Strangeness production in Pb-Pb collisions at LHC energies with ALICE

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Abstract. The results on the production of strange and multi-strange hadrons (K^0_S, Λ, Ξ and Ω) measured with ALICE in Pb-Pb collisions at the top LHC energy of $\sqrt{s_{\rm NN}} = 5.02$ TeV are reported. Thanks to its excellent tracking and particle identification capabilities, ALICE is able to measure weakly decaying particles through the topological reconstruction of the identified hadronic decay products. Results are presented as a function of centrality and include transverse momentum spectra measured at central rapidity, $p_{\rm T}$-dependent Λ/K^0_S ratios and integrated yields. A systematic study of strangeness production is of fundamental importance for determining the thermal properties of the system created in ultrarelativistic heavy ion collisions. In order to study strangeness enhancement, the yields of studied particles are normalised to the corresponding measurement of pion production in the various centrality classes. The results are compared to measurements performed at lower energies, as well as to different systems and to predictions from statistical hadronization models.

1 Introduction

Measurement of strangeness production represents an important source of information about the strongly interacting system created in relativistic heavy-ion collisions. LHC Run II data from Pb-Pb collisions constitute a large statistics sample at high collision energy. In these proceedings we describe new results on the production of K^0_S, Λ ($\overline{\Lambda}$), Ξ ($\overline{\Xi}$) and Ω ($\overline{\Omega}$) in Pb-Pb collisions at the energy of $\sqrt{s_{\rm NN}} = 5.02$ TeV. We first describe the method used for the identification of these particles and then the main results concerning transverse momentum spectra and hadrochemistry.

2 Strange and multi-strange hadron detection in ALICE

The ALICE detector was designed for the study of heavy-ion collisions at the LHC. Its Inner Tracking System (ITS), which consists of six layers of silicon detectors, provides precision tracking and vertexing close to the interaction point. The Time Projection Chamber (TPC) has an excellent tracking performance in high multiplicity collisions, such as central Pb-Pb collisions. It also allows for particle identification through the measurement of the specific energy loss. The V0 detector consists of two scintillator hodoscopes covering the forward pseudo-rapidity regions on both sides of the interaction point. It is used for triggering and multiplicity and centrality estimation. Full description of the ALICE sub-detectors can be found in [1].

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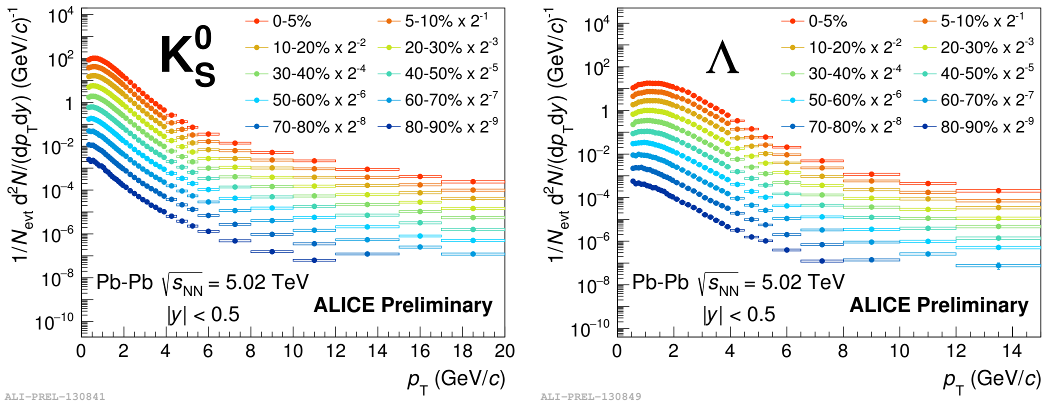

Figure 1. Transverse momentum spectra of K^0_S and Λ for different centrality intervals in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV.

Strange (K^0_S and Λ) and multi-strange (Ξ and Ω) hadrons are reconstructed via their characteristic weak decay topologies, decaying into two and three charged particles, respectively. Charged particle tracks are reconstructed with ITS and TPC and particle identification is based on a selection on the specific energy loss in the TPC. Charged particle tracks are combined in an invariant mass analysis to reconstruct weak decay candidates. These candidates are required to fulfill selection criteria based on geometric (topological) and kinematic quantities. Yields are extracted by bin counting from the invariant mass distribution in each transverse momentum and centrality bin. Acceptance and efficiency corrections are calculated using Monte Carlo simulations.

3 Transverse momentum spectra

The transverse momentum spectra for K^0_S and Λ are shown in Fig. 1. For all particles under study, going from peripheral to central collisions, a hardening of the spectral shapes is observed. The hardening is more pronounced for heavier particles. This behaviour is qualitatively consistent with expectations from hydrodynamical models. It is also consistent with similar observations for other light-flavour hadrons.

The simultaneous blast-wave model fit to $\pi^{\pm}$, $K^{\pm}$ and p ($\overline{\text{p}}$) in Pb-Pb collisions at 5.02 TeV follows the trend from 2.76 TeV with further increase in radial expansion velocity. Strange and multi-strange baryons are not well described by this fit in Pb-Pb collisions, suggesting different kinetic freeze-out conditions for strange and non-strange particles. In contrast, in p-Pb collisions strange and non-strange particles are described by common blast-wave parameters [2].

The Λ to K^0_S ratio in Pb-Pb collisions is shown in Fig. 2. At 5.02 TeV we observe the same features as at the lower energy of 2.76 TeV. From peripheral to central collisions, there is a depletion at low p_T ($\lesssim 2$ GeV/c), an enhancement at intermediate p_T ($\sim 2-7$ GeV/c) and no change at high p_T ($\gtrsim 7$ GeV/c). Comparison with models at $\sqrt{s_{NN}}$ = 2.76 TeV shows that the behaviour at low p_T is explained by hydrodynamical models, while the peak at intermediate p_T is described qualitatively by recombination models [3]. EPOS [4], which includes radial flow and jet-medium interactions, describes the dependence over the entire p_T range.

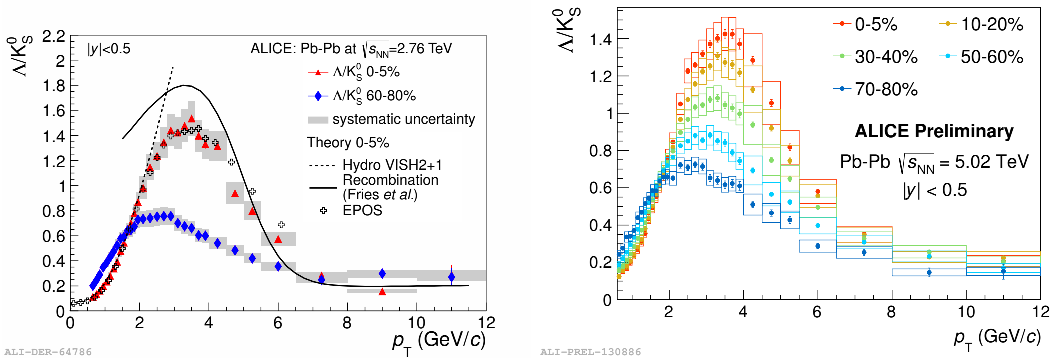

Figure 2. Λ/K^0_S yield ratio as a function of transverse momentum in different centrality classes in Pb-Pb collisions. Left: $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV [5] Right: $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

4 Hadrochemistry

Strangeness enhancement is one of the first proposed signatures of the formation of the quark-gluon plasma (QGP), first suggested by Rafelski and Müller in 1982 [6]. The enhancement was observed at SPS [7], RHIC [8] and LHC [9] and has been found to increase with centrality and strangeness content of the particle and decrease with the energy of the colliding system. At SPS and RHIC the strangeness enhancement was studied by measuring the ratio of the yield in AA collisions and the yield in pp collision at the same energy, normalized to the number of participants. Since the production of charged particles does not scale linearly with the number of participants [10], this is not an ideal quantity to study.

A better observable is the ratio of the yield of the studied particle to the pion yield, which is shown in Fig. 3. We observe a smooth evolution across different colliding systems (pp, p-Pb and Pb-Pb) and no significant dependence on collision energy. For single-strange particles (K^0_S and Λ), there is an indication of an increasing trend with increasing multiplicity in small systems, while for multi-strange particles (Ξ and Ω), the increase is significant. For all particles, there is a flat trend in Pb-Pb collisions at high multiplicity.

Statistical hadronization models based on the grand-canonical approach have been demonstrated to be able to predict particle yield ratios in heavy-ion collisions over a large energy range [11]. Fig. 3 shows that the predictions of statistical hadronization models using a chemical freezeout temperature of 156 MeV are comparable with the measured values in Pb-Pb collisions. In this statistical picture, the lower production of strangeness in small systems (pp collisions) is the consequence of the small phase-space volume available, and it is referred to as canonical suppression [12].

5 Conclusions

The most recent results of the ALICE experiment on the production of strange and multi-strange hadrons in Pb-Pb collisions at 5.02 TeV have been reported. The measured p_{T} spectra show a mass dependent hardening with centrality, as expected from radial flow. The baryon to meson ratio shows the same behaviour as in 2.76 TeV Pb-Pb collisions. We observe a continuous behaviour of the yield ratio to pions versus multiplicity across colliding systems (pp, p-Pb and Pb-Pb). The new data presented here shows that there is not a significant change of this ratio going from 2.76 TeV to 5.02 TeV.

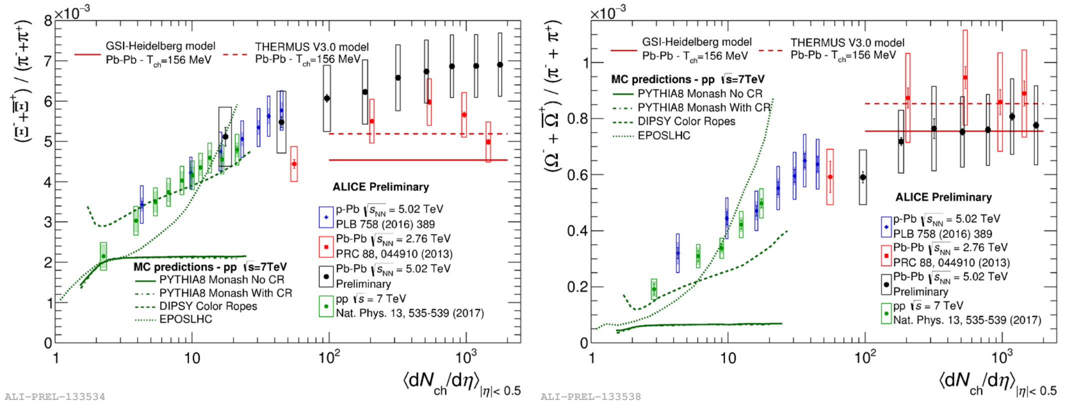

Figure 3. Ratio of Ξ and Ω yields to pion yield as a function of charged particle multiplicity density at medium pseudo-rapidity. Data from pp collisions at 7 TeV (small circles), p-Pb collisions at 5.02 TeV (pluses), Pb-Pb collisions at 2.76 TeV (squares), Pb-Pb collisions at 5.02 TeV (big circles) and comparisons to statistical hadronization models are shown. Open boxes are total systematic uncertainties and shaded boxes show the component that is uncorrelated over multiplicity.

References

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