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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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Abstract. Di-hadron correlation measurements have been used to probe di-jet production in 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 Pythia calculations, and the implications for energy loss and jet fragmentation are discussed.

Keywords: Relativistic heavy-ion collisions, Hard scattering in relativistic heavy ion collisions, Particle correlations and fluctuations, Fragmentation into hadrons
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1. Introduction

Recent experiments at RHIC have shown that in high-energy heavy-ion collisions, a strongly coupled medium consisting of deconfined quarks and gluons has been produced [1]. This medium is opaque to hard scattered partons, which lose energy as they traverse the medium and subsequently their fragmentation is modified [2]. This fragmentation has been studied using azimuthal correlations of hadrons with large transverse momentum (p_T).

Due to the large particle multiplicities observed in heavy-ion collisions, our current method of measuring jet-like correlations is via di-hadron correlations. Using these correlations, fragmentation functions, $D(z)$, have been measured where z is defined as $\frac{p_T}{E_T^{jet}}$, and p_T is the transverse momentum of a particle in a jet with E_T^{jet} being the transverse energy of the jet. As E_T^{jet} is difficult to measure in heavy-ion collsions ,p_T^{trig}, the transverse momentum of a trigger particle, is used as a proxy for E_T^{jet}. Subsequently, current measurements of fragmentation functions via di-hadron correlations could have limited sensitivity to true fragmentations functions. In this regard, multi-hadron triggered correlations may be a way of extending di-hadron correlations. This paper presents first results from a study to understand how this method, substituting a trigger particle for a cluster of multiple high-p_T hadrons in a cone, enhances the method of di-hadron correlations.

2. Experimental Setup

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

3. Analysis and discussion

Charged tracks from primary vertices are used to construct multi-hadron and di-hadron azimuthal distributions. The tracks are selected within the pseudo-rapidity range of $|\eta| < 1$. The uncorrelated background is removed using the zero yield at minimum (ZYAM) [4] method. As elliptic flow (v_2) is less than a 1% modulation of

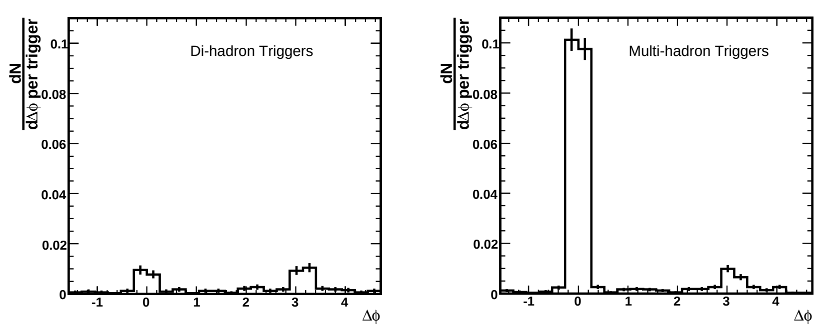

Fig. 1. Background subtracted azimuthal distributions for di-hadron triggers (left) and multi-hadron triggers (right) for $12 < p_T^{trig} < 15$ GeV/c and 4.0 GeV/c $< p_T^{assoc} < 5.0$ GeV/c. A minimum secondary seed of 3.0 GeV/c is used.

the background in the ranges selected for p_T^{trig} and p_T^{assoc} and the signal to background is much larger than 1%, the elliptic flow modulation is considered negligible in this analysis.

When forming multi-hadron triggers, all tracks which pass the track quality cuts with $p_T > 5.0$ GeV/c are collected as "primary seeds". Then within a cone radius ($r = \sqrt{\Delta\phi^2 + \Delta\eta^2}$) of 0.3, all "secondary seeds" which fall above a minimum p_T cut are collected. Minimum secondary seed cuts of 2,3, and 4 GeV/c have been used for a systematic study. Next, the sum of the primary and secondary seeds is taken to be the trigger p_T. To illustrate, a multi-hadron trigger of 12 GeV/c might be a combination of a 6 GeV/c primary seed and two secondary seeds of 3 and 3 GeV/c each, while in the di-hadron case, a 12 GeV/c trigger is a 12 GeV/c hadron. With the multi-hadron triggers defined, azimuthal difference distributions are calculated between the primary seed in the cone and associated tracks with p_T greater than the minimum secondary seed p_T cut. Representative distributions are shown in Figure 1. For the multi-hadron triggers there is a bias on the near-side due to the algorithm which artifically enhances the yield. With these distributions, recoil (away-side) yields are extracted and studied for various p_T^{trig} bins.

Unfortunately, not all multi-hadron triggers sample jets. This is because random combinations occur in the multi-hadron cluster algorithm. That is, tracks designated as secondary seeds included in a multi-hadron cluster may not be part of a jet but a random coincidence. To study this effect, the radial distributions of primary seeds for two different cases are constructed: with associated tracks in the same event and with associated tracks in different events. These distributions are shown in Figure 2 with the open histograms showing same event correlations and the grey filled histograms showing correlations with different events, the background triggers. To aid comparison, the background histograms have been scaled

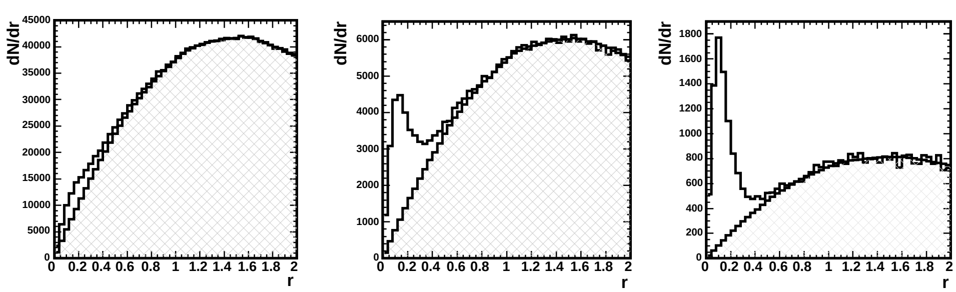

Fig. 2. Radial distributions of triggers with associated tracks from the same event (white histograms) and from different events (hatched histograms). Panels from left to right show minimum secondary seed cuts of 2.0, 3.0, and 4.0 GeV/c respectively.

to the signal histograms. The secondary seed p_T increases with $p_T > 2.0$, 3.0, and 4.0 GeV/c (left to right) and the signal-to-background increases from 0.2 to 0.7 to 2.0 respectively. A radius of 0.3 along with a minimum secondary seed p_T cut greater than 3.0 GeV/c leads to a reasonable signal to background for this study. Future plans include background subtracted yields calculated with an estimate of background trigger yields.

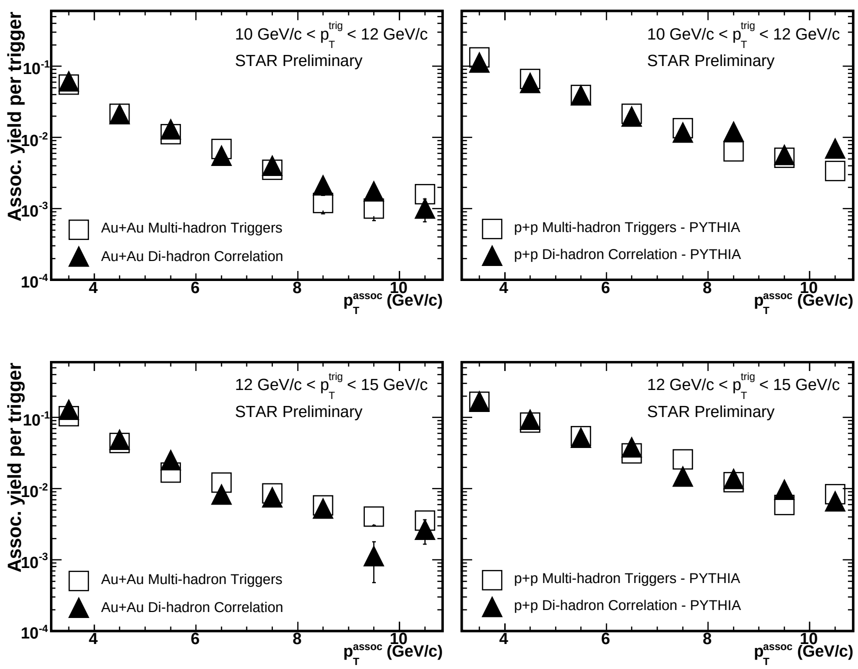

Fig. 3. Recoil yield per trigger for two p_T bins: $10 < p_T^{trig} < 12$ GeV/c (upper panels) and $12 < p_T^{trig} < 15$ GeV/c (lower panels). Data is presented on the left (Au+Au), Pythia predictions are presented on the right (p+p). A minimum secondary seed cut of $p_T > 3.0$ GeV/c is applied.

Figures 3, 4, and 5 show recoil (away-side) yields for three p_T bins: $10 < p_T^{trig} < 12$ GeV/c, $12 < p_T^{trig} < 15$ GeV/c, and $15 < p_T^{trig} < 18$ GeV/c respectively. Figure 3 shows a comparison between multi-hadron (open squares) and di-hadron (solid triangles) triggers with a minimum secondary seed cut of 3.0 GeV/c for the data (left panels) and Pythia (right panels) and for two p_T^{trig} bins: $10 < p_T^{trig} < 12$ GeV/c and $12 < p_T^{trig} < 15$ GeV/c . The same comparisons are shown in Figure 4 but for a higher minimum secondary seed cut of 4.0 GeV/c. Figure 5 shows the comparisons for the higher p_T^{trig} range of $15-18$ GeV/c and both minimum secondary seed cuts.

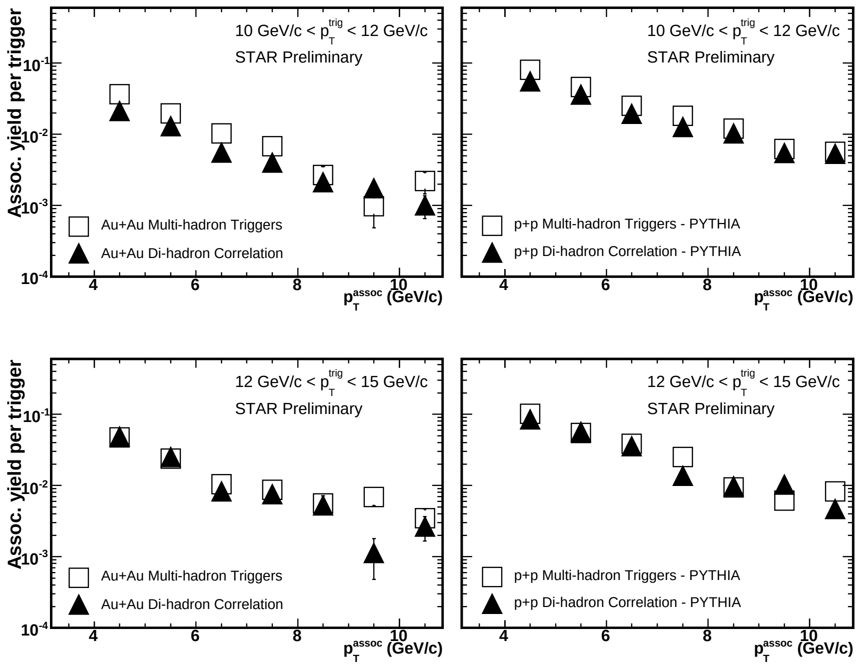

Fig. 4. Recoil yield per trigger for two p_T bins: $10 < p_T^{trig} < 12$ GeV/c (upper panels) and $12 < p_T^{trig} < 15$ GeV/c (lower panels). Data is presented on the left (Au+Au), Pythia predictions are presented on the right (p+p). A minimum secondary seed cut of $p_T > 4.0$ GeV/c is applied.

The associated per-trigger yields for both single-hadron and multi-hadron triggers in Figures 3, 4, and 5, are similar, suggesting the selection of a similar underlying jet-energy distribution by both methods. The same analysis run over Pythia events also shows this similarity between di-hadron correlations and multi-hadron triggered correlation measurements, although the per-trigger yields are generally higher than measured in the data.

4. Conclusions

This paper has presented first results on the use of multi-hadron triggers investigated as the next step toward full jet reconstruction in heavy-ion collisions. A cone radius of 0.3 coupled with a minimum secondary seed cut greater than 3.0 GeV/c leads to a reasonable signal to background ratio of 0.7. Moreover, the away-side yields for multi-hadron correlations and from di-hadron measurements are consistent. This

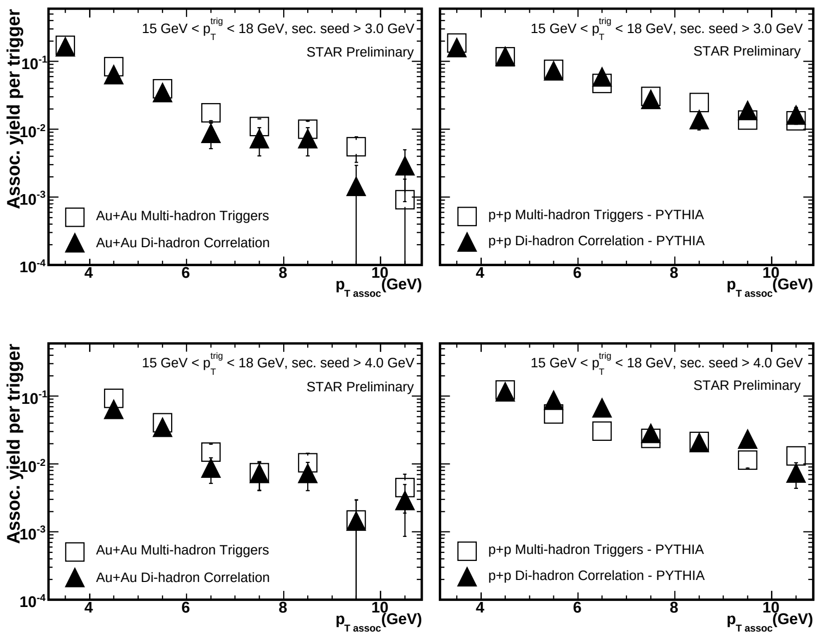

Fig. 5. Recoil yield per trigger for $15 < p_T^{trig} < 18$ GeV/c. Data is presented on the left (Au+Au), Pythia predictions are presented on the right (p+p). A minimum secondary seed cut of $p_T > 3.0$ GeV/c is applied in the top panels. A minimum secondary seed cut of $p_T > 4.0$ GeV/c is applied in the bottom panels.

effect is also reproduced in Pythia simulations. Further analysis of the Pythia events to compare the underlying jet energy selections for di-hadron analysis and multi-hadron triggered analysis is ongoing.

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