HIGH p_{T} SUPPRESSION OF Λ AND K^0_{s} IN Pb–Pb COLLISIONS AT $\sqrt{s_{NN}} = 2.76$ TeV WITH ALICE*

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(Received January 16, 2012)

The nuclear modification factors R_{AA} and R_{CP} of Λ and K^0_{s} in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV measured by the ALICE experiment at the LHC are presented. In central collisions a strong suppression at high p_{T} ($p_{\mathrm{T}} \sim 8$ GeV/c) with respect to pp collisions is observed similar for Λ and K^0_{s}. The p_{T} region below is dominated by an enhancement of Λ over the suppressed K^0_{s}. The results are compared to those for charged particles and to Λ from lower collision energies.

DOI:10.5506/APhysPolBSupp.5.355
PACS numbers: 25.75.Bh, 25.75.Dw

1. Introduction

The comparison of transverse momentum spectra from AA collisions to those from pp collisions is of importance for understanding the parton energy loss in the medium created in heavy-ion collisions. Especially, high momentum hadrons are diagnostic means to probe the medium before freezeout via their energy loss due to in-medium interactions since they are expected to be only weakly affected by flow. The relative energy loss can be quantitatively expressed by so-called nuclear modification factors R_{AA} (Eq. (1a)) and R_{CP} (Eq. (1b)) [1]

$$R_{AA} = \frac{1}{\langle N_{\mathrm{bin}} \rangle} \frac{(dN/dp_{\mathrm{T}})_{AA}}{(dN/dp_{\mathrm{T}})_{pp}}\,, \tag{1a}$$

$$R_{\mathrm{CP}} = \frac{\left\langle N^{\mathrm{peripheral}}_{\mathrm{bin}} \right\rangle}{\left\langle N^{\mathrm{central}}_{\mathrm{bin}} \right\rangle} \frac{(dN/dp_{\mathrm{T}})^{AA}_{\mathrm{central}}}{(dN/dp_{\mathrm{T}})^{AA}_{\mathrm{peripheral}}}\,, \tag{1b}$$

with $\langle N_{\mathrm{bin}} \rangle$, number of binary nucleon–nucleon collisions in (central or peripheral) AA collisions.

* Presented at the Conference "Strangeness in Quark Matter 2011", Kraków, Poland, September 18–24, 2011.

In [2] the ALICE Collaboration reported a strong suppression of inclusive charged particles in central Pb–Pb collisions relative to pp at $\sqrt{s_{NN}} = 2.76$ TeV in the region $p_{\mathrm{T}} = 6$–8 GeV/c followed by a rise up to $p_{\mathrm{T}} = 50$ GeV/c. The modification of the spectra of identified particles and especially the comparison of baryons and mesons may allow to disentangle differences between the energy loss of quarks and gluons. A difference in the modification pattern of baryons and mesons due to enhanced baryon production at intermediate p_{T} ($p_{\mathrm{T}} = 2$–4 GeV/c) is commonly referred to as the baryon-to-meson anomaly. In this contribution, the Λ baryon and the K^0_{s} meson are studied in order to give a more detailed view of the parton energy loss at LHC energies.

2. Analysis

The Λ and K^0_{s} are reconstructed employing a topological secondary vertex finder using tracking information from the TPC (Time Projection Chamber) and the ITS (Inner Tracking System). For each p_{T} interval the yields are obtained by integrating over the invariant mass peak after the combinatorial background subtraction. The latter is based on a fit of the background with a polynomial of first and second order excluding the mass peak region. Systematic uncertainties related to the reconstruction efficiency cancel partially in the ratios R_{AA} and R_{CP}. The systematic errors given below are based on a conservative estimate of the uncertainty on the centrality dependence of the reconstruction efficiency. The p_{T} spectra of Λ are corrected for feed-down using a preliminary centrality and p_{T} dependent estimate of the contribution from Ξ. The uncertainty related to the centrality dependence of this estimate contributes mainly at low p_{T} and is included in the systematic errors of R_{AA} and R_{CP}. The following results are extracted from two centrality classes in Pb–Pb collisions (0–5%, 60–80%) at $\sqrt{s_{NN}} = 2.76$ TeV and from the corresponding pp reference data at $\sqrt{s} = 2.76$ TeV.

3. Results

The R_{CP} for Λ and K^0_{s} of central (0–5%) to peripheral (60–80%) Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV are shown in the left panel of Fig. 1. The results of K^0_{s} agree with the R_{CP} of charged kaons and of inclusive charged particles [2] for the whole p_{T} range. Two p_{T} domains can be distinguished for the Λ–R_{CP}: at high p_{T} ($p_{\mathrm{T}} > 8$ GeV/c) a common modification of Λ and K^0_{s} with charged particles is observed, while at lower the Λ–R_{CP} shows a clear enhancement over the K^0_{s}–R_{CP}, which seems to support the conjecture of a baryon-to-meson anomaly, as observed at RHIC (discussed in detail in [3]). In the right panel of Fig. 1 the ALICE results for Λ–R_{CP} are compared to that obtained by the STAR Collaboration for $\Lambda + \overline{\Lambda}$ at

$\sqrt{s_{NN}}$ = 200 GeV [4]. Within the uncertainties of the measurements, the results for R_{CP} are comparable. It should be mentioned though that the ALICE results indicate that the Λ–R_{CP} enhancement is extended towards higher p_{T}.

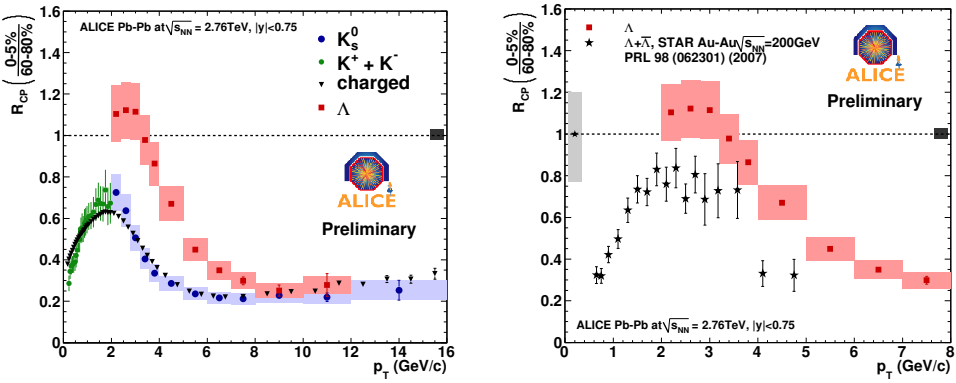

Fig. 1. The nuclear modification factor R_{CP} of Λ and K^0_{s} between central (0–5%) and peripheral (60–80%) Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. The boxes around the data points indicate the systematic error for K^0_{s} and Λ. The uncertainty due to the calculation of $\langle N_{\mathrm{bin}} \rangle$ is given by the gray boxes at the dotted line. Left panel: For the charged kaons (small filled circles) and the charged particles (filled triangles) only statistical errors are shown. Right panel: the comparison to the measurement for $\Lambda + \overline{\Lambda}$ in Au–Au collisions at $\sqrt{s_{NN}} = 200$ GeV measured by the STAR Collaboration [4]. The light gray box at unity indicates the error on $\langle N_{\mathrm{bin}} \rangle$ for the STAR measurements.

The modification of the Λ and K^0_{s} p_{T} spectra relative to pp at the same energy is shown in Fig. 2. In order to evaluate the modification, the results are presented together with the R_{AA} of charged particles [2]. The left panel shows R_{AA} for peripheral and the right panel for central collisions, respectively. As already seen in the measurement of R_{CP}, the suppression of K^0_{s} is comparable to that of charged particles for the whole p_{T} range, in peripheral as well as in central collisions. In contrast, the Λ are differently suppressed at lower and higher p_{T}: in particular only little nuclear modification, $R_{AA} \approx 1$, is observed for Λ at $p_{\mathrm{T}} = 2$–5 GeV/c which results in an enhancement of the Λ–R_{AA} over the K^0_{s}–R_{AA} as it is indicated by the R_{CP} results. However, at large p_{T}, modification is as strong as for the K^0_{s}–R_{AA} and hence as for that of charged particles.

Considering the R_{AA} of K^0_{s} in peripheral events (left panel of Fig. 2), it indicates a nearly constant and a rather moderate but significant suppression of $R_{AA} \approx 0.6$. Due to this moderate p_{T} dependence of both, the Λ and K^0_{s} nuclear modification factors for peripheral collisions, R_{AA} is ex-

pected to behave similarly to R_{CP} for central collisions, only being scaled by some factor. This can be seen in the right panel in Fig. 2, where the Λ– and K^0_{s}–R_{AA} for central events is depicted. A strong suppression at high p_{T} with respect to pp collisions is observed for both hadrons which again is similar to the suppression of charged particles. The observation of a compatible suppression of strange and non-strange hadrons can be interpreted as a flavour independent modification at high p_{T}. Corresponding results were obtained for D mesons supporting this interpretation [5].

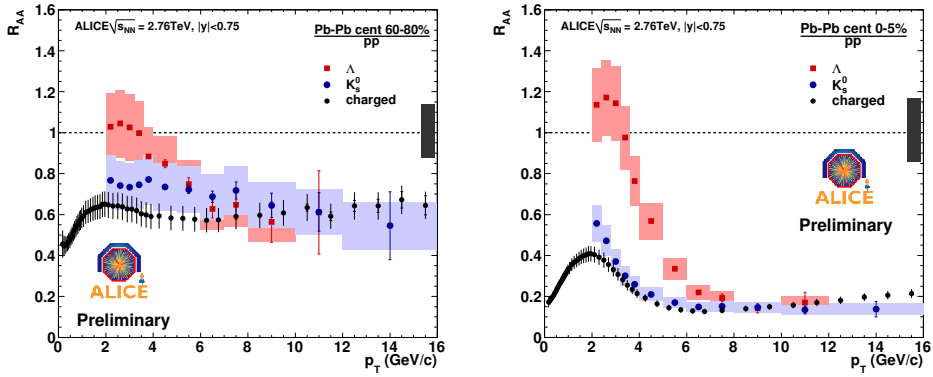

Fig. 2. The nuclear modification factor R_{AA} of K^0_{s} and Λ for peripheral (60–80%) Pb–Pb collisions (left panel) and for central (0–5%) Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV (right panel). Definition of errors as in Fig. 1. In both panels the charged hadron R_{AA} is shown in addition. Vertical error bars indicate the systematic uncertainties and the horizontal ticks show the statistical errors.

Figure 3 shows the comparison of Λ–R_{AA} to the measurements by the STAR Collaboration at $\sqrt{s_{NN}} = 200$ GeV for the mentioned centralities [6]. At LHC energies we observe a much smaller modification than at RHIC energies. Taking into account that the STAR Λ–R_{CP} is compatible to our measurement the significant difference between STAR and ALICE Λ–R_{AA} at $p_{\mathrm{T}} \approx 3$ GeV/c may be driven by the pp references rather than by nuclear effects. As the STAR results are limited to the intermediate p_{T} region, no statement on high p_{T} suppression of Λ and $K^0_{\mathrm{s}}$with respect to pp collisions from RHIC to LHC energies is possible yet.

Finally, in Fig. 4 the ALICE results for R_{AA} of Λ and K^0_{s} and charged pions in central collisions are compared to calculations from the HIJING/B$\overline{\mathrm{B}}$ v2.0 model [7]. In the case of mesons, the results are well described by the model up to $p_{\mathrm{T}} = 10$ GeV/c. However, for Λ–R_{AA} the calculations exceed the data at high p_{T} and the calculated maximum is at lower p_{T}. Hence, the common flavour and strangeness content independent high p_{T} suppression of Λ and K^0_{s}, as seen in the data, is not reproduced by the model.

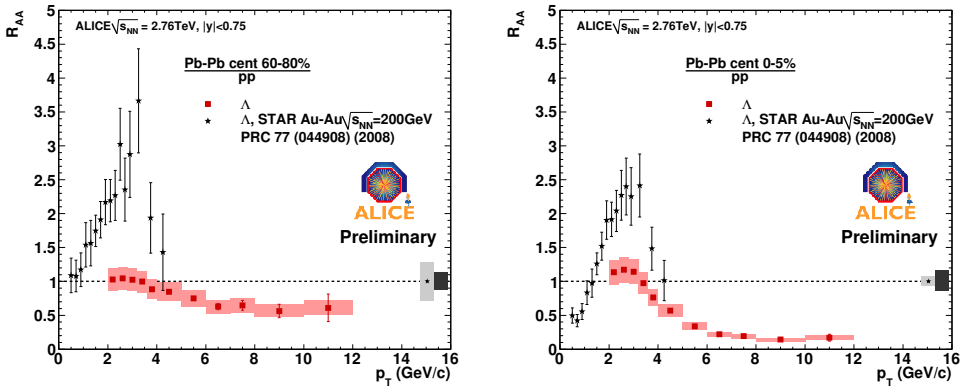

Fig. 3. The nuclear modification factor R_{AA} of Λ in comparison to the measurement for Au–Au collisions at $\sqrt{s_{NN}} = 200$ GeV by the STAR Collaboration [6]. The left panel shows the result for peripheral (60–80%) and the right panel R_{AA} for central (0–5%) collisions. Definition of errors as in Fig. 1.

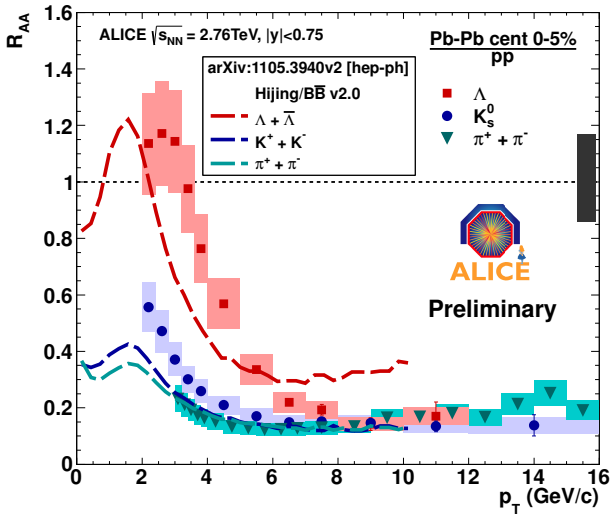

Fig. 4. The nuclear modification factor R_{AA} of Λ, K^0_{s} and charged pions for central (0–5%) Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV in comparison to HIJING/B$\overline{\mathrm{B}}$ v2.0 model calculations [7]. Definition of errors as in Fig. 1.

4. Summary

We have presented the measurements of the nuclear modification factors of Λ and K^0_{s} up to $p_{\mathrm{T}} = 16$ GeV/c in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. For both particle species a strong suppression at high p_{T} ($p_{\mathrm{T}} > 8$ GeV/c) in central collisions with respect to pp is observed. A similar suppression

at high p_{T} of both hadrons is found in the ratio of central-to-peripheral collisions, too. The nuclear modification of Λ and K^0_{s} is compatible with the modification of charged particles at high p_{T}. At lower p_{T} ($p_{\mathrm{T}} < 5$ GeV/c) we observe an enhancement of the Λ–R_{AA} with respect to the K^0_{s}–R_{AA}, which can be related to the baryon-to-meson anomaly. While the R_{CP} is similar at RHIC and LHC energies, we find significantly less Λ–R_{AA} enhancement relative to K^0_{s}–R_{AA} at intermediate p_{T} in central and peripheral events, as compared to the STAR results. Regarding the comparison to model calculations with the HIJING/B$\overline{\mathrm{B}}$ v2.0 model, we observe an agreement with our results for K^0_{s} and charged pion R_{AA}, whereas the R_{AA} of Λ is not described by the model.

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