Insight into ϕ meson production in small systems with ALICE at the LHC

Sandeep Dudi for the ALICE Collaboration*
Physics Department, Panjab University, Chandigarh, INDIA

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 ϕ 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 ϕ meson is useful for the study of strangeness enhancement. The ϕ 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 Ξ) may be canonically suppressed [1]. Recent results obtained by using the ALICE detector show that although the ϕ meson has zero net strangeness content, it behaves like a particle with open strangeness in large collision system. Measurements of ϕ-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 ϕ vector meson is reconstructed through an invariant mass analysis using the hadronic decay channel into K^+K^- (branching ratio: 49.2%) [2]. The ϕ meson signals in different transverse momentum ($p_{\rm T}$) 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 ϕ 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 $p_{\rm T}$ 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 ϕ mesons in p–Pb collisions at $\sqrt{s_{\rm NN}}$ = 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 $p_{\rm T}$ integrated ϕ-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_s, Λ, ϕ, Ξ, and Ω 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 dependance is observed in these ratios. The larger the strangeness content of the particle, the

*Electronic address: sandeep.dudi@cern.ch

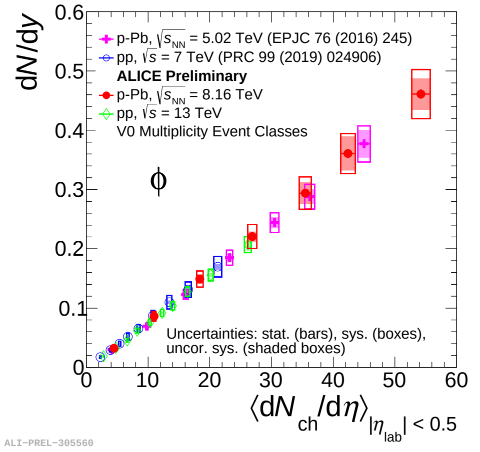

FIG. 1: Transverse momentum Integrated yield (dN/dy) of ϕ as a function of $\langle dN_{ch}/d\eta\rangle_{|\eta_{lab}|<0.5}$ in pp collisions at $\sqrt{s}$ = 7 and 13 TeV and in p–Pb collisions at $\sqrt{s}$ = 5.02 and 8.16 TeV.

stronger the observed enhancement. This effect is due to strangeness and not due to the baryon number or mass of the hadron. At high multiplicity in pp and p–Pb collisions the yield ratios have similar values to those observed in Pb–Pb collisions.

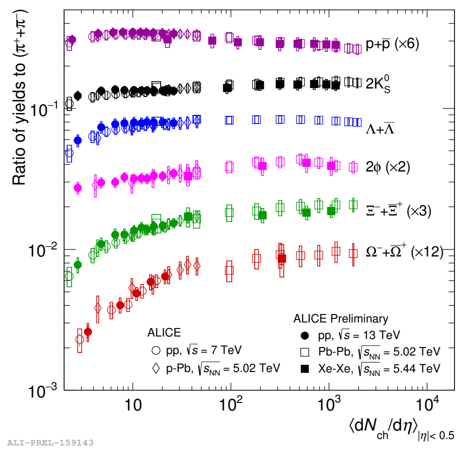

FIG. 2: Ratio of yields of hadrons (p, K^0_s, Λ, ϕ, Ω, Ξ) to pions as a function of $\langle dN_{ch}/d\eta\rangle_{|\eta_{lab}|<0.5}$ in pp collisions at $\sqrt{s}$ = 7 and 13 TeV, in p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 [4], in Xe–Xe collisions at $\sqrt{s_{NN}}$ = 5.44 and in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV.

The Ξ/ϕ 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 ϕ meson is 0, while net strangeness of Ξ is 2.In Fig. 3 it is possible to see that Ξ/ϕ 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 ϕ meson behaves as if it had an effective strangeness $\leq$ 2. Comparing the ϕ with particles having strangeness 1 or 2, one observe that the ϕ meson behaves like a particle with open strangeness.

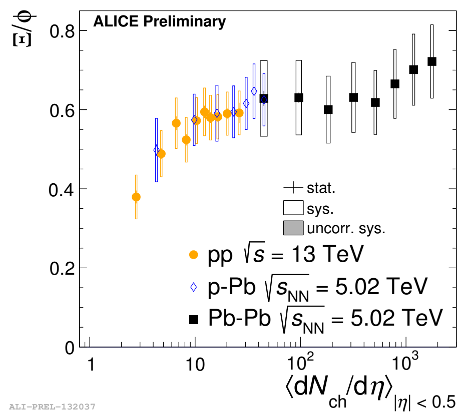

FIG. 3: Ξ/ϕ ratio as a function of $\langle dN_{ch}/d\eta\rangle_{\eta_{lab}|<0.5}$ in pp collisions at $\sqrt{s}$ = 13 TeV, in p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV and in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV.

Acknowledgments

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