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The ratios of identified strange associated hadrons in the di-hadron correlation in STAR

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Abstract : Di-hadron correlations will help understand the parton densities near jets traversing the medium, the process of hadron formation and the di-hadron correlation away-side shape. We report on the di-hadron correlations between unidentified charged hadron triggers with identified associated strange particles Λ and K_S^0) in Au+Au collisions at 200 GeV in STAR. Particle yields and ratios are extracted on the near-side and away-side of the trigger particle. The baryon to meson ratios for associated particles as a function of $\Delta\phi$ are also extracted. The shape of these ratios on the away-side is studied to understand the away-side's pattern. The particle-type composition in the hump regions in away-side is compared to that in the near-side peak. These ratios may help to elucidate the particle composition in the away-side and near-side of the correlation pattern arising due to a fast parton traversing the medium.

Keywords : Quark gluon plasma, jet quenching.

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1. Introduction

Studies of two-particle azimuthal correlations have revealed detailed information about jet interactions with the medium [1–3]. In di-hadron correlations from central Au+Au collisions the away-side jet opposing the high p_T triggered particle disappears [1,4], while the remnants of the away-side jet are recovered at lower p_T values [5]. The distribution of these remnants in $\Delta\phi$ is highly modified in comparison to p+p collisions : the away-side correlation is no longer peaked at $\Delta\phi = \pi$ but instead has two peaks shifted to either side of π [6]. Several scenarios have been proposed to account for this splitting. More information may be obtained about the interaction of fast partons with the medium by studying the particle-type composition of the di-hadron correlations. The coalescence of constituent quarks has been used to describe successfully much of the increase in the baryon-to-meson ratios [7]. By extension, one might expect a larger baryon-to-meson ratio for intermediate p_T hadrons on the away-side due to the coalescence of quenched fragments with each other or with constituents from the medium. For these reasons, measurements of the baryon-to-meson ratio on the near- and away-side of jets should be useful for understanding the interaction of fast partons with the medium.

We will present measurements of di-hadron correlations of unidentified trigger hadrons with identified K_S^0, Λ, or $\bar{\Lambda}$ associated partners in $\sqrt{s_{NN}}$ = 200 GeV Au+Au collisions. For this analysis, a trigger hadron is any charged track with $3 < p_T < 6$ GeV/c while associated partners are taken from $1 < p_T < 4$ GeV/c. In the $|\Delta\eta| < 1$ range, we get the yield $dN/d\Delta\phi$ for K_S^0, Λ and $\bar{\Lambda}$ as a function of $\Delta\phi$. The same procedure is carried out on a mixed event sample to obtain a background distribution used to correct for imperfect detector acceptance. The v_2 modulated background distribution is subtracted from the corrected $dN/d\Delta\phi$ distribution by zero-yield at the minimum (ZYAM) [9] assumptions. The following form is used to describe the v_2 modulated combinatorial background [9,10] : $B(\Delta\phi) = b_0(1 + 2\langle v_2^A \times v_2^B \rangle\cos(2\Delta\phi))$. The nominal v_2 is taken as the average of v_2 from an event plane analysis (v_2\{EP\}) [15] and v_2 from a 4-particle cumulant analysis (v_2\{4\}) [11] for the charged hadron or v_2 from the Lee-Yang Zero method analysis (v_2\{LYZ\}) [12] for K_S^0, Λ , or $\bar{\Lambda}$ [14,16]. The difference between v_2\{4\}(v_2\{LYZ\}) and v_2\{EP\} results and the v_2 fluctuations [13] are considered in the systematic errors.

2. Results and discussion

The acceptance, efficiency, and background subtracted di-hadron $dN/d\Delta\phi$ distributions are shown in Fig. 1, all data are from 10–40% centrality bins in $\sqrt{s_{NN}}$ = 200 GeV Au+Au collisions. The left panel shows the hadron-K_S^0, and the hadron –(Λ+$\bar{\Lambda}$) $dN/d\Delta\phi$ distributions; the right panel shows the hadron-Λ and hadron-$\bar{\Lambda}$ correlations

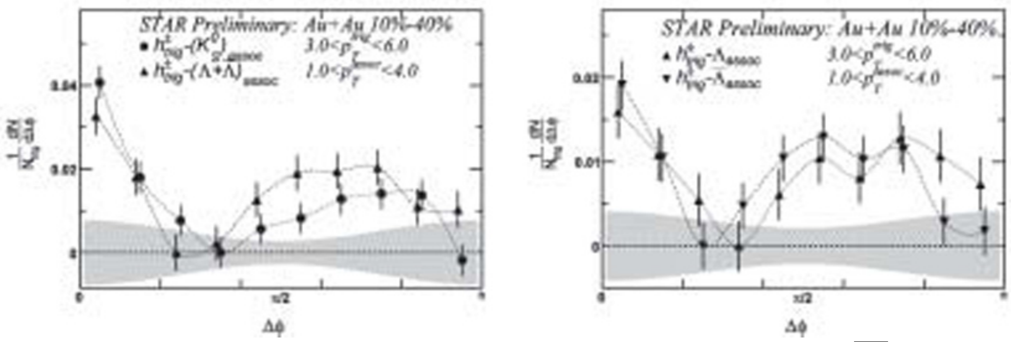

Figure 1. The correlation function in 10–40% centrality bins in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The charged hadron trigger particles p_T range is $3.0 < p_T < 6.0$; the identified associated strange particles p_T range is $1.0 < p_T < 4.0$. The yellow band around the zero corresponds to the systematic error. Left panel : Hadron-K_S^0, $-\Lambda + \bar{\Lambda}$ correlation function, the associate particles are K_S^0 or $\Lambda + \bar{\Lambda}$. Right panel : Hadron Λ, $-\bar{\Lambda}$ correlation function, the associate particles are Λ, or $\bar{\Lambda}$.

separately. For all particle combinations a strong correlation is seen on the near-side of the charged hadron trigger ($\Delta\phi$ < 0.35π) as would be expected from fragmentation of a fast parton or jet; but on the away-side the distributions seems a broadened peak or double hump. This is consistent with the di-hadron distributions from STAR [8]. These features are similar to those already observed for unidentified di-hadron distributions which have much better statistics [9]. We extract the conditional yields of identified K_S^0, Λ and $\bar{\Lambda}$ particles on the near-side (0. < $\Delta\phi$ < 0.35π) and away-side (0.35π < $\Delta\phi$ < π) of the trigger hadron.

Figure 2 shows the Λ/K_S^0 ratio for *p*+*p*, mid-peripheral Au+Au [17], and central Au+Au collisions scaled by 0.5. The measurements of the Λ + $\bar{\Lambda}/K_S^0$ ratio made for particles associated with a trigger hadron (p_T > 3.0) are also presented. We find that both STAR and PHENIX measurements [7,18] are consistent with a larger baryon-to-meson ratio on the away-side than on the near-side. In addition, on the near-side the baryon-to-meson ratio is closer to values measured in *p*+*p* collisions while on the away-side the ratio is closer to that measured in central or mid-central Au+Au collisions. This observation may indicate that a larger parton density of matter is traversed by the away-side jet. This larger parton density may lead to an enhancement in baryon production. Such an effect is expected if the baryon enhancement in the

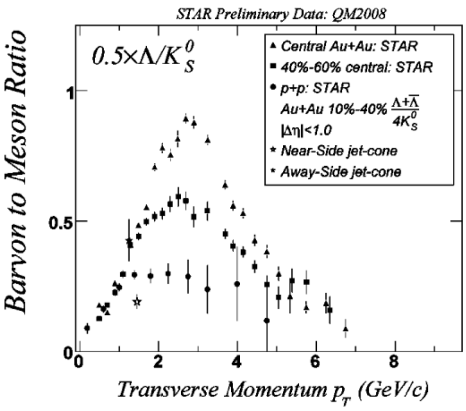

Figure 2. Λ to K_S^0 ratio in central Au+Au, mid-peripheral Au+Au and minimum-bias *p*+*p* collisions. The measurement of the Λ to K_S^0 ratio for particles associated with a trigger hadron (p_T > 3.0) is shown. Values are scaled by 0.5. In the plots, the yellow band is the systematic error.

intermediate p_T region observed in Au+Au collisions is due to multi-parton interactions such as gluon junctions [19] or quark coalescence [20]. But within the current systematic errors it is difficult to make a firm conclusion.

In Fig. 3 the centrality dependence of baryon-to-meson ratio on the near-side and away-side in the Au+Au collisions at 200 GeV is shown. For some centrality bins, the ratios on the away-side seem higher than the ratios on the near-side. The baryon-to-meson ratios show independence from centrality on the near-side. This manifests

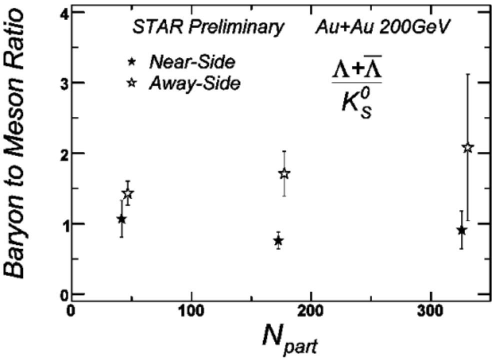

Figure 3. The centrality dependence of baryon-to-meson ratios on the near-side and away-side in the Au+Au collisions at 200 GeV. The baryon-to-meson ratios in the near-side are independence with the centrality, but the ratios in the away-side seem increase with the centrality.

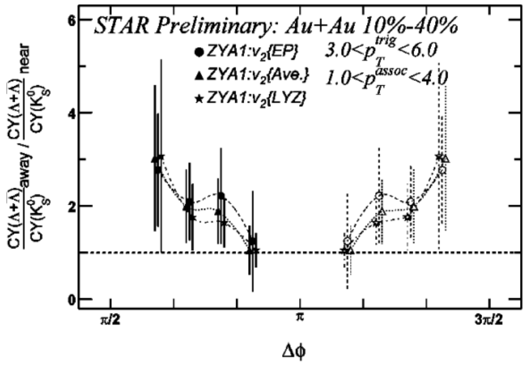

Figure 4. The baryon-to-meson ratio on the away-side *vs.* $\Delta\phi$ scaled by the same ratio in the near-side jet-cone. Data are for 10% – 40% Au+Au collisions at 200 GeV. This double ratio appears to be insensitive to the background subtraction method.

that the jet which is in the surface around the near-side will fast come out the medium. In the away-side, the ratios increase with the centrality from the peripheral to central. It seems that the jet will interact with the high density matter around the away-side, and in the central the parton density seems higher than the peripheral. There are still large errors in the experimental data so a definite conclusion is difficult.

Figure 4 shows the particle ratios (ratios of the conditional yields) on the away-side as a function of $\Delta\phi$ in 10–40% centrality. The ratios are normalized by the corresponding ratio measured in the near-side jet-cone so that unity corresponds to the case where the away-side particle composition is the same as that in the near-side jet cone. We find that this double ratio is largely independent of the elliptic flow used in the background subtraction indicating that such an analysis is able to reduce systematic uncertainties. In both cases the data from $\Delta\phi < \pi$ (closed symbols) has been reflected to $\Delta\phi > \pi$ (open symbols). The uncertainty on this measurement remains large and precludes strong conclusions about the shape or magnitude of the ratios. We observe some indication that the $(\bar{\Lambda}+\Lambda)/K_S^0$ ratios may be larger at around $\Delta\phi = \pi/2$ than they are at $\Delta\phi = \pi$. This may be consistent, for example, with the increase of the parton density at large angles as discussed above.

3. Summary

We measured di-hadron azimuthal angle correlation in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. Charged hadron (3.0 < p_T < 6.0 GeV/c) are used as the trigger particle; K_S^0s, Λs and $\bar{\Lambda}$s (1.0 < p_T < 4.0 GeV/c) are used as the associated particles. We extracted the conditional yields of identified associate particles on the near- and away-side of the jet trigger and calculated the near and away-side particle ratios. The systematic uncertainty from υ_2 and the background normalization are large. These uncertainties can be reduced with more data and a better understanding of υ_2. The ratios on the away-side are close to the inclusive measurement in Au+Au collision and seem to increase with the centrality, while the ratios on the near-side are close to the measurement in *p*+*p* collision and show independence with the centrality. We studied the shape of away-side particle ratios and find that this shape is insensitive to several sources of systematic uncertainty. Our measurements are consistent with the physical picture that the parton density may be higher at large angles away from $\Delta\phi = \pi$. These measurements should help elucidate how fast partons interact with the matter created in Au+Au collisions at RHIC.

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