Suppression of inclusive J/ψ and ψ(2S) production in p-Pb collisions with ALICE at the LHC

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The ALICE Collaboration has studied both J/ψ and ψ(2S) production in p-Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV [1–3], through their dimuon decay channel, in the Muon Spectrometer which covers the pseudorapidity range $-4 \leq \eta \leq -2.5$. The ALICE detector is described in detail in [4]. Data have been collected under two different configurations, inverting the direction of the p and Pb beams. In this way both forward ($2.03 \leq y_{\rm cms} \leq 3.53$) and backward ($-4.46 \leq y_{\rm cms} \leq -2.96$) centre of mass rapidities could be accessed, with the positive y defined in the direction of the proton beam. The difference in the covered y ranges reflects the shift of the centre of mass of the nucleon-nucleon collisions ($\Delta y_{\rm NN} = 0.465$) with respect to the laboratory frame, induced by the different energies per nucleon of the colliding beams. The J/ψ and ψ(2S) yields are extracted by fitting the dimuon invariant mass distributions with a superposition of signals and background shapes. For the signal, pseudo-Gaussian or Crystal Ball functions with asymmetric tails on both sides of the resonance peak are used, while for the background a Gaussian with a mass-dependent width or polynomial $\times$ exponential functions are adopted.

The production cross section of ψ(2S) in p-Pb is compared to the J/ψ one and to the corresponding quantities in pp collisions at $\sqrt{s}$ = 7 TeV (no LHC results are available at $\sqrt{s}$ = 5.02 TeV) using the double ratio $[\sigma_{\psi(2S)}/\sigma_{J/\psi}]_{\rm pPb}/[\sigma_{\psi(2S)}/\sigma_{J/\psi}]_{\rm pp}$ [2, 3]. The nuclear modification factor of ψ(2S) is obtained by combining the J/ψ $R_{\rm pPb}$ [1] and the double ratio, as

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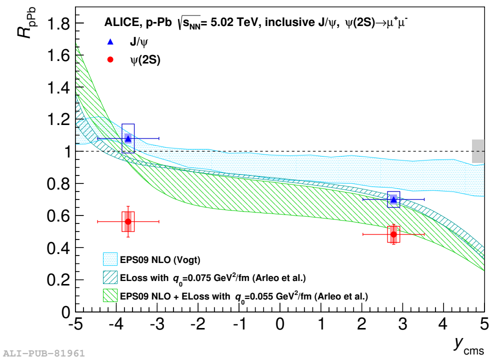

FIG. 1: J/ψ and ψ(2S) $R_{\rm pPb}$ versus y compared to theoretical models.

$R^{\psi(2S)}_{\rm pPb} = R^{J/\psi}_{\rm pPb} \times (\sigma^{\psi(2S)}_{\rm pPb}/\sigma^{J/\psi}_{\rm pPb}) \times (\sigma^{J/\psi}_{\rm pp}/\sigma^{\psi(2S)}_{\rm pp})$. In Fig. 1, $R^{\psi(2S)}_{\rm pPb}$ is compared with $R^{J/\psi}_{\rm pPb}$ and also with theoretical calculations based on nuclear shadowing [5], coherent energy loss or both [6]. The suppression of ψ(2S) production is much stronger than that of J/ψ and reaches a factor of 2 with respect to pp. Since the kinematic distributions of gluons producing the J/ψ or the ψ(2S) are rather similar and since the coherent energy loss does not depend on the final quantum numbers of the resonances, the same theoretical calculations hold for both J/ψ and ψ(2S). Theoretical models predict y dependence which are in reasonable agreement with the J/ψ results but no model can describe the ψ(2S) data. These results show that other mechanisms must be invoked in order to describe the ψ(2S) suppression in p-Pb collisions.

The $R_{\rm pPb}$ is also computed as a function of $p_{\rm T}$ both at backward and forward y and the results are shown in Fig. 2 and 3, respectively. At both rapidities, the $R^{\psi(2S)}_{\rm pPb}$ shows a strong suppression with a slightly more evident $p_{\rm T}$ dependence at backward-y. The ψ(2S) is more suppressed than the J/ψ, as already observed

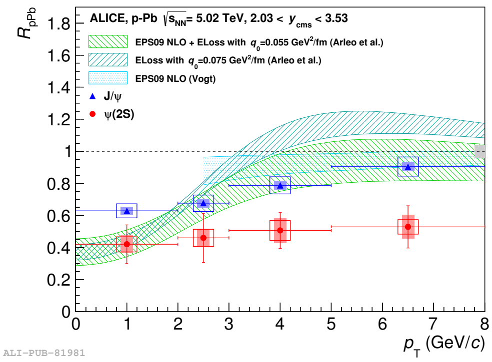

FIG. 2: p_{T} dependence of J/ψ and ψ(2S) R_{pPb} compared to theoretical calculations in the forward y region.

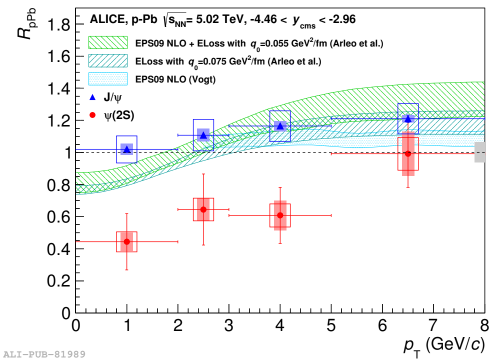

FIG. 3: Same as Fig 2 but in the backward y region.

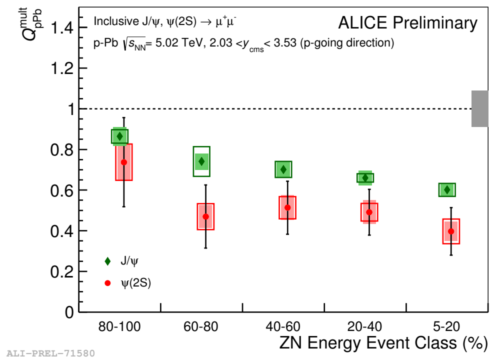

FIG. 4: J/ψ and ψ(2S) Q_{pPb} versus event activity in the forward y region.

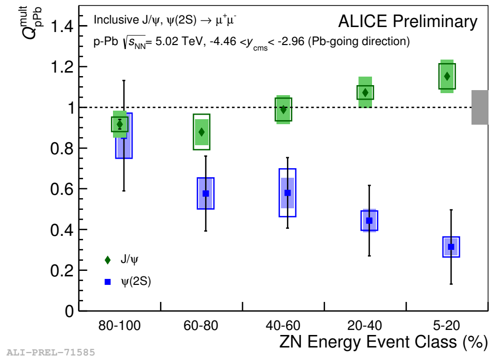

FIG. 5: Same as Fig 4 but in the backward y region.

for the p_{T}-integrated result. Theoretical calculations are in fair agreement with the $R_{\mathrm{pPb}}^{\mathrm{J}/\psi}$ but clearly overestimate the $R_{\mathrm{pPb}}^{\psi(2\mathrm{S})}$ behaviour.

Finally, the ψ(2S) production is studied as a function of the event activity both at backward and forward y [3], as shown in Fig. 4 and 5, respectively. The event activity determination is described in details in Refs. [7]. Since the centrality estimation in p-Pb collisions can be biased by the choice of the estimator, the nuclear modification factor is, in this case, named Q_{pPb} [7]. The ψ(2S) Q_{pPb} shows a strong suppression, which increases with increasing event activity, and is rather similar in both the forward and the backward y regions. The J/ψ Q_{pPb} shows a similar decreasing trend at forward-y as a function of the event activity. On the contrary, the J/ψ and ψ(2S) Q_{pPb} patterns observed at backward-y are rather different, with the ψ(2S) significantly more suppressed for large event activity classes.

References

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