Measurement of the J/ψ elliptic flow at mid-rapidity in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

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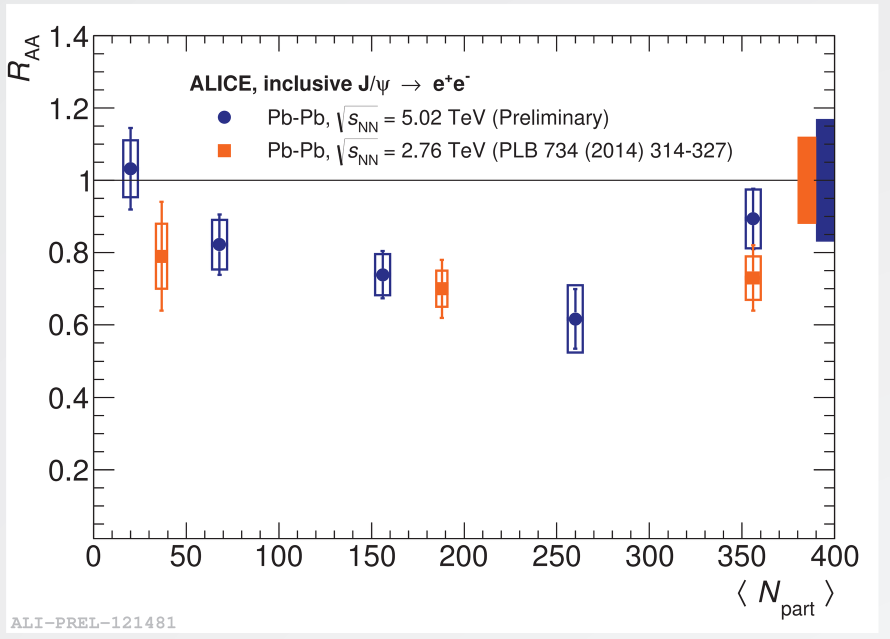
Motivation

J/ψ measurements in $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV and 5.02 TeV Pb–Pb collisions show a smaller suppression than expected from color screening, when compared to binary-scaled pp collisions. An answer to this behavior is presented by models containing a regeneration component [1,2,3]. In these models a possible (re)combination of (un)correlated c$\bar{\mathrm{c}}$-pairs enhances the J/ψ production. Since those c$\bar{\mathrm{c}}$-pairs interact with the bulk medium before forming a J/ψ, they should be coupled to the medium flow. Hence the measurement of the elliptic flow (v_2) for J/ψ imposes strong constraints on the J/ψ production models in high-energy Pb–Pb collisions.

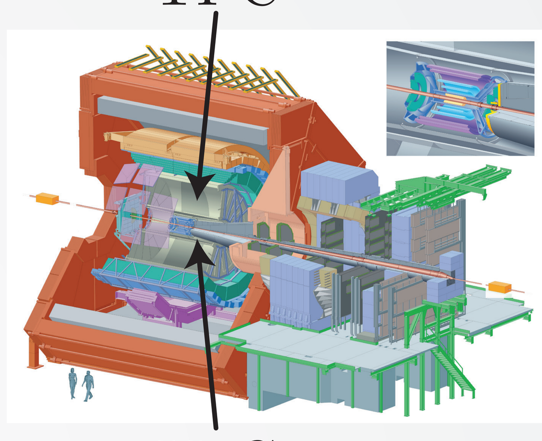


The figure shows the $J/\psi R_{\mathrm{AA}}$ for $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV and $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV. The R_{AA} for $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV shows a similar behavior like the one for $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV. A different behavior at high $\langle N_{\mathrm{Part}} \rangle$ is observed compared to results at lower energies (i.e. $\sqrt{s_{\mathrm{NN}}} = 0.2$ TeV [5]) and interpreted as an indication for a regeneration component in the J/ψ production mechanisms.

Data

The analysis is based on Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV, that were measured during LHC's 2015 Pb–Pb campaign with ALICE. For the elliptic flow extraction the 20-40% most central collisions are used which corresponds to ~18.5M events after all event cuts. The electron identification is done with the Time Projection Chamber (TPC) via dE/dx combined with information from the Time Of Flight detector. For the event-plane estimation the TPC, and for comparison the V0C were used.

TPC



V0C

Method

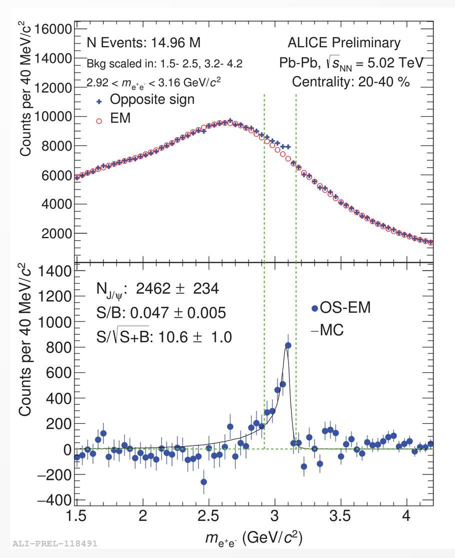
The elliptic flow of the J/ψ is extracted via a fit performed on the average elliptic flow versus the invariant mass of the measured di-electron pairs. The elliptic flow of a di-electron pair ($v_2^{\mathrm{J}/\psi}$) is calculated from the azimuthal angle of the J/ψ ($\varphi_{\mathrm{J}/\psi}$) with respect to the event-plane angle (Ψ_{EP}):

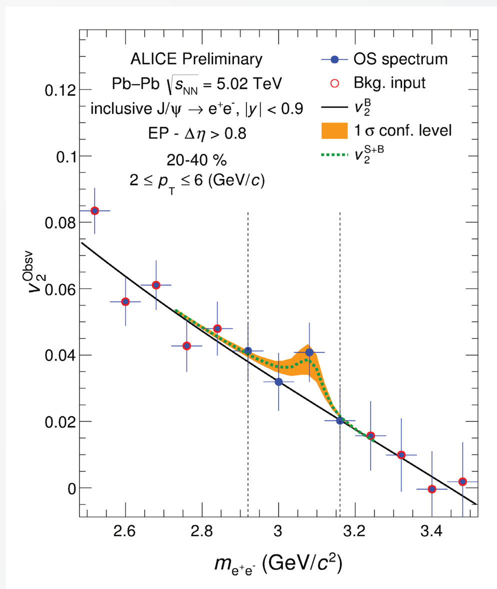
$$\langle v_2^{\mathrm{J}/\psi} \rangle = \langle \cos(2 \cdot (\varphi_{\mathrm{J}/\psi} - \Psi_{EP})) \rangle$$

The function for the fit of the average elliptic flow is defined as:

$$\langle v_2^{\mathrm{S+B}} \rangle = \frac{\mathrm{S} \cdot \langle v_2^{\mathrm{J}/\psi} \rangle + \mathrm{B} \cdot \langle v_2^{\mathrm{B}} \rangle}{\mathrm{S+B}}$$

The function contains only one unknown parameter: $\langle v_2^{\mathrm{J}/\psi} \rangle$. The signal (S) and the background (B) are taken from the J/ψ signal extraction. The total elliptic flow ($\langle v_2^{\mathrm{S+B}} \rangle$) corresponds to the average observed elliptic flow of the di-electron pairs. The elliptic flow of the background ($\langle v_2^{\mathrm{B}} \rangle$) is measured by a fit to the $\langle v_2^{\mathrm{S+B}} \rangle$ distribution excluding the J/ψ mass region.





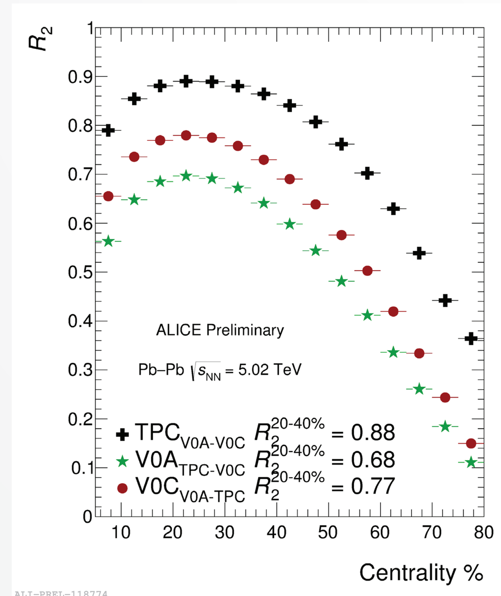
The two plots demonstrate the $\langle v_2^{\mathrm{J}/\psi} \rangle$ extraction via the fit. The left plot is an example for a J/ψ signal extraction, with the raw opposite-sign and the background spectrum from event-mixing in the top panel and the background subtracted signal spectrum in the bottom pad. The right plot shows the average elliptic flow as function of the invariant mass of the di-electron pairs, including the performed fits for the $\langle v_2^{\mathrm{J}/\psi} \rangle$ extraction.

Corrections

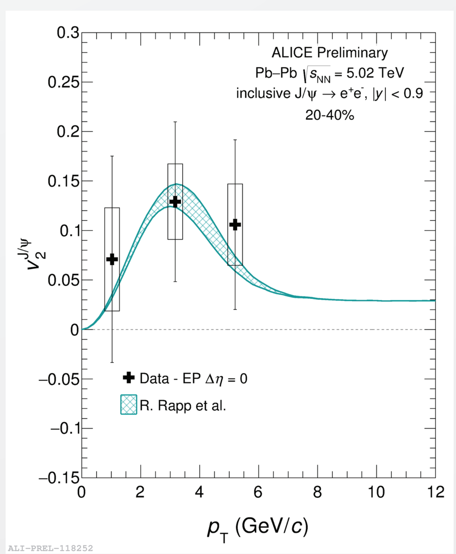
The elliptic flow measurement has to be corrected for the event-plane resolution, which is calculated using the three sub-detector method:

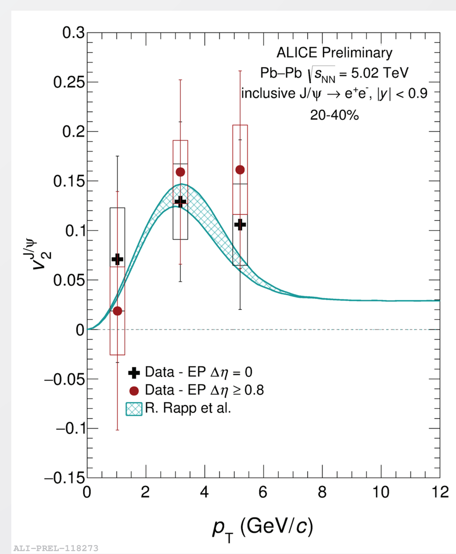
$$R_n^A = \sqrt{\frac{\langle cos(n(\Psi_n^A - \Psi_n^B)) \rangle \langle cos(n(\Psi_n^A - \Psi_n^C)) \rangle}{\langle cos(n(\Psi_n^B - \Psi_n^C)) \rangle}}.$$

The correction (R_2) corresponding to the 20-40% centrality interval was obtained as a weighted average using the centrality dependent J/ψ-yield as weight.



Results

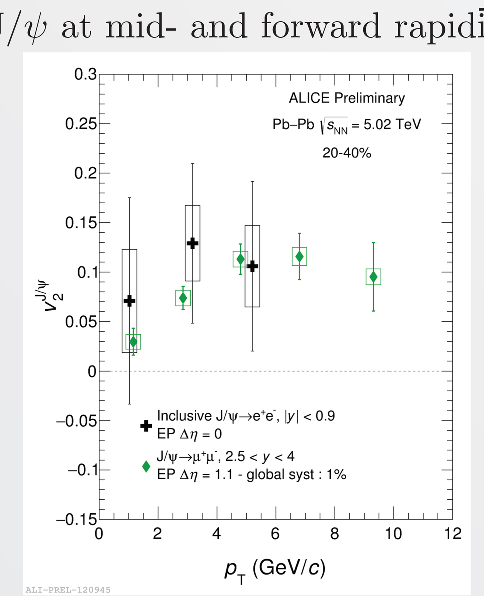




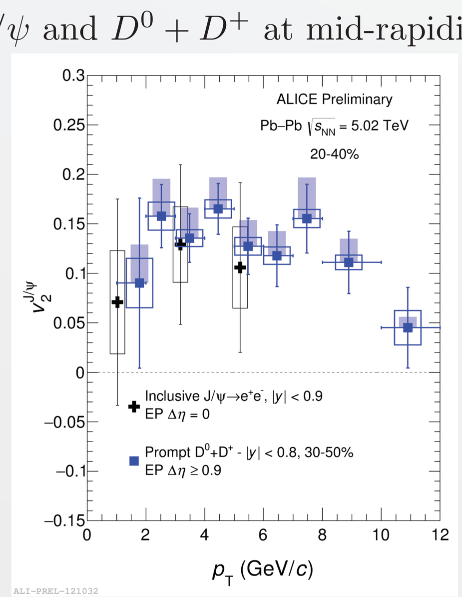
The results, independent of the used event-plane estimator, agree within uncertainties with the calculation from R.Rapp et al. [4]. That calculation is a weighted average of primordial-suppressed, (re)generated and non-prompt J/ψ from b-feeddown. A hint for a non-zero J/ψ elliptic flow is observed for $2 \leq p_{\mathrm{T}}^{\mathrm{J}/\psi} \leq 6$ (GeV/c).

Comparisons

J/ψ at mid- and forward rapidity



J/ψ and $D^0 + D^+$ at mid-rapidity



The results for the J/ψ at mid- and forward rapidity agree within uncertainties. The D mesons as the main c-quark carrier clearly flow. The observation of a similar behavior for the J/ψ would impose strong constraints on the models. Within the uncertainties the results for the D mesons and the J/ψ at mid-rapidity agree, but only a more significant measurement of the J/ψ elliptic flow can result in a clearer picture.

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