Insight into $\phi$ meson production in small systems with ALICE at the LHC

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Introduction

The measurement of hadronic resonance production in high-energy heavy-ion collisions provides an important contribution for understanding particle production mechanisms. Measurements in smaller collision systems such as pp and p–Pb act as a reference for the interpretation of the heavy-ion results. Due to their short lifetime, resonances are ideal candidates to probe the dynamics of the hadronic phase formed in heavy-ion collisions. The lifetime of $\phi$ meson (46.3 fm/c) is long compared to that of other hadronic resonances as well as the lifetime of the fireball produced in the heavy-ion collisions. The $\phi$ meson is useful for the study of strangeness enhancement. The $\phi$ meson contains strange quark and antiquark ($s\bar{s}$), with net strangeness content equal to zero. Its production should therefore not be canonically suppressed, while the production of hadrons with open strangeness (e.g. kaons or $\Xi$) may be canonically suppressed [1]. Recent results obtained by using the ALICE detector show that although the $\phi$ meson has zero net strangeness content, it behaves like a particle with open strangeness in large collision system. Measurements of $\phi$-meson production as a function of the multiplicity may help to distinguish between the various explanations of strangeness enhancement in small systems.

Analysis details

The $\phi$ vector meson is reconstructed through an invariant mass analysis using the hadronic decay channel into $K^+K^-$ (branching ratio: 49.2%) [2]. The $\phi$ meson signals in different transverse momentum ($p_T$) intervals and multiplicity classes is obtained by subtracting the combinatorial background from unlike-sign pair invariant-mass distributions. After the combinatorial background subtraction a residual background remains, which mainly arises from other sources of correlated pairs and mis-identified particle-decay products. The extracted $\phi$ signal is fitted with a Voigtian function (which is a convolution of Breit-Wigner and Gaussian functions). A polynomial function is used to describe the residual background. In each $p_T$ interval, the raw yield is obtained from the fit to the signal peak for the various multiplicity classes. To determine the final $p_T$ spectra the raw yields are corrected for detector acceptance, reconstruction efficiency and decay branching ratio.

Recent measurements of $\phi$ mesons in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ and 8.16 TeV and in pp collisions at $\sqrt{s} = 7$ and 13 TeV, are presented.

Results and Discussion

Figure 1 shows the $p_T$ integrated $\phi$-meson yield ($dN/dy$) as a function of charged-particle multiplicity in different colliding systems and at different energies. $dN/dy$ increases with increasing charged-particle multiplicity. It also appears that the event multiplicity drives the particle production, irrespective of the colliding system type and energies. Figure 2 shows the ratios of the yields of p, $K^0$, $\Lambda$, $\phi$, $\Xi$, and $\Omega$ to pions as a function of charged particle multiplicity in various systems at different energies. A significant enhancement of strange to non-strange hadron production is observed with increasing charged particle multiplicity in pp and p–Pb collisions [3]. No significant energy dependence is observed in these ratios. The larger the strangeness content of the particle, the

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The $\Xi/\phi$ ratio as a function of charged-particle multiplicity for three different collision systems and energies is shown in Fig. 3. The net strangeness content of $\phi$ meson is 0, while net strangeness of $\Xi$ is 2. In Fig. 3 it is possible to see that $\Xi/\phi$ ratio slightly increases in pp and p–Pb as a function of the charged particle multiplicity, but is fairly constant or slightly increases across a wide range of multiplicities. This indicates that the $\phi$ meson behaves as if it had an effective strangeness ≤ 2. Comparing the $\phi$ with particles having strangeness 1 or 2, one observe that the $\phi$ meson behaves like a particle with open strangeness.

FIG. 2: Ratio of yields of hadrons (p, $K^0_s$, $\Lambda$, $\phi$, $\Omega$, $\Xi$) to pions as a function of $\langle dN_{ch}/d\eta \rangle_{|\eta|<0.5}$ in pp collisions at $\sqrt{s} = 7$ and 13 TeV, in p–Pb collisions at $\sqrt{s} = 5.02$ and 8.16 TeV.

FIG. 3: $\Xi/\phi$ ratio as a function of $\langle dN_{ch}/d\eta \rangle_{|\eta|<0.5}$ in pp collisions at $\sqrt{s} = 13$ TeV, in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV and in Pb–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV.

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References