Strangeness production associated to a high-p_{T} particle in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV with ALICE

Xitzel Sánchez Castro for the ALICE Collaboration

IPHC, Université de Strasbourg, CNRS-IN2P3, 23 rue du loess, BP28, 67037 Strasbourg cedex 2, FR

E-mail: xsanchez@cern.ch

Abstract.
Particle production in heavy-ion collisions at RHIC and the LHC reveals an enhancement of the baryon-to-meson ratios with respect to pp collisions. The observed suppression of high-p_{T} particles raises the question of how the jet fragments may (re)distribute in ultra-relativistic heavy-ion collisions. With two-hadron correlations, we can study the particle composition in jets in order to get a better understanding of the aforementioned observables and the particle production mechanisms in the dense medium. In these proceedings, we present the status of the current analysis using two-hadron angular correlations for Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV using the ALICE detector. We study the two different possibilities, considering the strange particle as either the trigger particle or the associated particle. Results on $\mathrm{K^0_S}$-$\mathrm{h^\pm}$, $(\Lambda+\overline{\Lambda})$-$\mathrm{h^\pm}$ and $\mathrm{h^\pm}$-$\mathrm{K^0_S}$ correlations are shown for central collisions.

1. Introduction

The main purpose of studying heavy-ion collisions at ultra-relativistic energies is to understand the phase transition of nuclear matter into a state of deconfined partons: the so called Quark-Gluon Plasma. At RHIC and LHC energies, a large enhancement of baryon-to-meson ratios is observed in the intermediate transverse momentum (p_{T}) range (from 2 to 6 GeV/c) of central collisions, as compared to peripheral and to pp collisions [1, 2, 3]. The recent ALICE results in Pb–Pb collisions show this phenomenon, with the measurement of $\Lambda/\mathrm{K^0_S}$ ratio for different collision centralities [1]. An interplay between parton coalescence and parton fragmentation is suggested to explain the baryon-to-meson enhancement at intermediate p_{T} [4, 5]. Other models that include hydrodynamical radial flow in their description intend also to explain the baryon enhancement [6].

Studies of two-particle correlations, using strange hadrons as associated particles, can help to understand better whether the baryon enhancement is an effect from the particles produced in the thermalized medium, or whether the fragmented hadrons from the hard scattering between partons are contributing as well [7]. This hypothesis can be verified by separating particles produced together with a high-p_{T} particle and from the bulk. Consequently, we can estimate the baryon-to-meson ratio associated to each hadronization mechanism and study their relative contribution according the transverse momentum range.

Additional information about the color-charge interaction of partons with the medium, via quark and gluon fragmentation, can be inferred on a statistical basis using the two-hadron angular correlation technique. Previous measurements have shown that gluon jets have a larger particle multiplicity with softer fragmented hadrons and are found to be broader than quark jets. It has also been shown that, compared with mesons, baryons are more likely to be produced in gluon jets [8].

In these proceedings we present the status of the ongoing analysis performed with strange particles using the two-particle correlation technique. The data used for the analysis were recorded for Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV during the 2011 run using the ALICE detector at the LHC.

2. The ALICE experiment

A detailed description of the ALICE experiment can be found in [9]. It consists of a forward muon detector and a number of central detectors which fully cover a pseudorapidity range of $|\eta| < 0.9$. The central detectors are embedded in a 0.5 T magnetic solenoid with the field parallel to the beam direction (z-axis). The Inner Tracking System (ITS) and the Time Projection Chamber (TPC) are the main detectors for track and vertex finding, covering an acceptance of $|\eta| < 0.9$. Using these two subsystems, we reconstruct neutral kaons and Λ exploiting the topology of the following weak decays: $\mathrm{K}^0_{\mathrm{S}} \rightarrow \pi^+\pi^-$, $\Lambda \rightarrow \mathrm{p}^+\pi^-$. The main advantage of working with these strange particles is that we can apply the same reconstruction technique for both $\mathrm{K}^0_{\mathrm{S}}$ (meson) and Λ (baryon) over a wide momentum range from 0.4 GeV/c (0.6 GeV/c for Λ) to 12 GeV/c. The events were collected using an interaction trigger based on the information coming from the VZERO scintillator counters. Only events with coincident signal recorded in the VZERO-C and VZERO-A detectors were accepted. The centrality of the collision is determined with the VZERO detector and the Zero Degree Calorimeters (ZDCs) [10].

3. Correlations with strange particles

Using the most central Pb–Pb collisions, two different cases are considered for the correlations, the strange particle is used as: (i) the trigger particle (ii) the associated particle in the event. We select a particle with a high p_{T} (trigger particle) and the associated particles within a given p_{T} interval, both taken from the same event. The associated particles must have a transverse momentum lower than the trigger one ($p_{\mathrm{T},Assoc} < p_{\mathrm{T},Trig}$). The correlation is measured as a function of the distance in the azimuthal direction ($\Delta\varphi = \varphi_{Trig} - \varphi_{Assoc}$) and in pseudorapidity ($\Delta\eta = \eta_{Trig} - \eta_{Assoc}$) between the two particles. The obtained two-dimensional distribution is normalized to the total number of trigger particles (N_{Trig}). The signal distribution $S(\Delta\varphi, \Delta\eta) = 1/N_{Trig}\, \mathrm{d}^2N_{same}/\mathrm{d}\Delta\varphi\, \mathrm{d}\Delta\eta$ is corrected for the detector acceptance using mixed-event correlations ($B(\Delta\varphi, \Delta\eta) = \alpha\, \mathrm{d}^2N_{mixed}/\mathrm{d}\Delta\varphi\, \mathrm{d}\Delta\eta$). The mixed events are constructed by correlating a trigger particle in one event with associated particles in another event, with the condition that both events have similar z-vertex positions within the 2-cm-wide and a 5% centrality interval. The mixed-event distributions are scaled by a factor α that is chosen in such a way that $B(\Delta\varphi, \Delta\eta)$ is equal to unity in $\Delta\varphi \approx 0$ and $\Delta\eta \approx 0$.

The acceptance-corrected distribution is

$$\frac{1}{N_{Trig}} \frac{\mathrm{d}^2N_{Assoc}}{\mathrm{d}\Delta\varphi\, \mathrm{d}\Delta\eta} = \frac{S(\Delta\varphi, \Delta\eta)}{B(\Delta\varphi, \Delta\eta)}. \tag{1}$$

Further corrections, such as single track efficiency, contamination from decays of secondary particles and track merging/splitting, still need to be applied.

Figure 1 shows the acceptance-corrected distributions (illustrated in the range $|\Delta\eta| < 1.5$) with $\mathrm{K}^0_{\mathrm{S}}$ and Λ (or $\overline{\Lambda}$) for trigger particles selected in the range $6 < p_{\mathrm{T}} <$15 GeV/c in the

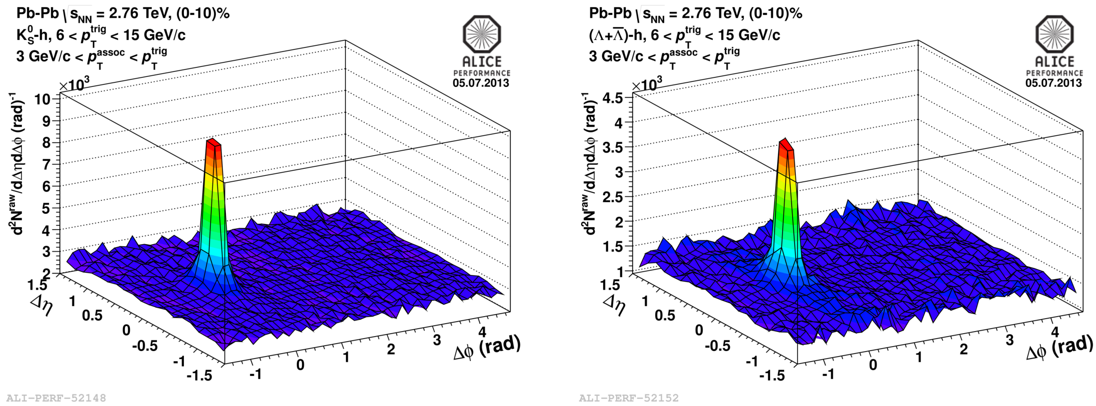

Figure 1. $\mathrm{K^0_S}$-$\mathrm{h^\pm}$ correlations (left plot) and $(\Lambda+\overline{\Lambda})$-$\mathrm{h^\pm}$ correlations (right plot) in the 0-10% centrality interval. The distributions are acceptance-corrected only.

0-10% centrality interval. The $\mathrm{K^0_S}$ and Λ candidates are selected in the invariant mass range $0.48 < m_{\pi^+\pi^-} < 0.52$ GeV/c^2 and $1.108 < m_{\mathrm{p}^+\pi^-} < 1.125$ GeV/c^2, respectively. Primary charged particles are selected as associated particles in the range 3 GeV/c $< p_{\mathrm{T},Assoc} < p_{\mathrm{T},Trig}$. The total number of analyzed events is about 30×10^6.

Further extraction of the signal is done by the method commonly known as η-gap [11], which assumes that the contribution from elliptic flow is $\Delta\eta$-independent. The bulk production is estimated in the range $1.0 < |\Delta\eta| < 1.8$, where no contribution from jets is expected, and it is subtracted from the near-side correlation in the acceptance range $|\Delta\eta| < 0.8$ to isolate the jet-like correlations.

At low p_{T}, the combinatorial background in the invariant mass distribution of $\mathrm{K^0_S}$ and Λ is significant, and therefore the correlation analysis requires special attention to remove the background. In Figure 2 we present an example of the $\mathrm{h^\pm} - \mathrm{K^0_S}$ angular correlations for events selected in 0-5% interval of the collision centrality and within $|\Delta\eta| < 1$. Distributions are neither corrected for the acceptance nor for the reconstruction efficiency yet. The trigger particles are unidentified charged particles in the range $5 < p_{\mathrm{T},Trig} < 10$ GeV/c. Neutral kaon

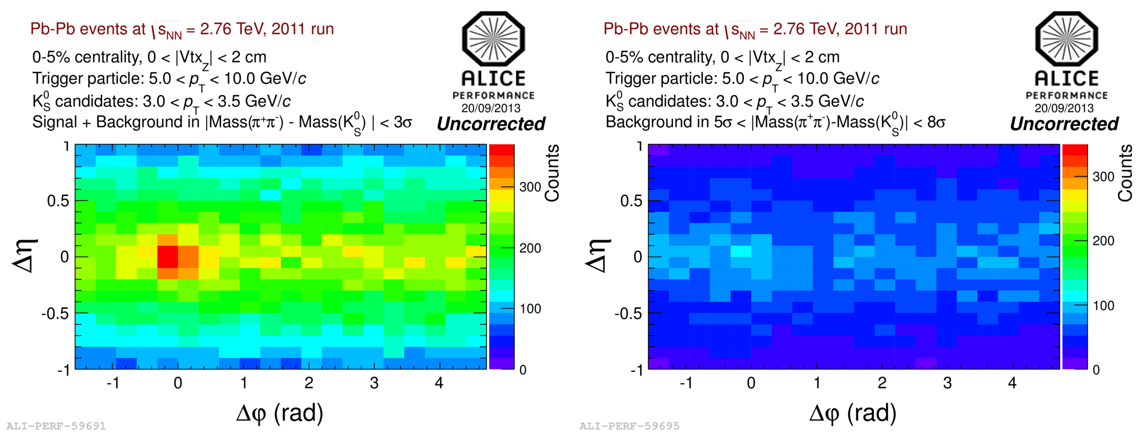

Figure 2. Correlations of $\mathrm{K^0_S}$ candidates with a charged trigger particle ($\mathrm{h^\pm}$-$\mathrm{K^0_S}$). Distributions are obtained by selecting the invariant mass region of the $\mathrm{K^0_S}$ candidates: $|m_{\pi^+\pi^-} - m_{\mathrm{K^0_S}}| < 3\sigma$ (left plot signal) and $5\sigma < |m_{\pi^+\pi^-} - m_{\mathrm{K^0_S}}| < 8\sigma$ (right plot background).

candidates ($3.0 < p_{\mathrm{T},Assoc} < 3.5$ GeV/c) are selected in two different invariant mass region: $|m_{\pi^+\pi^-} - m_{\mathrm{K^0_S}}| < 3\sigma$ (signal region) and $5\sigma < |m_{\pi^+\pi^-} - m_{\mathrm{K^0_S}}| < 8\sigma$ (background region). It is noticeable that candidates in the background region present a correlation with the trigger particle. This feature makes the analysis challenging. A similar structure is observed for the case when the Λ baryon is used as the associated particle. Studies to obtain the ratio of the Λ and $\mathrm{K^0_S}$ yields associated to jets and from the bulk sample in the near-side region are ongoing, for the $p_{\mathrm{T},Assoc}$ interval 2-7 GeV/c and for more peripheral collisions. The origin of the baryon-to-meson enhancement could be understood by comparing the $\Lambda/\mathrm{K^0_S}$ in the bulk and in the jet with the inclusive analysis.

4. Summary

We have presented the current status of two-particle correlations using strange hadrons as trigger particles ($\mathrm{K^0_S}, \Lambda$) and as associated particles ($\mathrm{K^0_S}$) in central Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV. These studies with identified hadrons may help to understand (i) the interaction of quark- and gluon-induced jets with the medium (using an identified hadron, $\mathrm{K^0_S}$ or Λ, as a trigger particle) and (ii) the origin of the baryon-to-meson enhancement at intermediate p_{T} by separating the contribution of the particles produced in the jet region and in the bulk region. The large sample of Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV collected with the ALICE detector during the 2011 run at the LHC allows for both measurements in the near future.

References

[1] B. B. Abelev *et al.* [ALICE Collaboration] 2013 *Phys. Rev. Lett.* **111** 222301 [arXiv:1307.5530 [nucl-ex]]
[2] K. Adcox *et al.* [PHENIX Collaboration] 2004 *Phys. Rev.* C **69** 024904 [arXiv:0307010 [nucl-ex]]
[3] B. I. Abelev *et al.* [STAR Collaboration] 2006 *Phys. Rev. Lett.* **97** 152301 [arXiv:0606003 [nucl-ex]]
[4] R. J. Fries, V. Greco and P. Sorensen 2008 *Ann. Rev. Nucl. Part. Sci.* **58** 177 [arXiv:0807.4939 [nucl-th]]
[5] R. C. Hwa and C. B. Yang 2004 *Phys. Rev.* C **70** 024905 [arXiv:0401001 [nucl-th]]
[6] B. Abelev *et al.* [ALICE Collaboration] 2012 *Phys. Rev. Lett.* **109**, 252301 [arXiv:1208.1974 [hep-ex]]
[7] J. -X. Zuo [for the STAR Collaboration] 2008 *J. Phys.* G **35** 044027 [arXiv:0710.4203 [nucl-ex]]
[8] K. Ackerstaff *et al.* [OPAL Collaboration] 1999 *Eur. Phys. J.* C **8** 241 [arXiv:9805025 [hep-ex]]
[9] K. Aamodt *et al.* [ALICE Collaboration] 2008 *JINST* **3** S08002
[10] B. Abelev *et al.* [ALICE Collaboration] 2013 *Phys. Rev.* C **88** 044909 [arXiv:1301.4361 [nucl-ex]]
[11] A. Morsch [arXiv:1207.7187 [nucl-ex]]