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

Jhuma Ghosh (for the ALICE Collaboration)*
Saha Institute of Nuclear Physics Division, Sector - 1, Block - AF Bidhan nagar, Kolkata- 700064 , INDIA

Charmonia have smaller sizes than light hadrons (down to a few tenths of fm) and large binding energies. They are produced in the initial hard scatterings and therefore they are sensitive to the formation of the Quark-Gluon Plasma (QGP). Due to these properties, they can be used as an useful probe of QGP. The $c\bar{c}$ binding can be screened by the high density of colour charges present in the QGP, leading to a suppression of the charmonium yields in high-energy nuclear collisions compared to the corresponding production rates in elementary pp collisions at the same energy [1]. The suppression is quantified by the nuclear modification factor:

$$R^{\mathrm{J}/\psi}_{\mathrm{pPb}} = \frac{N^{\mathrm{corr}}_{\mathrm{J}/\psi}}{\langle T_{\mathrm{pPb}}\rangle N_{\mathrm{MB}} BR(\mathrm{J}/\psi \to \mu\mu)\sigma^{\mathrm{J}/\psi}_{\mathrm{pp}}} \quad (1)$$

where $N^{\mathrm{corr}}_{\mathrm{J}/\psi}$ is the number of J/ψ after the acceptance $\times$ efficiency correction. $< T_{\mathrm{pPb}} >$ is the average nuclear thickness function. N_{MB} is the number of minimum bias collisions and $\sigma^{\mathrm{J}/\psi}_{\mathrm{pp}}$ is the corresponding production cross section of J/ψ in pp collisions.
In p-Pb collisions, where no QGP effect is expected, modification of the charmonium yields allows an investigation of cold nuclear matter effects (CNM). Mechanisms as shadowing, coherent energy loss and comovers absorption can be possible explanation of this modification.

The ALICE Collaboration has studied both J/ψ ([2],[3])and ψ(2S) production in p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV and 8.16 TeV, via the dimuon decay channel, in the muon spectrometer which covers the pseudo-rapidity range -4 < η < -2.5. The description of ALICE detector is given in detail in [4]. Data have been collected under two different configurations, inverting the direction of the p and Pb beams. In these two cases, there is a difference in the covered y ranges due to the shift of the centre of mass of the nucleon-nucleon collisions ($\triangle y_{\mathrm{NN}}$ = 0.465) with respect to the laboratory frame. In this way both forward (2.03 < y_{cms} < 3.53) and backward (-4.46 < y_{cms} < -2.96) centre of mass rapidities could be accessed, with the positive y defined as the proton beam going in the direction of the muon spectrometer. The ψ(2S) yields are extracted by fitting the dimuon invariant mass distributions with a superposition of signal and background shapes. The NA60 and Extended Crystal Ball [5] functions with asymmetric tails on both sides of the resonance peak have been used for fitting the signal. The background has been fitted with a Gaussian with a mass-dependent width and 4th order polynomial times exponential functions.

The ratio of production cross section of ψ(2S) to that of J/ψ in p-Pb(Pb-p) collisions to the same ratio in pp collisions has been studied using the double ratio ($[\sigma_{\psi(2S)}/\sigma_{\mathrm{J}/\psi}]_{\mathrm{pPb}}/[\sigma_{\psi(2S)}/\sigma_{\mathrm{J}/\psi}]_{\mathrm{pp}}$). The nuclear modification factor of ψ(2S) is obtained by combining the J/ψ $R^{\mathrm{J}/\psi}_{\mathrm{pPb}}$ and the double ratio, as

$$R^{\psi(2S)}_{\mathrm{pPb}} = R^{\mathrm{J}/\psi}_{\mathrm{pPb}} \times (\sigma^{\psi(2S)}_{\mathrm{pPb}}/\sigma^{\mathrm{J}/\psi}_{\mathrm{pPb}}) \times (\sigma^{\mathrm{J}/\psi}_{\mathrm{pp}}/\sigma^{\psi(2S)}_{\mathrm{pp}}). \quad (2)$$

The pp reference is based on the ALICE measurements in pp collisions. Figure 1 shows

*Electronic address: jhuma.ghosh@cern.ch

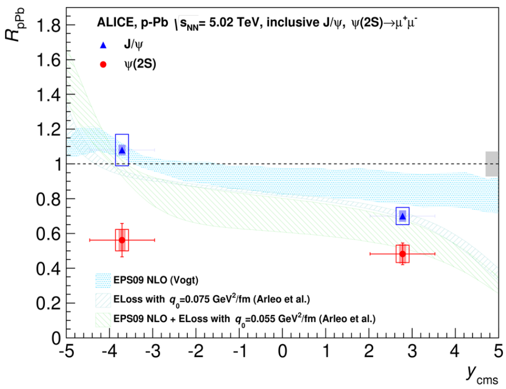

FIG. 1: J/ψ and ψ(2S)$R_{\rm pPb}$ versus y

$R_{\rm pPb}^{\psi(2S)}$ [6] together with $R_{\rm pPb}^{J/\psi}$ [7] obtained in p-Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV. It has been compared with the theoretical calculations based on nuclear shadowing [8], coherent energy loss or a combination of the two mechanisms [9]. The suppression of ψ(2S) production is much stronger than that of J/ψ particularly in the backward rapidity region. 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 a y dependence which is 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 new preliminary results of $R_{\rm pPb}$ of ψ(2S) at $\sqrt{s_{\rm NN}}$ = 8.16 TeV will be discussed in the symposium. $R_{\rm pPb}$ of ψ(2S) as a function of $p_{\rm T}$ and y will also be investigated. The results will be presented and compared to J/ψ and with theoretical calculations.

References

[1] T. Matsui and H. Satz, Phys. Lett. B178 (1986) 416.
[2] ALICE PAS: ALICE-PUBLIC-2017-001.
[3] ALICE-PUBLIC-2017-007.
[4] K. Aamodt et al., (ALICE Collaboration) JINST 3, S08002 (2008).
[5] ALICE-PUBLIC-2015-006, https://cds.cern.ch/record/2060096.
[6] B. Abelev, et al., (ALICE collaboration) JHEP 12(2014)073.
[7] B. Abelev et al., (ALICE collaboration) JHEP 02 (2014) 073.
[8] J.L. Albacete et al., Int. J. Mod. Phys. E22, 1330007 (2013) and priv. comm.
[9] F. Arleo and S. Peigne, JHEP 1303, 122 (2013).