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 √s_{NN} = 2.76 TeV and pp collisions at √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 √s_{NN} = 62.4 and 200 GeV from RHIC.

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

In this article, 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 √s_{NN} = 2.76 TeV as a function of transverse momentum and for different collision centrality bins, as well as in pp collisions at √s = 0.9 and 7 TeV.
2. Reconstruction of the $K^0_S$ and $\Lambda$ in ALICE

The ALICE experiment is well suited for $K^0_S$ and $\Lambda$ 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 $\Lambda$ particles were reconstructed via their V0 decay topology \cite{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 $\Lambda$ at $p_T \sim 3$ GeV/c (close to the $\Lambda/K^0_S$ 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 $\Lambda$ 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 $\%$ \cite{6}.

The spectra of $\Lambda$ were corrected for the contribution of $\Lambda$’s coming from decays of $\Xi^-$ and $\Xi^0$. This was done by re-scaling the corresponding distributions extracted from Monte Carlo simulations with the $p_T$ spectrum of $\Xi^-$ reconstructed in real data, assuming that the number $\Xi^0$ is proportional to the reconstructed number of $\Xi^-$. 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 life-time 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 $\Lambda$ was of the order of 1 $\%$. However, the systematic deviation from the corresponding nominal values was $\sim 3$–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 $\Lambda$’s generated in the detector material (2 $\%$).

3. Preliminary results

The $\Lambda/K^0_S$ ratios as a function of $p_T$ for different centralities in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV are shown in Fig. 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 $\sim 1.5$ for the 0–5 $\%$ most central events.
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Figure 1. Left: $\Lambda/K_S^0$ 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 $\Lambda/K_S^0$ ratios shown on the left compared with those measured in Au–Au collisions at $\sqrt{s_{NN}} = 200$ GeV.

4. Comparison with previous measurements

Comparing these preliminary $\Lambda/K_S^0$ ratios with those measured by the STAR Collaboration in Au–Au collisions at $\sqrt{s_{NN}} = 200$ GeV, we notice that, in the case of most central events, the baryon/meson ratio at the LHC decreases less rapidly with $p_T$ than at RHIC (see Fig. 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 Fig. 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 Fig. 2 (left), the maximum value of the $\Lambda/K_S^0$ ratio increases with the beam energy.

The position in $p_T$ of the $\Lambda/K_S^0$ 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 the Fig. 2 (right).

5. Conclusions

We have presented the measurements of $\Lambda/K_S^0$ 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 $\Lambda/K^0_S$ ratio as a function of the transverse momentum shows a broad maximum around $p_T \sim 3\text{ GeV}/c$. The maximum value of the ratio increases with the collision centrality reaching the value of $\sim 1.5$ for the 0-5 % most central events.

As the collision centrality decreases, the maximum of the $\Lambda/K^0_S$ ratio becomes less pronounced and diminishes to a value of $\sim 0.6$. 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 $\Lambda/K^0_S$ 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 it was predicted, for example, in Ref. [4]. However, the baryon enhancement in central nucleus-nucleus collisions at the LHC decreases less rapidly with $p_T$ and, at $p_T \sim 6\text{ GeV}/c$, is a factor $\sim 2$ higher compared with that at RHIC.

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