System size dependence of hadronic resonances production in pp, p–Pb and Pb–Pb collisions in ALICE at the LHC

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Introduction

In heavy-ion (AA) collisions at ultra-relativistic energies the production of a deconfined state of nuclear matter, the quark-gluon plasma (QGP), is expected from quantum chromodynamics predictions[1, 2]. The system produced in such collisions evolves through different stages, including an early partonic and a hadronic phase. Resonances having short lifetimes (few fm/c) can be used to probe different stages of the system produced in such collisions. Among the various resonances, $\mathrm{K}^*(892)^0$ has a lifetime of $\tau_{\mathrm{K}^{*0}} \sim 4$ fm/c whereas $\phi(1020)$ has a lifetime nearly ten times larger than K^{*0}, $\tau_\phi \sim 45$ fm/c. Therefore, a systematic comparison of resonance measurements may serve as a tool for investigating the hadronic phase of the collision [3]. In particular, particle spectra provide information about both the kinetic (where elastic collisions cease) freeze-out of the system and about collective flow. The ratios of hadronic resonance yields to the yields of longer-lived hadrons are used to investigate rescattering or re-generation effects that affect the resonance yields established at chemical freeze-out (when inelastic interactions cease) that decrease or increase the measurable yields, respectively. Comparison of resonances with different lifetimes can be used to extract information about the lifetime of the hadronic phase. The nuclear modification factors (R_{pPb}, R_{AA}) are used to study the in medium energy loss of partons traversing the dense color-charged medium. The interpretation of heavy-ion results depends crucially on the comparison with results from smaller collision systems such as proton-proton (pp) or proton-nucleus (pA). In particular, the measurements in pp are the reference for obtaining the nuclear modification factors. ALICE has measured these resonances in different collision systems and energies [4, 5].

In this conference we present the new results on resonance production in pp and Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV. These results are based on Run-II data sets collected by the ALICE detector in 2015.

Resonance reconstruction

The K^{*0} and ϕ mesons are measured through the invariant-mass reconstruction of their decay daughters in the charged hadronic decay channels, $\mathrm{K}^{*0}(\overline{\mathrm{K}}^{*0}) \rightarrow \mathrm{K}^+\pi^-(\mathrm{K}^-\pi^+)$ and $\phi \rightarrow \mathrm{K}^+\mathrm{K}^-$. These resonances are measured in the mid-rapidity region. In the invariant-mass method one needs to estimate the combinatorial background which is constructed by using an event-mixing technique. A smaller, residual background still remains after combinatorial background subtraction. The resonance signals after the combinatorial background subtraction are fitted with a Breit-Wigner function describing the resonance peak and a polynomial function describing the residual background. The raw yields are extracted from the residual background-subtracted resonance signal distribution. To measure the corrected transverse momentum (p_{T}) spectra the raw yields are corrected for detector acceptance, reconstruction efficiency and branching ratio.

Results and discussion

The production of K^{*0} and ϕ is measured in minimum bias pp and eight centrality classes in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$= 5.02 TeV in a wide range of p_{T} (0.4-20 GeV/c). The p_{T} integrated particle yields (dN/dy) and mean p_{T} ($\langle p_{\mathrm{T}} \rangle$) of K^{*0} and ϕ in minimum bias and each centrality class are obtained from the measured p_{T} spectra. Figure 1 shows the $\langle p_{\mathrm{T}} \rangle$ of K^{*0} and ϕ (compared with π, K, and p) as a func-

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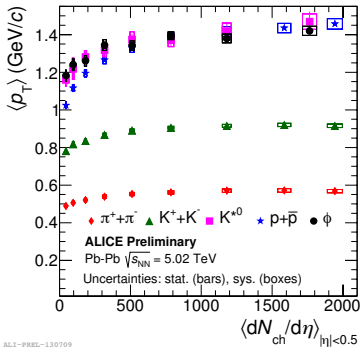

FIG. 1: Mean p_T of $\pi, \mathrm{K}, \mathrm{K}^{*0}$, p and ϕ as a function of the average charged particle multiplicity density in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV.

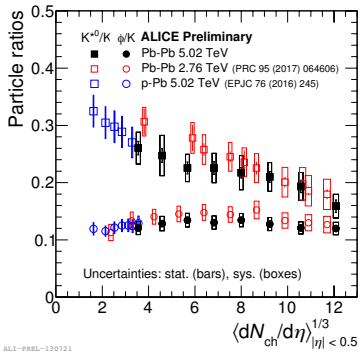

FIG. 2: Ratios,i.e $\mathrm{K}^{*0}/\mathrm{K}$ and ϕ/K ratios as functions of $\langle \mathrm{d}N_{ch}/\mathrm{d}\eta \rangle^{1/3}$ in pp, p–Pb, and Pb–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. Ratios from lower energy Pb-Pb collisions are also shown [4].

tion of the average charged particle multiplicity density, $\langle \mathrm{d}N_{ch}/\mathrm{d}\eta \rangle$ measured at mid-rapidity ($|y| < 0.5$) in Pb–Pb collisions. All particles show an increase in $\langle p_{\mathrm{T}} \rangle$ from most peripheral to most central Pb–Pb collisions. It is observed that particles with similar mass, such as K^{*0}, p and ϕ, have similar $\langle p_{\mathrm{T}} \rangle$ for $\langle \mathrm{d}N_{ch}/\mathrm{d}\eta \rangle > 500$ in Pb–Pb collisions. This can be attributed to the presence of radial flow, as consequence of collectivity established in the QGP. The mass-ordering (particles with higher mass are measured to have larger $\langle p_{\mathrm{T}} \rangle$) observed in the most central events for resonances seems to weaken going towards peripheral Pb–Pb collisions. The ratios ϕ/K and $\mathrm{K}^{*0}/\mathrm{K}$ measured in Pb–Pb collisions compared to the published measurements in p–Pb [5] at $\sqrt{s_{NN}} = 5.02$ TeV are shown in Fig. 2. Lower energy data is included in Fig. 2 and is observed to be compatible within uncertainties The ϕ/K ratio is nearly independent across all systems and centrality classes whereas the $\mathrm{K}^{*0}/\mathrm{K}$ ratio exhibits a decreasing trend towards the most central Pb–Pb. There are two competing processes, re-scattering and re-generation. This decrease in $\mathrm{K}^{*0}/\mathrm{K}$ ratio can be explained in terms of re-scattering effects. The relative suppression of integrated K^{*0} yield in central Pb-Pb collisions depends on the time interval between chemical and kinetic freeze-out and the interaction cross-section of the daughter hadrons. Due to the relatively longer lifetime of the ϕ-meson, it is expected that the re-scattering and re-generation effects are negligible. A suppression towards more central collisions is also observed for other short-lived resonances such as the $\rho(770)^0$ and $\Lambda(1520)$, which corroborates the hypothesis of dominating re-scattering effects in the hadronic phase.

Summary

We present a systematic study of hadronic resonance production in pp, p–Pb and Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. The $\langle p_{\mathrm{T}} \rangle$ of K^{*0}, p and ϕ is the same in mid-central and central Pb–Pb collisions, as expected from hydrodynamical models. The $\mathrm{K}^{*0}/\mathrm{K}$ ratio is suppressed in central collisions, consistent with the re-scattering of its decay daughters during the hadronic phase, while the ϕ/K ratio is not suppressed due to the longer lifetime of ϕ-meson.

Acknowledgments

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