Probing rescattering effect in heavy-ion collisions with ALICE at LHC

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Introduction

Hadronic resonances are short-lived particles which decay via strong interaction. During the hadron gas phase that follows the hadronisation of the medium created in heavy-ion collisions and spans from the chemical to the kinetic freeze-out, resonances having lifetimes comparable to the duration of the hadronic phase take part in two processes, called regeneration and rescattering. These effects lead to the modification of their yields, which depend on their lifetime, the hadronic cross section of their decay products, and the hadronic phase lifetime. Rescatterings with other hadrons in the medium alter the momentum of the resonance decay products and prevent the reconstruction of the resonance with an invariant-mass analysis. In turn, pseudo-elastic scattering could also regenerate the resonance leading to an enhancement of their yields. Both these competing effects determine the final yield of the resonances at kinetic freeze out. These processes can be studied from the ratios of the yields of resonances to stable particles having same quark content, as a function of system size and comparing with model predictions with and without hadronic interactions.

With its excellent tracking and particle-identification capabilities, the ALICE experiment has measured a comprehensive set of both mesonic and baryonic resonances. Recent results on resonance production in pp, p–Pb, Xe–Xe, and Pb–Pb collisions at various centre-of-mass energies, highlighting new results on $K^{*\pm}(892)$, $\Sigma(1385)$ and $\Xi(1820)$, are presented. The measurements are used to study the system-size and collision energy evolution of transverse-momentum spectra, yields, and mean transverse momentum of different resonances, along with their yield ratios to stable hadrons. These results are compared to lower energy measurements and model calculations if available.

Analysis details

The analysis is performed on ALICE data collected during pp, p–Pb, Xe–Xe, and Pb–Pb runs using the ALICE detectors [1]. All events considered in this analysis are recorded using a minimum bias trigger that requires coincident signals in both V0A and V0C detectors. The V0 signal, which is proportional to the sum of charge particle multiplicity in the V0A and V0C detectors, is used in classifying Pb−Pb, Xe−Xe events into different centrality classes and pp, p−Pb events into different multiplicty classes. Resonance yields are extracted from the invariant-mass distribution of their hadronic decay products. The event mixing technique [2] is used to describe the combinatorial background. The signal yields for the resonances in different centrality (multiplicity) classes and various p_{T} intervals are obtained after subtracting the combinatorial background from the same event invariant mass distributions. The residual correlated background, remaining after the subtraction of the event-mixing background, is described by a polynomial function with parameters fitted to data.

Results

Figure 1 shows the transverse-momentum spectra of $K^{*\pm}$ in Pb−Pb collisions at $\sqrt{s_{\mathrm{NN}}} =$ 5.02 TeV. The inverse slope of the spectra

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increases with increasing multiplicity. The mean of the distribution shifts towards higher values with increasing multiplicity consistent with radial flow effect.

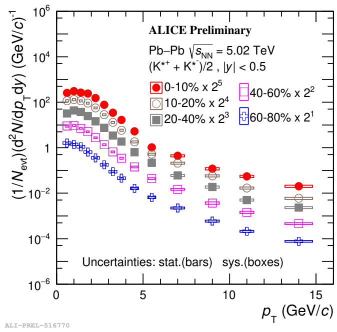

FIG. 1: Corrected p_T spectra of $K^{*\pm}$ for different centrality classes in Pb−Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV.

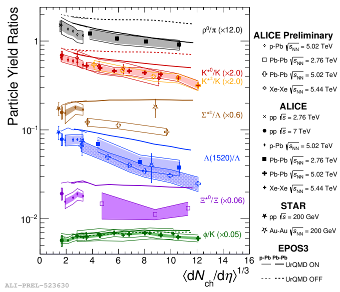

FIG. 2: Particle yield ratios as a function of $\langle dN_{ch}/d\eta\rangle^{1/3}$ in pp, p−Pb, Xe−Xe and Pb−Pb collisions.

To study the rescattering versus regeneration effects, the ratios of the yields of different resonances to stable hadrons are calculated. Figure 2 shows those ratios as a function of $\langle dN_{ch}/d\eta\rangle^{1/3}_{|\eta|<0.5}$ which is used as a proxy for the system size. The ratios are shown for different systems spanning values of $\sqrt{s_{NN}}$ from 200 GeV to 5.02 TeV. Measurements are further compared with EPOS model calculations [3] with and without UrQMD, that simulates the interactions of particles with other hadrons in the hadron gas. We observe that the yield ratios for resonances having lifetime comparable to that of hadronic phase (for e.g. ρ^0, K*, $\Lambda(1520)$, $\Sigma^{*\pm}$) decrease with increasing system size whereas yield ratios for longer lived resonances like ϕ remain fairly constant with increasing system size. The suppression of the yield of short-lived resonances with increasing multiplicity is qualitatively consistent with EPOS with UrQMD predictions. This observation suggests that rescattering dominates over regeneration effects in the hadronic phase of heavy-ion collisions. To probe the p_T dependence of rescattering effects, K^{*0} and ϕ p_T spectra in central Pb–Pb collisions are compared in Figure 3 with Blast Wave Model predictions whose parameters are obtained from a simultaneous fit of π, K, and p spectra. While the ϕ p_T spectrum is well described by the Blast Wave calculations, the measured K^{*0} spectrum is lower than the predictions for $p_T < 3.5$ GeV/c as shown in Figure 3, thus suggesting that rescattering effects are dominant at low p_T.

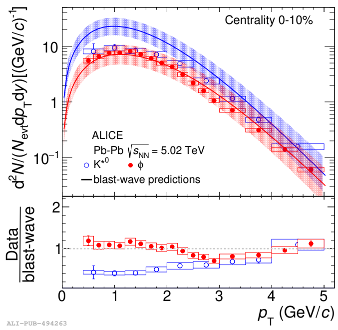

FIG. 3: p_T spectra of K^{*0} (blue marker) and ϕ (red marker) mesons compared with Blast wave model predictions in 0−10% centrality.

Acknowledgments

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References

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[3] T. Pierog et al, Phys. Rev. C 92, 034906