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Particle-yield modification in jet-like azimuthal V^0–hadron correlations in Pb–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV with ALICE at the LHC

Anaam Mustafa[a,*]

[a] *Institute of Particle Physics,Central China Normal University 430079, Wuhan, China*

E-mail: mustafa.naji.anaam@cern.ch

The measurement of azimuthal correlations between two particles is a powerful tool to investigate the properties of strongly-interacting nuclear matter created in ultra-relativistic heavy-ion collisions. In particular, studying the near-side and away-side hadron yields associated with trigger particles can provide important information to understand both the jet-medium interaction and hadron production mechanism. We study two-particle correlations with $V^0(K^0_S, \Lambda/\overline{\Lambda})$ and charge hadrons as trigger particles of transverse momentum $8 < p_{T,trig} < 16$ GeV/c, and associated charged particles of $1 < p_{T,assoc} < 10$ GeV/c at mid-rapidity in pp and Pb–Pb collisions at a center-of-mass energy of 5.02 TeV per nucleon pair. After subtracting the contributions of the flow background v_2 and v_3, the per-trigger yields are extracted for two-particle azimuthal differences $|\Delta\varphi| < 0.9$ on the near-side and $|\Delta\varphi - \pi| < 1.2$ on the away-side. The ratio of the per-trigger yields in Pb–Pb collisions with respect to pp collisions, I_{AA}, is measured in the near-side and away-side in the most central 0–10% collisions. On the away-side, the per-trigger yields in Pb–Pb are strongly suppressed to the level of $I_{AA} \approx 0.6$ for $p_{T,assoc} > 3$ GeV/c as expected from strong in-medium energy loss, while with decreasing momenta an enhancement develops reaching to $I_{AA} = 2.5$ at low $p_{T,assoc}$. On the near side, an enhancement of per-trigger yields in Pb–Pb to the level of $I_{AA} = 2$ is observed. These results are compared to the published results obtained via π^0-h and h-h correlations in Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV and they are in good agreement.

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1. Introduction

Ultra-relativistic heavy-ion collisions produce the quark–gluon plasma (QGP), the deconfined state of quarks and gluons. One of the most remarkable signatures of QGP formation turned out to be "jet quenching", the phenomenon where high transverse momentum p_T partons suffer from energy loss by medium-induced gluon radiation and collisions with medium constituents [3–5]. The observables presented in this article to assess jet modification are the nuclear modification factors I_{AA} defined as the ratios of the integrated jet-like charged hadron yields in Pb–Pb over those in pp collisions.

$$I_{AA} = \int_X J_{\text{Pb–Pb}}(\Delta\varphi)\mathrm{d}\Delta\varphi / \int_X J_{\text{pp}}(\Delta\varphi)\mathrm{d}\Delta\varphi, \tag{1}$$

where $J_{\text{Pb–Pb}}$ and J_{pp} are the jet-like charged hadron yields in Pb–Pb and pp, respectively, and X denotes either the near-side (NS) or the away-side (AS) region. The per-trigger yield modification factor, I_{AA}, has been measured for the near- and away-side in 0–10% most central Pb–Pb collisions at a center-of-mass energy of 5.02 TeV per nucleon pair of unidentified charged hadron with $1 < p_{T,\text{assoc}} < 10$ GeV/c associated with three trigger-particle species (K^0_S, $\Lambda/\overline{\Lambda}$, and charged hadron) with transverse momentum $8 < p_{T,\text{trig}} < 16$ GeV/c.

2. Experimental setup and datasets

The ALICE detector is described in details in [2]. The detectors used for the present analysis are the Inner Tracking System (ITS) and the Time Projection Chamber (TPC) which are employed for vertex finding, tracking, and particle identification. The collision centrality is determined with the forward scintillators (V0). In this analysis 64×10^6 minimum-bias Pb–Pb events at $\sqrt{s_{NN}}$ = 5.02 TeV as well as around 1×10^9 pp events at $\sqrt{s}$ = 5.02 TeV are used. Events with a reconstructed vertex position within 7 cm and 10 cm from the nominal interaction point along the beam line in Pb–Pb and pp collisions, respectively, are accepted. Charged hadrons (denoted as h) are reconstructed in the pseudorapidity range $|\eta| < 0.8$, the K^0_S mesons and $\Lambda(\overline{\Lambda})$ baryons (V^0 particles) are reconstructed via their most probable decay channels and by exploiting their characteristic V^0 decay topologies [6].

3. Data analysis

Angular correlations between V^0 (K^0_S, $\Lambda/\overline{\Lambda}$), and charged hadron as trigger particles with transverse momentum $8 < p_{T,\text{trig}} < 16$ GeV/c and unidentified charged hadron as associated particles with $1 < p_{T,\text{assoc}} < 10$ GeV/c are measured by the ALICE experiment. The correlation function is defined as a function of the azimuthal angle difference $\Delta\varphi = \varphi_{\text{trig}} - \varphi_{\text{assoc}}$ and pseudorapidity difference $\Delta\eta = \eta_{\text{trig}} - \eta_{\text{assoc}}$ between trigger and associated particles by

$$C(\Delta\varphi, \Delta\eta) = \frac{1}{N_{\text{trig}}} \frac{d^2 N_{\text{assoc}}}{d\Delta\varphi d\Delta\eta}, \tag{2}$$

where N_{trig} is the number of trigger particles and N_{assoc} is the number of associated particles [1, 3]. Pair acceptance corrections have been evaluated with a mixed-event technique, where

$(\Delta\varphi, \Delta\eta)$ distributions with the trigger and the associated particles originated from different events are constructed. In addition, the correlation function has been corrected for the reconstruction efficiency of primary charged particles and V^0 as well as for the contamination from secondary particles. For the measurement of I_{AA}, the yield of associated particles per trigger particles as a function of the azimuthal angle difference $\Delta\varphi$ is given by

$$C(\Delta\varphi) = \frac{1}{N_{\text{trig}}} \frac{dN_{\text{assoc}}}{d\Delta\varphi}. \tag{3}$$

Since the flow contributions to the background are not negligible in Pb–Pb collisions, the background contributions to the yield extraction in Pb–Pb are estimated by

$$B(\Delta\varphi) = B_0 \left(1 + 2\sum_n v_n^{\text{trig}} v_n^{\text{assoc}} \cos(n\Delta\varphi)\right), \tag{4}$$

where v_n^{trig} and v_n^{assoc} are the flow of trigger and associated particles, respectively, and n is the harmonic number (n=2, 3). The constant B_0 is determined by zero yield at minimum (ZYAM) assumption. Finally, the jet-like correlations can be obtained by

$$J(\Delta\varphi) = C(\Delta\varphi) - B(\Delta\varphi). \tag{5}$$

4. Results and discussion

The correlation function $C(\Delta\varphi)$ for the three different trigger particles (K^0_S, $\Lambda/\overline{\Lambda}$, h) of $8 < p_{\text{T,trig}} < 16$ GeV/c, and associated charged particles of $2 < p_{\text{T,assoc}} < 3$ GeV/c together with the background estimated according to Eq. 4 in Pb–Pb collisions and the baseline in pp collisions are shown in Figure 1.

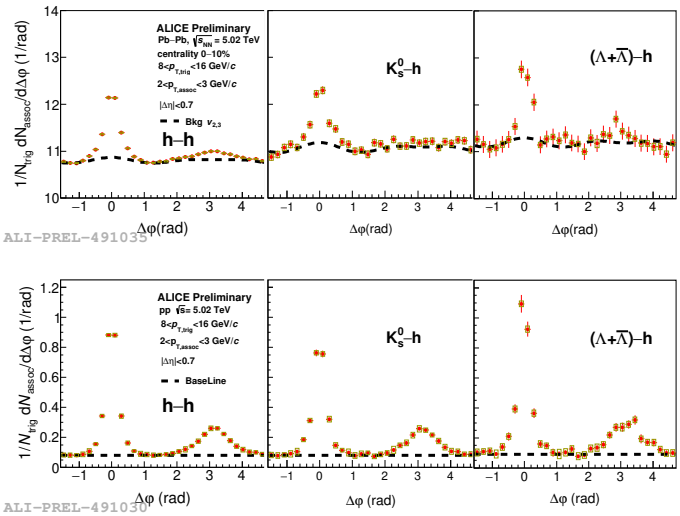

Figure 1: $C(\Delta\varphi)$ for the three different trigger with $2 < p_{\text{T,assoc}} < 3$ GeV/c and background estimated according to Eq. 4 in the 0–10% most central Pb–Pb collisions (top panels) and baseline in pp collisions (bottom panels).

The I_{AA} of h-h, K^0_S-h, and $(\Lambda+\overline{\Lambda})$-h are shown in upper plots of Figure. 2. The results indicate strong suppression of per-trigger yields in Pb–Pb in $p_{T,assoc} > 3$ GeV/c on the away side and moderated enhancement in $p_{T,assoc} < 3$ GeV/c for both near-side and away-side, bottom plots show the comparison of I_{AA} to the published results obtained via π^0-h and h-h correlations in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV. A good agreement is found between various measurements [3, 4].

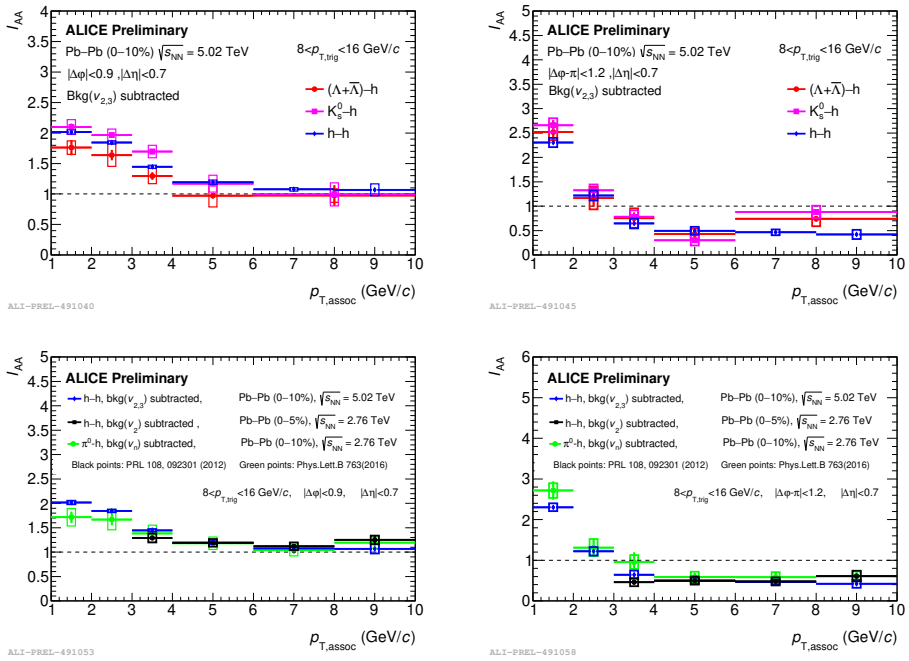

Figure 2: (upper panels)show I_{AA} of K^0_S-h (magenta points), $(\Lambda+\overline{\Lambda})$-h (red points), and h-h (blue points), for the near-side (left) and away-side (right), (bottom panels) show the comparison of I_{AA} with published result of h-h (black points)and π^0-h (green points) [3, 4].

5. Summary

Two-particle correlations with V^0 and charged hadron of transverse momenta $8 < p_{T,trig} < 16$ GeV/c as trigger particles and charged hadrons of $1 < p_{T,assoc} < 10$ GeV/c as associated particles versus azimuthal angle difference $\Delta\varphi$ at midrapidity in pp and central Pb–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV has been measured. The per-trigger yields have been extracted for $|\Delta\varphi| < 0.9$ on the near-side and $|\Delta\varphi - \pi| < 1.2$ on the away-side. The ratio of the per-trigger yields in Pb–Pb collisions with respect to pp collisions, I_{AA}, is measured in the near-side and away-side. On away-side, the yield of associated charged hadron in Pb–Pb drops to about 60% of that observed in pp collisions for $p_{T,assoc} > 3$ GeV/c, while a moderate enhancement increasing with decreasing momenta reaches to I_{AA} = 2.5 at lowest $p_{T,assoc}$. On the near-side, an enhancement to I_{AA} = 2 has been observed at lowest $p_{T,assoc}$. The data has been compared with published results at $\sqrt{s_{NN}}$ = 2.76 TeV and they are in good agreement.

Acknowledgments

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