Charge Correlation in Near Side Hadron-Hadron Jets at $\sqrt{s_{NN}} = 200$ GeV in PHENIX

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Abstract. We analyze the relative azimuthal ($\Delta \phi$) distribution of same-charge and opposite-charge particle pairs. We then remove elliptic flow background using the ZYAM method. Comparisons between near angle $\Delta \phi$ peak widths are presented for various centralities.

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1. Introduction

In high energy heavy ion collisions at RHIC, the dihadron correlation function is known to be strongly modified by the medium. These modifications are reflected in changes in the $p_T$ spectrum, flavor composition, shape and yield of the jet. It has been shown$^\text{(1)}$ that there is a charge-asymmetry within jets that favors oppositely charged particle pairs. By splitting the correlation function by charge-pair, we can better study both the jet signal and detector effects.

2. Two Particle Azimuthal Correlation

2.1. The Correlation Function

This analysis is based on 1 billion $Au - Au$ events from the PHENIX run 4 dataset at $\sqrt{s_{NN}} = 200$ GeV. We construct the correlation function ($C(\Delta \phi)$) using trigger particles between 2.5-4 GeV/c, correlated with associated particles with momentum between 2-3 GeV/c. The correlation function is represented by the following formula:

$$C(\Delta \phi) = J(\Delta \phi) + \xi(1 + 2v_{2,\text{trig}}v_{2,\text{assoc}}\cos(2\Delta \phi))$$  (1)
where $J(\Delta \phi)$ is the jet signal and $v_{2,\text{trig}}$ and $v_{2,\text{assoc}}$ are the elliptic flow for the trigger and associated particles, respectively. $\xi$ is the normalization factor. Fig. 1 shows the correlation function of same-sign and opposite-sign pairs for three centrality bins.

![Fig. 1. The $\Delta \phi$ correlation functions for various centralities.](image)

On the near side, the magnitude of the same-charge pair distribution is consistently smaller than the opposite-pair distribution. The two distributions show differences that persist until around ±1.2 rad. The away-side distributions agree with each other because the trigger particles and the associated particles come from different jets, and have no intrinsic charge correlation.

### 2.2. The Charge-Pair Dependence of the Jet Shape

We then subtract the elliptic flow background from the correlation function using the “Zero Yield at Minimum” (ZYAM) method\(^2\) ($J(\Delta \phi_{\text{zyam}}) = 0$). Figure 2 shows the results. The systematic errors shown are dominated by uncertainties in $v_2$, which are correlated between same-sign and opposite-sign pairs. Note that the points on the away-side are no longer directly on top of each other. This is because even at the minimum, the jet still produces some yield. This overestimation of the elliptic flow background results in more over-subtraction in the opposite-sign pairs (where the jet signal is greater) than in the same-sign pairs.

The rest of this discussion focuses on the near-side jet shape. In figure 3 we present the near side jet width for the same-charge, opposite-charge and min bias pairs, obtained by fitting a gaussian function over ±1.2 radians. The stability of the fit is evaluated by varying the fit range from ±0.7 radians to ±1.5 radians and by fitting the entire distribution to a triple gaussian formula (the two additional gaussians are used to describe the split in the away-side distribution\(^3\)). The systematic error shown is the maximum/minimum width obtained. The width of the same-charge, opposite-charge, and min-bias pairs agree with each other within errors. This demonstrates that the errors inherent in the ZYAM assumption (that
$J(\phi_{zyam}) = 0$ do not significantly change the shape of the near-side jet.

There are a number of possible causes for the broadening of the jet in most central collisions. It could be that the jet is broadened as it traverses the medium. The more medium to traverse, the greater the broadening. It is also possible that this broadening is related to the decrease of per-trigger baryon yields vs. meson yields in central collisions[4]. We know that at higher centrality, more baryons are produced, so this could just be an effect of the jet composition and not of the medium.

We can subtract the two distributions in Fig. 1 without changing the width of the near side distribution. The $v_2$ term and the away-side jet are not dependent on charge sign, so they will be subtracted out. The only part that will remain is the near-side jet difference.

$$\Delta J(\Delta \phi) = C_{opp}(\Delta \phi) - C_{same}(\Delta \phi) = J_{opp}(\Delta \phi) - J_{same}(\Delta \phi)$$  \hspace{1cm} (2)
This jet difference is fitted to a single gaussian centered at zero over a range of \( \pm 1.5 \) radians. Systematic errors on the width of the near side jet are generated by varying the fit range between \( \pm 1 \) and \( \pm 3 \) radians. The resulting jet width for different centrality bins is presented in Fig 4. The distribution once again shows a decrease in the jet width in more central collisions, consistent with Fig 3.

3. Summary

Analysis of the same-charge and opposite-charge two particle azimuthal correlations are very interesting because both \( v_2 \) and the away-side jet are both charge independent. The opposite-charge correlation function shows a larger jet signal than the same-charge correlation function, relative to the elliptic flow background. We show that the jet width broadens in the most central collisions for both the opposite-charge and same-charge pair distributions.

References

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