Chapter 88
Strangeness- and Rapidity-Dependent Studies in Small Systems with ALICE at the LHC

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Abstract We report about recent studies of strange hadron production in p–Pb at $\sqrt{s_{\mathrm{NN}}} = 5.02, 8.16$ TeV and in pp collisions at $\sqrt{s} = 7, 13$ TeV. The transverse momentum (p_{T}) integrated yields and particle ratios as a function of charged-particle multiplicity are reported to study the particle production mechanism and the strangeness enhancement. The rapidity asymmetry (Y_{asym}) for ϕ and K^{*0} is measured in p–Pb collisions to explore possible nuclear effects. The Y_{asym} is measured as a function of transverse momentum (p_{T}) in various multiplicity classes and are compared with EPOS and HIJING model predictions.

88.1 Introduction

The study of hadron production in pp and p–Pb collisions systems can be used as a reference for the interpretation of the heavy-ion results. As resonances are short-lived particles (lifetime $\approx 10^{-23}$ s), they carry the information regarding the dynamic evolution of particle production in heavy-ion collisions [1]. The measurement of strange hadron production in high-energy hadronic interactions provides a way to study the characteristics of quantum chromodynamics (QCD), the theory of strongly interacting matter. The particle production in asymmetric collision system (e.g. p–Pb) is influenced by nuclear effects in the initial state. Partons from the proton side (backward rapidity) are expected to undergo multiple scattering while traversing the Pb nucleus. Pb-side yields (forward rapidity) are likely to be affected by the properties of the nucleus. Previously, a rapidity-dependent study has been done in d–Au collisions at the Relativistic Heavy-Ion Collider (RHIC) for pions and protons

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[2]. The rapidity-dependent study of particle production can be carried out by using a ratio called the rapidity asymmetry (Y_{asym}), defined as

$$Y_{\mathrm{asym}}(p_{\mathrm{T}}) = \frac{Y_{\mathrm{F}}(p_{\mathrm{T}})}{Y_{\mathrm{B}}(p_{\mathrm{T}})}, \tag{88.1}$$

where Y_{F} and Y_{B} are the spectra measured at forward and backward rapidities, respectively.

The study of Y_{asym} will help to determine the relative contributions of various physics processes to particle production, such as multiple scattering, nuclear shadowing, recombination of thermal partons and parton saturation [2].

We present the measurement of the integrated yields of ϕ mesons and the integrated-yield ratios of p, $\mathrm{K}^0_{\mathrm{s}}$, Λ, ϕ, Ω and Ξ to pions as a function of charged-particle multiplicity in pp and p–Pb collisions. In addition, the Y_{asym} of ϕ and K^{*0} in p–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV are discussed.

88.2 Results

Figure 88.1 shows multiplicity-scaled integrated yields of the ϕ as a function of the charged-particle multiplicity in pp collisions at $\sqrt{s}$ = 7 [3] and 13 TeV and, in p–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 [4] and 8.16 TeV. The multiplicity-scaled integrated yield is constant within uncertainty as a function of $\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta \rangle$. The integrated yield is independent of collision systems and energy. The right plot of Fig. 88.1 shows

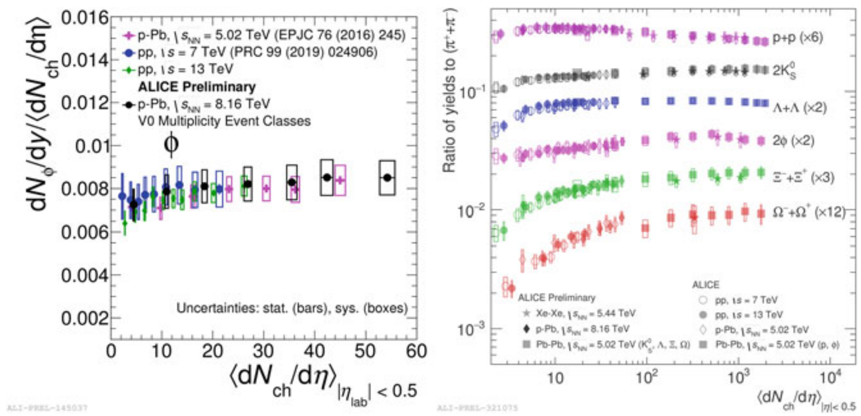

Fig. 88.1 [Left Plot] The multiplicity-scaled integrated yield ($\mathrm{d}N/\mathrm{d}y/\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta \rangle$ for ϕ as a function of $\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta \rangle$ in pp collisions at $\sqrt{s}$ = 7 and 13 TeV and in p–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 and 8.16 TeV. [Right plot] The ratio of yield of hadrons (p, $\mathrm{K}^0_{\mathrm{s}}$, Λ, ϕ, Ω, Ξ) to pions as a function of $\langle \mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta \rangle$ in pp, p–Pb, Pb–Pb and Xe–Xe collisions

the ratios of the yields of p, K_s^0, Λ, ϕ, Ξ and Ω to pions as a function of charged-particle multiplicity in various collision systems at different energies. The strange to non-strange particle yield ratio shows a significant enhancement with increasing charged-particle multiplicity in pp and p–Pb collisions [5]. No significant energy dependence is observed. Particles having a higher strangeness content show strong enhancement in the yield ratio as a function of the charged-particle multiplicity. The yield ratios show similar behaviour at high multiplicity in pp and p–Pb collisions as the measurements in Pb–Pb collisions.

The rapidity asymmetry ratios (Y_{asym}) for ϕ and K^{*0} as a function of p_T for various multiplicity classes based on the V0A detector in p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV are shown in Fig. 88.2. An asymmetry is observed at low p_T, whereas it is consistent with unity within uncertainties at high p_T. The Y_{asym} value are large at high multiplicity, and it decreases as going from high to low multiplicity classes. Y_{asym} for ϕ and K^{*0} shows similar behaviour within uncertainties. Figure 88.3 shows the comparison of ϕ and K^{*0} Y_{asym} in 0–100% multiplicity class with EPOS [6] and HIJING [7] model predictions. Both the models reproduce the data at low p_T, whereas they deviate at high p_T. The HIJING model predictions with and without shadowing parameters show similar behaviour within uncertainties, whereas a large deviation is observed in case of K^{*0} then ϕ at high p_T. The EPOS model calculations with UrQMD [8] ON and OFF also show a similar behaviour within uncertainty. The EPOS model shows less deviation for K^{*0} at high p_T than the HIJING model.

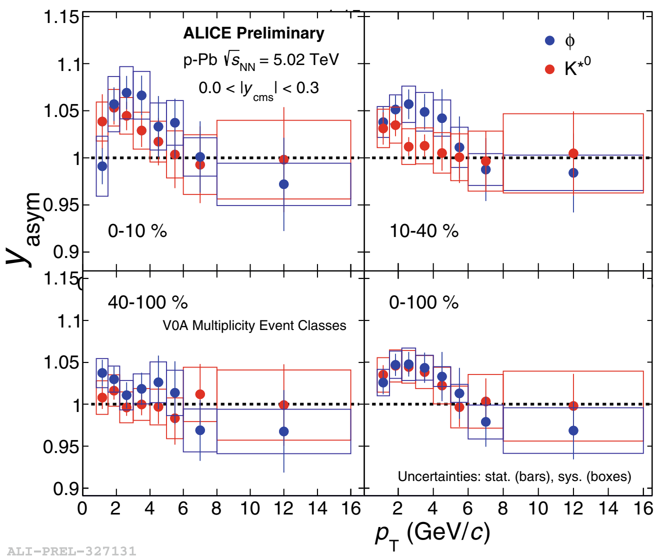

Fig. 88.2 The Y_{asym} of ϕ and K^{*0} as function of p_T for various multiplicity classes in p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV at mid-rapidity

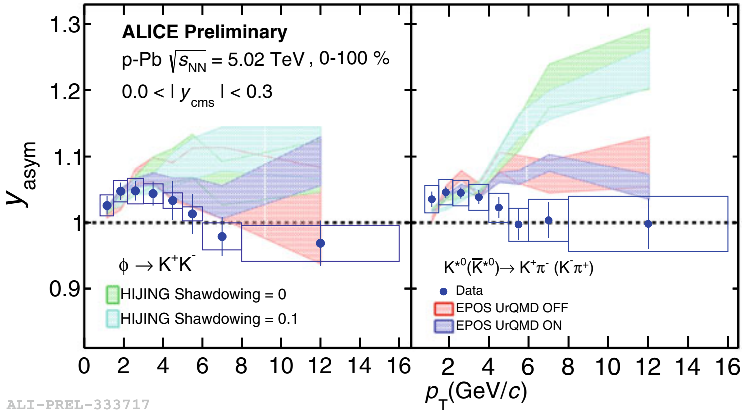

Fig. 88.3 The Y_{asym} of ϕ and K^{*0} with model (EPOS, HIJING) predictions as a function of p_T for 0–100 % multiplicity in p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV at midrapidity

88.3 Summary

The multiplicity-scaled integrated yield of ϕ as a function of the charged-particle multiplicity is independent of collision system and energies. Strangeness enhancement is observed from strange to non-strange hadron yield ratios to pions in pp and p–Pb collisions. The enhancement is larger for particles having larger strangeness content. High multiplicity pp and p–Pb collisions show similar ratios as those measured in Pb–Pb collisions. A rapidity asymmetry is observed at low p_T in the high multiplicity class. Y_{asym} decreases from high to low multiplicity class and it is consistent with unity at high p_T within uncertainties. EPOS and HIJING models explain the Y_{asym} data at low p_T but show deviation at high p_T. The deviation is more important for HIJING than for EPOS. Y_{asym} is also observed to be species independent.

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