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Near-side $\Delta\eta$ correlations of high-p_t hadrons from STAR

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Abstract. Systematic measurements of pseudorapidity ($\Delta\eta$) and azimuthal ($\Delta\varphi$) correlations between high-p_t charged hadrons and associated particles from the high statistics 200 GeV Au + Au and Cu + Cu datasets will be presented. In previous measurements differences in the near-side $\Delta\eta$ correlation between central Au + Au and the lighter systems, d + Au and $p + p$, were observed, including a long-range near-side correlation in Au + Au collisions. Studies to characterize the properties of the long-range correlation will be presented.

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Azimuthal dihadron correlation studies in d + Au and Au + Au collisions [2, 3] have shown that hard partons from initial-state, back-to-back scatterings interact strongly with the system that is created, and can be used as a probe of the medium. The observation of additional near-side long-range $\Delta\eta$ correlations for soft hadrons ($p_t < 2$ GeV) in Au + Au collisions was first noted in [1]. Similar effects were observed in dihadron correlations in [4, 5] but in a kinematic regime where parton fragmentation may play a significant role. In these proceedings the enhanced statistics in Au + Au and Cu + Cu will be used for systematic studies of the correlated yield dependence on centrality, transverse momentum of the trigger ($p_{t,\mathrm{trigger}}$) and associated particles ($p_{t,\mathrm{assoc.}}$) to characterize the properties of the long-range $\Delta\eta$ correlation.

To extract the correlated yield of the near-side long-range $\Delta\eta$ correlation (*ridge yield*) from dihadron correlation measurements, we take advantage of the η and φ acceptance of the STAR-TPC, by projecting the two dimensional ($\Delta\eta \times \Delta\varphi$) correlation function onto $\Delta\varphi$ and $\Delta\eta$ in different $\Delta\eta \times \Delta\varphi$ regions after correcting for the finite $\Delta\eta$ pair- acceptance. Three methods were used to characterize the short-range *jet-like* (J) and *ridge-like* (R) contributions to the near-side jet yield[1] in $\Delta\eta$ and $\Delta\varphi$:

– $\Delta\varphi$(J + R) method: Projecting onto $\Delta\varphi$ with the full experimental $\Delta\eta$ acceptance and subtracting the elliptic flow (v_2) modulated background.
– $\Delta\varphi$(J) method: Subtracting the $\Delta\varphi$ projection for $|\Delta\eta| > 0.7$ from the $\Delta\varphi$ projection $|\Delta\eta| \le 0.7$ (near-side).
– $\Delta\eta$(J) method: Projecting onto $\Delta\eta$ in a $\Delta\varphi$ window $|\Delta\varphi| < 0.7$ (near-side). A constant fit to the measurements was used to subtract the background.

In Fig. 1 the near-side yield is shown as a function of N_{part} for all three methods. The agreement of the measured jet-like yield using the $\Delta\eta$(J) and $\Delta\varphi$(J) method as function of N_{part} supports the assumption that the ridge-like correlation is uniform in the $\Delta\eta$ acceptance. Further detailed studies of the ridge shape in the high statistics Au + Au central data set will be pursued. Note that the jet-like correlated yield is independent of centrality and agrees with the $p + p$ reference measurements [5]. In contrast the $\Delta\varphi$(J + R) method shows a significant increase of

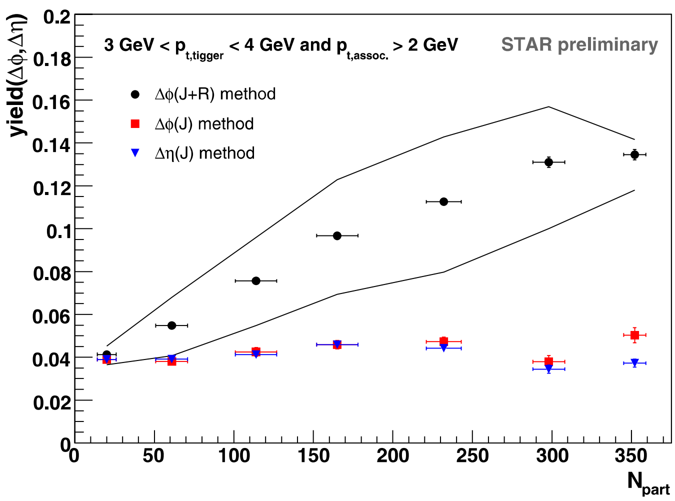

Fig. 1. Near-side yield as a function of N_{part} in Au + Au

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[1] The near-side yield is defined as the integral of a Gaussian fit to the $\Delta\varphi$, $\Delta\eta$ correlation functions.

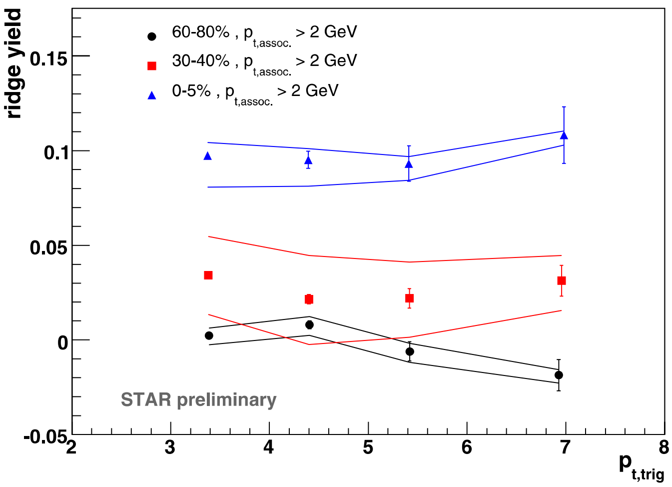

Fig. 2. (Absolute) Ridge yield for different centralities as a function of $p_{\mathrm{t,trigger}}$ for $p_{\mathrm{t,assoc.}} > 2$ GeV in Au + Au

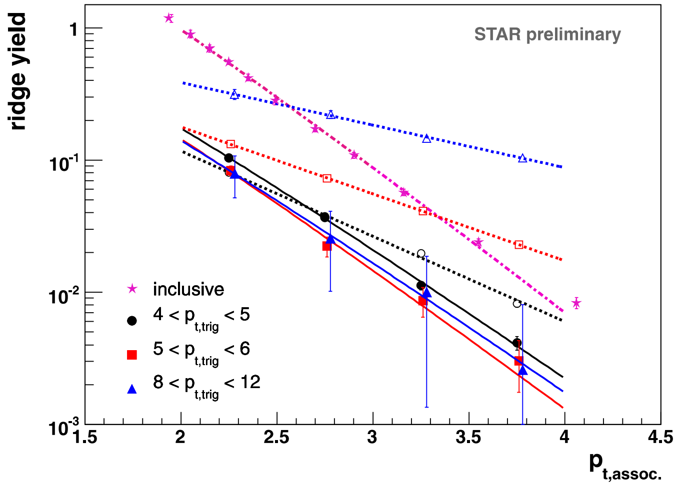

Fig. 3. Ridge/jet-like yield (*filled/open symbols*) as function of $p_{\mathrm{t,assoc.}}$ for different $p_{\mathrm{t,trigger}}$ in 0–10% central Au + Au collisions. As reference the inclusive spectrum (0–5% central Au + Au, *stars*) is also shown [9]. The *lines* represents exponential fits to the data

the near-side yield with centrality due to the inclusion of the correlated yield at large $\Delta\eta$ (ridge).

Therefore one can define the (absolute) ridge yield = yield($\Delta\varphi$(J + R)) − yield($\Delta\eta$(J))[2]. The main systematic error is due to the uncertainty in the elliptic flow measurement for the $\Delta\varphi(\mathrm{J}+\mathrm{R})$ method. The v_2 values used in this analysis are: the mean of the reaction plane ($v_2\{\mathrm{RP}\}$) and four-particle cumulant method ($v_2\{4\}$) [6] in Au + Au and the scalar product method $v_2\{\mathrm{CuCu}-pp\}$ in Cu + Cu [7]. The systematic uncertainties were estimated using $v_2\{\mathrm{RP}\}$ as maximum and $v_2\{4\}$ as minimum v_2 values for Au + Au (represented as lines in all figures). For Cu + Cu $v_2 = 0$ as minimum v_2 value was used.

One important feature of the near-side long-range $\Delta\eta$ correlation is the observation that the (absolute) ridge yield is independent of $p_{\mathrm{t,trigger}}$ for each centrality class, but increasing with centrality as shown in Fig. 2. If the ridge is caused by radiative energy loss coupling to longitudinal flow [8], the $p_{\mathrm{t,trigger}}$ independence of the ridge yield would be consistent with a jet energy independent energy-loss mechanism. This would indicate, that the near-side parton experienced some energy loss by probing a finite path-length in the medium before fragmenting.

To characterize in more detail the properties of particles associated to the ridge-like respective jet-like near-side correlation we use the $p_{\mathrm{t,assoc.}}$ spectrum in different $p_{\mathrm{t,trigger}}$ windows, as shown in Fig. 3. An exponential function $\frac{\mathrm{d}N}{\mathrm{d}p_{\mathrm{t}}} \propto p_{\mathrm{t}} e^{-p_{\mathrm{t}}/T}$ is fitted to the data to extract the slope of the the $p_{\mathrm{t,assoc.}}$ spectrum. Results are given in Table 1. The $p_{\mathrm{t,assoc.}}$ spectrum for the near-side jet-like correlation is harder than the inclusive spectrum – even for the lowest $p_{\mathrm{t,trigger}}$ window – and shows a significant hardening as function of $p_{\mathrm{t,trigger}}$, as one would expect from jet fragmentation. In contrast to the jet-like part, the slope of the ridge-like correlation is basically independent of $p_{\mathrm{t,trigger}}$ and only slightly harder, by approximately 40–50 MeV, than the inclusive spectrum.

This observation suggests that the near-side $\Delta\eta \times \Delta\varphi$ correlation consists of two distinct components. The jet-like part, consistent with the $p+p$ and $d+\mathrm{Au}$ di-hadron reference measurements [4, 5], and the ridge-like part with more bulk-like than jet-like properties, elongated in $\Delta\eta$, but still correlated in $\Delta\varphi$ with the near-side jet. One might speculate that the appearance of the ridge could be interpreted as a direct measure of the medium response to energy loss in central Au + Au collisions.

Another experimental possibility allowing further insight into the ridge properties is to study the ridge-like correlation for identified associated particles. The quantity used in this analysis is the relative ridge yield defined by normalizing the ridge yield to the jet-like yield $\Delta\eta$(J). In Fig. 4 the relative ridge yield for identified associated $\pi^{\pm}$, $p+\bar{p}$ and, as a reference, for charged particles in 0–10% central Au + Au is shown. From the measurements presented in Fig. 4 one can conclude that the proton content of the ridge-like correlation is larger than [that of] the jet-like correlation. In order to distinguish between recombination of thermal partons in the recombination framework [10] or a change of the $\pi^{\pm}$, $p+\bar{p}$ ratio in the jet fragmentation

Table 1. Slope parameter T from an exponential fit (see Fig. 3) to the $p_{\mathrm{t,assoc.}}$ spectrum in different $p_{\mathrm{t,trigger}}$ bins for ridge-like (T_{Ridge}) and jet-like (T_{Jet}) near-side correlations

$p_{\mathrm{t,trigger}}$ [GeV]	T_{Ridge} [MeV]	T_{Jet} [MeV]
4–5	395.8 ± 9	545.7 ± 13
5–6	370.1 ± 30	664.4 ± 22
6–8	447.3 ± 46	777.1 ± 29
8–12	393.2 ± 121	934.1 ± 55

[2] One should note that the absolute (and relative) ridge yield depend on the $\Delta\eta$ integration window, which has been chosen as $|\Delta\eta| < 1.7$ in this analysis.

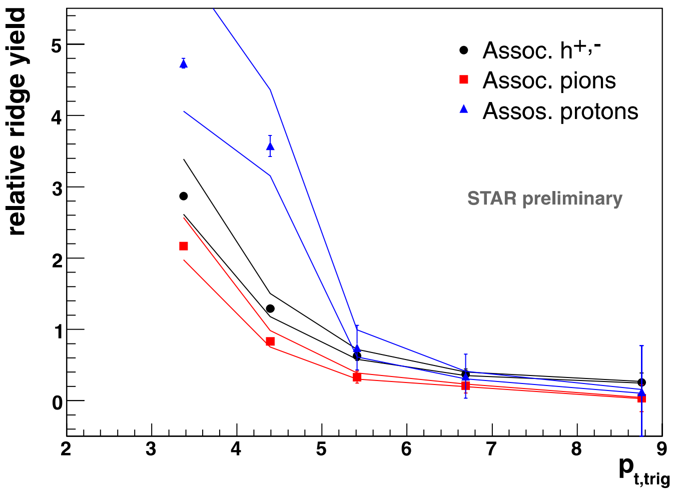

Fig. 4. Relative ridge yield for identified associated $\pi^{\pm}$, $p+\overline{p}$ and charged particles as function of $p_{\mathrm{t,trigger}}$ in 0–10% central Au + Au collisions

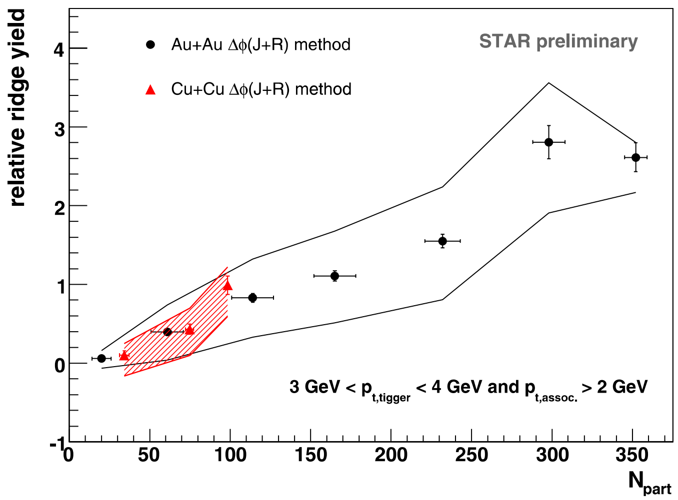

Fig. 5. Centrality dependence of the relative ridge yield for Au + Au and Cu + Cu. The *lines* represent the systematic error due to uncertainties in the elliptic flow measurements

as the cause of the enhanced proton content in the ridge, a measurement of the (absolute) ridge yield is necessary. This measurement is still in progress and results will be available in the near future. A study focused on identified associated strange particles is already available and can be found in [11].

In Fig. 5 the centrality dependence of the relative ridge yield in Au + Au compared with Cu + Cu collisions is shown. In the overlapping N_{part} region the relative ridge yield in Cu + Cu is similar to Au + Au. A similar N_{part} scaling in Au + Au and Cu + Cu collisions is observed for the nuclear modification factor [12], indicating that these effects could have the same origin.

The underlying physics of these effects is not quite clear yet, but the independence of the (absolute) ridge yield on $p_{\mathrm{t,trigger}}$ is consistent with a picture on which the ridge is caused by the coupling of induced radiation to longitudinal flow [8] with a radiation spectrum that is independent of the jet energy. Alternative approaches to describe these phenomena are based on a combination of jet-quenching and strong radial flow [13] or on recombination of locally thermal enhanced partons due to partonic energy loss in the recombination framework [10]. To what extent the presented results – slope of the ridge-like correlations slightly harder than the inclusive spectrum and a first look at identified associated $\pi^{\pm}$ and $p+\bar{p}$ – might help to distinguish between these models is unclear yet. A comparison of quantitative theoretical calculations to the experimental measurements are needed in order to understand the origin of the ridge yield.

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