Eur. Phys. J. C (2009) 61: 589–595
DOI 10.1140/epjc/s10052-009-0928-z

THE EUROPEAN
PHYSICAL JOURNAL C

Regular Article - Experimental Physics

# Near-side high-$p_T$ correlations: the ridge

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Received: 14 September 2008 / Revised: 17 January 2009 / Published online: 3 March 2009

**Abstract** An overview of results on near-side high-$p_T$ triggered correlations in heavy-ion collisions at RHIC energy is presented. These correlations reveal a novel, long-range pseudo-rapidity correlation, commonly referred to as *the ridge* which is not present in $p+p$ or $d+Au$ collisions. The centrality, collision system, energy, transverse momentum, path length dependence as well as particle composition of the ridge will be discussed and compared with the properties of the jet-like component at near side. The data are also confronted with theoretical calculations.

**PACS** 25.75.-q · 25.75.Gz

## 1 Introduction

Collisions of heavy nuclei at ultra-relativistic energies are a unique environment for the creation and investigation of nuclear matter under extreme conditions of high temperature and energy density. In the previous several years, experiments at the Relativistic Heavy Ion Collider (RHIC) have collected convincing evidence for the creation of a dense, strongly interacting nuclear matter which is opaque to jets and exhibits strong collective flow behavior [1–4]. The very first measurements of particle production at RHIC revealed a strong suppression of inclusive transverse momentum ($p_T$) spectra in central $Au+Au$ collisions with respect to $p+p$ collisions. Further investigation of the nuclear modification factors for light flavor particle species has shown that in the intermediate transverse momentum range ($p_T = 2$–$6\ \text{GeV}/c$) mesons show a larger suppression than baryons. This observation together with enhanced baryon/meson particle ratios proves that jet fragmentation is not a dominant source of particle production out to $p_T = 6\ \text{GeV}/c$ [5–8].

The increased amount of measured data allowed one to move from inclusive measurements towards di-hadron azimuthal correlations which are nowadays commonly used to study jet-like processes and jet–medium interaction in heavy-ion collisions at RHIC. The measurements of di-hadron correlations in central $Au+Au$ collisions resulted in several striking observations which are not present in $p+p$ and $d+Au$ collisions. The observation of disappearance of the away-side correlated yield at intermediate $p_T$, consistent with parton energy loss in nuclear medium, is compensated for by an increased production of low transverse momenta ($p_T < 2\ \text{GeV}/c$) associated particles on the away side. The resulting away-side distribution is broad with a double peak shape around $\Delta\phi \sim \pi$ [9]. Physics mechanisms suggested to explain the away-side peak shape modification include Mach cone shock waves generated by a parton propagating through the medium [10–14] or Čerenkov gluon radiation [15, 16]. An overview of the current status and understanding of the away-side peak shape modification is published in this volume [17].

In this paper we concentrate on another remarkable feature of di-hadron correlations at RHIC—the observation of an additional long-range pseudo-rapidity correlation at near side, commonly referred to as *the ridge* [18, 19]. The observation of the ridge phenomenon has been reported by the STAR Collaboration at the first Hard Probes conference in 2004 [18, 20]. This observation has been followed by a detailed experimental investigation of the ridge phenomenon and has also triggered intense theoretical discussions on the physics origin of the ridge.

The paper is structured as follows. In the first part, an overview of measured properties of the ridge using two- and three-particle correlation techniques is given. In particular, the centrality, transverse momentum, system size, particle type and path length dependence of the ridge is discussed. The second part of the paper is devoted to an overview of theoretical models explaining the physics origin of the ridge and confrontation of these theoretical predictions with the experimental data.

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## 2 Near-side ridge

Figure 2.1 shows the distributions of charged hadrons associated with a trigger hadron measured in central Au + Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV by the STAR [19], PHOBOS [21] and PHENIX [22] experiments at RHIC. The distributions were constructed by selecting a charged trigger particle within the transverse momentum interval $p_{\mathrm{T}}^{\mathrm{trig}} = (p_{\mathrm{T}}^{\mathrm{trig}}(\mathrm{min}), p_{\mathrm{T}}^{\mathrm{trig}}(\mathrm{max}))$, associated charged particles satisfying the condition $p_{\mathrm{T}}^{\mathrm{assoc}}(\mathrm{min}) < p_{\mathrm{T}}^{\mathrm{assoc}} < p_{\mathrm{T}}^{\mathrm{trig}}$ and calculating relative azimuthal ($\Delta\phi$) and pseudo-rapidity ($\Delta\eta$) angular differences between these trigger and associated particles. The correlations are corrected for the reconstruction efficiency of associated charged particles and experimental acceptance in $\Delta\phi$ and $\Delta\eta$.

Despite slightly different transverse momentum selections for trigger ($p_{\mathrm{T}}^{\mathrm{trig}}$) and associated ($p_{\mathrm{T}}^{\mathrm{assoc}}$) particles, all three experiments observe that a jet-like peak at small angular separations expected from jet fragmentation is accompanied by an extended correlation in $\Delta\eta$, *the ridge*, for associated particles with $p_{\mathrm{T}}^{\mathrm{assoc}} < 3$ GeV/$c$. This long-range correlation in pseudo-rapidity is unique to heavy-ion collisions and has not been observed in p + p or d + Au collisions. Although there has been an indication that the ridge-like correlations extend beyond $|\Delta\eta| > 2$ [23], the data recently released by the PHOBOS experiment [21] for $-2 < \Delta\eta < 4$ brought a solid confirmation of this observation and further extended the knowledge about the uniformity of the ridge-like correlations.

Before we come to a detailed discussion of the measured ridge properties, let us define several variables which will be used throughout the rest of the paper. To extract the ridge and jet-like yields, the two-dimensional $\Delta\eta - \Delta\phi$ distributions are normalized to the number of trigger particles and projected onto $\Delta\phi$ and $\Delta\eta$ in different $\Delta\eta$ and $\Delta\phi$ regions. Projecting the distributions onto $\Delta\phi$ within a certain $|\Delta\eta| < \Delta\eta(\mathrm{max})$ interval and subtracting the elliptic flow ($v_2$) modulated background results in the near-side yield, which is the sum of both ridge and jet-like yields. The commonly used method at RHIC to do this subtraction is based on the ZYAM (Zero Yield at Minimum) method [24], which assumes that the correlations can be decomposed into "jet" and harmonic distributions. While the elliptic flow is approximately uniform within the STAR pseudo-rapidity acceptance $|\eta| < 1.0$, this is not the case for the PHOBOS data extending over several units of pseudo-rapidity. Therefore, for the PHOBOS data the elliptic flow contribution to the correlation function is subtracted by using a $v_2$ parameterization, which is a function of centrality, $p_{\mathrm{T}}$ as well as of $\eta$. The jet-like yield is typically obtained by analyzing the correlations in two $\Delta\eta$ windows: $|\Delta\eta| < 0.7$ containing both jet-like and ridge correlations, and $|\Delta\eta| > 0.7$ containing only the ridge contributions, assuming that the jet-like contribution at large $\Delta\eta$ is negligible. The jet-like yield is thus free of systematic uncertainties due to the $v_2$ subtraction if a uniformity of $v_2$ with $\eta$ is assumed. This is a valid approximation for the STAR jet-like yields shown in this paper. An alternative way to obtain the jet-like yield is to use a $\Delta\eta$ projection by requiring $|\Delta\phi| < 0.7$ and extracting the jet-like yield as an area under the Gaussian peak sitting on a top of a flat background consisting of ridge and elliptic flow contributions. It has been found that the jet-like yields obtained by both mentioned methods agree well within the errors [19]. The ridge yield is then eventually obtained by subtracting from the total near-side yield the jet-like yield. The systematic errors on the ridge yield due to the elliptic flow subtraction are estimated by subtracting the $v_2$ measured by the event plane method, which gives the lower bound on the measured yield, and by subtracting the $v_2$ from the four-particle cumulant method, which determines the upper bound of the ridge yield. These systematic errors are point-to-point correlated.

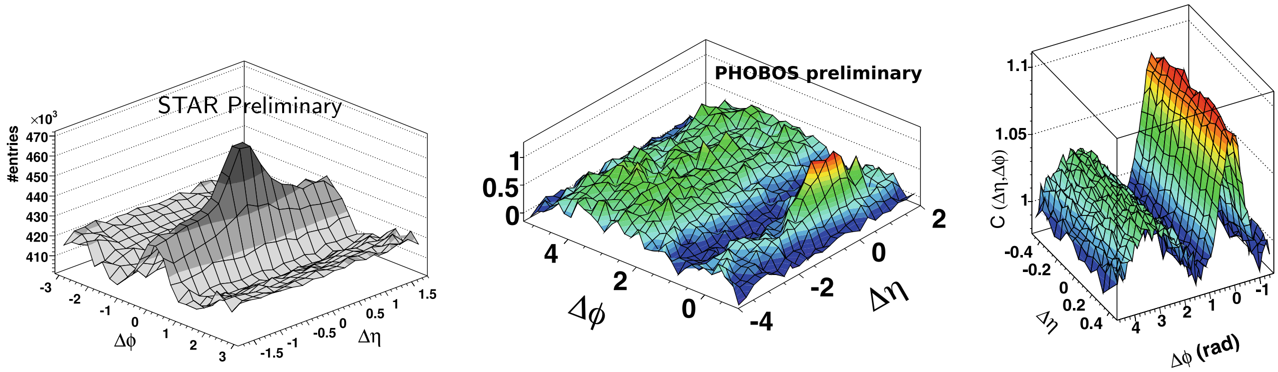

**Fig. 2.1** Di-hadron $\Delta\eta$–$\Delta\phi$ correlations in central Au + Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV. (*Left*) The STAR measurement of the raw correlation function for $p_{\mathrm{T}}^{\mathrm{trig}} = 3$–$6$ GeV/$c$ and 2 GeV/$c < p_{\mathrm{T}}^{\mathrm{assoc}} < p_{\mathrm{T}}^{\mathrm{trig}}$ in 0–12% central collisions [19]. (*Middle*) The PHOBOS measurement for $p_{\mathrm{T}}^{\mathrm{trig}} > 2.5$ GeV/$c$ and $p_{\mathrm{T}}^{\mathrm{assoc}} > 20$ MeV/$c$ for 0–20% most central collisions [21]. (*Right*) The PHENIX measurement for $p_{\mathrm{T}}^{\mathrm{trig}} = 2$–$3$ GeV/$c$ and $p_{\mathrm{T}}^{\mathrm{assoc}} = 2$–$3$ GeV/$c$ in 0–20% central collisions [22]

### 2.1 Centrality, energy and system size dependence

The centrality dependence of ridge and jet-like yields of charged particles associated with charged and strange ($\Lambda$, $K_s^0$, $\Xi$) trigger particles in d + Au, Cu + Cu and Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV measured by STAR is shown in Fig. 2.2 [25]. For all studied trigger particle species, the yield of charged particles associated with the ridge shows a significant increase by a factor of 3–4 going from d + Au to central Au+Au collisions. In contrast, the jet-like yield is within errors independent of centrality and collision system and consistent with that measured in d + Au collisions. The data may indicate that there is a trigger particle dependence for both, ridge and jet-like yields. However, the systematic errors due to finite two track resolution and the degree of correlation of systematic errors are still under study and may be sufficient to explain the observed differences.

The PHOBOS results on the centrality dependence of the ridge yield measured in $-4 < \Delta\eta < 2$, i.e. away from the near-side jet-like peak, for charged di-hadron correlations are shown in Fig. 2.3. The steep increase of the ridge magnitude with $N_{\text{part}}$ is similar to the STAR measurements discussed above. Within the errors, the ridge yield at the large $\Delta\eta$ measured is consistent with zero in the most peripheral bin (40–50%, $N_{\text{part}} \approx 80$) measured by the PHOBOS experiment. However, the systematic errors do not yet exclude a smooth disappearance of the ridge as one approaches p + p collisions.

Further studies of the energy dependence of the jet-like and ridge yields in di-hadron correlations have shown that although both yields are considerably smaller at the collision energy $\sqrt{s_{NN}} = 62$ GeV than at $\sqrt{s_{NN}} = 200$ GeV, similar features are observed at both energies and the ridge/jet-like ratio is roughly independent of energy as demonstrated in Fig. 2.4. More details can be found in [25].

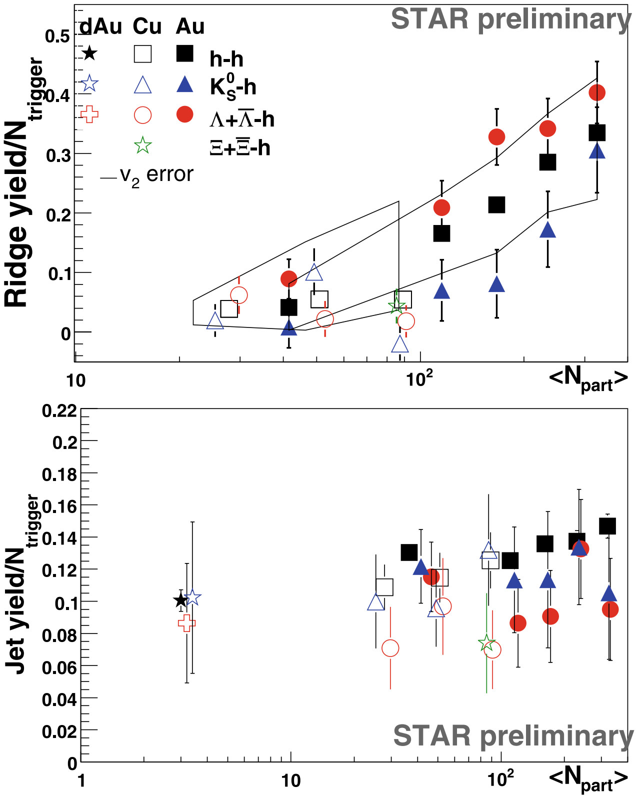

**Fig. 2.2** Centrality dependence of ridge (*top*) and jet-like (*bottom*) yields measured by the STAR experiment for various trigger particles in d + Au, Cu + Cu and Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The trigger particles were selected with $p_T^{\text{trig}} = 3$–$6$ GeV/$c$ and the associated particles with 1.5 GeV/$c < p_T^{\text{assoc}} < p_T^{\text{trig}}$. The *lines* are systematic uncertainties due to the elliptic flow subtraction for unidentified trigger particles. The systematic errors due to the $v_2$ subtraction are comparable for $K_S^0$ triggers and roughly 3/2 times larger for $\Lambda$ and $\Xi$ trigger particles. The figure is from [25]

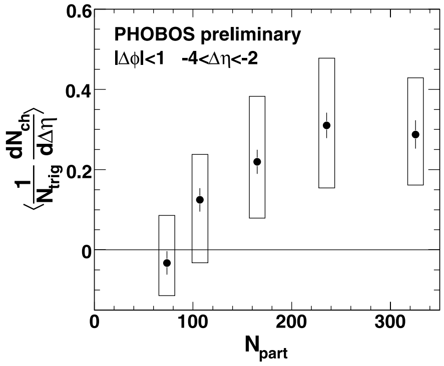

**Fig. 2.3** Centrality dependence of the ridge yield of charged particles with $p_T^{\text{trig}} > 2.5$ GeV/$c$ and $p_T^{\text{assoc}} > 20$ MeV/$c$ measured by the PHOBOS experiment in $-4 < \Delta\eta < 2$. The boxes correspond to errors on the elliptic flow $v_2$ estimate and ZYAM background subtraction procedure. The figure is from [21]

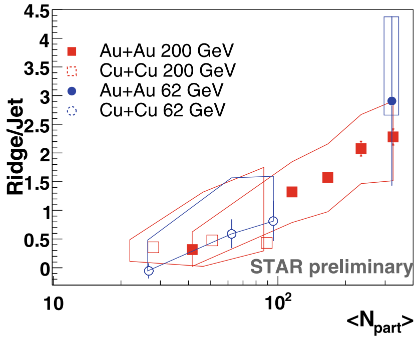

**Fig. 2.4** Collision energy dependence of ridge/jet-like yield ratio measured by the STAR experiment for di-hadron correlations in Cu + Cu and Au + Au collisions at $\sqrt{s_{NN}} = 62$ and 200 GeV. The trigger particles were selected with $p_T^{\text{trig}} > 2.5$ GeV/$c$ and the associated particles with 1.5 GeV/$c < p_T^{\text{assoc}} < p_T^{\text{trig}}$. The *lines* are systematic uncertainties due to the elliptic flow subtraction. The figure is from [25]

## 2.2 Transverse momentum dependence

It is important to investigate the dependence of the ridge-like correlations on the transverse momentum of the trigger as well as on the associated particles. Figure 2.5 shows the dependence of the ridge yield on the transverse momentum of trigger particles, $p_{\mathrm{T}}^{\mathrm{trig}}$ for charged di-hadron correlations. The yields are shown for associated charged hadrons with $p_{\mathrm{T}}^{\mathrm{assoc}} > 2$ GeV/$c$ from peripheral to central Au + Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV. The ridge yield is approximately independent of $p_{\mathrm{T}}^{\mathrm{trig}}$ and persists up to $p_{\mathrm{T}}^{\mathrm{trig}} \approx 8$ GeV/$c$, being limited by the statistics of the available data. The fact that the ridge exists in the $p_{\mathrm{T}}$ domain where parton fragmentation governs the particle production indicates that its physical origin is associated with jet production. The high statistics data collected in Run 7 at RHIC will extend the reach in $p_{\mathrm{T}}^{\mathrm{trig}}$ and thus bring further knowledge at even higher $p_{\mathrm{T}}^{\mathrm{trig}}$.

A detailed study of the $p_{\mathrm{T}}$ spectra of particles associated with the ridge in different $p_{\mathrm{T}}^{\mathrm{trig}}$ windows and its comparison to the $p_{\mathrm{T}}$ spectra of particles produced in the bulk and associated with the jet is presented in Fig. 2.6. The inverse slope extracted from an exponential fit to the $p_{\mathrm{T}}$ spectra is for the ridge-like yield independent of $p_{\mathrm{T}}^{\mathrm{trig}}$ and only slightly larger (by ≈40–50 MeV) than that of the inclusive charged-particle $p_{\mathrm{T}}$ spectrum. Contrary to this observation, the jet-like yield has a significantly harder spectrum, with an inverse slope increasing steeply with $p_{\mathrm{T}}^{\mathrm{trig}}$ which is in line with jet fragmentation.

## 2.3 Particle composition of the ridge

Next the results on particle composition in the jet-like and ridge components are discussed. The baryon/meson ratios in both non-strange and strange quark sectors measured at RHIC, steeply increase with $p_{\mathrm{T}}$ up to about $p_{\mathrm{T}} \approx 3$ GeV/$c$, where the enhancement of baryon/meson production reaches its maximum value of ≈3 relative to p + p collisions. A fall-off of the baryon/meson ratio is observed for $p_{\mathrm{T}} > 3$ GeV/$c$ and both, non-strange and strange baryon/meson ratios, approach each other and eventually reach the values measured in p + p collisions at $p_{\mathrm{T}} \approx 6$ GeV/$c$. This finding can be rather successfully explained by the parton recombination and coalescence models. A study of baryon/meson ratios in the ridge is therefore the key measurement which will help to quantify what role the recombination and coalescence particle production mechanisms play in its origin.

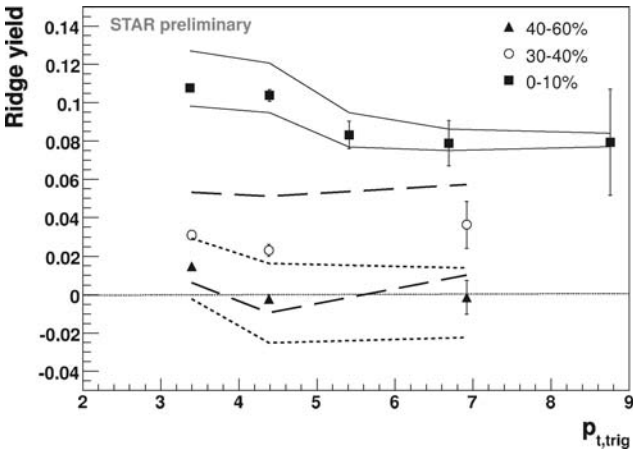

**Fig. 2.5** Ridge yield in $|\Delta\eta| < 1.7$ as a function of $p_{\mathrm{T}}^{\mathrm{trig}}$ for $p_{\mathrm{T}}^{\mathrm{assoc}} > 2$ GeV/$c$ and several centrality bins in Au + Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV measured by the STAR experiment. The lines are systematic uncertainties due to the elliptic flow subtraction. The figure is from [19]

The data measured by both the STAR [25–27] and PHENIX [22] Collaborations show that the baryon/meson ratios in the ridge are enhanced with respect to those in the elementary collisions. This is in detail demonstrated in Fig. 2.7 which shows the $p_{\mathrm{T}}$ dependence of the p/$\pi$ ratio in the jet-like component and in the ridge together with the values from inclusive $p_{\mathrm{T}}$ spectra in Au + Au and p + p collisions [27]. While the baryon/meson ratios for the jet-like component agree with those measured in p + p and d + Au collisions, the ratios in the ridge are similar to that from the inclusive measurements in Au + Au collisions. This observation thus supports ridge models, where hadronization is based on parton recombination.

## 2.4 Path length dependence

Additional information on the ridge origin can be obtained from the analysis of di-hadron correlations with respect to

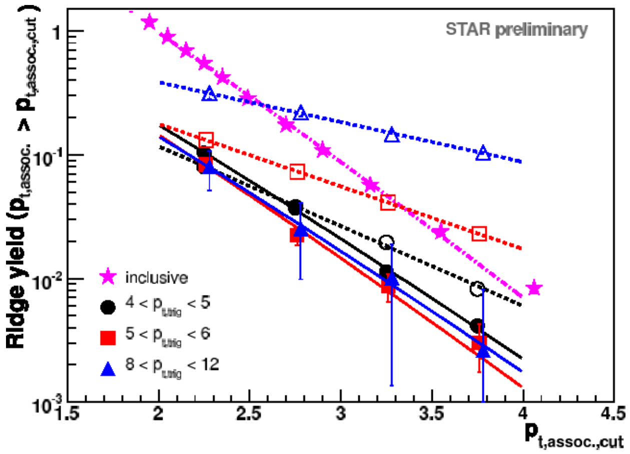

**Fig. 2.6** Near-side $p_{\mathrm{T}}^{\mathrm{assoc}}$ charged hadron spectra for several $p_{\mathrm{T}}^{\mathrm{trig}}$ ranges in central (0–12%) Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV measured by STAR. The spectra of charged particles associated with jet-like correlations are shown as open symbols, for the ridge solid symbols are used. For completeness, the inclusive particle $p_{\mathrm{T}}$ spectrum is plotted as well (*stars*). The *lines* are exponential fits to the measured $p_{\mathrm{T}}^{\mathrm{assoc}}$ spectra. The figure is from [19]

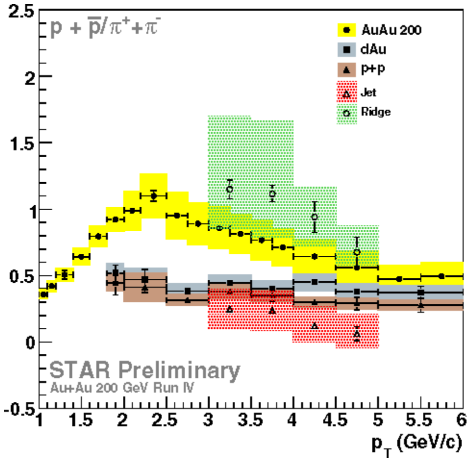

**Fig. 2.7** Proton/pion ratios in the ridge (*open circles*) and jet-like component (*open triangles*) compared to the inclusive particle ratios in $p+p$ (*solid triangles*), $d+Au$ (*solid square*) and $Au+Au$ (*solid circles*) collisions measured at $\sqrt{s_{NN}}=200$ GeV by the STAR experiment. The figure is from [27]

the orientation of event plane. By imposing further condition on the trigger particle and selecting trigger particles with a given azimuthal angular difference with respect to the event plane, path length effects can be investigated.

Figure 2.8 shows the STAR measurements of the event plane dependence of the ridge and jet-like yields in $Au+Au$ collisions at $\sqrt{s_{NN}}=200$ GeV [28]. The jet-like yield is about constant or only slightly increases with the angle with respect to the event plane, but the ridge yield shows sensitivity to the path length traversed. While the ridge yields in the event plane for both semi-central (20–60%) and central (0–5%) collisions are similar in magnitude, in semi-central collisions the ridge magnitude decreases more steeply with the azimuthal angle difference between the trigger particle and the event plane. This observation implies a strong near-side "jet"–medium interaction in the event plane resulting in the ridge formation and a minimal interaction perpendicular to the event plane in semi-central collisions. In central collisions this dependence is much weaker, in line with an almost symmetric shape of the collision zone, and in the direction perpendicular to the event plane the ridge remains sizable. This may indicate a connection between surface geometry and the formation of the ridge.

## 2.5 Three-particle $\Delta\eta$ correlations

In this paragraph we present studies of three-particle correlations in pseudo-rapidity, $\Delta\eta_1-\Delta\eta_2$, where $\Delta\eta_{1(2)}=\eta^{\mathrm{trig}}-\eta^{\mathrm{assoc}1(2)}$. Despite the fact that the yields in the three-particle correlations are extracted on a statistical basis as in the case of the two-particle correlations discussed above, information based on 'event-by-event' correlations of two particles associated with the same trigger particle allows us to study finer structures of the ridge.

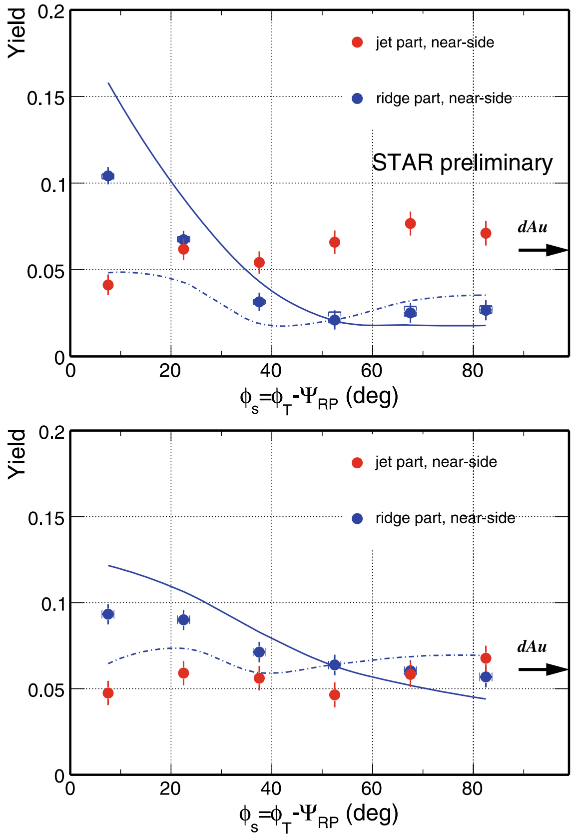

**Fig. 2.8** Ridge and jet-like yields from di-hadron correlations in semi-central (*top*) and central (*bottom*) $Au+Au$ collisions at $\sqrt{s_{NN}}=200$ GeV measured by STAR as a function of angular difference between the trigger particle and the event plane. The *lines* are systematic uncertainties due to the elliptic flow subtraction. The figure is from [28]

First studies of the three-particle pseudo-rapidity correlations were performed in $d+Au$ and $Au+Au$ collisions at $\sqrt{s_{NN}}=200$ GeV by the STAR experiment [29]. For this study, charged trigger particles with $p_T^{\mathrm{trig}}=3\text{–}10$ GeV/$c$ and associated charged particles with $p_T^{\mathrm{assoc}}=1\text{–}3$ GeV/$c$ have been used. The resulting $\Delta\eta_1-\Delta\eta_2$ distributions after the background subtraction are displayed in Fig. 2.9. For a detailed explanation of the analysis method, background subtraction technique and systematic error evaluation, we refer the reader to [29].

A clear jet-like peak is present at $(\Delta\eta_1,\Delta\eta_2)\sim(0,0)$ in both, $d+Au$ and $Au+Au$ collisions. In addition, a uniform overall excess of associated particle pairs is observed in semi-central and central $Au+Au$ collisions. Further detailed studies of on-diagonal, off-diagonal, radial and angular projections confirmed this observation and showed that within errors no significant correlation exists between the particles in the ridge (cf. [29]). The fact that no evidence for horizontal or vertical strips in the correlations has been found indicates that coexistence of the ridge and the jet fragmentation in vacuum is small.

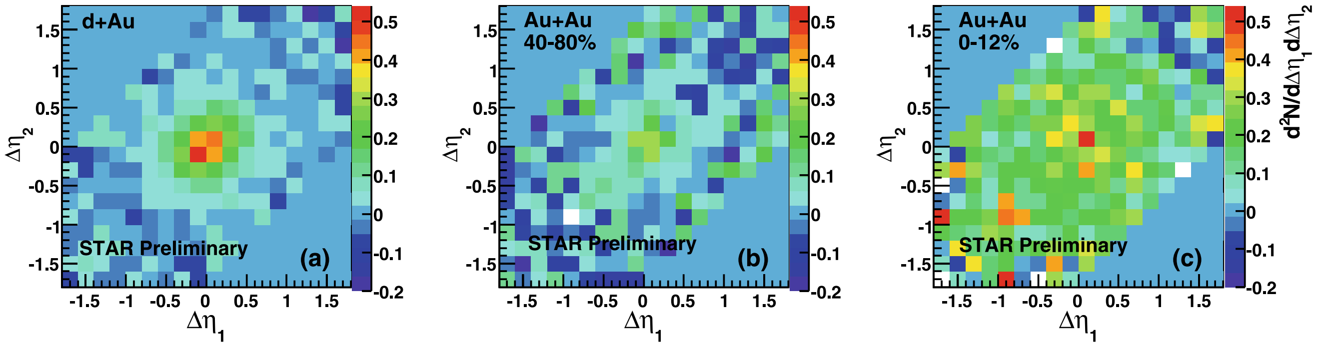

**Fig. 2.9** Three-particle correlations in $\Delta\eta$ for small azimuthal angle difference ($\Delta\phi < 0.7$) between associated particles and trigger particle measured by STAR for (**a**) minimum bias d + Au collisions, (**b**) 40–80% Au + Au collisions and (**c**) 0–12% central Au + Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV. The figure is from [29]

## 3 Model predictions

The observation of the ridge phenomenon has led to intense theoretical discussions since it has been observed for the first time. Several models are qualitatively able to explain the physics origin of the ridge. Here we discuss some of them.

The large increase of the ridge yield from Cu + Cu to central Au + Au collisions with respect to d + Au collisions together with the observed enhanced baryon/meson ratios can be qualitatively understood in the framework of parton recombination and coalescence [30], which has been successful in describing the increased baryon/meson ratios in the inclusive particle production in heavy-ion collisions at RHIC energy. The recombination model also predicts that the inverse slope of the $p_{\mathrm{T}}$ spectra of particles in the ridge should be only slightly higher, by few tens of MeV, than those of particles produced in the bulk which is in line with the data.

There are several models available in which the presence of longitudinal flow creates ridge-like correlation structures. The interaction of high-$p_{\mathrm{T}}$ partons with a dense medium under the presence of strong longitudinal flow and coupling of the induced gluon radiation to longitudinal flow is predicted to form a ridge in $\Delta\eta$ [31]. The physical mechanism suggested in [32] relates the origin of the ridge to the spontaneous formation of extended color fields in a longitudinally expanding medium due to the presence of plasma instabilities. The momentum range of the partons contained in the ridge is in the recombination regime and therefore it should reflect itself in the baryon/meson ratio of associated hadrons. The effects of momentum broadening in an anisotropic plasma induced by energy loss have been studied in [33]. Model predictions connecting the origin of the ridge with the longitudinal flow would in general expect an excess of associated particles along the diagonal in three-particle $\Delta\eta$–$\Delta\eta$ correlations, which is not supported by the data. Moreover, the fact that the ridge extends (at least) in six units of $\Delta\eta$ would likely require the presence of unrealistically strong longitudinal flow.

A completely different mechanism for the ridge origin is based on jet quenching in combination with the strong radial flow [34]. The radial expansion of the system is predicted to create strong position-momentum correlations that lead to characteristic rapidity, azimuthal and $p_{\mathrm{T}}$ correlations among produced particles. First quantitative predictions based on this mechanism were published in [35]. The model agrees qualitatively well with the observation of a stiffer inverse slope of $p_{\mathrm{T}}^{\mathrm{assoc}}$ spectra and increased baryon/meson ratios in the ridge, but it predicts a broad correlation at the near side. A recent implementation of the transverse radial flow effects in Pythia simulated data [36] under the assumption of maximal coupling, i.e. without jet quenching, is able to quantitatively describe features observed in two-particle correlations. In this model the near-side peak increases with the radial expansion velocity $\beta_{\mathrm{r}}$ (kinematical focusing), while the away-side peak flattens out, separates in two "bumps" and is refocused at near side at large $\beta_{\mathrm{r}}$. This approach, even though very simplified, is able to simultaneously reproduce the disappearance of the away-side peak and formation of the dip structure and the ridge formation at near side. However, the model violates momentum conservation and the data do not show narrowing of the ridge for $p_{\mathrm{T}}^{\mathrm{assoc}} < 3$ GeV/$c$ as predicted by the current version of this model.

In the momentum kick model [37], partons in the medium suffer a collision with a jet and acquire a momentum kick along the jet direction forming a ridge structure. The momentum kick model is at the moment the most quantitative one. It is able to describe the $p_{\mathrm{T}}^{\mathrm{assoc}}$ spectra, enhanced baryon/meson ratios, system and energy dependence of the ridge yields, and at the same time it predicts the existence of the ridge yield at large $\Delta\eta$ in agreement with the PHOBOS measurements. The predictions of the three-particle pseudorapidity correlations are in progress.

## 4 Summary

In summary, we have presented an overview of the experimental data on the large pseudo-rapidity correlations at near side, the ridge, which are present in heavy-ion collisions at RHIC energy. Experimentally, the ridge properties have been studied in great detail including its centrality, collision system, energy, transverse momentum, path length and particle composition.

The fact that the ridge persists up to $p_T^{\mathrm{trig}} \approx 8$ GeV/$c$ suggests that the ridge origin is associated with the jet production. It is found that the ridge properties (transverse momentum spectra, particle composition) are close to those measured for particles produced in the bulk and thus favor models with hadronization based on parton recombination and coalescence. The recent observations of the uniformity of the ridge over six units in $\Delta\eta$ and a uniform excess of associated particles in three-particle $\Delta\eta$–$\Delta\eta$ correlations challenge models describing the ridge and seem to disfavor models based on longitudinal flow.

In this paper, we have focused on describing the properties of the 'high-$p_T$' ridge in the triggered correlation studies; however, the STAR experiment has also found that a 'soft' ridge exists at low transverse momenta in untriggered correlations [38]. As for the high-$p_T$ ridge, the width of this soft ridge is broad in $\Delta\eta$ and narrow in $\Delta\phi$. The discussion of the soft ridge phenomenon goes beyond the scope of this paper, but we would like to refer the interested reader to a recent discussion of this phenomenon in the framework of the color glass condensate, which in combination with transverse radial flow is expected to create a ridge-like structure [39, 40]. It remains to be seen whether and how both ridge phenomena are related to each other.

More studies with even higher-$p_T$ trigger particles, at large $\eta$ and $\Delta\eta$ and a detailed investigation of three-particle pseudo-rapidity correlations are still needed. Some of these measurements will be possible with the new data collected at RHIC. On the theoretical side, more quantitative model predictions are required. Ideally, the models should be able to describe simultaneously the energy content in the ridge, nuclear modification factors and the interplay of the medium modification of both near and away-side correlation peaks.

**Acknowledgements** The work has been supported by the IRP AVOZ10480505, by the Grant Agency of the Czech Republic under Contract No. 202/07/0079 and by the grant LC07048 of the Ministry of Education of the Czech Republic.

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