J/ψ production as a function of charged-particle multiplicity in pp collisions at $\sqrt{s}$ = 5.02 TeV with ALICE

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Why multiplicity dependence of quarkonium production?

The study of quarkonium production in ultra-relativistic pp collisions provides a crucial test for hadronisation models and QCD as well as a baseline for Pb-Pb measurements. The charged-particle multiplicity is important to estimate the general properties of the collisions. Identified hadron production as a function of charged-particle multiplicity has drawn much attention in the recent time as the study might provide insight on the collective behavior in small systems like pp and p-Pb collisions [1]. This study is useful for understanding Multiple Parton Interaction (MPI), its contribution to hard processes and correlation between soft and hard processes [2]. This phenomenon has been investigated by ALICE for J/ψ and D mesons [3]. The effects related to MPIs observed in pp collisions might be also relevant in high-multiplicity p-Pb collisions.

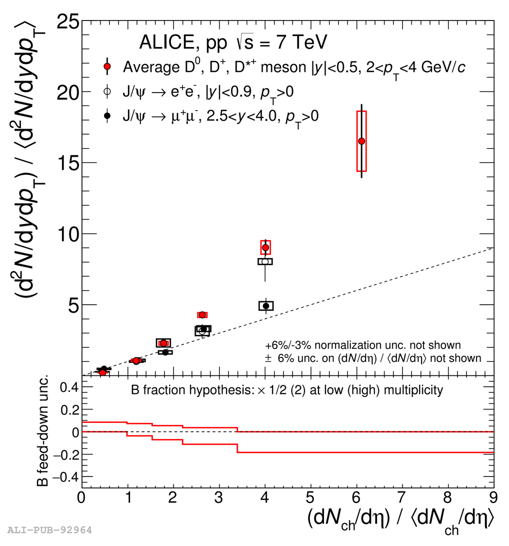

Figure 1: J/ψ and D meson yield as a function of charged particle multiplicity in pp collisions.

Experimental setup

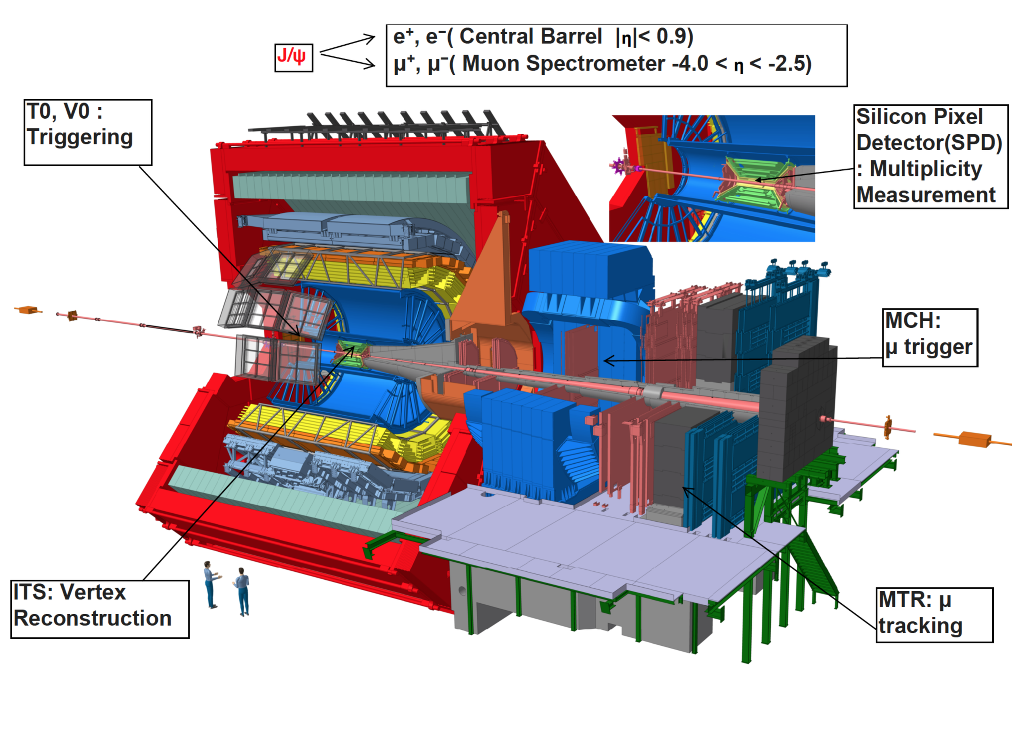

Figure 2: The ALICE detector.

- Data has been taken in 2015 in pp collisions at $\sqrt{s}$ = 5.02 TeV.
- The integrated luminosity is $L_{\rm int} = 106.3 \pm 2.1 nb^{-1}$.

Main Observable

Relative J/ψ yield in the multiplicity bin is calculated using following equation:

$$\frac{Y^{bin}_{J/\psi}}{Y^{tot}_{J/\psi}} = \frac{N^{bin}_{J/\psi}}{N^{tot}_{J/\psi}} \times \frac{N^{tot}_{\rm MB}}{N^{bin}_{\rm MB}} \times \frac{1}{\epsilon_{MB}} \quad (1)$$

where $N_{J/\psi}$ and $N_{\rm MB}$ define the number of J/ψ and the number of minimum-bias (MB) events respectively. ϵ_{MB} is the minimum-bias trigger efficiency.

Charged particle pseudo-rapidity density for each multiplicity bin in the pseudo-rapidity range $(-1 < \eta < 1)$ is measured using the mean number of tracklets measured in the SPD:

$$\langle dN_{ch}/d\eta \rangle_i = \frac{\alpha.\langle N^{corr}_{trk} \rangle_i}{\Delta\eta} \quad (2)$$

where $\langle N^{Corr}_{trk} \rangle_i$ is the corrected mean number of tracklets for each multiplicity bin and α is inverse of the acceptance efficiency of the SPD [4].

Experimental Method

Event selection

- Events with a reconstructed SPD vertex.
- Events in which SPD vertex has number of contributor ≥ 1.
- Events with SPD z-vertex resolution ($\sigma^{\rm SPD}_{Z_v}$) > 0.25 cm.
- SPD z-vertex within 10 cm.

Tracklet Correction: Data-driven method

The measured mean number of tracklets needs to be corrected in order to account for the dependence of the SPD acceptance and efficiency on z^{SPD}_v. The flat mean tracklet distribution over z^{SPD}_v is observed after the corrections [5]. The correction is done on an event by event basis following:

$$\Delta N = N_{\rm tr}(z)\frac{\langle N_{\rm tr}(z_0)\rangle - \langle N_{\rm tr}(z)\rangle}{\langle N_{\rm tr}(z)\rangle} \quad (3)$$

$$N^{corr}_{\rm tr}(z) = N_{\rm tr}(z) + \Delta N_{\rm rand} \quad (4)$$

where $\Delta N_{\rm rand}$ can be taken as positive, negative or both depending on whether the reference value $< N_{tr}(z_0) >$ is minimum, maximum or mean as compared to the event-averaged values.

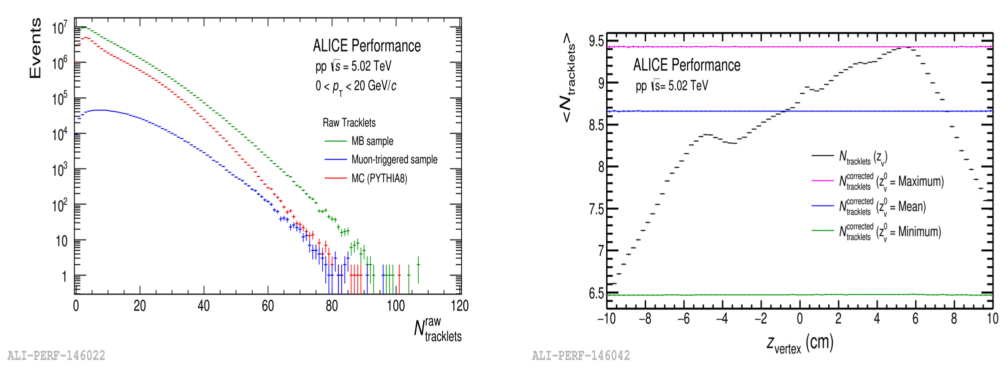

Figure 3: (Left) Raw tracklets distribution for MB, Muon triggered and MC events. (Right) Tracklet corrections using data-driven method in data.

Charged-particle estimation

The charged particles are estimated from the corrected reconstructed tracklets from MC.

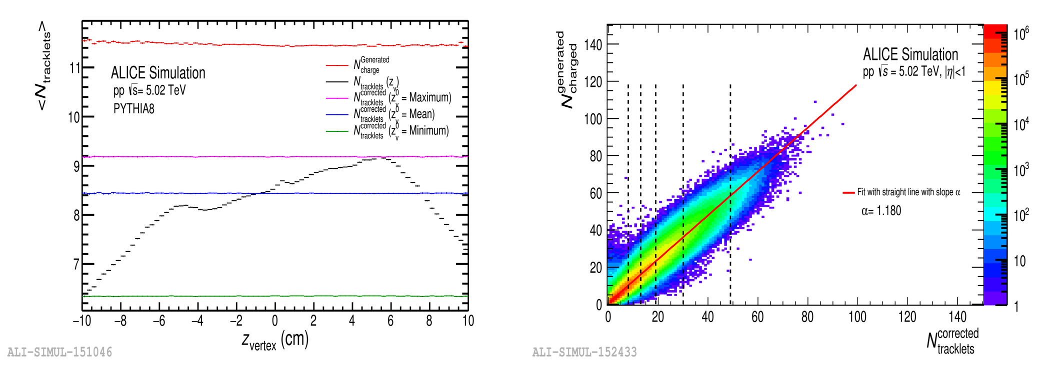

Figure 4: (Left) Tracklet corrections using data-driven method in MC. (Right) The $N^{\rm Gen}_{\rm ch}$ to corrected $N_{\rm trk}$ correlation plot is used to extract α

Muon track selection

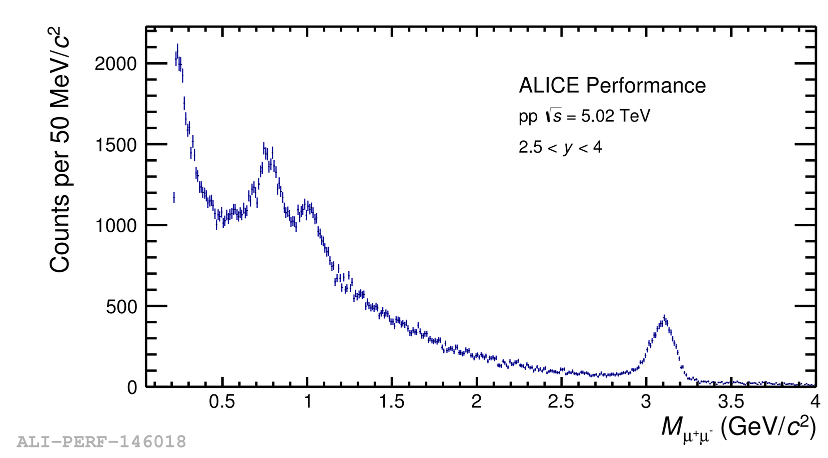

Figure 5: Invariant mass of opposite sign muon pairs.

1. Both muon tracks in the tracking chambers must match with trigger tracks with a $p_{\rm T} 0.5 {\rm GeV}/c$ threshold.
2. The track must be in the pseudo-rapidity range $-4.0 < \eta < -2.5$.
3. Transverse radius coordinate of the track, at the end of the front absorber, must be in the range $17.6 < R_{\rm abs} < 89.5$ cm.
4. Dimuon rapidity must be in the range $-4.0 < y < -2.5$.

Signal Extraction and systematic uncertainty

Signal extraction has been performed using extended Crystal Ball and NA60 functions. A variable-width Gaussian and ratio of first to second order polynomial are taken as background functions. 12 tests are performed, which are considered in the evaluation of the systematic uncertainties. The signal has been extracted in several multiplicity bins.

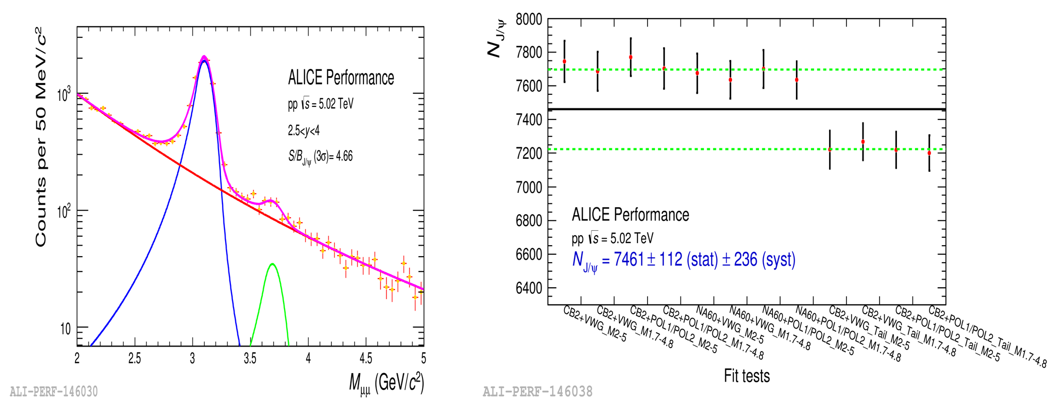

Figure 6: (left)An example of J/ψ signal extraction. (Right) Systematic uncertainty of the signal extraction.

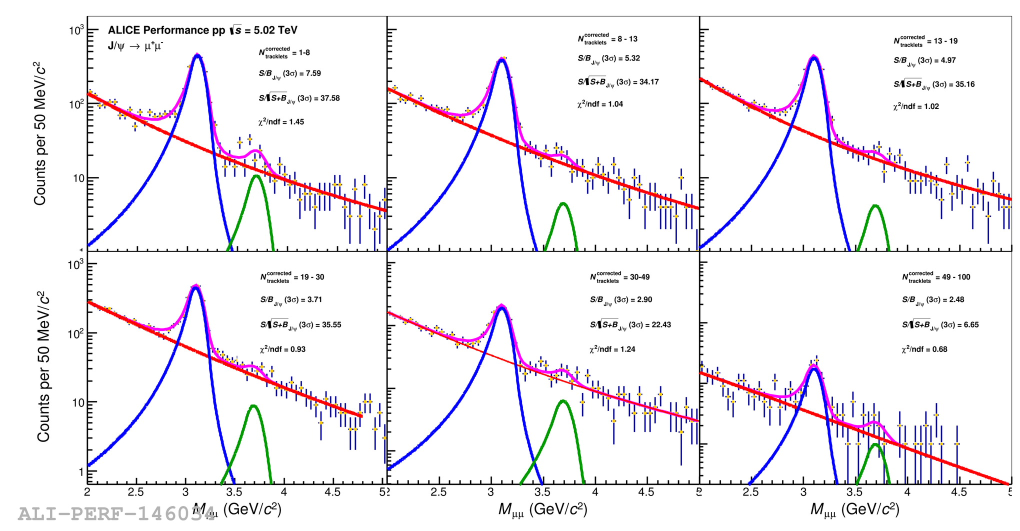

Figure 7: J/ψ signal extraction in multiplicity bins at forward rapidity in pp collision at $\sqrt{s}$ = 5.02 TeV.

Summary and outlook

- The analysis technique for the measurement of the J/ψ yield as a function of multiplicity has been presented.
- SPD tracklet correction and signal extraction are performed in pp collisions at $\sqrt{s}$ = 5.02 TeV.
- The systematic uncertainty on the charged-particle multiplicity estimation is ongoing.
- The systematic uncertainty on N^{Tot}_{MB} and N^{i}_{MB} are to be finalized.
- Finally, multiplicity dependence of J/ψ yield will be shown in pp at $\sqrt{s}$ = 5.02 TeV and compared to the result obtained in pp collisions at $\sqrt{s}$ = 7 TeV.
- The study at lower energy might help us to explore the energy dependence.

References

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[5] ALICE Collaboration, Physics Letters B 712 (2012) 165-175.