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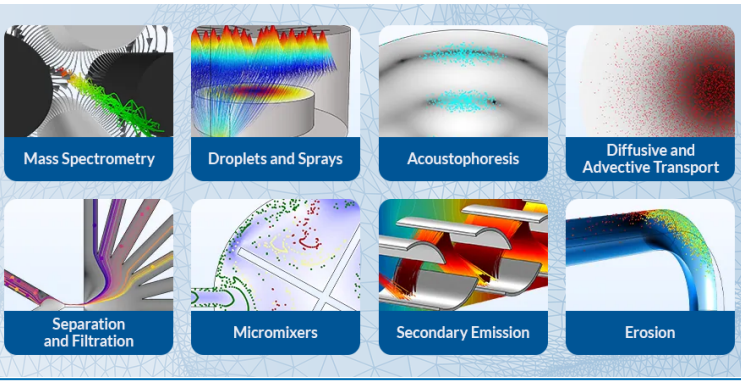

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K^0_S and Λ production in Pb–Pb collisions with the ALICE experiment

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Abstract

We present the study of K^0_S and Λ production performed with the ALICE experiment at the LHC in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV and pp collisions at $\sqrt{s} = 0.9$ and 7 TeV. The K^0_S and Λ particles are reconstructed via their V0 decay topology allowing their identification up to high transverse momenta. The corresponding baryon/meson ratios as a function of transverse momentum are extracted for Pb–Pb collisions in centrality bins and in the transverse momentum range from 1 to 6 GeV/c. They are also compared with those measured in pp events at the LHC energies of 0.9 and 7 TeV as well as in Au–Au collisions at $\sqrt{s_{NN}} = 62.4$ and 200 GeV from RHIC.

(Some figures in this article are in colour only in the electronic version)

1. Introduction

One of the most interesting results obtained at RHIC in Au–Au collisions was the observation that the baryon–(anti-baryon) production at intermediate transverse momenta becomes comparable to that of mesons [1, 2]. The topological decay reconstruction of K^0_S and Λ provides a unique opportunity to extend the baryon and meson identification to much larger transverse momenta than would be possible using conventional particle identification methods. Measurement performed by the STAR Collaboration (see, for example, [1, 3]) showed that the baryon/meson ratio reaches its maximum at $p_T \sim 2.5$ GeV/c and starts decreasing at higher momenta. The maximum value of the Λ/K^0_S ratio in central collisions was found to exceed unity.

The question of why, in nucleus–nucleus collisions, baryons at intermediate p_T appear to be more easily produced than mesons is still open. Possible explanations involve interplays between soft and hard mechanisms of particle production (also at the partonic level) like those

[1] A list of members of the ALICE Collaboration can be found at the end of this issue.

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discussed, for example, in [4]. The evolution of the baryon/meson ratio with collision energy may yield additional information about this 'baryon anomaly'.

In this paper, we present the Λ/K^0_S ratios measured by the ALICE experiment at the LHC in 1.1×10^7 minimum bias Pb–Pb events at $\sqrt{s_{NN}} = 2.76$ TeV as a function of transverse momentum and for different collision centrality bins, as well as in pp collisions at $\sqrt{s} = 0.9$ and 7 TeV.

2. Reconstruction of the K^0_S and Λ in ALICE

The ALICE experiment is well suited for K^0_S and Λ reconstruction over a wide momentum range. For the results discussed here, the momentum range $1 < p_T < 6$ GeV/c is defined by our current level of understanding the systematic uncertainties.

The K^0_S and Λ particles were reconstructed via their V0 decay topology [5]. The method was the same for both pp and Pb–Pb collisions. The typical reconstruction efficiencies (extracted from Monte Carlo studies) were about 40% for K^0_S and 30% for Λ at $p_T \sim 3$ GeV/c (close to the Λ/K^0_S maximum). In the momentum range $2.5 < p_T < 5.5$ GeV/c, the variation of the ratio of the reconstruction efficiencies for K^0_S and Λ was no larger than 1–2%.

The p_T spectra of K^0_S obtained in centrality bins in Pb–Pb collisions were compared with the spectra of charged kaons reconstructed by the ALICE Time Projection Chamber and the time of flight detector. At $p_T > 1$ GeV/c, the two sets of spectra agreed within 1–2% [6].

The spectra of Λ were corrected for the contribution of Λ's coming from decays of Ξ^- and Ξ^0. This was done by re-scaling the corresponding distributions extracted from Monte Carlo simulations with the p_T spectrum of Ξ^- reconstructed in real data, assuming that the number Ξ^0 is proportional to the reconstructed number of Ξ^-. The obtained feed-down corrections turned out to be of the order of 20% and changed within only a few per cent as a function of event centrality and transverse momentum.

The efficiency and feed-down corrections were checked with the lifetime distributions for the V0 particles. These distributions were corrected as functions of two variables, p_T and decay length. This was done for all the event centrality bins separately. The statistical error of the reconstructed life times for K^0_S and Λ was of the order of 1%. However, the systematic deviation from the corresponding nominal values was ~3–4% in the case of the most central events.

Altogether, we considered the following main sources of systematic uncertainties, listed here along with their contributions to the overall uncertainty: signal extraction (3%), efficiency correction (7% for $p_T < 1$ GeV/c, 1% for $p_T > 2.5$ GeV/c), feed-down correction (5%), admixture of Λ's generated in the detector material (2%).

3. Preliminary results

The Λ/K^0_S ratios as a function of p_T for different centralities in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV are shown in figure 1 (left). The same ratios for minimum bias pp events at 0.9 and 7 TeV are also given. The baryon/meson ratio in pp interactions always stays below 1 and is quite similar to what is observed in peripheral Pb–Pb collisions. As the collision centrality increases, the baryon/meson ratio develops a maximum at $p_T \sim 3$ GeV/c reaching a value of ~1.5 for the 0–5% most central events.

4. Comparison with previous measurements

Comparing these preliminary Λ/K^0_S ratios with those measured by the STAR Collaboration in Au–Au collisions at $\sqrt{s_{NN}} = 200$ GeV, we note that, in the case of most central events,

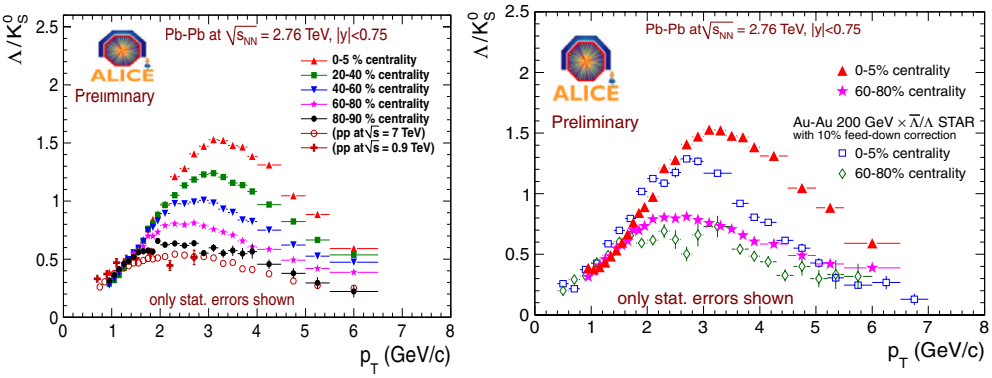

Figure 1. Left: Λ/K^0_S ratios as a function of p_T for different centralities in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, and also for minimum bias pp collisions at $\sqrt{s} = 0.9$ and 7 TeV. Right: selected Λ/K^0_S ratios shown on the left compared with those measured in Au–Au collisions at $\sqrt{s_{NN}} = 200$ GeV.

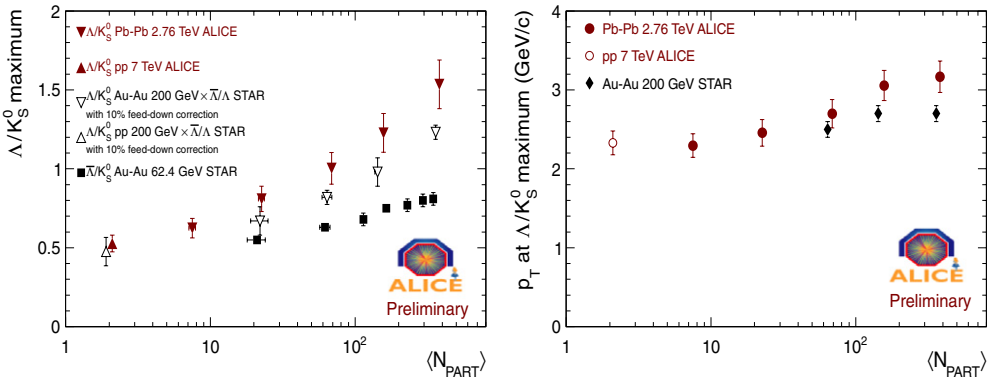

Figure 2. Left: maximum value of the Λ/K^0_S ratio as a function of number of participants compared between different colliding systems and energies. Right: position in p_T of the Λ/K^0_S maximum as a function of number of participants compared between Pb–Pb at $\sqrt{s_{NN}} = 2.76$ TeV, pp at $\sqrt{s} = 7$ TeV and Au–Au at $\sqrt{s_{NN}} = 200$ GeV collisions.

the baryon/meson ratio at the LHC decreases less rapidly with p_T than at RHIC (see figure 1 (right)). The preliminary STAR data points [3] shown in this figure are multiplied by the $\bar{\Lambda}/\Lambda = 0.8$ factor calculated from the data reported in [7] (to account for the non-unity of the anti-baryon/baryon ratio at RHIC) and subtracted a 10% feed-down correction quoted in [1].

A comparison between the maximum values of (anti-)baryon/meson ratios measured by ALICE in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV and those obtained by STAR in Au–Au events at $\sqrt{s_{NN}} = 62.4$ and 200 GeV is presented in figure 2 (left). The Au–Au points at 62.4 GeV are plotted as they are published in [8]. To compare the STAR measurements at 200 GeV with the ALICE results, we multiply the STAR values from [9] by the same $\bar{\Lambda}/\Lambda$ factor and apply the same feed-down correction as mentioned above. As is evident in figure 2 (left), the maximum value of the Λ/K^0_S ratio increases with the beam energy.

The position in p_T of the Λ/K^0_S maximum measured at Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV is slightly shifted towards higher transverse momenta with respect to that observed in Au–Au events at $\sqrt{s_{NN}} = 200$ GeV, as shown in figure 2 (right).

5. Conclusions

We have presented the measurements of Λ/K^0_S ratios in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV performed with the ALICE experiment at the LHC. The ratios are compared to those measured by ALICE in pp collisions at $\sqrt{s} = 0.9$ and 7 TeV as well as with the STAR results in Au–Au events at $\sqrt{s_{NN}} = 62.4$ and 200 GeV.

In Pb–Pb collisions, the Λ/K^0_S ratio as a function of the transverse momentum shows a broad maximum around $p_T \sim 3$ GeV/c. The maximum value of the ratio increases with the collision centrality reaching the value of ~1.5 for the 0–5% most central events.

As the collision centrality decreases, the maximum of the Λ/K^0_S ratio becomes less pronounced and diminishes to a value of ~0.6. The same behaviour of the ratio is observed in pp events at $\sqrt{s} = 0.9$ and 7 TeV which bracket in energy the Pb–Pb results reported here.

Comparison with similar measurements performed by the STAR Collaboration in Au–Au collisions at $\sqrt{s_{NN}} = 62.4$ and 200 GeV shows that the value at the Λ/K^0_S maximum increases with the beam energy. At the same time, the position of the maximum in p_T shifts towards higher transverse momenta. The magnitude of this shift is smaller than was predicted, for example, in [4]. However, the baryon enhancement in central nucleus–nucleus collisions at the LHC decreases less rapidly with p_T and, at $p_T \sim 6$ GeV/c, is a factor ~2 higher compared with that at RHIC.

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