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Quarkonia production at forward rapidity in Pb+Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV with the ALICE detector

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Abstract. The study of formation of heavy quarkonia in relativistic heavy-ion collisions provides important insight into the properties of the produced high-density QCD medium. Lattice QCD studies show sequential suppression of quarkonia states with increasing temperature; which affirms that a full spectroscopy can provide us a thermometer for the matter produced under extreme conditions in relativistic heavy-ion collisions and one of the most direct probes of deconfinement. Muons from the decay of charmonium resonances are detected in ALICE experiment in $p + p$ and Pb+Pb collisions with a muon spectrometer, covering the forward rapidity region ($2.5 < y < 4$). The analysis of the inclusive J/ψ production in the first Pb+Pb data collected in the fall of 2010 at a centre of mass energy of $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV is discussed. Preliminary results on the nuclear modification factor (R_{AA}) and the central to peripheral nuclear modification factor (R_{CP}) are presented.

Keywords. Quark-gluon plasma; muon spectrometer; quarkonia; Large Hadron Collider; heavy-ion collisions.

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1. Introduction

The quarkonia produced in ultrarelativistic heavy-ion collisions are considered as excellent effective probes of the strongly interacting medium and also as a signature of deconfinement [1]. In such hot deconfined matter, the colour screening dissolves the binding of the heavy quark–antiquark pair. This leads the higher excited quarkonium states to dissolve at lower temperature. Studying the suppression pattern of quarkonia in AA collisions (where the plasma of deconfined quarks and gluons, the quark-gluon plasma (QGP) is expected to form), along with the comparative quarkonia production in pp collisions will allow one to set an estimate of the initial temperature of the medium [1]. Extensive experimental results at SPS [2] (including feed-down from other less bound resonances like ψ' and χ_c) and RHIC [3] of J/ψ production in AA collisions clearly indicate that even the strong bound J/ψ ground state is suppressed.

However, at Large Hadron Collider (LHC) energies the J/ψ production can be even enhanced due to the coalescence of uncorrelated $c\bar{c}$ pairs in the medium which can cause a regeneration [4]. Initial-state effects like modifications of the parton distribution functions

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in the nucleus relative to the nucleon (also known as shadowing) need to be taken into account [1]. The final-state effects like nuclear absorption are expected to be practically irrelevant at LHC energies. Studying the *pA* collisions at LHC energies is henceforth crucial to quantify the role of initial shadowing effects. Using the muon spectrometer [5], charm and beauty particles can be measured in the forward rapidity region via its dimuon decay. The ALICE muon spectrometer physics program [5] is based on the measurement of heavy-flavour production in forward rapidity region ($2.5 < y < 4$) for *pp*, *pA* and *AA* collisions at LHC energies.

2. R_{AA} and R_{CP}

The first Pb+Pb collisions were delivered by LHC at a centre of mass energy $\sqrt{s_{\mathrm{NN}}} =$ 2.76 TeV in the fall of 2010 at an unexplored regime of almost 14 times higher than top RHIC energy. The results presented here are based on samples corresponding to an integrated luminosity of 2.7 $\mu\mathrm{b}^{-1}$. The nuclear modification factors defined as R_{AA} or R_{CP} allow us to quantify the medium effects on J/ψ production. R_{AA} gives the deviation in J/ψ yields from *AA* collisions relative to the scaled (according to the number of binary nucleon–nucleon collisions) yields of J/ψ from *pp* collisions. Figure 1 shows the inclusive J/ψ R_{AA} measured at forward rapidity ($2.5 < y < 4$) as a function of the average number of nucleons participating to the collision ($\langle N_{\mathrm{part}}\rangle$) which has been calculated using the Glauber model. $\langle N_{\mathrm{part}}\rangle$ has been weighted by the number of binary nucleon–nucleon collisions (N_{coll}) due to the bias caused by large centrality bins. This correction is small, except for the most peripheral bin where $\langle N_{\mathrm{part}}\rangle$ = 46 while the weighted value is 70. These results show weak centrality dependence and an integrated $R_{\mathrm{AA}}^{0-80\%} = 0.49 \pm 0.03(\mathrm{stat.}) \pm 0.11(\mathrm{syst.})$. Comparison with the RHIC measurements at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV [6] from the PHENIX experiment shows that the inclusive J/ψ R_{AA} at 2.76 TeV in the ALICE forward rapidity region are higher than that measured at 200 GeV in the rapidity domain of $1.2 < |y| < 2.2$. However, the midrapidity values at 200 GeV

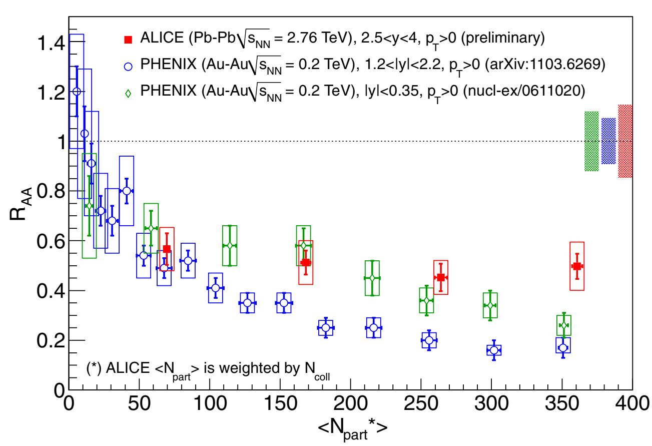

Figure 1. J/ψ R_{AA} in Pb+Pb at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV as a function of $\langle N_{\mathrm{part}}\rangle$ compared with PHENIX results in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV.

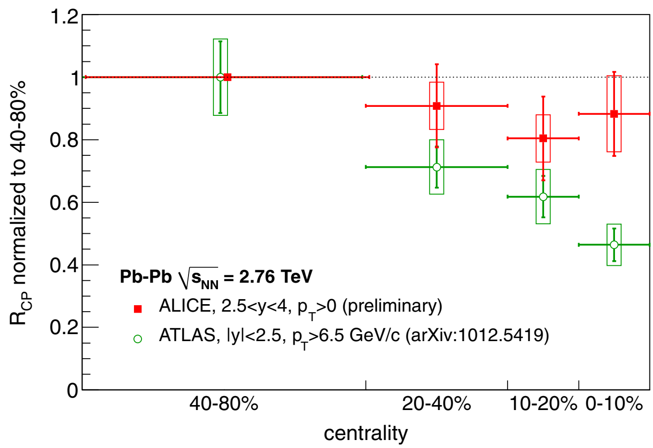

Figure 2. J/ψ $R_{\rm CP}$ as a function of centrality compared with ATLAS results. Error bars represent the statistical uncertainties, open boxes show the centrality-dependent systematic uncertainties while the centrality-independent uncertainties are represented by filled boxes.

(except in the most central collisions) are closer. The contribution from the B feed down to the J/ψ production in our rapidity and $p_{\rm T}$ domain has been measured and estimated to be $\approx$10% in pp collisions at $\sqrt{s_{\rm NN}} = 7$ TeV [7]. $R_{\rm CP}$ can provide similar information based on the relative yield in central (C) and peripheral (P) collisions scaled by the mean number of binary collisions, but does not depend on the reference pp system. Figure 2 shows the ALICE forward rapidity measurements of J/ψ $R_{\rm CP}$ results compared with the ATLAS measurements for the same centrality classes [8]. The J/ψ mesons measured at forward rapidity down to $p_{\rm T} = 0$ are less suppressed than the high-$p_{\rm T}$ J/ψ mesons at midrapidity (80% of the J/ψ particles measured by ATLAS have a $p_{\rm T}$ larger than 6.5 GeV/c).

3. Summary and outlook

Nuclear modification factors $R_{\rm AA}$ or $R_{\rm CP}$ are measured in the first heavy-ion 2010 run of LHC. The inclusive J/ψ production in Pb+Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV shows a notable suppression and no significant dependence on centrality. At central events, a smaller suppression has been found compared to PHENIX results at RHIC energies. The regeneration mechanism may explain these experimental results. The roles of the suppression and regeneration mechanisms could be disentangled by quantifying the initial shadowing effect with data from the forthcoming $p+$Pb run at LHC.

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