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

Brooke Haag*
University of California at Davis, Davis, USA

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 we use p_T^{trig} as a proxy for E_T^{jet}, the current method has limited sensitivity to true fragmentations functions. As a way of extending the method of di-hadron correlations, we propose multi-hadron triggered correlations. 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. For more on STAR triggering and reconstruction refer to [3].

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

*Electronic address: `bahaag@ucdavis.edu`

minimum (ZYAM). To first order elliptic flow (v_2) is considered a negligible contribution to the background because in the ranges selected for p_T^{trig} and p_T^{assoc} $< v_2^{trig} >< v_2^{assoc} > \sim 0$.

The method for forming multi-hadron triggers begins with collecting all tracks which pass the aforementioned criteria with $p_T > 5.0\ GeV$. We refer to these as "primary seeds". We then define a cone radius ($r = \sqrt{\Delta\phi^2 + \Delta\eta^2}$) around that primary seed of 0.3. Within that radius we collect all "secondary seeds" which fall above a minimum p_T cut. For a systematic study, cuts of 2,3, and 4 GeV 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 could be a combination of a 5 GeV primary seed and two secondary seeds of 4 and 3 GeV each while in the di-hadron case a 12 GeV trigger is a 12 GeV 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.

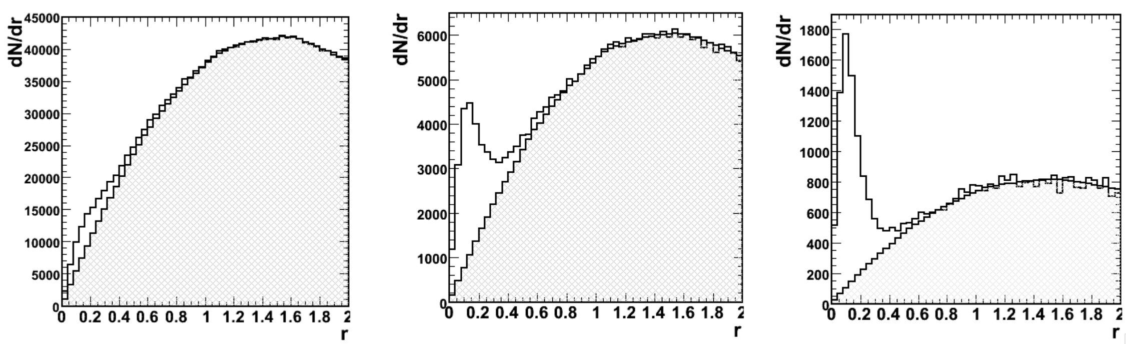

FIG. 1: Radial distributions of triggers with associated tracks from the same event (white histograms) and from different events (hatched histograms). Panels from left to right show minimum secondary seed cuts of 2.0, 3.0, and 4.0 GeV respectively.

We know that random combinations occur in the multi-hadron trigger algorithm. In other words, a primary seed may be matched with secondary seeds that are not from a jet but rather just coincidentally close in phase space. To study the contribution of random triggers, we look at the radial distributions of primary seeds for two cases: 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. From left to right each plot increases with minimum minimum secondary seed $p_T > 2.0$, 3.0, and 4.0 GeV respectively.

The gray filled histograms in Figure 1 show an estimate of the background triggers in the analysis. They are the result of pairing a trigger from one event with associated tracks from other events. The overlaid open histograms show the true signal, matches between triggers in one event and associated tracks in the same event. The background histograms have been scaled to the signal histograms for the sake of shape comparison. From left to right, the histograms reflect minimum associated track p_T cuts of 2.0, 3.0, and 4.0 GeV with S/B of 0.2, 0.7, and 2.0 respectively. Clearly a radius of 0.3 and with a minimum secondary seed p_T cut greater than 3.0 GeV 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 we present recoil (away-side) yields for two p_T bins: $10 < p_T^{trig} < 12\ GeV$ and $12 < p_T^{trig} < 15\ GeV$ with 1 GeV slices in p_T^{assoc} from 3 to 11 GeV. Figure 2 shows a comparison of di-hadron (solid triangles) and multi-hadron (open squares) triggers with a minimum secondary seed cut of 3.0 GeV and the aforementioned p_T^{trig} bins for the data (left panels) and pythia (right

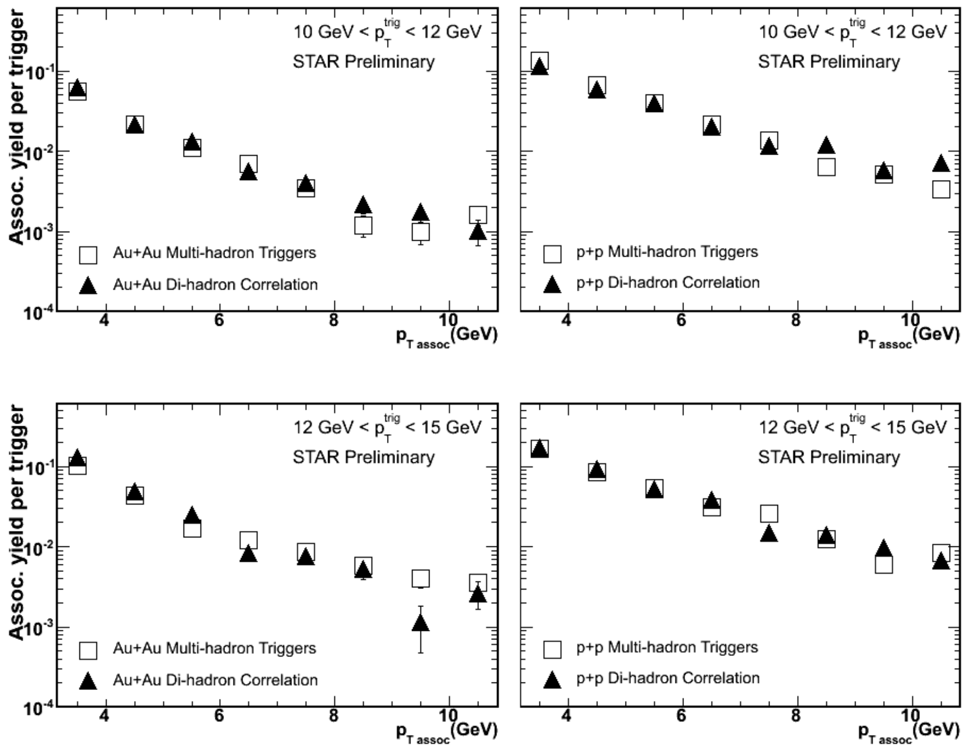

FIG. 2: Recoil yield per trigger for two p_T bins: $10 < p_T^{trig} < 12$ GeV (upper panels) and $12 < p_T^{trig} < 15$ GeV (lower panels). Data is presented on the left (Au+Au), pythia predictions are presented on the right (p+p). A minimum secondary seed cut of $p_T > 3.0$ GeV is applied.

panels). Figure 3 shows the same comparisons but for a minimum secondary seed cut of 4.0 GeV.

In the data, the multi-hadron and di-hadron yields largely overlap especially in the higher p_T bin of $12 < p_T^{trig} < 15$ GeV. In pythia, they overlap as well, confirming the trend in the data, though the per-trigger yields are generally higher in pythia. We conclude that the multi-hadron triggers extend di-hadron correlation measurements to a lower z_T range.

IV. SUMMARY

In summary, we have investigated multi-hadron triggers as the next step toward full jet reconstruction. We see that a cone radius of 0.3 and a minimum secondary seed cut greater than 3.0 GeV maximizes the signal to background ratio. Away-side yields for multi-hadron correlations are consistent with yields observed via di-hadron measurements. Subsequently, multi-hadron correlations extend di-hadron correlation methods to a lower z_T range. The method is promising though more work is needed. Namely, we plan to calculate corrected yields including an estimate of the background trigger yield.

References

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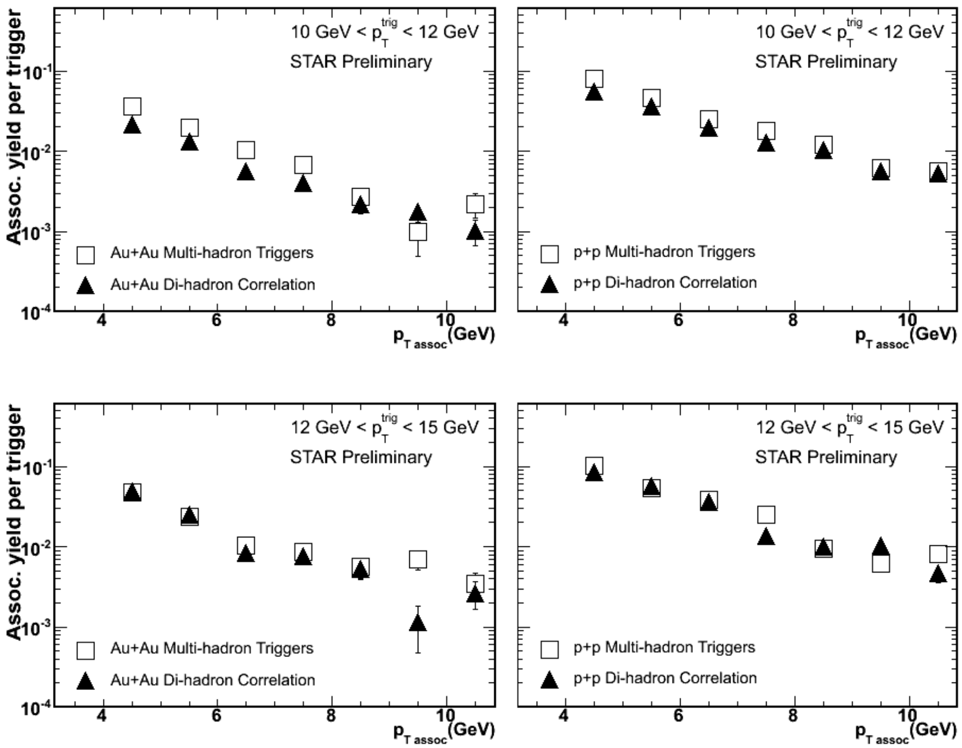

FIG. 3: Recoil yield per trigger for two p_T bins: $10 < p_T^{trig} < 12\ GeV$ (upper panels) and $12 < p_T^{trig} < 15\ GeV$ (lower panels). Data is presented on the left (Au+Au), pythia predictions are presented on the right (p+p). A minimum secondary seed cut of $p_T > 4.0\ GeV$ is applied.

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