

Measuring away-side jet modifications in Au+Au collisions at RHIC

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Abstract. We report measurements of jet correlations in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV by the STAR experiment. In this analysis we devise a novel method to subtract flow background using data itself. The correlation width is studied as a function of centrality and associated particle p_T . The width is found to increase with centrality at modest to high associated particle p_T . The increase can arise from jet modification by medium and/or event averaging of away-side jets deflected by medium flow. The discrimination of the physics mechanisms requires further study by three-particle correlations.

1. Introduction

Jets are quenched in relativistic heavy ion collisions due to interactions in the dense medium [1, 2]. Jet-quenching can be measured via jet-like dihadron correlations. Measurements of jet medium modifications have so far been obscured because of the large underlying anisotropic flow background. The background subtraction was usually done by the ZYAM (zero yield at minimum) method [3] in the previous azimuthal di-hadron correlation measurements [2, 4]. Those measurements are usually coming with large uncertainties.

In this analysis, we attempt to subtract the flow background using the data itself. Fig. 1 shows a cartoon of the methodology. Di-hadron correlations are analyzed in two η regions symmetric about midrapidity, one (close-region) close to and the other (far-region) far away from the P_x (Eq. 1) cut η window. The away-side jet contributes to the close-region but not as much to the far-region due to the large $\Delta\eta$ gap. The correlation difference measures the away-side jet shape where the anisotropic flow background is cleanly subtracted.

2. Event and track selections

This analysis uses 4.3×10^8 minimum-bias-triggered (MB) Au+Au events at the nucleon-nucleon center-of-mass energy of $\sqrt{s_{NN}} = 200$ GeV taken by the STAR experiment in 2011. The minimum bias trigger condition is defined as a coincidence signal between the east and west vertex position detectors (VPD) [5] located at $4.4 < |\eta| < 4.9$. The main detector used for this analysis is the Time Projection Chamber (TPC) [6]. Particle tracks are reconstructed in the TPC. The events are required to have the reconstructed primary vertex within 30 cm of the TPC center along the beam direction. To remove secondary tracks from particle decays, only tracks that extrapolate to within 2 cm of the primary vertex are used. Tracks are required to be reconstructed with



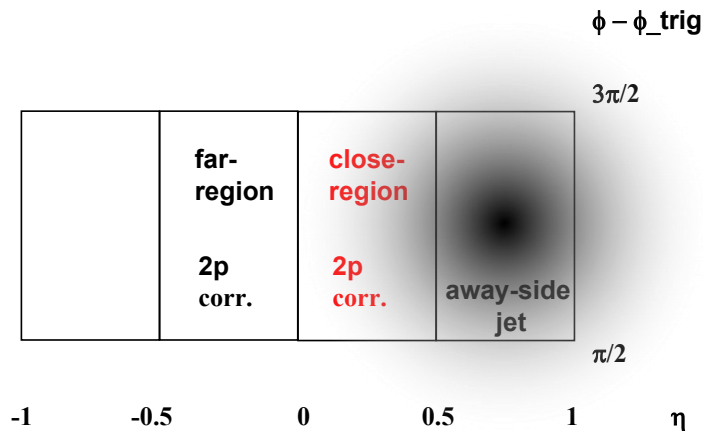


Figure 1. Cartoon of the methodology. We select events with a large recoil P_x (Eq. 1) from a high- p_T trigger particle within a given η window (in the cartoon, $0.5 < \eta < 1$) to enhance the away-side jet population. Di-hadron correlations are analyzed in two η ranges symmetric about midrapidity, one ($0 < \eta < 0.5$) close to and the other ($-0.5 < \eta < 0$) far away from the P_x cut η window. Anisotropic flow background are the same in close-region and far-region.

at least 20 out of a maximum of 45 hits in the TPC. The ratio of the number of hits used in track reconstruction to the number of possible hits is required to be greater than 0.51 to eliminate multiple track segments being reconstructed from a single particle trajectory. The track pseudo-rapidity cut is $|\eta| < 1$ in the TPC.

3. Data analysis

We select events with a large recoil P_x from a high- p_T trigger particle within a given η window to enhance the away-side jet population. P_x is defined as

$$P_x|_{\eta_1 \leq \eta \leq \eta_2} = \sum_{\cos(\phi - \phi_{trig}) < 0} p_T \cdot \cos(\phi - \phi_{trig}) / \epsilon. \quad (1)$$

Only away-side particles are included in the P_x calculation so that the η distribution of the trigger particle is unbiased by this selection. Single-particle acceptance and detection efficiency ϵ is applied. The ϕ -dependent correction is obtained from the inverse of the single-particle ϕ distribution whose average is normalized to unity. This correction has been done as a function of time and data with similar efficiency are grouped together. The η -dependent correction is obtained by treating symmetrized $dN/d\eta$ distributions from z_{vtx} range $|z_{vtx}| < 2$ cm as the baseline. The ratio of the $dN/d\eta$ distribution from each z_{vtx} bin to this baseline would be the η - and also z_{vtx} -dependent corrections.

Fig. 2 shows P_x distributions from a high- p_T trigger particle with $3 < p_T^{trig} < 10$ GeV/c. The distributions from central and peripheral collisions are different because of the number of tracks. For each centrality, we cut on the left tail of the distribution (10% of events) to enhance the away-side jet population.

The azimuthal dihadron correlation is given by

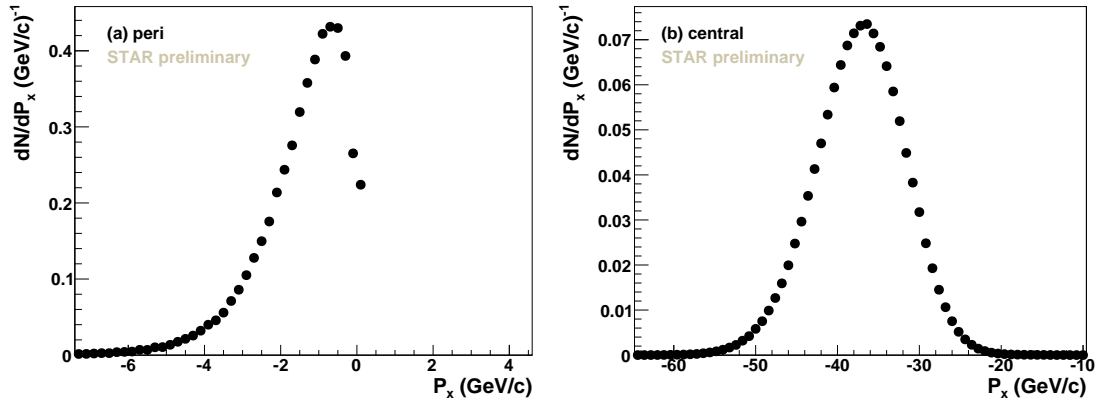


Figure 2. Distributions of recoil P_x from a high- p_T trigger particle with $3 < p_T^{trig} < 10$ GeV/ c for peripheral (70% – 80%) and central (0% – 5%) collisions.

$$\frac{1}{N_{trig}} \frac{dN}{d\Delta\phi} = \frac{1}{N_{trig}} \int d\Delta\eta \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)}. \quad (2)$$

where $S(\Delta\eta, \Delta\phi) = \frac{1}{N_{trig}} \frac{d^2N}{d\Delta\eta d\Delta\phi}$ and $B(\Delta\eta, \Delta\phi) = \frac{d^2N}{d\Delta\eta d\Delta\phi}$ are the signal and mixed-event background distributions. The mixed-event background serves as the correction for the detector two-particle acceptance. The mixed-event background distributions are normalized to have an average of unity where the two-particle $\Delta\eta$ acceptance is 100%. The ϕ -averaged single particle efficiency is not corrected because this analysis deals with only the correlation shape, not the absolute amplitude.

4. Results

The left plot in Fig. 3 shows the dihadron azimuthal correlations for close-region and far-region in min-bias Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The near-side peaks are almost identical while

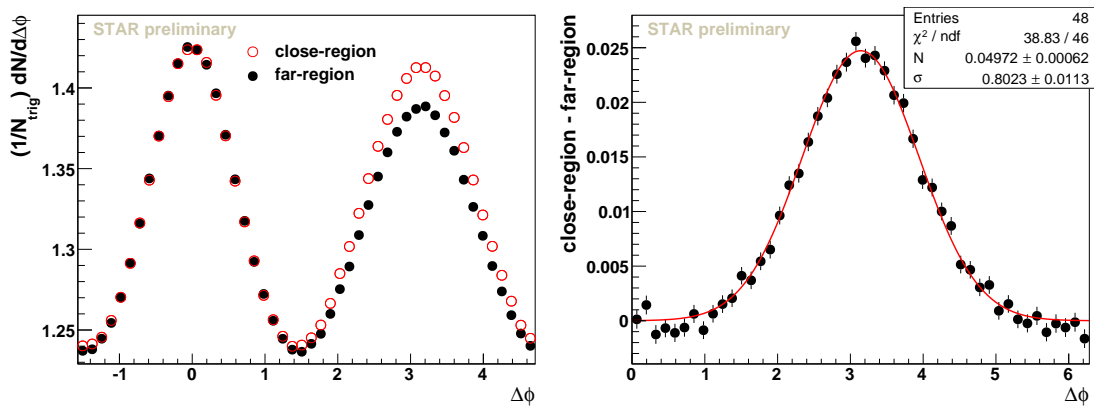


Figure 3. (left) Dihadron azimuthal correlations in close-region (open circles) and far-region (solid circles) for $3 < p_T^{trig} < 10$ GeV/ c and $1 < p_T^{assoc} < 2$ GeV/ c in min-bias Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. (right) The difference between close- and far-regions azimuthal correlations. The x-axes of the histograms are adjusted to show the full shape of the away-side peak ($\Delta\phi = \pi$). The curve is a Gaussian fit to the away-side jet shape with the mean value fixed at π .

the away-side peaks are different. The difference is from away-side jet contributions. The right plot in Fig. 3 shows the difference between close-region correlations and far-region correlations, which measures the away-side jet correlation shape. A Gaussian fit is applied to extract the away-side jet correlation width. A good χ^2 per degree of freedom (ndf) is obtained.

Fig. 4 shows away-side jet correlation width as a function of centrality for various p_T^{assoc} . The systematic uncertainties are estimated by varying P_x cut from allowing 10% of events to 2%, 5%, 15%, 20%, 30% and 50% of events. The P_x cut gives a systematic error of 3.1%. An additional 3.8% tracking systematic uncertainty is obtained by varying track quality cuts.

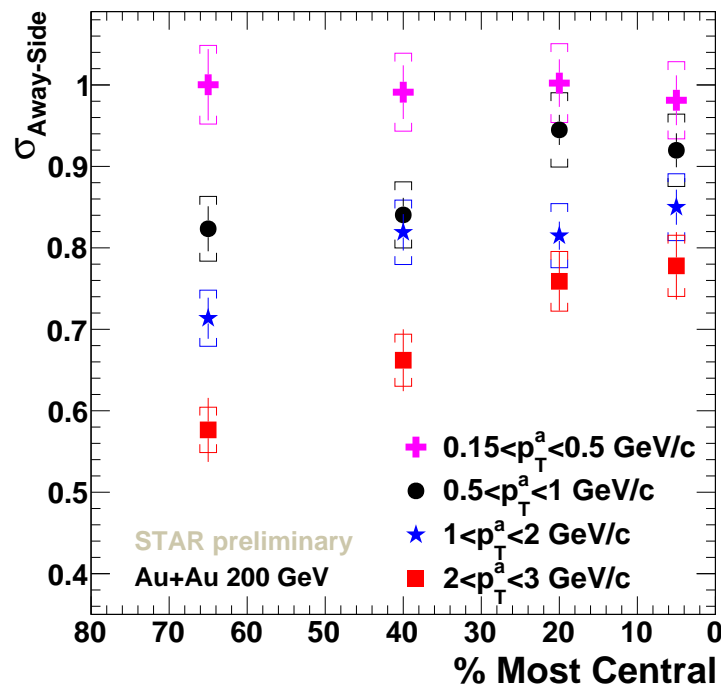


Figure 4. Away-side jet correlation width as a function of centrality for $3 < p_T^{trig} < 10$ GeV/c and various p_T^{assoc} bins in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The horizontal caps indicate the systematic errors.

5. Conclusions

A novel method was devised to measure away-side jet correlations with a clean, robust flow subtraction using data itself. The away-side jet correlation width broadens with increasing centrality at modest to high p_T^{assoc} and is insensitive to centrality at low p_T^{assoc} . The possible physics mechanisms are, among others, jet modification and jet deflection. Discrimination of these mechanisms requires further study, such as 3-particle correlations [7].

References

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