Multiplicity dependence of resonance production in pp collisions at $\sqrt{s} = 13$ TeV with ALICE

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Introduction

Resonances are short lived particles having lifetimes $\sim 10^{-23}$ s and can be used to study the properties of the hadronic phase in heavy-ion collisions. In fact, in central Pb-Pb collisions, where the lifetime of the hadronic phase is similar to that of resonances, regeneration and rescattering [1] effects become important. At the LHC, the pseudo-rapidity densities at mid rapidity ($\langle dN_{ch}/d\eta \rangle$) of final state charged particles in pp and p-Pb collisions are comparable with semi-peripheral Au-Au collisions at RHIC energies and peripheral Pb-Pb collisions at LHC energies [2–4]. Recent measurements in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV [5] and pp collisions at $\sqrt{s} = 7$ TeV show a decreasing trend in $K^*/K$ ratio as a function of $\langle dN_{ch}/d\eta \rangle$, similar to heavy-ion collisions. Multiplicity-dependent studies in pp and p-Pb collisions are therefore interesting as they allow to probe the possible presence of hadronic medium effects on final state observables even in pp and p-Pb collisions. A study of the multiplicity dependence of $\phi$ meson production is important in the context of the study of strangeness production, since $\phi$ is an $s\bar{s}$ pair and its net strangeness content is 0 and we do not know if it behaves like a $S = 0$ particle or a $S = 2$ particle. Therefore, a multiplicity-differential study of $\phi$ meson production is advocated by many theorists in order to provide an input for the tuning of MC generators.

In this contribution we present the recent measurements of $K^*$ and $\phi$ meson production as a function of $\langle dN_{ch}/d\eta \rangle$ in pp collisions at $\sqrt{s} = 13$ TeV. Transverse momentum ($p_T$) integrated particle yields ($dN/dy$) are shown as a function of $\langle dN_{ch}/d\eta \rangle$. These results are compared with the measurements from p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV [5] and pp collisions at $\sqrt{s} = 7$ TeV. We also present the resonance to stable particle ratios ($K^*/K$ and $\phi/K$) and compare the results with the measurements from p-Pb and Pb-Pb collisions.

Analysis details

These analyses are based on a data sample of $\sim$43M minimum bias triggered events collected by ALICE in 2015. All events in which at least one charged particle has been detected within $|y| < 1.0$ are considered for this analysis. Events are divided into classes depending on the multiplicity in the V0 detectors. These are two plastic scintillator detectors, V0A and V0C, placed in the pseudorapidity ranges $2.8 < \eta < 5.1$ and $-3.7 < \eta < -1.7$, covering the full azimuthal angle. Charged particle multiplicity is then measured at midrapidity for each class. The whole data sample has been divided into ten event multiplicity classes (denoted as I-X), where I and X correspond to highest and lowest V0M multiplicity event classes, respectively. $K^*$ and $\phi$ mesons are reconstructed using an invariant mass analysis of their hadronic decays. Branching ratios for $K^*(K^0) \rightarrow K^+\pi^- (K^-\pi^+)$ and $\phi \rightarrow K^+\pi^-$ are 66.66% and 48.9%, respectively.

Results

The measurements of $K^*$ and $\phi$ mesons are performed at mid rapidity ($|y| < 0.5$) over the $p_T$ ranges 0 to 15 GeV/c and 0.4 to 8 GeV/c, respectively. $dN/dy$ is obtained by integrating the $p_T$ spectrum in the measured $p_T$ region and estimating the yield in the unmeasured region using a Levy-Tsallis fit function [6, 7].

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Figure 1 shows $p_T$ spectra of $K^{*0}$ in different V0M multiplicity classes along with their ratios to the corresponding spectrum in minimum bias collisions. Ratios suggest that the $p_T$ spectrum gets harder with increasing multiplicity. Figure 2 shows $dN/dy$ of $K^{*0}$ as a function of $\langle dN_{ch}/d\eta \rangle$. The results are compared with the measurements from p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV [5] and pp collisions at $\sqrt{s} = 7$ TeV. The measurements for all different collisions are consistent with each other at similar multiplicities and fall on a single line, which suggests that the particle production is independent of collision system and collision energy and mainly driven by $\langle dN_{ch}/d\eta \rangle$. $p_T$ integrated $K^{*0}/K$ and $\phi/K$ ratios as a function of $\langle dN_{ch}/d\eta \rangle^{1/3}$ in pp, p-Pb and Pb-Pb collisions are shown in Fig. 3. A smooth evolution is observed for these ratios as a function of $\langle dN_{ch}/d\eta \rangle^{1/3}$, from low multiplicity pp to central Pb-Pb collisions. The results from pp collisions at $\sqrt{s} = 13$ TeV are consistent with the measurements from p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV [5]. The $\phi/K$ ratio is nearly flat across all systems and multiplicities. On the other hand, the $K^{*0}/K$ ratio shows a decreasing trend with increasing multiplicity in all three systems. This decrease in the $K^{*0}/K$ yield ratios in central Pb-Pb collisions can be understood as being due to rescattering of $K^{*0}$ decay daughters in the hadronic phase.

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References