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J/ψ yield enhancement at very low transverse momentum in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02\,\mathrm{TeV}$ with ALICE

Zhuo Zhou[1]*, **for the ALICE Collaboration** †
[1] *University of Bergen, Norway*
E-mail: zhuo.zhou@uib.no

A large excess in the yield of J/ψ at very low transverse momentum ($p_T < 300\mathrm{MeV}/c$) and forward rapidity ($2.5 < y < 4.0$) was recently reported by ALICE using the LHC Run-1 data, in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76\,\mathrm{TeV}$. This is suggestive of coherent J/ψ photo-production, similar to measurements in ultra-peripheral collisions (UPC), where the nuclei only interact electromagnetically.

During the LHC Run-2, the measurement of the very low p_T J/ψ at mid-rapidity ($-0.9 < y < 0.9$) in the di-electron decay channel was possible thanks to the large sample of recorded Pb-Pb collisions. The central barrel detectors provide a good momentum resolution, and make the measurement sensitive to the key characteristics of J/ψ coherent photo-production, like the corresponding transverse momentum spectrum.

In this talk, it will focus on the J/ψ production in the very low-p_T range in peripheral Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02\,TeV$. The p_T spectrum shape for coherent production will be shown and compared to UPC measurements.

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*Speaker.
†ALICE Collaboration

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1. Introduction

ALICE measured for the first time an excess of J/ψ at very low transverse momentum ($p_T < 300 MeV/c$) in peripheral hadronic Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV at forward rapidity using the MUON arm [1]. The likely origin of the observed excess is coherent J/ψ photo-production at impact parameters smaller than twice the nuclear radius. This work extends the previous measurements to the dielectron decay channel at mid-rapidity, but also brings an important improvement. The good tracking and particle identification precision of the ALICE central barrel provides sensitivity to the J/ψ p_T distribution shape which is a key characteristic for the coherent photo-production.

2. Analysis

The analysis is based on a Pb-Pb dataset taken at $\sqrt{s_{NN}} = 5.02$ TeV, which fulfils the minimum bias trigger, in the 50-90% centrality range with the ALICE detector. J/ψ mesons are reconstructed in dielectron decay channel, at mid-rapidity (-0.9$< y <$0.9) and down to zero of transverse momentum ($p_T = 0$). The ALICE detectors used in the analysis are the Inner Tracking System (ITS) for vertex reconstruction and tracking, the Time Projection Chamber (TPC) for tracking and particle identification, the V0 scintillators for triggering and centrality, and the Zero Degree Calorimeters (ZDC) for background rejection [2]. The electrons are identified using their specific energy loss in the TPC. The electrons from photon conversions has been reduced by removing electrons from the pairs with very low invariant mass from the pairing.

The raw J/ψ signal is obtained from the invariant mass distribution of unlike-sign dielectron pairs by subtracting the combinatorial background, using bin counting in the mass region $2.92 - 3.16\ GeV/c^2$. The combinatorial background is estimated using the mixed event method. For the mixed event method, only events with similar properties were mixed together. The J/ψ reconstruction efficiency is evaluated using Monte-Carlo simulations where all the running conditions are reproduced.

3. Results

The p_T-dependent J/ψ production density is obtained from the raw yields ($N^{raw}(p_T)$) using the formula

$$B.R. \times \frac{d^2N}{dy dp_T}(p_T) = \frac{1}{N_{ev}} \frac{N^{raw}(p_T)}{\Delta y \Delta p_T (A \times \varepsilon)} \tag{3.1}$$

Where N_{ev} is the number of events in the data sample analyzed, $A \times \varepsilon$ is the acceptance and efficiency correction and y is the rapidity of J/ψ. In order to calculate the acceptance and efficiency corrections, a full transversal polarization in the J/ψ helicity frame was assumed. The total systematic uncertainty due to the efficiency correction and signal extraction procedures is 7%.

The contribution from hadronically produced J/ψ in the low-p_T region is evaluated by fitting the corrected J/ψ spectrum in the range $p_T > 0.5$ GeV/c with a power-law function and extrapolating the function to zero p_T. Due to the steeply falling hadronic spectrum towards zero p_T, the con-

tamination with hadronic J/ψ is found to be below 1%. The p_T-integrated rapidity density in the di-electron decay channel in the range $p_T < 300$ MeV$/c$ grows from $5.5 \pm 1.1(\text{stat}) \pm 0.4(\text{syst}) \times 10^{-4}$ in the peripheral 70-90% collisions to $10.2 \pm 2.0\%(\text{stat}) \pm 0.7(\text{syst}) \times 10^{-4}$ in the peripheral 70-90% collisions as shown in figure 1.

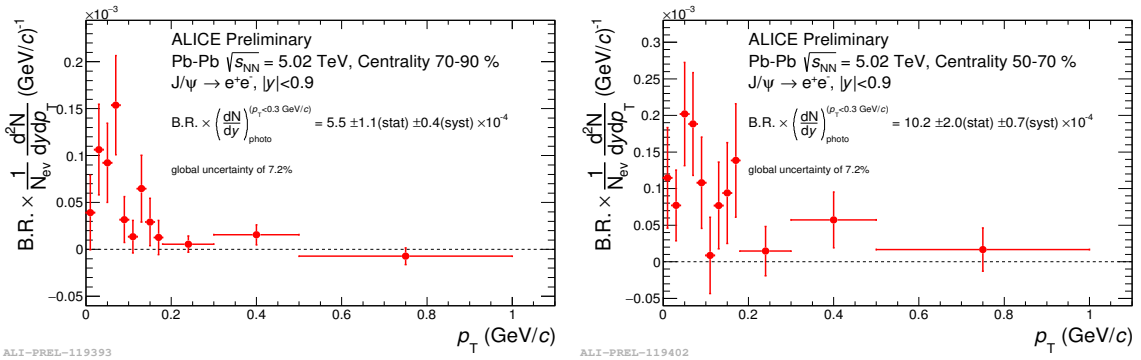

Figure 1: The corrected J/ψ yield as a function of p_T in 70-90% Pb-Pb collisions (left) and in 50-70% Pb-Pb collisions (right). It is remarkable that an excess at low p_T is clearly observed for peripheral collision in these 2 centrality bins.

In order to understand the origin of the low-p_T J/ψ production we compare the raw yields we obtain in this analysis to the ones obtained in the analysis of ultra-peripheral Pb-Pb events at $\sqrt{s_{NN}} = 5.02$ TeV. In figure 2, a good agreement is observed with the ultra-peripheral measurement in the region p_T <300 MeV/c for both centrality ranges studied. Above 300 MeV/c the UPC and our measurements no longer agree, primarily due to the contribution from hadronically produced J/ψ.

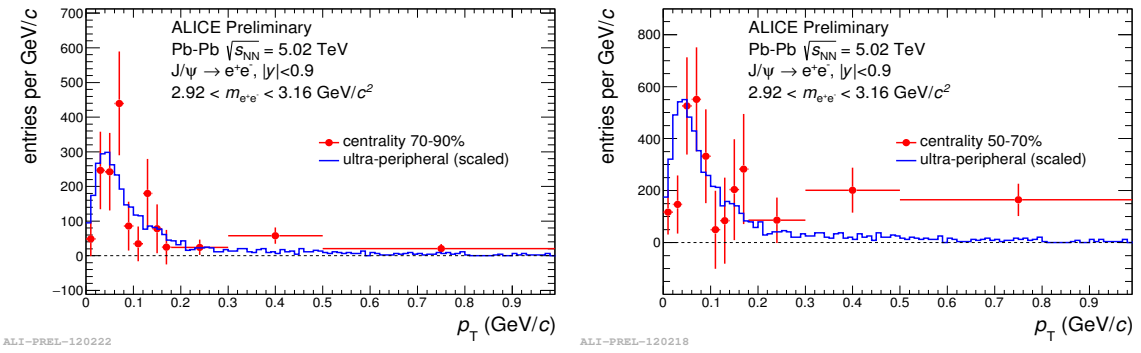

Figure 2: J/ψ yield as a function of p_T in 70-90% (left) and 50-70% (right) in Pb-Pb collisions compared to UPC results.

4. Conclusion

We reported on the very low-p_T J/ψ production in Pb-Pb collisions in the centrality ranges 50-70% and 70-90%. The observed p_T spectrum in the range p_T <300 MeV/c is in very good agreement with the measurements in ultra-peripheral collisions, confirming the predominantly coherent photo-production origin in this kinematical range, despite the fact that the impact parameter

of the collisions is smaller than two nuclear radii. We also observe that the production density for the coherent J/ψ at low p_T grows significantly between the two centrality ranges studied which could be understood qualitatively as a consequence of the strengthening of the electromagnetic fields with decreasing impact parameter.

References

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[2] ALICE Collaboration, JINST 3 (2008) S08002