MASTERS THESIS PROJECT
(ANTEPROYECTO)

TITLE:

TITULO:

RESEARCH LINE (LGAC):
Fisica Matematica

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Abstract

This project consists on perform an analysis and calibration of the LHC luminosity data recorded by the CMS experiment during the new phase starting in 2022 (Run 3) using the Pixel Cluster Counting (PCC) method. Luminosity gives a measure of how many collisions are happening in a particle accelerator and a precise determination of this will allows us precise tests of the Standard Model and searches for new physics like dark matter and supersymmetry theories. The PCC method is an offline technique for the calculation of instantaneous luminosity by counting the number of pixel clusters in the detector. The high densities of pixels of the Inner Tracker of the CMS detector gives a low hit occupancy in the sensors during the proton-proton collisions, this leads to a very linear response and small uncertainties for the luminosity measurement.

1 BACKGROUND

The standard model (SM) of particle physics is so far the best theoretical model to describe the interaction of elementary particles mediated by three of the four fundamental forces of nature which are electromagnetic force, strong nuclear force and the weak nuclear force. The SM is divided into two categories, the bosonic sector and the fermionic sector. The bosonic sector contains particles which mediate the fundamental forces of nature and the fermionic sector contains particles which make up all known matter in our universe. There are three generations of fermion particles: the first generation consists of up (u) quark, down (d) quark, electron and electron neutrino, the second generation consist of charm (c) quark, strange (s) quark, muon and muon neutrino, and the third generation has the top (t) quark, bottom (b) quark, tau and tau neutrino. The bosonic sector consists of the gauge bosons: gluon, photon, $W^{\pm}$, Z^0 which mediate strong nuclear force, electromagnetic force and weak nuclear force respectively. The Higgs boson (H), is the last of the gauge bosons, it gives mass to the other SM particles via electroweak symmetry breaking mechanism **?**. The heavy particles ($W^{\pm}$, Z^0, H, and top) can only be produced at high energy particle colliders like the Large Hadron Collider (LHC) operating at a center-of-mass energy of 13 TeV in Geneva, Switzerland (Figure **??**). Until the 90s, existence of almost all the SM particles were confirmed except the top quark and the Higgs boson. These had eluded previous experiments due to difficulties in the production and reconstruction of its decay products. The top quark was discovered in 1995 at the Tevatron collider of the Fermilab laboratory, this proton collider operated with a center-of-mass energy of 1.8 TeV until 2010. In 2012, the ATLAS and CMS experiments, with detectors placed at two points where the proton beams collide in the LHC, announced the discovery of a new particle with a mass of 125 GeV. This particle has been identified as the Higgs boson by measuring its properties and comparing to those predicted by the SM.

Luminosity, L, is a key parameter at particle colliders along with the energy available in the collision. L is one of the main figures of merit that quantify the potential for observing new particles and measuring their properties. The instantaneous luminosity $L(t)$ is the process-independent ratio between the rate $R(t)$ of events produced per unit time and the cross section for a given process σ: $L(t) = R(t)/\sigma$. During Run 1 (2011-2012) LHC reached a peak instantaneous luminosity of 0.77×10^{34} cm^{-2}s^{-1} and delivered an integrated luminosity of about 25 fb^{-1} with a precision of about 2.0% [1]. In the first part of Run 2 (2015-2016), the delivered luminosity has been measured to be 38.4 fb^{-1} with an unprecedented precision of

[1] 1 barn is a unit of area corresponding to 10^{-24} cm^2 and 1 femtobarn (fb) = 10^{-39} cm^2. For comparison, the total Higgs production cross section is 48600 fb.