J/ψ production in pp collisions at $\sqrt{s} = 5.02$ TeV with ALICE at LHC

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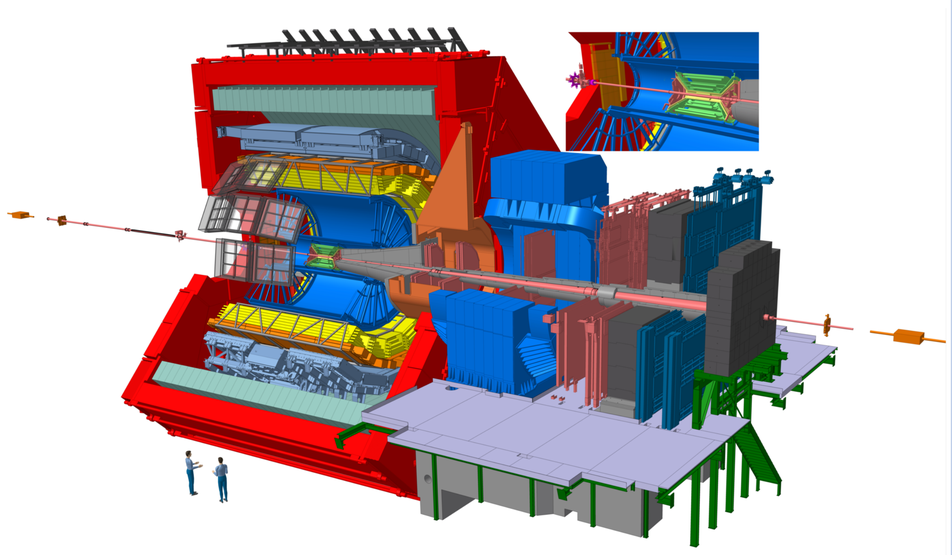
Physics Motivation

Production of J/ψ, which is the first excited $c\bar{c}$ state, is a complex and not yet fully understood phenomenon combining both hard and soft scales of QCD. The $c\bar{c}$ pair is produced in the initial hard scattering and can be described by means of perturbative QCD calculations. The subsequent hadronisation is on the other hand non-perturbative. Moreover, a non-negligible fraction of produced J/ψ originates from decays of B-hadrons, which relate to the production of bottom quark pairs in the collision.

Measurement of charmonia production in pp collisions also presents an important reference for measurement in heavy-ion collisions. In utralrelativistic heavy-ion collisions, we expect the formation of a hot and dense deconfined matter, the so called Quark-Gluon Plasma (QGP) in which quarks and gluons are no longer confined inside hadrons. Since the charm quarks are produced in the initial stages of the collisions before the QGP is created, they experience the full evolution of the created medium. Modification of spectra of charmed hadrons could thus give us information on the created medium [1].

Experimental Setup



ALICE is a dedicated heavy ion experiment, composed of two main parts: the **Central Barrel** and the **Muon Spectrometer** in the forward region. The Muon Spectrometer covers the kinematic region $-\mathbf{4} < \eta < -\mathbf{2.5}$ and $\mathbf{171}^\circ < \theta < \mathbf{178}^\circ$.

Analysis of J/ψ differential pp cross-section

The J/ψ differential cross-section is given as

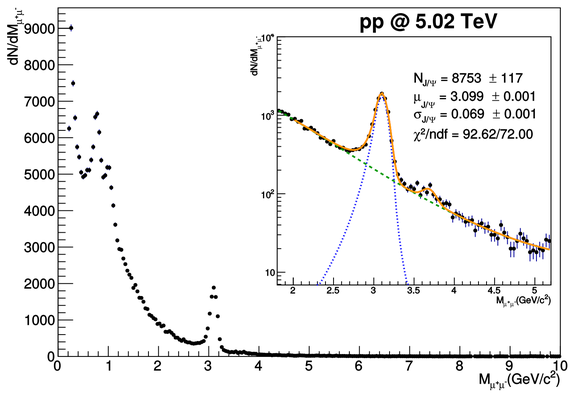
$$\frac{\mathrm{d}^2\sigma^{pp}_{J/\Psi}}{\mathrm{d}p_T\mathrm{d}y} = \frac{\mathrm{d}^2 N^{pp}_{J/\Psi}/\mathrm{d}p_T\mathrm{d}y}{BR_{J/\Psi\to\mu\mu}\, A\times\varepsilon} \times \frac{\sigma^{pp}_{MB}}{N^{MB}_{evt}}$$

number of reconstructed J/Psi — detector response — luminosity^{-1}

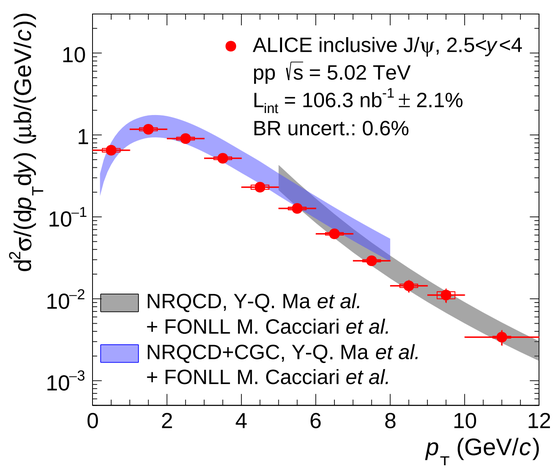
number of reconstructed J/ψ determined from data
$BR_{J/\psi\to\mu\mu} = 5.96 \pm 0.03\%$
detector response from Monte Carlo (MC) simulations
integrated luminosity taken from independent measurement

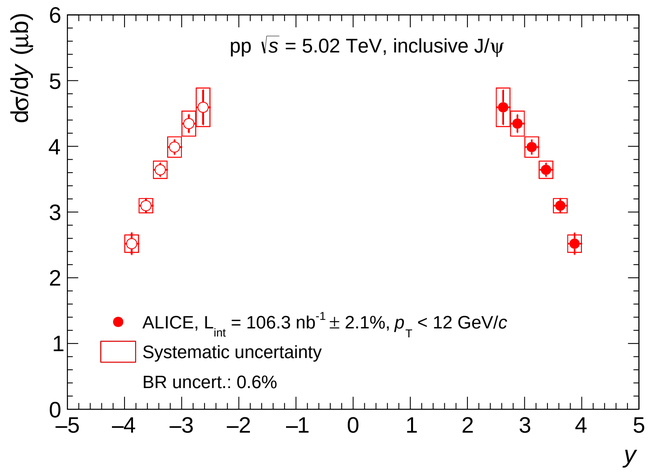
Signal Extraction:

- invariant mass analysis of unlike sign dimuon pairs
- we search for a peak around J/ψ mass region $M^{\mathrm{PDG}}_{J/\psi} = (3.096 \pm 6\cdot 10^{-6})$ GeV/c^2 [2]
- double pseudo-Gaussian function with power-law tails to account for J/ψ and $\psi(2S)$
  - example shows Crystal Ball function
  - Variable Width Gaussian background



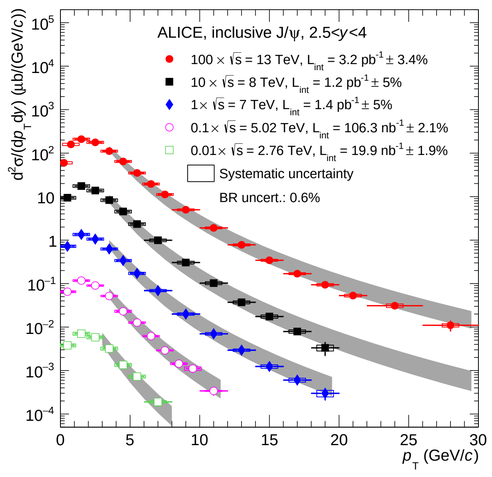
J/ψ differential cross-section

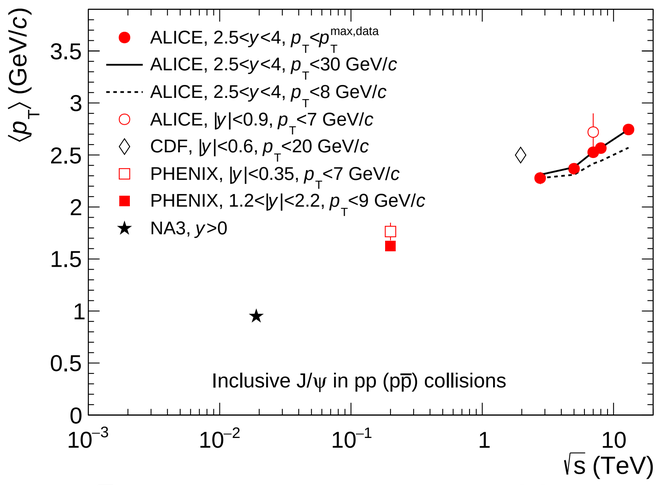




ALICE measured inclusive J/ψ production in the forward rapidity region in pp collisions at $\sqrt{s} = 5.02$ TeV, up to $p_T < 12$ GeV/c and at $2.5 < y < 4$ [3].

J/ψ production is well described by the Non-Relativistic Quantum ChromoDynamics (NRQCD) formalism [4]. At forward rapidity, the Colour Glass Condensate model (CGC) provides the low p_{T} description taking into account the gluon saturation at small x in the incoming protons [5]. The so-called non-prompt contribution from B feed-down is well described by FONLL calculations [6].

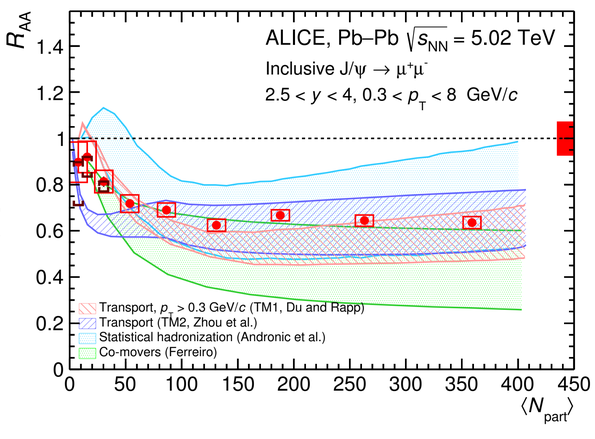




J/ψ production was measured in ALICE at pp energies $\sqrt{s} = 2.76$, 5.02, 7, 8 and 13 TeV [3]. This allowed us to study the energy dependence of inclusive J/ψ production at forward rapidity. The data are described by the combination the calculations of NRQCD [7] for prompt and FONLL [6] for non-prompt J/ψ in the full available p_T range and at all energies.

The production cross-section increases with energy collision. Also, the p_{T} spectrum hardens with $\sqrt{s}$. We observe a steady increase of $\langle p_{\mathrm{T}}\rangle$ with increasing $\sqrt{s}$. The y-dependent shape is constant w. r. t. $\sqrt{s}$ within uncertainties [3].

$$R_{AA} = \frac{1}{\langle T_{AA}\rangle}\frac{\mathrm{d}^2 N_{AA}/\mathrm{d}p_T\mathrm{d}y}{\mathrm{d}^2\sigma_{pp}/\mathrm{d}p_T\mathrm{d}y}$$



R_{AA} measured in ALICE at $\sqrt{s_{NN}} = 5.02$ TeV shows a suppresion of J/ψ measured in Pb-Pb at $\sqrt{s_{NN}} = 5.02$ TeV with rexpect to pp at the same $\sqrt{s}$ [8]. The measurement is consistent with a scenario combining both suppression of J/ψ in the medium and (re)generation from $c\bar{c}$ pairs.

pp collisions provide a reference for QGP studies!

Conclusion

ALICE measured the inclusive J/ψ production at forward rapidity in pp collisions at $\sqrt{s} = 5.02$ TeV. Combined with measurements at other energies in the range $\sqrt{s} = 2.76 - 13$ TeV, the results provide an insight into the energy dependence of the inclusive forward J/ψ production. We observe an increase of the production with $\sqrt{s}$.

The measurement at $\sqrt{s} = 5.02$ TeV also serves as a vacuum reference for the Pb-Pb measurement at $\sqrt{s_{NN}} = 5.02$ TeV. The R_{AA} shows a suppression of J/ψ yields, which is attributed to the presence of the hot and dense medium created in the collision. The data are consistent with available theoretical predictions that also take into account possible (re)generation of J/ψ in the plasma.

References

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