The Measurement of B_s^0 Meson Spectra in p-Pb Collisions at 8.16 TeV.

by

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DISSERTATION

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To my family and friends

Acknowledgments

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Abstract

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Introduction

The primary goal of this work is to study the b-quark hadronization by measuring the exclusive production of B_s^0 mesons in p-Pb collisions. Furthermore, we aim to prove the relation between energy loss and flavor.

Chapter1

The Standard Model of Particle Physics

Several particles were discovered after years of experimental observations, and this led to the development of the Standard Model (SM) during the 1970s. The SM does not only describe the fundamental particles and interactions (except for gravitation) but also predicts new particles. The fundamental particles in the SM have a property known as spin and are divided into two main groups, Fermions, and Bosons, as shown in Fig 1.1.

Fermions obey the Pauli exclusion principle, have half-integer spin, and there exists an antiparticle with the same properties but opposite quantum numbers, such as electric charge. They are subdivided into Quarks and Leptons, both groups having six particles, and they are further grouped into three generations according to their mass. Quarks (u, d, s, c, t, b) are always found in bound states known as hadrons. A bounded state of a quark and an antiquark forms a meson, while three bounded quarks form a baryon. Leptons on the other hand have integer spin and are electrically charged (e, μ, τ) or neutral (their corresponding neutrinos, ν_e, ν_μ, ν_τ).

Bosons are known as the force or interaction carriers and are divided into vector and scalar bosons. The scalar boson is the Higgs boson, and it gives the other elementary particles mass. The vector bosons are related to the fundamental interactions. The photon is the electromagnetic interaction carrier, the massive bosons, $W^\pm$ and Z, mediate the weak force and gluons the strong force. The theory that describes the strong force is known as Quantum Chromodynamics (QCD) and will be briefly discussed in the next section.

SM is considered the most successful theory developed by mankind, however, there are several physical phenomena it cannot explain. For instance, the existence of three and only three generations of fermions. It doesn't account for gravity and to date, there is no observation of the vector boson responsible for the gravitational interaction, also known as the graviton. It also doesn't describe why there is more matter than antimatter in the universe, among other properties.

A more complete description of the model requires the understanding of the underlying Quantum Field Theory (QFT) in which SM is based, and the symmetries of the Lie group SU(3)× SU(2)× U(1).

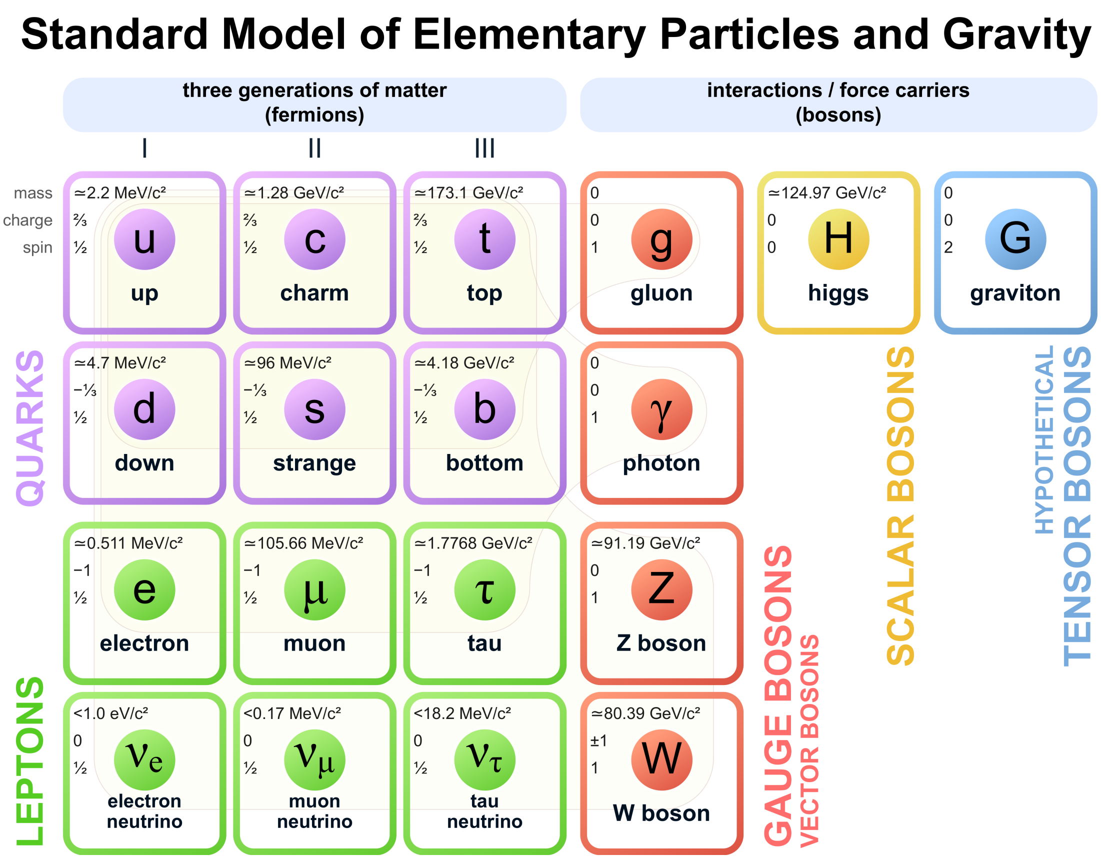

Figure 1.1: Standard Model. Fundamental particles are divided into Fermions and Bosons (force carriers). Fermions are divided into Quarks and Leptons and also in three differente generations. This figure was retrieved from

1.1 QCD

1.2 B_s^0

1.2.1 $B_s^0 \to J/\psi\phi$

Chapter2

The Large Hadron Collider

The Large Hadron Collider (LHC) is the largest particle collider in the world. It is located inside a 26.7 km long underground tunnel in the facilities of the European Organization for Nuclear Research (CERN), near Ginebra. This tunnel was used in the past for the Large Positron-Electron Collider (LEP) before it was shut down in 2000.

The initial goal of the LHC was to detect the Higgs Boson. For this purpose, it began operations in 2008, but due to a malfunction incident, it was shut down until the end of 2009. Finally, the Higgs boson was detected in 2012. On top of that, many other predictions of the SM have been confirmed using the LHC experimental infrastructure, and it has also been possible to study the phenomena the SM cannot explain, as described in the previous chapter.

The LHC is able to produce proton-proton (p+p) collisions at energies up to 7 TeV and lead ions (Pb-Pb) collisions at 2.76 TeV. p-Pb collisions are also possible at 5.02 TeV [1] and are of special interest in this manuscript. For such collisions, two beams of the target particles are generated using the Proton Synchrotron (PS) and the Super Proton Synchrotron (SPS) and then accelerated in opposite directions at energies up to 460 GeV.

There are four points where collisions occur, and there is a detector associated with each point, as shown in fig 2.1. Two of these detectors are for general purposes: A Toroidal LHC Apparatus (ATLAS) and Compact Muon Solenoid (CMS). The other two are the LHC beauty detector (LHCb) used to study heavy-flavor physics and indirect CP violations in b-mesons, and A Large Ion Collider Experiment (ALICE) used for heavy-ion collisions.

The results and analysis presented in later chapters are based on CMS. Therefore, a detailed description of this detector will be given in the next section.

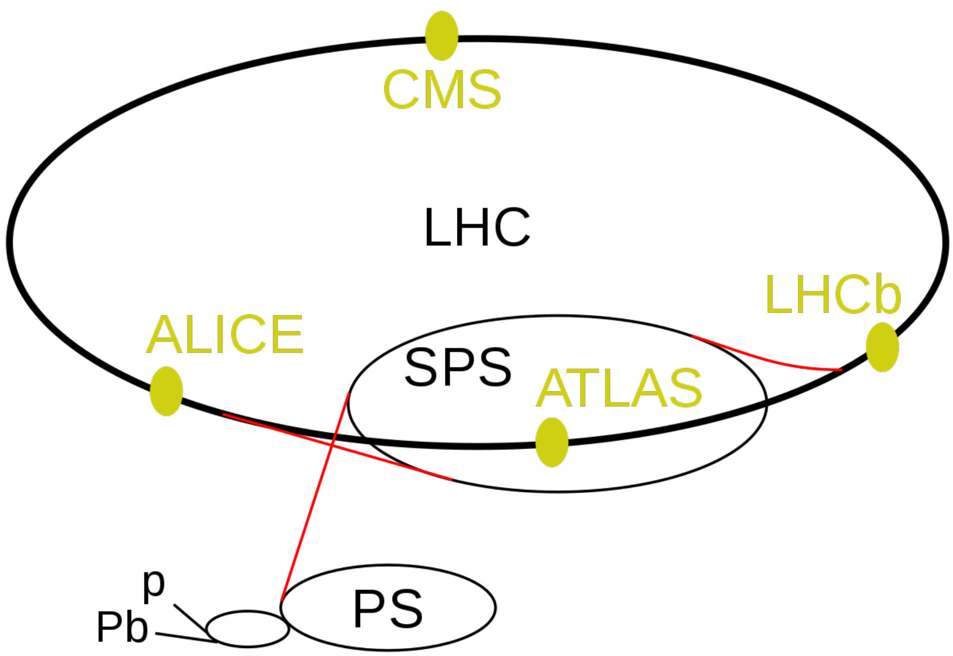

Figure 2.1: LHC experimental chain. The yellow dots represent the four main experiments. This figure was retrieved from

2.1 The CMS Detector

CMS is a general purpose detector used to reconstruct the decay products in proton and heavy-ion collisions at high energies. It can detect nearly any particle, specially muons, with high precision. CMS is located in a cavern about 100 m underground near Cessy, France. It has a cylindrical geometry, with a full length of 21.5 m and a diameter of 15 m. With a total weight of 12500 t, it is the heaviest detector in the LHC. CMS is operated by a large collaboration of members worldwide, consisting of over 4000 particle physicists, engineers, computer scientists, technicians, and students from around 200 institutes and universities from more than 40 countries [2].

The main feature of CMS is a superconducting solenoid able to produce a internal, uniform 4T magnetic field. Inside the solenoid, there is a tracking system Before explaining with more detail the internal parts of the detector, the coordinate system will be introduced in the next subsection.

2.1.1 CMS coordinate system

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Chapter3

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Chapter6

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Chapter7

Conclusion

Cheers!!!

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