



Inclusive J/ψ and $\psi(2S)$ production in pp collisions at Forward Rapidity with ALICE at the LHC

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Introduction

- The Muon Spectrometer of ALICE (A Large Ion Collider Experiment) [1] at LHC (Large Hadron Collider) is designed to measure the charmonium and bottomonium states in the pseudo-rapidity interval $-4 \leq \eta_{ab} \leq -2.5$ and down to $p_T = 0$.

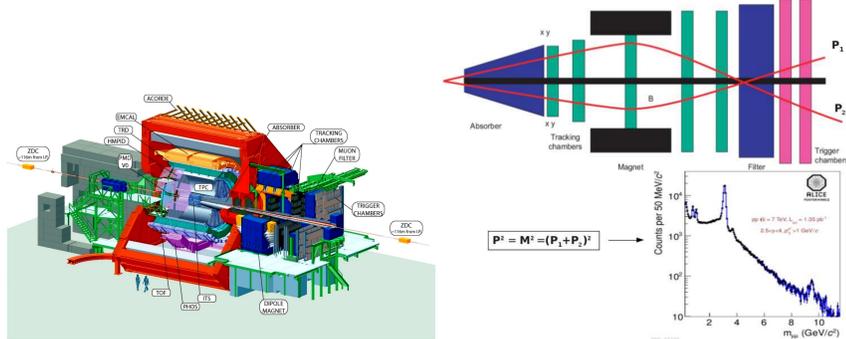


FIGURE 1:

Signal extraction

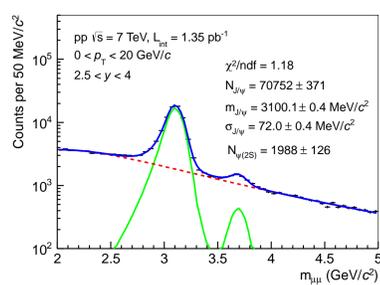


FIGURE 2:

- J/ψ and $\psi(2S)$ yields are extracted by fitting the opposite sign dimuon invariant mass spectrum with a superposition of signal and background shapes. Two Extended Crystal Ball (CB2) functions or two pseudo-Gaussian functions have been used for signals, while for the background a Variable Width Gaussian (VWG) function or a combination of a 4th order polynomial and exponential functions (Pol4 x Exp) has been adopted. Fig. 2 shows the fitted invariant mass distributions, integrated over p_T and y [2].
- The mass position and width of $\psi(2S)$ is fixed to the J/ψ ones, using the corresponding MC quantities.

Results

- All results and plots are taken from the arXiv:1403.3648.

The production cross-sections of J/ψ and $\psi(2S)$ have been determined using:

$$\sigma_\psi = \frac{N(\psi \rightarrow \mu^+\mu^-)}{(A \times \epsilon) \cdot BR(\psi \rightarrow \mu^+\mu^-) \cdot \mathcal{L}_{\text{int}}}$$

Where:

- $N(\psi \rightarrow \mu^+\mu^-)$ is the number of J/ψ or $\psi(2S)$ extracted from the fit to the invariant mass distribution.
- $A \times \epsilon$ is the acceptance times efficiency factor of J/ψ or $\psi(2S)$.
- $BR(\psi \rightarrow \mu^+\mu^-)$ is the branching ratio of J/ψ or $\psi(2S)$ in dimuon decay channel. For J/ψ , $BR(J/\psi \rightarrow \mu^+\mu^-)$ is $(5.93 \pm 0.06)\%$ and for $\psi(2S)$, $BR(\psi(2S) \rightarrow \mu^+\mu^-)$ is $(0.78 \pm 0.09)\%$.
- The integrated luminosity $\mathcal{L}_{\text{int}} = (1.35 \pm 0.07) \text{ pb}^{-1}$.

The inclusive production cross-sections of J/ψ and $\psi(2S)$, integrated in the p_T and y ranges are [2]:

$$\sigma_{J/\psi} = 6.69 \pm 0.04 \text{ (stat.)} \pm 0.63 \text{ (syst.)} \mu\text{b}$$

$$\sigma_{\psi(2S)} = 1.13 \pm 0.07 \text{ (stat.)} \pm 0.14 \text{ (syst.)} \mu\text{b}$$

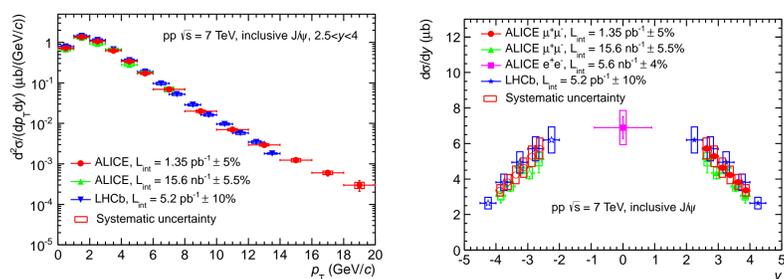


FIGURE 3:

- J/ψ and $\psi(2S)$ production cross-sections are also studied differentially in p_T and y [2] as shown in Fig. 3.
- J/ψ production cross-section results are in good agreement with the previous ALICE result [3] [4] and also with the measurement performed by the LHCb collaboration [5]. This measurement extends J/ψ cross-section to 20 GeV/c in p_T at forward rapidity.
- This is the first $\psi(2S)$ measurement in pp collisions at ALICE and the result is consistent with LHCb measurement [6] in the same rapidity interval.
- The inclusive $\psi(2S)/J/\psi$ ratio, integrated over p_T and y is $0.170 \pm 0.011 \text{ (stat.)} \pm 0.013 \text{ (syst.)} [2]$.
- Fig. 4 shows the $\psi(2S)/J/\psi$ ratio as a function of p_T and y [2]. A clear p_T dependence can be observed, consistent with LHCb [6]. No strong y dependence is visible, in the y range covered by the ALICE muon spectrometer.

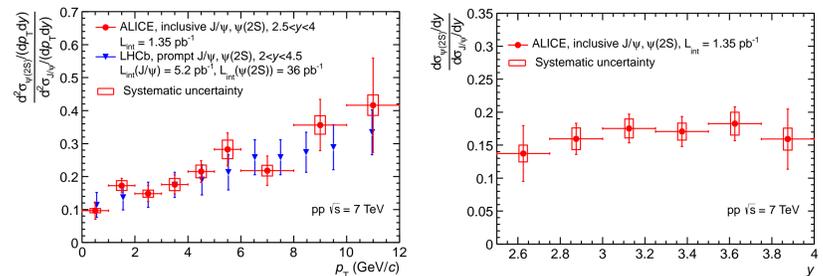


FIGURE 4:

Comparisons with theoretical models

- The results have been compared with theoretical calculations performed in the Color-Singlet Model (CSM) and the Non-Relativistic QCD (NRQCD) framework [2].

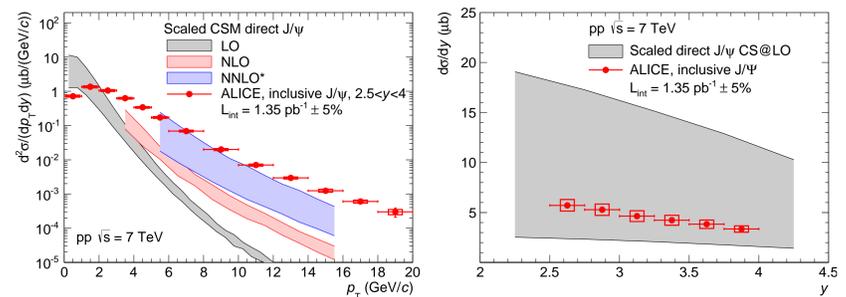


FIGURE 5:

- Fig. 5 shows that in the CSM, both LO and NLO calculations [7] underestimate the data at large p_T . The addition of the leading- p_T NNLO contributions helps to reduce this disagreement at the price of larger theoretical uncertainties.

- CSM LO calculations [8] reproduce the rapidity dependence of the p_T -integrated cross sections.

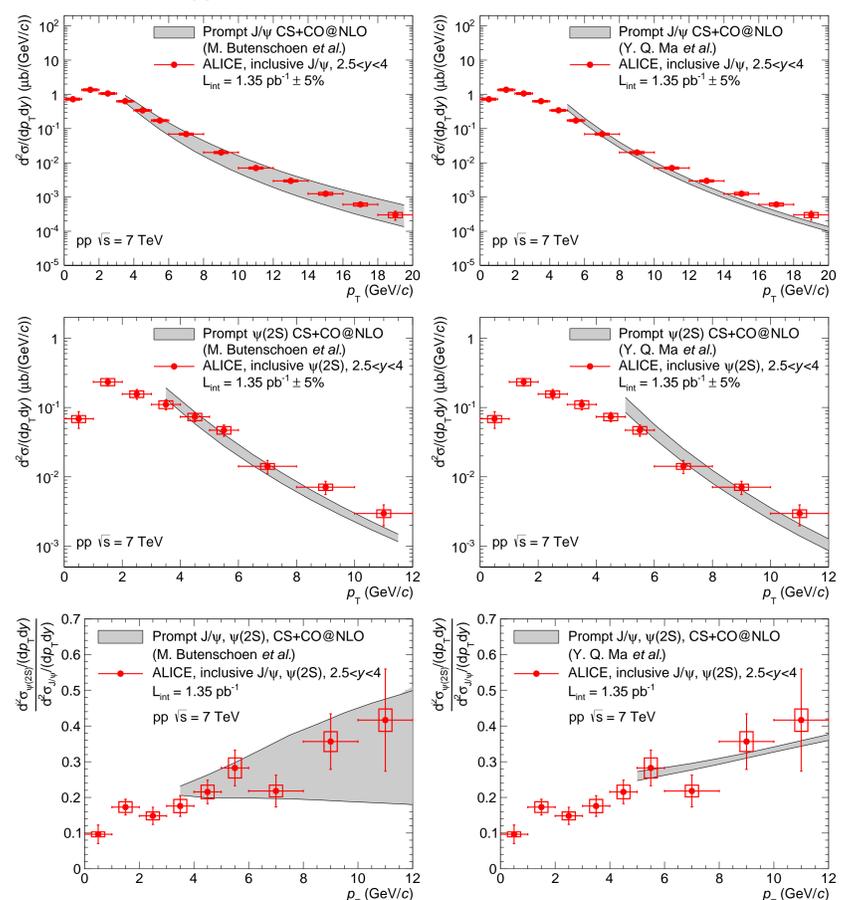


FIGURE 6:

- The NRQCD calculations include both leading order Color-Singlet (CS) contributions and Color-Octet (CO) contributions that are adjusted to experimental data by means of so-called Long-Range Matrix Elements (LRME).

- The two NRQCD calculations differ in the LRME parametrization: the first (left panels of Fig. 6) uses three matrix elements whereas the second (right panels of Fig. 6) uses only two linear combinations of these three elements. The results are in good agreement with the two NRQCD calculations [9] [10].

Conclusions

- The results on production cross-sections and $\psi(2S)/J/\psi$ ratio are in good agreement with the measurement performed by the LHCb collaboration and also with the theoretical calculations.
- All these results and more details can be found in ref. [2], submitted for publication.....

References

- [1] K. Aamodt *et al.*, (ALICE Collaboration) *J. Instrum.* 3, S08002 (2008).
- [2] B. Abelev *et al.*, (ALICE Collaboration) arXiv:1403.3648.
- [3] K. Aamodt *et al.*, (ALICE collaboration) *Phys. Lett.* B704, 442-455 (2011).
- [4] K. Aamodt *et al.*, (ALICE collaboration) *Phys. Lett.* B718, 692-698 (2012).
- [5] R. Aaij *et al.*, (LHCb collaboration) *Eur.Phys.J.* C71, 1645 (2011).
- [6] R. Aaij *et al.*, (LHCb collaboration) *Eur.Phys.J.* C72, 2100 (2012).
- [7] J.-P. Lansberg, *J. Phys.* G38, 124110 (2011).
- [8] J.-P. Lansberg, *Nucl. Phys.* A470 910 (2013).
- [9] M. Butenschoen and B. A. Kniehl, *Phys. Rev.* D84, 051501 (2011).
- [10] Y. Q. Ma, K. Wang, and K. T. Chao, *Phys. Rev.* D84, 114001 (2011).