Low-p_T J/ψ excess in Pb-Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV at y=0 with ALICE

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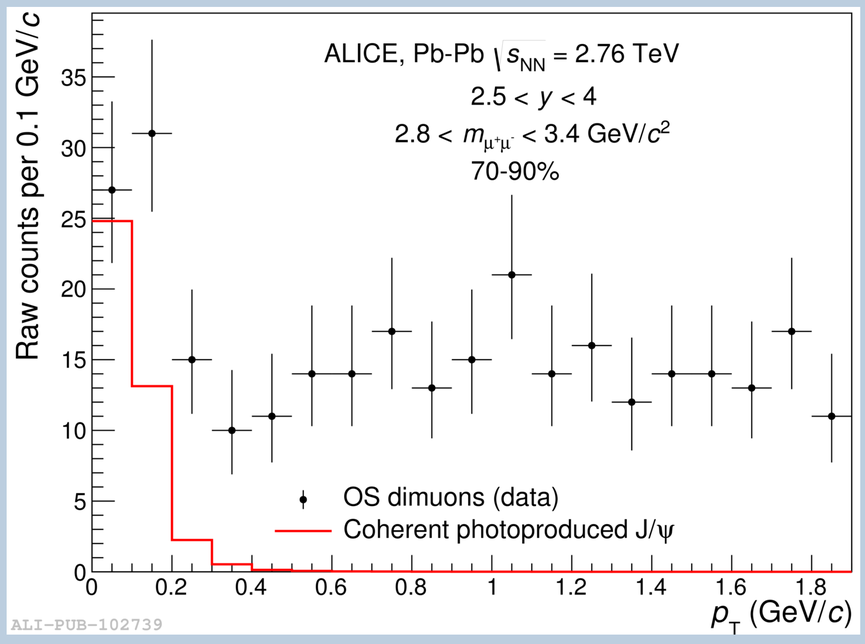
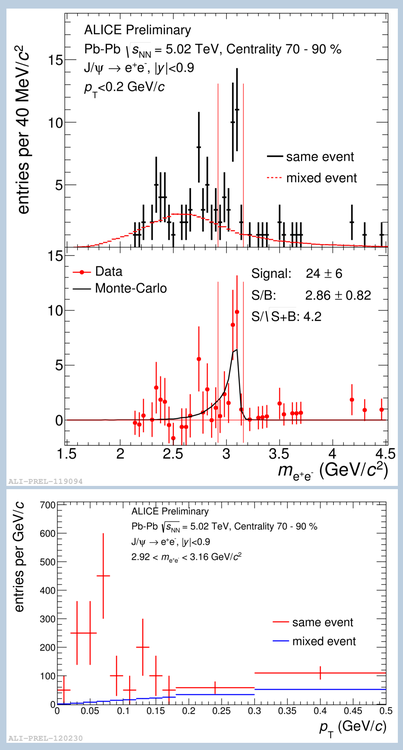
Motivation



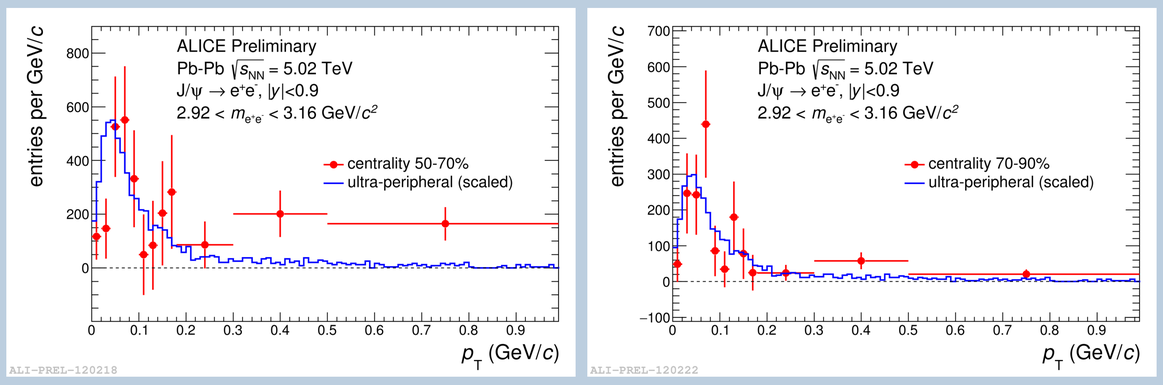
ALICE measured for the first time an excess of J/ψ at very low transverse momentum (p_T<300MeV/c) in peripheral hadronic Pb-Pb collisions at $\sqrt{s_{NN}}$ =2.76 TeV at forward rapidity using the MUON arm [1]. The likely origin of the observed excess is coherent J/ψ photoproduction at impact parameters 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 very good tracking and particle identification precision of the ALICE central barrel provides sensitivity to the J/ψ p_T distribution shape which is a characteristic signature for the coherent photoproduction.

J/ψ signal extraction



The raw J/ψ signal is obtained from the invariant mass distribution of unlike-sign dielectron pairs by subtracting the combinatorial background in the mass region 2.92-3.16 GeV/c^2.
The combinatorial background is obtained using the mixed event method. The mixed event background is scaled to match the same event unlike-sign distribution in the side-bands of the signal region. Alternatively, the matching is also done with the same-event like-sign distribution constructed as $2R\sqrt{N_{++}\times N_{--}}$ where $N_{++,--}$ are the number of positive and negative like-sign pairs and R is a factor accounting for the different 2-particle acceptance between like- and unlike-sign pairs.

Comparison with the UPC measurement

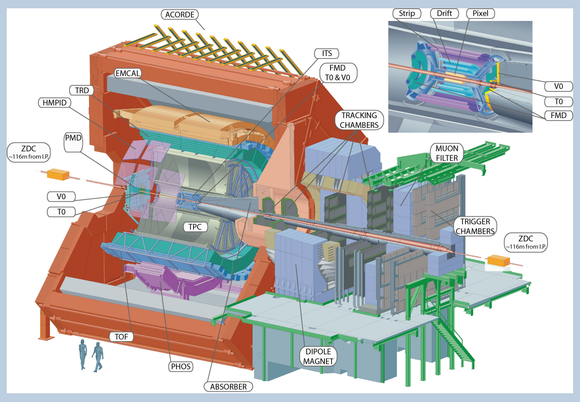


In order to understand the origin of the low-p_T J/ψ production we compare the raw yields we obtain in this analysis to the ones obtained in the analysis of ultra-peripheral Pb-Pb events at $\sqrt{s_{NN}}$ =5.02 TeV. A good agreement is observed with the ultra-peripheral measurement in the region p_T <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.
It would be important to understand whether the p_T distribution of the photoproduced J/ψ changes as a function of the collision centrality, however the large statistical uncertainty of the hadronic collisions data sample prevents a firm conclusion.

Experimental setup and data set

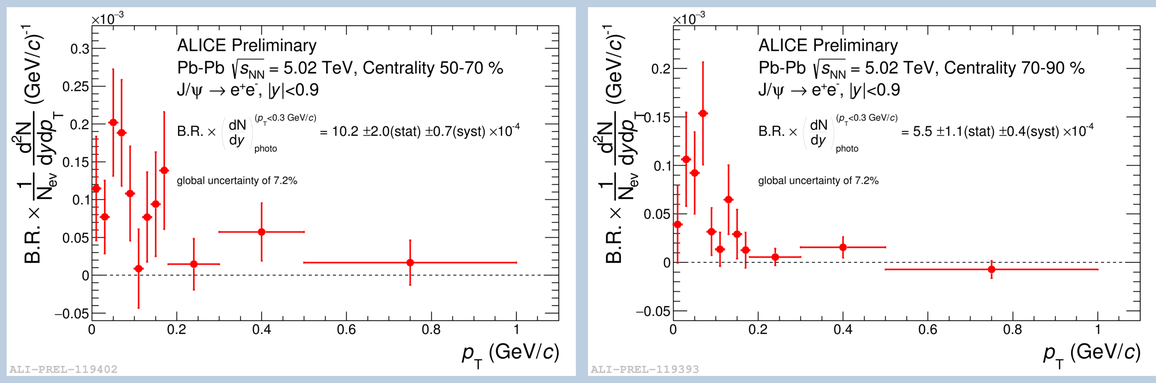
Technical details on ALICE detector can be found in [2]. Detectors used in this analysis are

- the Inner Tracking System (vertex reconstruction, tracking)
- the Time Projection Chamber (tracking, particle identification)
- the V0 scintillators (triggering, centrality) and the Zero Degree Calorimeters (background rejection)



The data set used in this analysis consists of 33 million Pb-Pb events at $\sqrt{s_{NN}}$ =5.02 TeV in the 50-90% centrality range.

Corrected photoproduced J/ψ yields



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

$$\text{B.R.} \times \frac{d^2N}{dydp_T}(p_T) = \frac{1}{N_{ev}} \frac{N^{raw}(p_T)}{\Delta y \Delta p_T (A \times \varepsilon)} \quad (1)$$

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 J/ψ rapidity. For the calculation of 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 contamination with hadronic J/ψ is found to be below 1%.
The p_T-integrated rapidity density in the dielectron decay channel in the range p_T <300 MeV/c grows from 5.5±1.1(stat)±0.4(syst)×10^{-4} in the peripheral 70-90% collisions to 10.2±2.0(stat)±0.7(syst)×10^{-4} in the more central 50-70% collisions.

Conclusions

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 photoproduction 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 strenghtening of the electromagnetic fields with decreasing impact parameter.

References

[1] ALICE Collaboration, Phys.Rev.Lett. 116 (2016) 22, 222301
[2] ALICE Collaboration, JINST 3 (2008) S08002