Very High-$p_T$ Triggered Dihadron Correlations in PbPb Collisions at 2.76 TeV with CMS

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Abstract

Measurements of dihadron correlations triggered by very high-$p_T$ particles in 2.76 TeV PbPb collisions are presented. The analysis explores the full 2011 PbPb data set corresponding to an integrated luminosity of 150 $\mu$b$^{-1}$ collected by CMS. Long-range correlations driven by single-particle azimuthal anisotropies (characterized by the Fourier harmonics, $v_n$) are measured up to $p_T \sim 50$ GeV/c. After subtracting the $v_2-v_4$ harmonic components, the associated particle yields on the near and away side of the residual jet-like dihadron correlations are studied over a wide kinematic range in trigger and associated particle $p_T$, as a function of collision centrality. By comparing to pp data at the same energy, a suppression of about 50% in the away-side associated yield is observed for $p_{T,\text{assoc}} > 3$ GeV/c. The yield is found to be significantly enhanced up to a factor of 3–4 on the away side at $p_{T,\text{assoc}} \sim 0.5$ GeV/c. A moderate enhancement is suggested on the near side.

1. Introduction

One of the key signatures of the QGP is its opaqueness to high-energy quarks and gluons, known as jet quenching. This effect can be measured using dihadron correlations by comparing the integrated-yields in PbPb to pp collision for the near and away-side regions. In order to isolate jet-like correlations the contributions from flow and anisotropies in the interaction region must be subtracted. The amount of suppression observed can be quantified by the $I_{AA}$ modification factor, which is the ratio of the integrated associated yields in PbPb to that in pp collisions as a function of $p_{T,\text{trig}}^{\text{assoc}}$ and $p_{T,\text{assoc}}^{\text{assoc}}$, as in Ref. [1]. These measurements provide important constraints on energy-loss models in a QGP medium.

2. Dihadron Correlations and Integrated Yields

Per-trigger-particle associated yield distributions are constructed using the standard procedure by dividing the signal distribution by the background distribution, which is described in more detail in Refs. [2, 3]. These measurement were done with the CMS experiment, details about the detector can be found here [4]. An example of a dihadron correlation distribution is shown in Fig. 1. The left plot, subfigure (a), shows the 2-D correlation as a function of $\Delta\eta$ and $\Delta\phi$. 

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1A list of members of the CMS Collaboration and acknowledgements can be found at the end of this issue.

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Δφ while the right plot, subfigure (b), shows the 1-D distribution projected onto the Δφ-axis. In order to isolate the jet-like correlations the bulk correlations coming from hydrodynamic flow and geometric anisotropies due to fluctuations in the initial nuclear interaction region need to be removed. This is done by subtracting a flow modulated background term which is characterized by the azimuthal anisotropy parameters, $v_2 - v_4$, which were measured in a separate analysis using the event plane method [5]. The subtraction procedure is done using the Zero Yield at Minimum (ZYAM) procedure and is described in more detail in Ref. [3]. Once the jet-like correlations have been isolated the 1-D distributions are then integrated over two distinct Δφ ranges to obtain the integrated yields. The range of integration to obtain yields is split up into the ”near-side” integrated yields ($0 < |Δφ| < 1$) and the ”away-side” integrated yields ($1 < |Δφ| < π$). The integrated yields are then used to calculate the near and away-side I$_{AA}$ modification factor, which is the ratio of the integrated yields in PbPb collisions to that in pp collisions.

![Figure 1: The per-trigger-particle associated yield of charged particles in (a) two-dimensions (2-D) as a function of $|Δη|$ and $|Δφ|$ and (b) one-dimension (1-D) as a function of Δφ averaged over $0 < Δη < 1$ for $p_T^{\text{trig}} > 20$ GeV/c and $1 < p_T^{\text{assoc}} < 3$ GeV/c from the 0-30% centrality range of PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. The near-side peak in (a) is truncated to better display the surrounding structure.](image_url)

3. Results

Away-side I$_{AA}$ as a function of $p_T^{\text{assoc}}$ is shown in Fig. 2 with $|Δη| < 1$ in four different $p_T^{\text{trig}}$ bins. The red points on the top row are for the 0–10% most central collisions while the blue points on the bottom row are for the 50–60% central collisions. The near-side I$_{AA}$ values are shown as a function of $N_{\text{part}}$ in Fig. 3 for four different $p_T^{\text{assoc}}$ bins with $19.2 < p_T^{\text{trig}} < 24$ GeV/c. The blue points show the results derived from the $v_n$-subtraction method at $0 < |Δη| < 1$ while the black points show the results derived from a different technique, the long-range Δη subtraction method, which is described in more detail in Ref. [3]. The away-side I$_{AA}$ values are shown as a function of $N_{\text{part}}$ in Fig. 4 for four different $p_T^{\text{assoc}}$ bins with $19.2 < p_T^{\text{trig}} < 24$ GeV/c and $0 < |Δη| < 1$. 


Figure 2: Away-side $I_{AA}$ values derived from the $v_n$-subtraction method at $|\Delta \eta| < 1$ shown for four different $p_T^{\text{trig}}$ ranges as a function of $p_T^{\text{assoc}}$ for PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV, the top for 0–10% centrality and bottom row for 50–60% centrality. The error bars represent statistical uncertainties while the brackets represent the systematic uncertainties.

Figure 3: Near-side $I_{AA}$ shown for four different $p_T^{\text{assoc}}$ ranges as a function of $N_{\text{part}}$ for $19.2 < p_T^{\text{trig}} < 24$ GeV/c in PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. The solid blue circles show the results derived from the $v_n$-subtraction method at $|\Delta \eta| < 1$, while the black squares show the results derived from the long-range $\Delta \eta$ subtraction method. The error bars represent statistical uncertainties while the brackets represent the systematic uncertainties.
4. Discussion and Summary

The near and away-side $I_{AA}$ values in $\sqrt{s_{NN}} = 2.76$ TeV PbPb collisions as a function of $p_T^{\text{trig}}$ and $p_T^{\text{assoc}}$ for different centrality ranges were measured. Long-range, hydrodynamic flow-like behavior is accounted for by a separate measurement of harmonic $v_n$ coefficients using the event-plane method. The away-side $I_{AA}$ for 0-10% central PbPb collisions shows a large enhancement of about factor of 3–4 at low $p_T^{\text{assoc}}$ and a suppression of about 50% at high $p_T^{\text{assoc}}$ for all $p_T^{\text{trig}}$ ranges studied in the analysis. This suggests that the energy loss of the high-$p_T$ partons in the medium is converted into low $p_T$ particles, particularly below $p_T = 2$ GeV/c. For intermediate and higher $p_T^{\text{assoc}}$ particles, the near-side $I_{AA}$ results suggest a significantly smaller difference between the pp and PbPb collision, which is consistent with small energy loss of the higher-$p_T$ particle predominantly coming from the surface of the medium. A moderate enhancement of about a factor of 2 is seen for lower $p_T^{\text{assoc}}$ in the near-side associated particle yield for the most central collisions. These measurements can be used to investigate the effects of parton energy loss mechanisms in the QGP medium.

References

[3] The CMS Collaboration, "Very high-$p_T$ dihadron correlations in PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV", CMS-PAS-HIN-12-010