J/ψ as a function of charged-particle multiplicity in pp collisions at √s =13 TeV with ALICE at the LHC

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1. Physics Motivation

❖ The relative J/ψ yield is increasing faster compared to charged-particle multiplicity, as reported by ALICE for pp collisions at $\sqrt{s}$ = 7 TeV [1].

Possible explanations

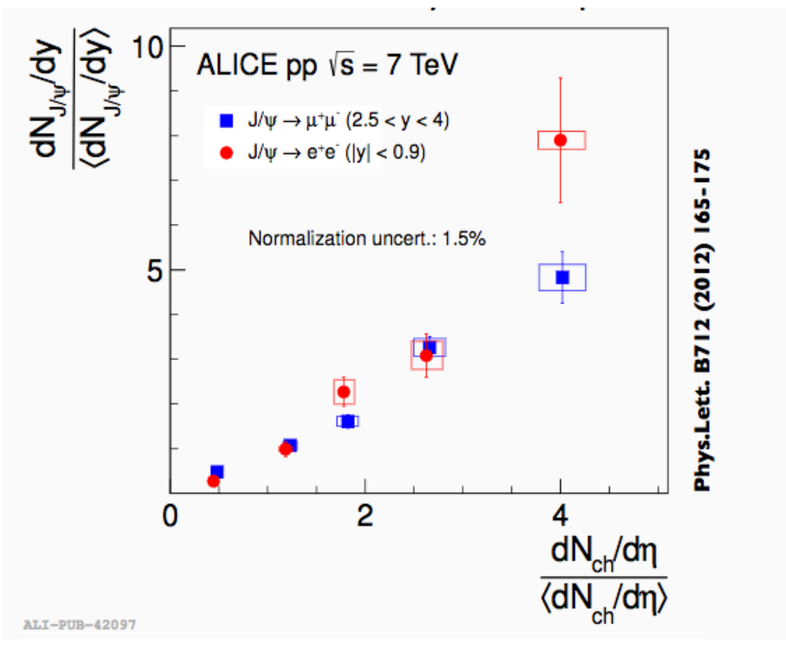
- Substantial contribution from Multiple-Parton Interactions (MPI) on harder scale.
- At very high center-of-mass energy, protons are not point like particles and hence there is possibility of impact parameter dependence of MPI.

Some other observations from pp collisions

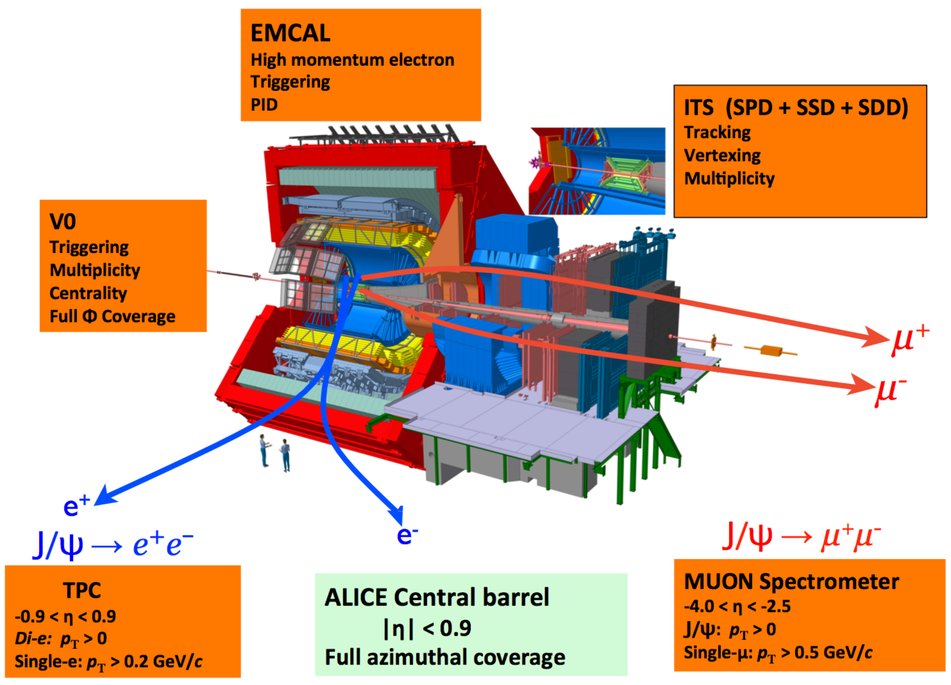
- Charged-particle multiplicity measured in high-multiplicity pp collisions at the LHC is equivalent to peripheral Cu-Cu collisions at $\sqrt{s_{NN}}$ = 200 GeV [2].
- The ridge observed in pp collisions at $\sqrt{s}$ = 0.9, 2.76 and 7 TeV[3,4] might be an indication of collective behavior.

Therefore, the system created in pp collisions needs to be understood properly.

❖ The charged-particle dependence of J/ψ production at higher center of mass energy of $\sqrt{s}$ = 13 TeV may shed light on the nature of the observed effect.



2. A Large Ion Collider Experiment (ALICE)

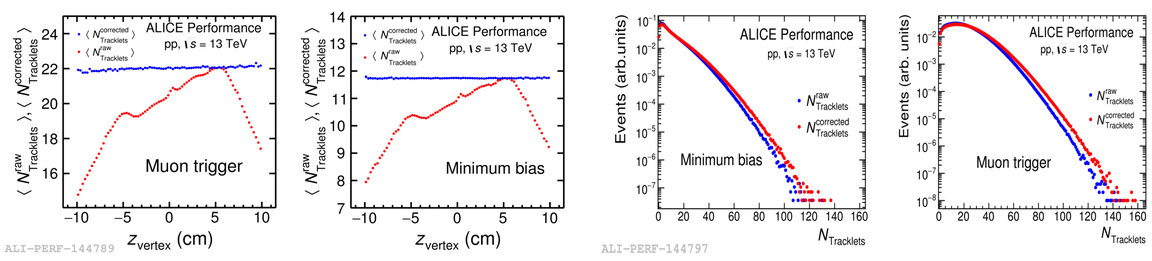


3. Multiplicity determination

Charged-particle multiplicity is measured using the number of SPD tracklets in |η|<1. The variation of the SPD efficiency with the z position of the primary vertex (z_{vertex}) is corrected using a data-driven method.

$$\Delta N = \frac{\langle N_{trk}\rangle(z_v^0) - \langle N_{trk}\rangle(z_v)}{\langle N_{trk}\rangle(z_v)} \qquad N_{trk}^{corr}(z_v) = N_{trk}(z_v) + \Delta N_{rand}$$

- Here ΔN_{rand} follows a Poissonian distribution centered around ΔN.
- z_v^0 corresponds to z_{vertex} position at which $\langle N_{trk}\rangle$ is maximum.
- The same z_{vertex} Vs. $\langle N_{trk}\rangle$ profile and reference value is used to correct minimum bias as well as dimuon triggered data.



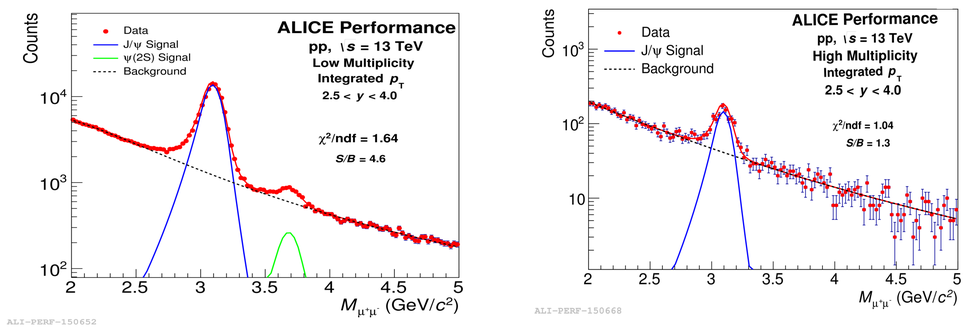
- The correction equalizes the number of tracklets as a function of z_{vtx}, assuming as constant SPD efficiency value, the one obtained at choosen reference z_0.
- The efficiency loss at the point z_0 and other track-to-particle-corrections needs to be taken into account to evaluate actual charged-particle value.

$$\frac{\langle dN_{ch}/d\eta\rangle_i}{\langle dN_{ch}/d\eta\rangle} = \frac{\alpha_i \langle N_{trk}^{corr}\rangle_i}{\langle dN_{ch}/d\eta\rangle_{INEL>0}}$$

- Here, α_i is the correction factor corresponding to each multiplicity bin. It is evaluated using Monte-Carlo.

4. Signal extraction in multiplicity bins for J/ψ→μ⁺ + μ⁻

The J/ψ are extracted by fitting the opposite sign dimuon invariant mass spectra in narrow multiplicity bins



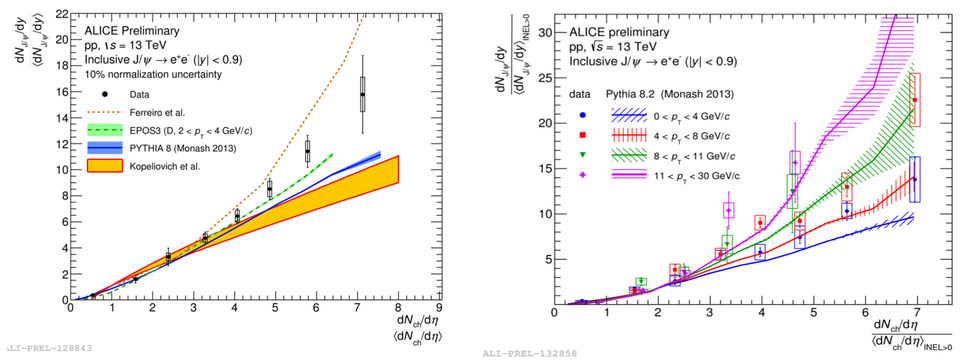
Example of J/ψ signal extraction in low and high multiplicity bins.

- **Signal**:: Extended crystal ball
- **background** :: Variable width Gaussian function.
- **Fitting range**:: 2.0 < $M_{\mu^+\mu^-}$ < 5.0 (GeV/c^2)

5. J/ψ yield as a function of charged-particle multiplicity

The analysis of the J/ψ yield versus charged-particle multiplicity at forward-rapidity is on-going. ALICE has also measured the J/ψ yields vs. multiplicity at mid-rapidity in the $e^+ + e^-$ decay channel.

Ferreiro PRC86 (2012) 034903
EPOS3 Phys. Rept.350 (2001) 93
PYTHIA8 Comput. Phys.Commun. 178(2008)852
Kopeliovich PRD88 (2013) 116002



- The models, which include MPI describe the data qualitatively and reveal the importance of MPI in J/ψ production.
- **EPOS**: The good description of the data with EPOS3 model shows that the energy density reached in pp collisions at the LHC might be high enough to apply hydrodynamical evolution.
- **Kopeliovich**: The inelastic collisions of the Fock components lead to high hadron multiplicity and the relative production of J/ψ is enhanced in such gluon-rich collisions.
- The behavior of J/ψ production as a function of multiplicity is steeper at higher transverse momentum.

6. Summary

- ALICE is investigating the J/ψ production as a function of charged-particle multiplicity in pp collisions at $\sqrt{s}$ = 13 TeV.
- Preliminary results of J/ψ production as a function of charged-particle multiplicity for J/ψ→$e^+ + e^-$ is presented.
- One of the most important observation obtained in J/ψ→$e^+ + e^-$ analysis is that, among all the models, EPOS is describing very well the the J/ψ yield vs. multiplicity data, which contain hydrodynamic evolution.
- A similar study at forward rapidity for J/ψ→$\mu^+ + \mu^-$ is ongoing, which will help to understand the hadronic activity in pp collisions.

7. References

[1] B.Abelev, et al., ALICE Collaboration, Physics Letters B 712 (2012) 165–175
[2] B. Alver, et al., PHOBOS Collaboration, Phys. Rev. C 83 (2011) 024913
[3] W. Li, et al., CMS Collaboration, J. Phys. G 38 (2011) 124027
[4] V. Khachatryan, et al., CMS Collaboration, JHEP 1009 (2010) 091

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