tests and benchmarking of the code will be mentioned.

Finally, in the last two chapters, we present our simulations, and the implications they have to the previously mentioned accelerators.

Chapter 2

Accelerators

2.1 LHC

1. HL-LHC
2. HE-LHC

2.2 FCC-hh

11

Chapter 3

Synchrotron Radiation

Chapter 4

Synrad3D

Chapter 5

Results

Chapter 6

Conclusions

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Chapter 7

References