

Title : Measurement of W bosons in p-Pb at 8.16 TeV and charmonia in Pb-Pb at 5.02 TeV with the CMS detector at the LHC

Keywords : W boson, charmonia, heavy-ion physics, quark-gluon plasma, CMS

Abstract : Heavy ions are collided at high energies at the Large Hadron Collider, allowing to study the properties of nuclear matter and to produce the hot and dense state of deconfined matter known as the Quark-Gluon Plasma (QGP). In order to probe the nuclear matter effects present in heavy-ion collisions, the production of two important hard probes is studied in this thesis: W bosons and charmonia (J/ψ and $\psi(2S)$ mesons).

The cold nuclear matter effects, associated to the nuclear modification of the parton distribution functions (PDFs), can be characterised by studying the formation of W bosons in heavy-ion collisions. The production of W bosons represents an important tool to assess the PDF modifications, which impact the initial hard scattering, since these bosons do not interact strongly with the collision-induced medium. The analysis of the W-boson production in p-Pb collisions at $\sqrt{s_{NN}} = 8.16$ TeV with the CMS detector is presented in the first part of this thesis. The results are in good agreement with PDF calculations including nuclear modifications, while they strongly disfavour the free-nucleon hypothesis at small momentum fractions x . Since the measurements are more precise than the model calculations, the W-boson results have the potential to constrain the nuclear PDF parametrisations, which could eventually improve our understanding of the PDF effects on other hard probes, such as charmonia.

The production of charmonia is sensitive to the formation and evolution of the strongly-interacting medium formed in heavy-ion collisions, thus making of it an excellent probe of the QGP. The suppression or enhancement of the different charmonium states is considered a signature of the presence of the QGP. In this thesis, the production of prompt and nonprompt J/ψ mesons is measured in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. In addition, the modification of the $\psi(2S)$ mesons relative to J/ψ mesons is reported for the same collision system. The nuclear modification factor of charmonia is determined as a function of centrality, rapidity and transverse momentum p_T . The production of prompt J/ψ mesons is suppressed in Pb-Pb collisions compared to binary-scaled p-p collisions, although a weaker suppression is observed at $3 < p_T < 6.5$ GeV/c in central Pb-Pb collisions. The production of b quarks, probed by the nonprompt charmonia, are also suppressed over the full kinematic region measured, and a reduced suppression is observed at high p_T . Regarding the $\psi(2S)$ mesons, they are found to be more strongly suppressed than J/ψ mesons in Pb-Pb collisions.

