The Compact Muon Solenoid Experiment

Conference Report

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Quarkonium production and suppression with CMS detector at LHC

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Abstract

Quarkonia are most important probes of the quark-gluon plasma since they are produced at early times and propagate through the medium, mapping its evolution. The Compact Muon Solenoid (CMS) detector is well suited to measure quarkonia via their decays to dimuon channel. This writeup summarizes quarkonium measurements in pp and PbPb collisions by CMS detector at $\sqrt{s_{NN}} = 2.76$ TeV and $\sqrt{s_{NN}} = 5.02$ TeV.

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Quarkonium production and suppression with CMS detector at LHC

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Keywords: Quark Gluon Plasma, Quarkonia, LHC, CMS

1 Introduction

The main goals of heavy-ion experiments is to validate the existence and study the properties of the quark-gluon plasma (QGP). The QGP is a state of deconfined quarks and gluons predicted by quantum chromodynamics (QCD) studies to exist at high temperatures and/or high energy density. One of the most striking expected signatures of QGP formation is the suppression of quarkonium states. The yields of both of the charmonium (J/ψ , $\psi(2S)$, χ_c , etc.) and the bottomonium ($\Upsilon(1S, 2S, 3S)$, χ_b , etc.) families are expected to suppress in heavy ion collisions. The suppression is predicted to occur above the critical temperature of the medium (T_c) and depends on the $Q\bar{Q}$ binding energy [1] alternatively the suppression can be understood in terms of quarkonium dissociation by collisions with gluons [2, 3]. Since the LHC first performed Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, a wealth of quarkonium results have become available [4, 5]. Some of these results are presented in this writeup and their significance is discussed. The latest results from the high statistics 5.02 TeV PbPb data collected in 2015 are also given in the writeup.

2 CMS detector at LHC

The central feature of CMS is a superconducting solenoid, of 6m internal diameter, providing a field of 3.8T. Within the field volume are the silicon pixel and strip

tracker, the crystal electromagnetic calorimeter (ECAL) and the brass/scintillator hadron calorimeter (HCAL). Muons are measured in gas-ionization detectors embedded in the steel return yoke. The muons are measured in the pseudorapidity window $|\eta| \leq 2.4$, with detection planes made of three technologies: Drift Tubes, Cathode Strip Chambers, and Resistive Plate Chambers. A much more detailed description of CMS can be found in ref. [6].

3 Quarkonium measurement with CMS detector at LHC

The production yields of $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ quarkonium states are measured through their decays into muon pairs in the CMS detector, in PbPb and pp collisions at the centre-of-mass energy per nucleon pair of 2.76 and 5.02 TeV. Figure 1 shows Nuclear modification factors, R_{AA} , as a function of the Υ meson p_T (left) and $|y|$ (right) at $\sqrt{s_{NN}} = 2.76$ TeV [7]. The R_{AA} results show a suppression of a factor of ≈ 2 and 8 for $\Upsilon(1S)$ and $\Upsilon(2S)$ states, respectively. No pronounced dependence on the Υ meson kinematics is observed. A

Fig. 1. The nuclear modification factor of $\Upsilon(1S)$ and $\Upsilon(2S)$ states in PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV as a function of transverse momentum (left) and rapidity (right) measured by CMS experiment [7].

useful variable to compare the strength of medium effects on the quarkonium ground state (1S) and excited state (nS) in PbPb collisions is the double ratio $((N_{nS}/N_{1S})_{PbPb}/(N_{nS}/N_{1S})_{pp})$ which is the ratio of the corresponding nuclear modification factors. Figure 2 (left) shows the double ratio of $\Upsilon(2S)$ as a function of collision centrality measured by CMS experiment at $\sqrt{s_{NN}} = 5.02$ TeV [8]. A large relative suppression of the $\Upsilon(2S)$ compared to the $\Upsilon(1S)$ in PbPb with respect to pp is observed. Figure 2 (right) shows the double ratio of $\psi(2S)$, in mid rapidity, as a function of collision centrality measured by CMS experiment

Fig. 2. The Double Ratio of $\Upsilon(2S)$ (left) and $\psi(2S)$ (right) as a function of collision centrality measured by CMS experiment at $\sqrt{s_{NN}} = 5.02$ TeV [8, 9]. The $\psi(2S)$ results are compared with an earlier measurement by CMS at $\sqrt{s_{NN}} = 2.76$ TeV [10].

at $\sqrt{s_{NN}} = 5.02$ TeV [9]. The double ratio is below unity in all bins, suggesting that the $\psi(2S)$ yield is more suppressed than the J/ψ yield in the kinematic range explored. No strong variations are observed with collision centrality. The double ratio shows reasonable agreement with the measurement made at $\sqrt{s_{NN}} = 2.76$ TeV in all the bins indicating no strong energy dependence on the relative suppression of charmonia states.

4 Summary

The $\Upsilon(1S)$ and $\Upsilon(2S)$ states are suppressed in PbPb relative to pp collisions at $\sqrt{s_{NN}} = 2.76$ TeV by factors of 2 and 8, respectively. The suppression does not show any strong kinematic dependence. The relative suppression of $\Upsilon(2S)$ is measured through the double ratios at $\sqrt{s_{NN}} = 5.02$. A large relative suppression of the $\Upsilon(2S)$ compared to the $\Upsilon(1S)$ in PbPb with respect to pp is observed. In the charmonia sector the excited state $\psi(2S)$ is found to be more suppressed than the ground state J/ψ at both centre of mass energies.

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