Azimuthal Correlations with High-p_T Multi-hadron Cluster Triggers in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV from STAR

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Di-hadron correlation measurements have been used to probe di-jet production in heavy ion collisions at RHIC. A strong suppression of the away-side high-p_T yield in these measurements is direct evidence that high-p_T partons lose energy as they traverse the strongly interacting medium. However, since the momentum of the trigger particle is not a good measure of the jet energy, azimuthal di-hadron correlations have limited sensitivity to the shape of the fragmentation function. We explore the possibility to better constrain the initial parton energy by using clusters of multiple high-p_T hadrons in a narrow cone as the 'trigger particle' in the azimuthal correlation analysis. We present first results from this analysis of multi-hadron triggered correlated yields in Au+Au collisions at $\sqrt{(}s_{NN}) = 200$ GeV from STAR. The results are compared to measurements in d+Au collisions and Pythia calculations, and the implications for energy loss and jet fragmentation are discussed.

I. INTRODUCTION

In heavy-ion collisions at RHIC, it is observed that a strongly coupled deconfined medium of quarks and gluons is formed [1]. As hard scattered partons traverse this medium, they interact and lose energy which subsequently modifies their fragmentation [2]. We study the fragmentation of hard scattered partons with azimuthal correlations of high-p_T hadrons which interact strongly and probe the medium.

To measure jet-like correlations in heavy-ion collisions, our current method is via di-hadron correlations. With di-hadron correlations, we have attempted to measure fragmentation functions, $D(z)$, where z is defined as $\frac{p_T}{E_T^{jet}}$. Because p_T^{trig} is used as a proxy for E_T^{jet}, the current method has limited sensitivity to true fragmentations functions. Multi-hadron triggered correlations may be a way of extending the method of di-hadron correlations.s The objective of this study is to understand how a cluster of multiple high-pt hadrons in a cone used as a 'trigger particle' in azimuthal correlations enhances the current method of di-hadron correlations.

II. EXPERIMENTAL SETUP

The data presented in this paper, from Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV, were collected during the year 4 run at RHIC. There are approximately 24M events used in this study. They are from the 0-12% most central events, selected via STAR's Zero Degree Calorimeters. Details of the STAR triggering and reconstruction are discussed elsewhere [3].

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III. ANALYSIS AND DISCUSSION

Multi-hadron and di-hadron azimuthal distributions are constructed using charged tracks from primary vertices in the range $|\eta| < 1$. Uncorrelated background is removed assuming zero yield at minimum (ZYAM). As elliptic flow (v_2) is a 1% modulation of the background in the ranges selected for p_T^{trig} and p_T^{assoc}, and the signal to background is much larger than 1%, it is considered a negligible effect.

The method for forming multi-hadron triggers begins with collecting all tracks which pass the track quality cuts with $p_T > 5.0$ GeV/c. These are referred to as "primary seeds". Then a cone radius ($r = \sqrt{\Delta\phi^2 + \Delta\eta^2}$) is defined around that primary seed of 0.3. Within that radius all "secondary seeds" which fall above a minimum p_T cut are collected. For a systematic study, cuts of 2,3, and 4 GeV/c have been used. The trigger p_T is then defined as the sum of the primary and secondary seeds. For example, a multi-hadron trigger of 12 GeV/c could be a combination of a 5 GeV/c primary seed and two secondary seeds of 4 and 3 GeV/c each, while in the di-hadron case, a 12 GeV/c trigger is a 12 GeV/c hadron. Once the multi-hadron triggers are defined, azimuthal difference distributions are made between the primary seed in the cone and associated tracks with p_T greater than the minimum secondary seed p_T cut. Recoil (away-side) yields are studied for various p_T^{trig} bins.

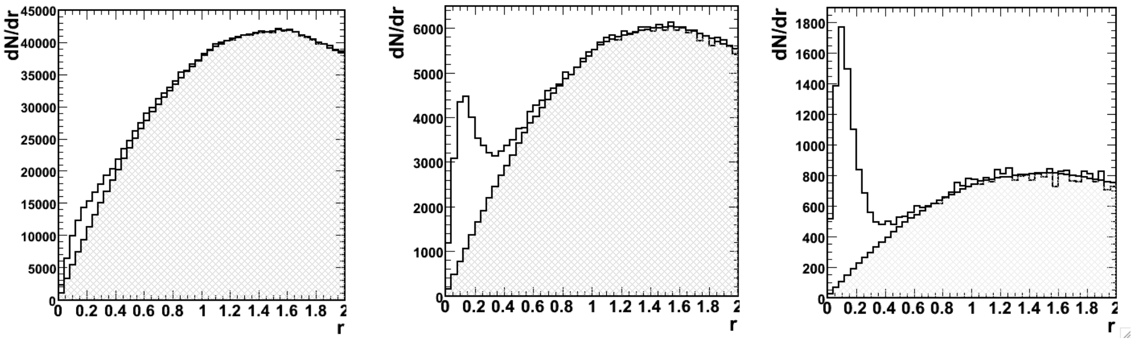

FIG. 1: Radial distributions of triggers with associated tracks from the same event (white histograms) and from different events (hatched histograms). Panels from left to right show minimum secondary seed cuts of 2.0, 3.0, and 4.0 GeV/c respectively.

Unfortunately, random combinations occur in the multi-hadron trigger algorithm. In other words, secondary seed tracks that are included in the multi-hadron cluster may not be part of the jet but a random coincidence. To study the contribution of random triggers, the radial distributions of primary seeds for two cases are constructed: with associated tracks in the same event and with associated tracks in different events. In Figure 1, these radial distributions are shown. The open histograms show same event correlations and the grey filled histograms show correlations with different events, the background triggers. From left to right each plot increases with minimum secondary seed $p_T > 2.0$, 3.0, and 4.0 GeV/c with S/B of 0.2, 0.7, and 2.0 respectively. The background histograms have been scaled to the signal histograms for the sake of shape comparison. Clearly, a radius of 0.3 with a minimum secondary seed p_T cut greater than 3.0 GeV/c optimizes signal to background for this study. Future plans include background subtracted yields utilizing an estimate of background trigger yields.

In Figures 2 and 3 recoil (away-side) yields for two p_T bins: $10 < p_T^{trig} < 12$ GeV/c and $12 < p_T^{trig} < 15$ GeV/c with 1 GeV/c slices in p_T^{assoc} from 3 to 11 GeV/c are presented. Figure 2 shows a comparison of di-hadron (solid triangles) and multi-hadron (open squares) triggers with a

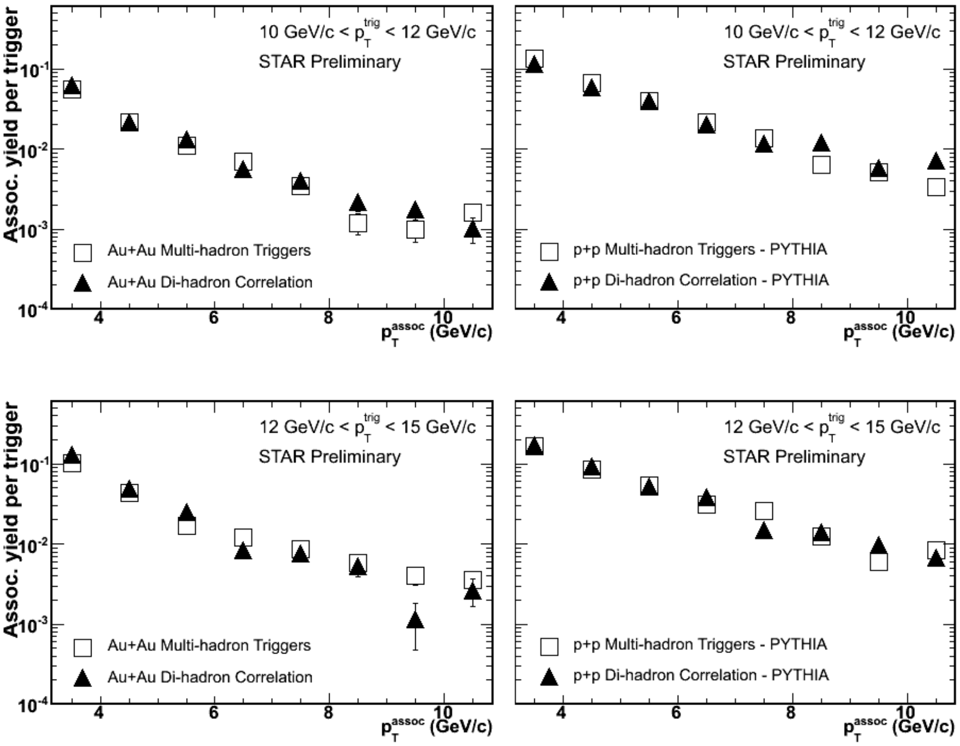

FIG. 2: Recoil yield per trigger for two p_T bins: $10 < p_T^{trig} < 12$ GeV/c (upper panels) and $12 < p_T^{trig} < 15$ GeV/c (lower panels). Data is presented on the left (Au+Au), Pythia predictions are presented on the right (p+p). A minimum secondary seed cut of $p_T > 3.0$ GeV/c is applied.

minimum secondary seed cut of 3.0 GeV/c and the p_T^{trig} bins p_T bins: $10 < p_T^{trig} < 12$ GeV/c and $12 < p_T^{trig} < 15$ GeV/c for the data (left panels) and Pythia (right panels). Figure 3 shows the same comparisons but for a minimum secondary seed cut of 4.0 GeV/c.

In Figures 2 and 3, the associated per-trigger yields with single-hadron triggers and multi-hadron triggers are similar suggesting that a similar underlying jet-energy distribution is selected by both methods. Events generated with Pythia also show this similarity between di-hadron correlations and multi-hadron triggered correlation measurements, although the per-trigger yields are generally higher than measured in the experiment.

IV. SUMMARY

In summary, multi-hadron triggers have been investigated as the next step toward full jet reconstruction. One important conclusion is that a cone radius of 0.3 and a minimum secondary seed cut greater than 3.0 GeV/c maximizes the signal to background ratio. Furthermore, away-side yields for multi-hadron correlations are consistent with yields observed via di-hadron measurements. To better understand this observation and how the underlying z_T distributions for the di-hadrons and the multi-hadrons compare, Pythia predictions are being studied. Qualitatively it can be seen that the multi-hadron correlations complement the di-hadron correlations, but more work is needed to understand how the underlying dynamics compare.

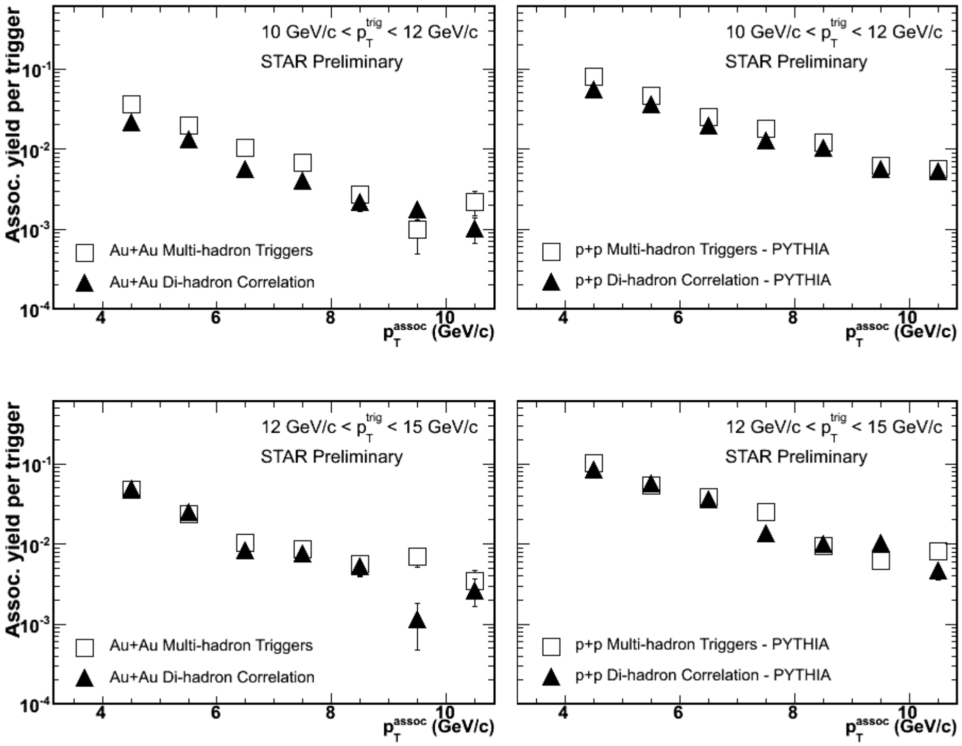

FIG. 3: Recoil yield per trigger for two p_T bins: $10 < p_T^{trig} < 12$ GeV/c (upper panels) and $12 < p_T^{trig} < 15$ GeV/c (lower panels). Data is presented on the left (Au+Au), Pythia predictions are presented on the right (p+p). A minimum secondary seed cut of $p_T > 4.0$ GeV/c is applied.

References

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