The Compact Muon Solenoid Experiment
Conference Report

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Prompt and non-prompt J/ψ production in pPb collisions with CMS

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Abstract

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Abstract

The mechanisms of charmonium production in the high-density medium created in heavy ion collisions are still not quantitatively understood. In order to disentangle among different mechanisms which changes the charmonium cross section, a multi-dimensional analysis is needed in a wide kinematic range and in various collision systems (pp, pA and AA). This paper will present the first measurement of the prompt and non-prompt J/ψ production with the CMS detector from the pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV with an integrated luminosity of 34.6 nb^{-1} in 2013. The ratio of the forward and backward production yields is measured in bins of J/ψ kinematics, as well as the event activity.

Keywords: CMS, Charmonia, J/ψ , pPb collisions

1. Introduction

The quarkonia are important probes of the Quark-Gluon Plasma (QGP) created in heavy ion collisions. It was predicted that the Debye screening of the heavy quark potential would result in a sequential suppression of the quarkonium states reflecting their binding energies [1]. The quarkonium production can be affected by several other processes apart from the existence of QGP: the modification of the parton distribution functions in a nucleon when bound within a nucleus (nPDFs) with respect to those in a free nucleon, the multiple scattering of partons in the nucleus before/after the hard scattering which leads to parton energy loss and p_T broadening, and nuclear absorption when passing through the nucleus [2]. The study of quarkonium production in pA collisions is critical in order to understand and disentangle such Cold Nuclear Matter (CNM) effects.

Similar nuclear effects can also affect the open heavy-flavor production, which can be indirectly studied by measuring the non-prompt J/ψ coming from b-hadron decays.

In this paper, the results of the prompt and non-prompt J/ψ production in pPb collisions at a center-of-mass energy per nucleon pair of 5.02 TeV with an integrated luminosity 34.6 nb^{-1} will be reported.

2. The CMS detector and analysis procedure

A detailed description of the CMS detector can be found in Ref. [3]. The CMS detector covers a broad ranges in Bjorken- x values from 10^{-4} to 10^{-2} , down to the shadowing regime, thanks to its highly selective dimuon trigger and excellent mass resolution.

The invariant mass spectrum of $\mu^+\mu^-$ pairs is fitted with the sum of a Crystal Ball (CB) and a Gaussian function for the signal, and with an exponential for the underlying background. The prompt J/ψ and those coming from b-hadron decays are separated using the pseudo-proper decay length, $l_{J/\psi} = L_{xy} m_{J/\psi} / p_T$, where L_{xy} is the transverse decay length in the laboratory frame. The invariant-mass spectrum and the $l_{J/\psi}$ distribution of $\mu^+\mu^-$ pairs are fitted simultaneously in an extended unbinned maximum likelihood fit [4].

3. Results

The rapidity dependence of the J/ψ production can provide key information on CNM effects. The effect was quantified by investigating the forward-to-backward production ratio (R_{FB}) defined by

$$R_{FB}(p_T, y) = \frac{d^2\sigma(p_T, y > 0)/dp_T dy}{d^2\sigma(p_T, y < 0)/dp_T dy} \quad (1)$$

, where the $d^2\sigma/dp_T dy$ is the J/ψ production cross section decayed into muon pairs in a given J/ψ p_T and y bin, and forward regions ($y > 0$) are defined by the proton-going direction.

Fig. 1 shows the p_T dependence of R_{FB} in three different rapidity ranges for prompt J/ψ . The data points are plotted at the bin-averaged values. The R_{FB} is closer to unity at high p_T , and decreases at low p_T . No strong rapidity dependence has been observed.

The R_{FB} of prompt J/ψ is further analyzed in terms of an event activity variable $E_T^{HF|\eta|>4}$, the transverse energy deposited in the forward hadronic calorimeter in $4 < |\eta| < 5.2$, as shown in Fig. 2. The centers of the bin abscissae are given by their bin-averaged values. The clear decreasing tendency of the R_{FB} with increasing $E_T^{HF|\eta|>4}$ has been observed over the whole kinematic ranges, and it is more pronounced at low p_T in the forward rapidity region.

Figure 1: p_T dependence of R_{FB} for prompt J/ψ in three rapidity ranges. The error bars show the statistical uncertainties, and the shaded boxes represent the quadratic sum of systematic uncertainties.

Figure 2: $E_T^{HF|\eta|>4}$ dependence of R_{FB} for prompt J/ψ with two different p_T ranges in the most forward region (left), and with the same p_T range in three different rapidity intervals (right). The error bars show the statistical uncertainties, and the shaded boxes represent the quadratic sum of systematic uncertainties.

The R_{FB} as a function of p_T and $E_T^{HF|\eta|>4}$ for non-prompt J/ψ are shown in Figs. 3 – 4. The results show a similar dependence as the prompt J/ψ results, while the significance is less within larger uncertainties.

4. Summary

The measurement of prompt and non-prompt J/ψ production in pPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV has been presented. The forward-to-backward production ratio R_{FB} is observed to be smaller than unity at low p_T and become consistent with unity for $p_T \gtrsim 10$ GeV/c. The R_{FB} has been also studied as a function of $E_T^{HF|\eta|>4}$, and found to decrease with the event activity both for prompt and non-prompt J/ψ 's. The results suggest hints of CNM effects in pPb collisions.

Figure 3: p_T dependence of R_{FB} for non-prompt J/ψ in three rapidity ranges. The error bars show the statistical uncertainties, and the shaded boxes represent the quadratic sum of systematic uncertainties.

Figure 4: $E_T^{HF|\eta|>4}$ dependence of R_{FB} for non-prompt J/ψ with two different p_T ranges in the most forward region (left), and with the same p_T range in three rapidity ranges (right). The error bars show the statistical uncertainties, and the shaded boxes represent the quadratic sum of systematic uncertainties.

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