Spin alignment of K^{*0} measured with ALICE detector at the LHC

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Introduction

A large angular momentum and intense magnetic field are expected to be produced in relativistic heavy-ion collisions at RHIC and LHC [1, 2]. Experimentally the proposed signature is the measurement of the spin alignment of vector mesons like K^{*0} and ϕ. The large angular momentum could lead to the observation of a non-uniform angular distribution of the decay products in the rest frame of the vector meson, with respect to the normal to the production plane (plane defined by the vector meson momentum and the beam axis) or to the reaction plane defined by the impact parameter and the beam axis of the system. The angular distribution allows for the estimation of the spin density matrix element. The angular distribution of vector mesons [3] is given by

$$\frac{dN}{d\cos\theta^*} = N_0[(1-\rho_{00}) + \frac{1}{R}\cos^2\theta^*(3\rho_{00}-1)], \quad (1)$$

where N_0 is a normalization constant and R is the event plane resolution. The experimentally reconstructed reaction plane is denoted as the event plane. For the production plane analysis $R = 1$ and for the event plane analysis R is the 2nd order event plane resolution. ρ_{00} is the zeroth element of the spin density matrix. θ^* is the angle formed by one of the vector meson decay daughters in the rest frame of the vector meson with the quantization axis. The quantization axis can be normal to the production plane or to the event plane. Any deviation of the ρ_{00} from 1/3 indicates a net spin alignment whereas $\rho_{00} = 1/3$ corresponds to the absence of spin alignment.

We present the new results on the spin alignment of K^{*0} vector mesons in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ and 5.02 TeV measured with respect to the production and to the event plane as a function of p_T and centrality using the ALICE detector. For null hypothesis, the spin alignment of K^{*0} in pp collisions at $\sqrt{s} = 13$ TeV and K^0_S (spin 0) in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV have also been studied.

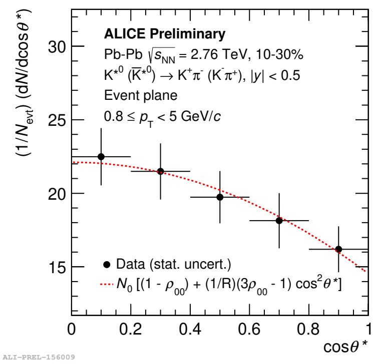

FIG. 1: $dN/d\cos\theta^*$ vs. $\cos\theta^*$ at mid-rapidity with respect to the event plane for 10-30% central Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. The error bars are statistical only.

Analysis and Results

K^{*0} is reconstructed through the hadronic decay channels K^{*0} ($\bar{K}^{*0}$) → $K^+\pi^-(K^-\pi^+)$ using the invariant mass method. The spin density matrix element ρ_{00} for vector mesons is determined from the angular distribution of the decay products given by eq. 1. The angular distribution of K^{*0} with respect to the event plane is shown in Fig. 1. The ρ_{00} values are obtained by fitting this distribution using eq. 1.

Figure 2 (a) shows the spin alignment of the K^{*0} with respect to the production plane as a function of p_T for centrality bin 10-50% in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ and 5.02 TeV along with the results from pp collisions at $\sqrt{s} =$ 13 TeV. The corresponding results for K^0_S for 20-40% centrality class in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV are also shown. Figure 2 (b) shows the comparison of ρ_{00} with respect to the production and event planes in Pb–Pb collisions

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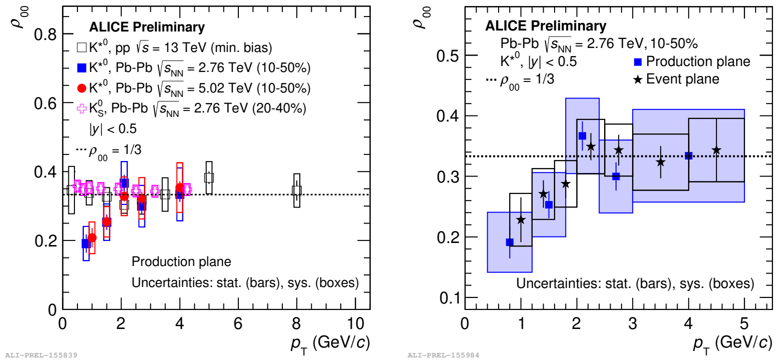

(a) (b)

FIG. 2: (a) ρ_{00} vs. $p_{\rm T}$ of K^{*0} with respect to the production plane in pp collisions at $\sqrt{s}$ = 13 TeV and for 10-50% Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 and 5.02 TeV. The corresponding results for K^0_S, a spin zero hadron, for 20-40% Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV are also shown. (b) Comparison of ρ_{00} with respect to production and event plane in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. The statistical and systematic uncertainties are shown as bars and boxes respectively. The dotted line at $\rho_{00} = 1/3$ shows the no spin alignment scenario.

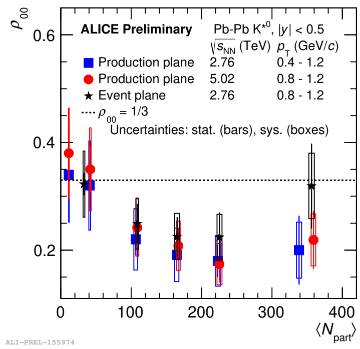

FIG. 3: ρ_{00} of K^{*0} as a function of $\langle N_{\rm part}\rangle$ with respect to production plane in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV (blue marker) and 5.02 TeV (red marker) and with respect to event plane (black marker) in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV for the lowest $p_{\rm T}$ bin. The statistical and systematic uncertainties are shown as bars and boxes respectively.

at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. For $p_{\rm T} < 2$ GeV/c, the observed value of ρ_{00} has a 2σ deviation from 1/3 in the case of K^{*0} in Pb–Pb collisions whereas $\rho_{00} \sim 1/3$ in the case of K^0_S in Pb–Pb and K^{*0} in pp collisions. Figure 3 shows the ρ_{00} of K^{*0} as a function of $\langle N_{\rm part}\rangle$ with respect to the production plane in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV and 5.02 TeV and with respect to the event plane in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV for the lowest $p_{\rm T}$ bin. The ρ_{00} values show a clear centrality dependence in Pb–Pb collisions for both the production and event planes. The maximum deviation of ρ_{00} values from 1/3 is for mid central (10-30%) collisions, in which a large angular momentum is expected. Within statistical and systematic uncertainties the ρ_{00} values do not show energy dependence and similar values are observed both for production and event planes.

Summary

We have presented the measurements of the spin alignment of K^{*0} with respect to both the production and event planes. The ρ_{00} values do not show energy dependence. The measured value of ρ_{00} for K^{*0} vector meson is less than 1/3 for $p_{\rm T} < 2$ GeV/c, hinting at a possible spin alignment in Pb-Pb collisions. The ρ_{00} values show a clear centrality dependence in Pb–Pb collisions for both production and event planes with maximum deviation from 1/3 for mid central (10-30%) collisions.

Acknowledgments

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References

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