

Spin alignment of vector mesons and hyperon polarization in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV

Ranbir Singh (for the ALICE Collaboration)*

National Institute of Science Education and Research, HBNI, Jatni - 752050 Odisha, INDIA

Introduction

The system created in ultrarelativistic non central heavy-ion collisions exhibits a large orbital angular momentum [1]. Particles produced in such collisions can become globally polarized along the direction of the system's angular momentum. The study of polarization of hyperons and vector mesons can provide information about the initial angular momentum and can also help to understand the evolution of the system created in heavy-ion collisions. This phenomenon creates a non-uniform angular distribution of the decay products with respect to the quantization axis in the rest frame of the mother particle. In experiments, the direction of the spin quantization axis can be determined in two ways: the normal to the production plane (plane defined by the momentum of hadron and the beam axis) as shown in Fig. 1 or the normal to the reaction plane (defined by the impact parameter and the beam axis) of the system. This angular distribution can be used to estimate the polarization of hyperons (P_H) and the spin density matrix element ρ_{00} for vector mesons. A significant deviation of the value of P_H from 0 and ρ_{00} from $1/3$ would indicate the presence of polarization for hyperons and vector mesons, respectively.

Such studies on the spin alignment of vector mesons have been carried out in Au-Au collisions at RHIC energies [2]. Here the measurements show the absence of polarization and are consistent with the measurements in pp collisions at same energy. Recently STAR experiment discovered global Λ polarization in non-central Au-Au collisions at lower centre-of-mass energies which vanishes with increas-

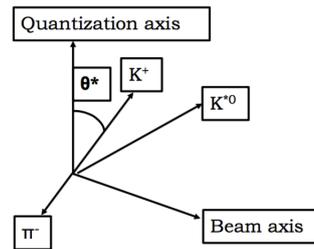


FIG. 1: A diagram of the quantization axis w.r.t. production plane.

ing energy [3].

Analysis technique

We have carried out a spin alignment study of K^{*0} vector meson and Λ hyperons with the ALICE detector in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. K^{*0} and Λ are reconstructed using invariant mass method through their respective hadronic decay channels, $K^{*0}(\bar{K}^{*0}) \rightarrow K^+\pi^-(K^-\pi^+)$ and $\Lambda \rightarrow p\pi^-$. The spin density matrix element ρ_{00} for vector mesons can be determined from the angular distribution of the decay products by

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

where, N_0 is the normalization constant and θ^* is the angle between the quantization axis and the momentum direction of a daughter particle in rest frame of the parent vector meson as shown in Fig. 1. The angular distribution of K^{*0} is shown in Fig. 2. The ρ_{00} values are obtained by fitting this distribution using eq. 1. In a similar way the polarization of Λ hyperon is calculated as discussed in [4].

*Electronic address: ranbir.singh@niser.ac.in

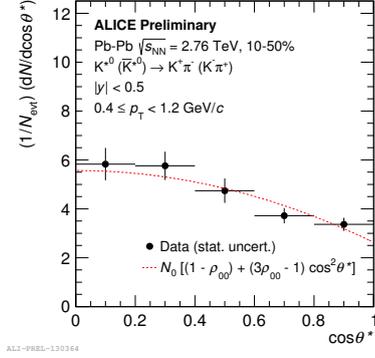


FIG. 2: The $\cos\theta^*$ distribution of K^{*0} for central-ity bin 10-50% in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV.

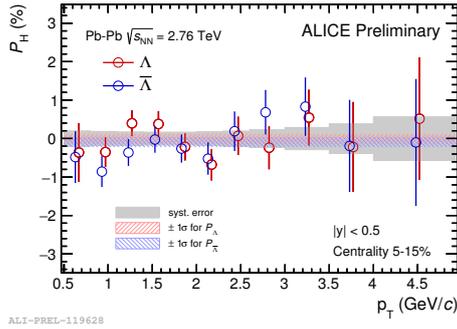


FIG. 3: Global polarization of Λ hyperon w.r.t. reaction plane as a function of p_T for centrality bin 5-15% in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV.

Results

Fig. 3 shows the polarization (P_H) of Λ and $\bar{\Lambda}$ as a function of transverse momentum (p_T) for centrality bin 5-15% in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. The value of P_H is consistent with zero, however for the combined Λ and $\bar{\Lambda}$ results, 1σ significance is observed. The results are consistent with the measurements at the top RHIC energy [3]. Fig. 4 shows the spin alignment of the K^{*0} as a function of p_T for centrality bin 10-50% in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. For $p_T < 2$ GeV/c, the observed value of ρ_{00} hints at a deviation from $1/3$ within 2σ which might indicate the spin alignment of vector meson at LHC energies.

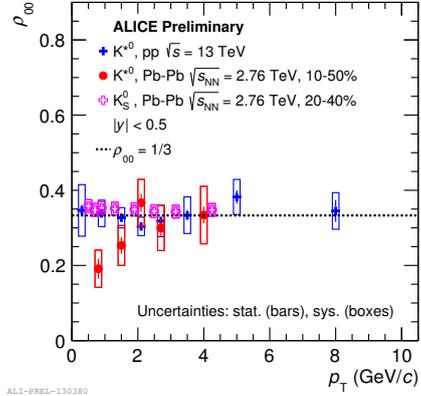


FIG. 4: The spin-density matrix elements ρ_{00} w.r.t. the production plane as a function of p_T for K^{*0} (centrality bin 10-50%), K_S^0 (centrality bin 20-40%) in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV and for K^{*0} in pp collisions at $\sqrt{s} = 13$ TeV. The dashed line at $\rho_{00} = 1/3$ indicates the expectation for unpolarized vector mesons.

Summary

We have presented the measurements of spin alignment of K^{*0} and polarization of Λ . The measured polarization values of Λ hyperons are consistent with zero within the precision of the measurement and follow the trend of polarization decreasing with increasing energy as observed by the STAR collaboration. The measured value of ρ_{00} for K^{*0} vector meson is less than $1/3$ for $p_T < 2$ GeV/c hinting at a possible spin alignment in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV.

Acknowledgments

DAE and DST are acknowledged for financial support.

References

- [1] F. Becattini et al., Phys. Rev. C **77**, 024906 (2008).
- [2] B. I. Abelev et al. (STAR Collaboration), Phys. Rev. C **77**, 061902 (2008).
- [3] B. I. Abelev et al. (STAR Collaboration), Nature **548**, 62 (2017).
- [4] B. I. Abelev et al. (STAR Collaboration), Phys. Rev. C **76**, 024915 (2007).