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Research Article

Dihadron Azimuthal Correlations in 200 GeV Au-Au and 2.76 TeV Pb-Pb Collisions

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In a multisource thermal model, we detailedly show dihadron azimuthal correlations for 20–40% and 50–80% in Au-Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV and over a centrality range from 10–15% to 70–80% in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV. The model can approximately describe the azimuthal correlations of particles produced in the collisions. The p_x amplitude of the corresponding source is magnified, and the source translates along the direction. The factor α_x, in most cases, increases with the increase of the centrality in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV.

1. Introduction

An important subject of high energy physics is to discuss the strongly interacting matter and nuclear matter at high temperature and high density by heavy-ion collisions at ultrarelativistic energies [1, 2]. In the initial stage of the collision, tremendous amounts of energy are accumulated at a finite zone in a short time. Then, they result in the creation of a nearly perfect quark-gluon plasma (QGP), which will undergo the hadronization and freeze-out and will finally produce lots of observed particles [3]. As we know, a description of strong nuclear interactions is quantum chromodynamics (QCD). Studying QCD phase transition and properties of quark matter is a main target of heavy-ion collisions at relativistic heavy ion collider (RHIC) and large hadron collider (LHC) [4]. But the evolution of the heavy-ion collisions and the production of hadrons are very complicated for us. In general, we can extract the evolution information of the colliding system by analyzing the properties of observable quantities, which contain multiplicity, transverse momentum, polar and elliptic flow, and angular correlation, and so on.

In recent years, a dihadron correlation has been one of the hot topics in particle and nuclear physics. Experimentally, RHIC and LHC have observed or will observe the dihadron azimuthal correlations in proton-proton, proton-nucleus, and nucleus-nucleus collisions. Some theoretical investigations [5–10] give many valuable and interesting results to explain the ridge phenomena, which were regarded as a contribution from jet-medium interactions. In these works, various models have been proposed. In this paper, we would like to apply a multisource thermal model to discuss azimuthal correlations of dihadron for different associated transverse momentum p_T^{assoc} intervals in 20–40% and 50–80%, which are measured in Au-Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV [11]. For a comparison, we will also use the model to discuss the azimuthal correlations of the dihadron for a wide centrality range in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV [12].

2. Dihadron Azimuthal Correlation in the Model and Experiments

As a presupposition in the multisource thermal model [13–15], the observed particles are projected isotropically

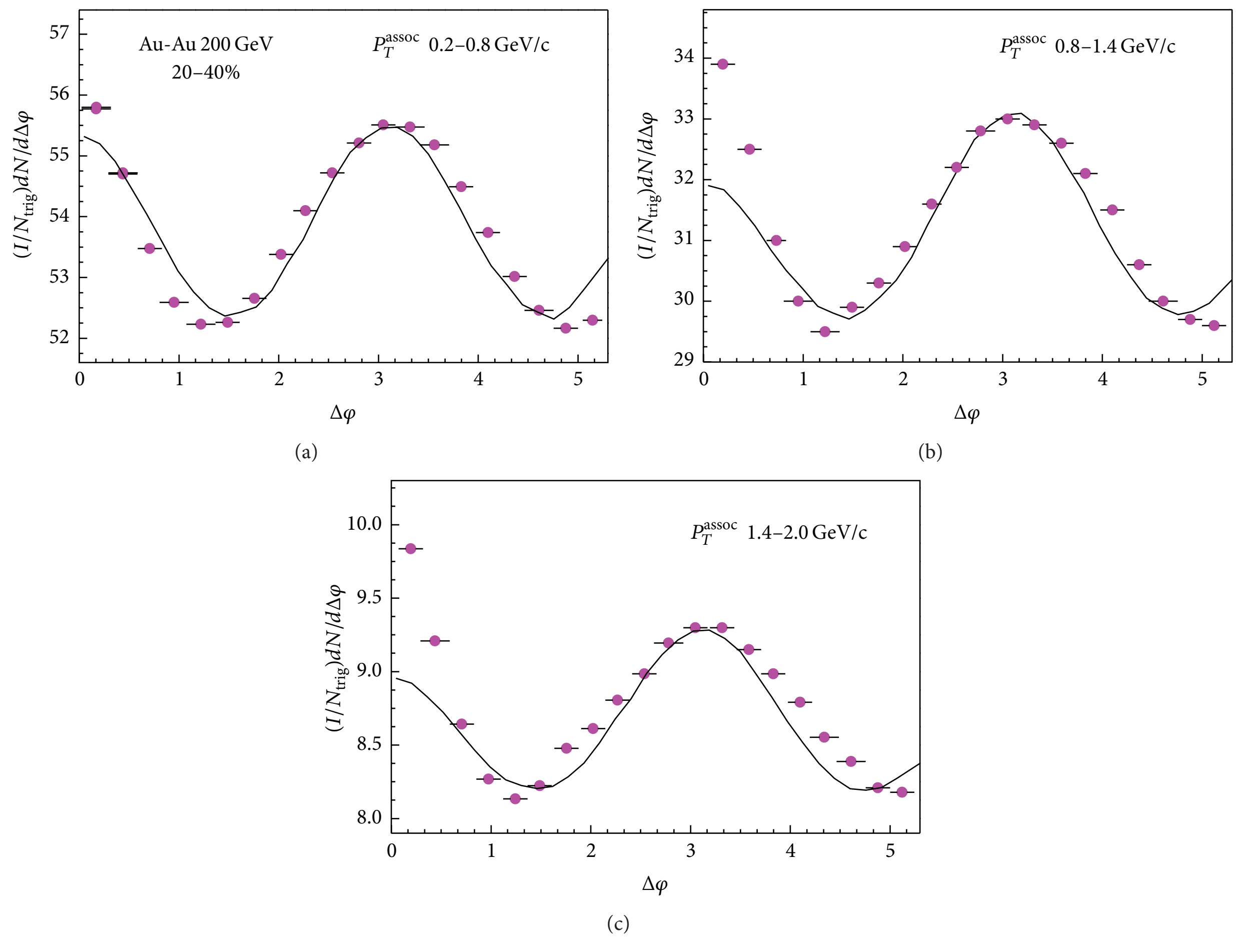

Figure 1: Dihadron azimuthal correlations for 20–40% in Au-Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The symbols denote the data of the RHIC [11], and the lines are the modeling results.

from different or the same coordinates in a system of high-energy collision. The emission coordinates compose a space of emission sources, which are at a local equilibrium state. For the particle pairs, the normal distribution is taken to calculate their spectra [16, 17]. The two particles may be considered to be from two emission coordinates in one source or two sources. Due to the interaction between the emissions, in momentum space (p_x', p_y', p_z'), the particle distribution is given by

$$p_x = \alpha_x p_x' + \beta_x,$$
$$p_y = \alpha_y p_y' + \beta_y, \tag{1}$$

where α_x and α_y denote the amplitude change of the momentum and β_x and β_y denote the translational amplitude. By the Monte Carlo method, the particle momentum is

$$p_x = \alpha_x \sigma \sqrt{-2\ln x_1}\cos(2\pi x_2) + \beta_x,$$
$$p_y = \alpha_y \sigma \sqrt{-2\ln y_1}\cos(2\pi y_2) + \beta_y, \tag{2}$$

where σ is the standard deviation. We obtain the formulation of the dihadron correlation,

$$\Delta\varphi = \arctan\left[\sigma\frac{\alpha_y\sqrt{-2\ln y_1}\cos(2\pi y_2) + \beta_y/\sigma}{\alpha_x\sqrt{-2\ln x_1}\cos(2\pi x_2) + \beta_x/\sigma}\right]. \tag{3}$$

Figures 1 and 2 show dihadron azimuthal correlations for 20–40% and 50–80% in Au-Au collisions at $\sqrt{s_{NN}} = 200$ GeV. The p_T^{assoc} ranges are 0.2–0.8 GeV, 0.8–1.4 GeV, and 1.4–2.0 GeV, respectively. The symbols indicate the experimental data observed in the RHIC [11], and the lines indicate the modeling results. Table 1 shows α_x and β_x extracted by fitting the data. The p_x amplitude of the source increases, and the source translates along a negative direction of the p_x [6, 18, 19]. For the same centrality, the values of α_x and $|\beta_x|$ increase with the increase of p_T^{assoc} intervals [20]. For the same p_T^{assoc} interval, the values of α_x for 50–80% are greater than those in 20–40%. It is found that the central 20–40% and 50–80% events both have a single-peak structure.

Figure 3 shows the azimuthal correlations of the per-trigger-particle associated hadrons produced in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. The symbols indicate the data measured by the CMS collaboration at the LHC [12], and the lines indicate the modeling results. The rapidity η interval

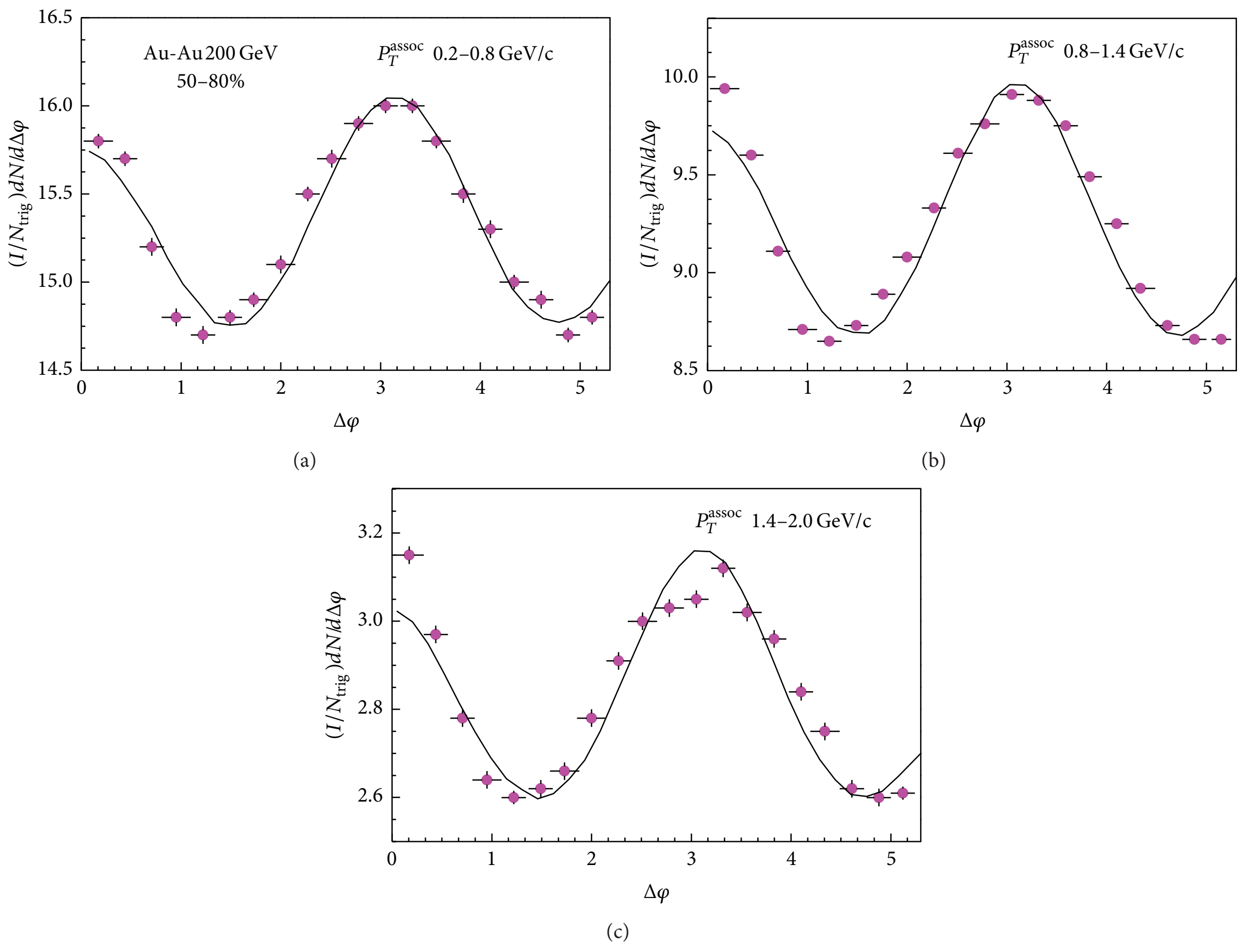

FIGURE 2: Same as Figure 1, but for 50–80%.

TABLE 1: Values of α_x and β_x extracted from Figures 1–5.

Figure	Centrality	α_x	β_x
Figure 1(a)	20–40%	1.029	−0.001
Figure 1(b)	20–40%	1.045	−0.015
Figure 1(c)	20–40%	1.050	−0.020
Figure 2(a)	50–80%	1.038	−0.008
Figure 2(b)	50–80%	1.065	−0.010
Figure 2(c)	50–80%	1.070	−0.040
Figure 3(a)	10–15%	1.025	−0.003
Figure 3(b)	15–20%	1.039	0.001
Figure 3(c)	20–25%	1.051	0.004
Figure 3(d)	25–30%	1.060	0.004
Figure 4(a)	30–35%	1.068	0.004
Figure 4(b)	35–40%	1.071	0.004
Figure 4(c)	40–50%	1.072	0.004
Figure 4(d)	50–60%	1.067	−0.007
Figure 5(a)	60–70%	1.057	−0.013
Figure 5(b)	70–80%	1.044	−0.040

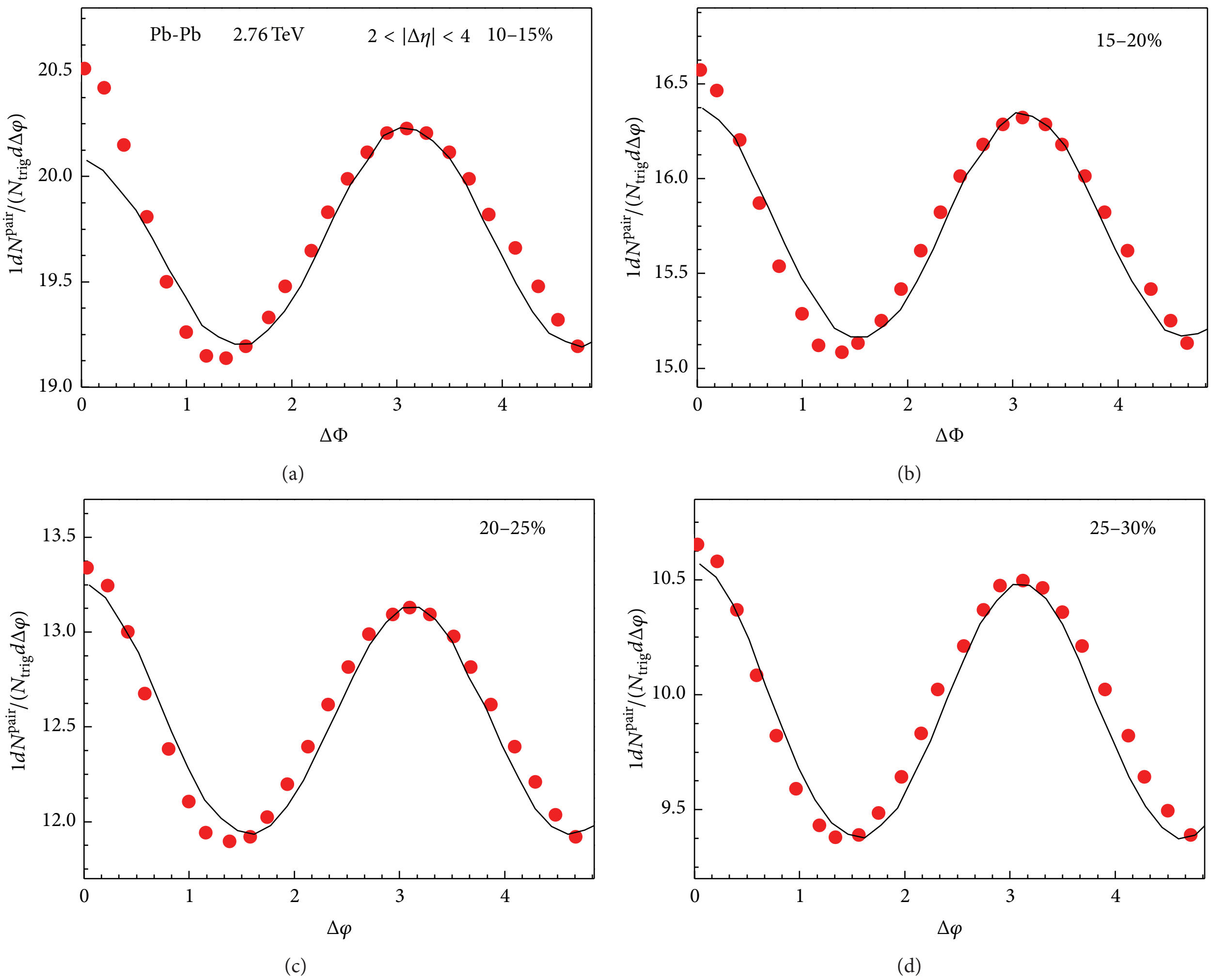

FIGURE 3: Azimuthal correlations of the per-trigger-particle associated hadrons for 10–15%, 15–20%, 20–25%, and 25–30% in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV in $3 < p_T^{trig} < 3.5$ GeV/c and $1 < p_T^{assoc} < 1.5$ GeV/c. The symbols denote the data of the CMS experiment at the LHC [12], and the lines denote the modeling results.

is 2–4 for trigger particles with p_T in 3–3.5 GeV and for associated particles with p_T in 1–1.5 GeV for centralities 10–15%, 15–20%, 20–25%, and 25–30%. The modeling results are in agreement with the data for the four centrality intervals. The values of α_x and β_x are listed in Table 1. The p_x amplitude of the source increases, and the source translates along the negative direction of the p_x for 10–15%. For the other three centralities, the source translates along the positive direction of the p_x. In addition, there is a single-peak shape in the figure for the four centrality bins.

Similar to Figure 3, we present the correlations as a function of $\Delta\varphi$ in Figures 4 and 5. The symbols indicate the data [12] for 30–35%, 35–40%, 40–50%, 50–60%, 60–70%, and 70–80%. The values of α_x and β_x are also given in Table 1. The p_x amplitude of the source is also magnified, and the source translates along the positive p_x direction for 30–35%, 35–40%, and 40–50% and along the negative p_x direction for the other centralities. With the increase of the centrality, the value of α_x increases over a range from 30–35% to 40–50% and decreases from 50–60% to 70–80%. In Figures 3 and 4, there is the single-hump phenomenon.

3. Conclusion

In a multisource thermal model, we investigate the dihadron azimuthal correlations for 20–40% and 50–80% in Au-Au collisions at $\sqrt{s_{NN}} = 200$ GeV in the associated transverse momentum p_T^{assoc} intervals, 0.2–0.8, 0.8–1.4, and 1.4–2.0 GeV. As a comparison, we also investigate the azimuthal correlations of particles produced in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV for trigger particles with p_T in 3–3.5 GeV and for associated particles with p_T in 1–1.5 GeV. By comparing the model results with the experimental data, we find that the model can approximately describe the dihadron azimuthal correlations of hadrons produced in Au-Au collisions at 200 GeV and in Pb-Pb collisions at 2.76 TeV. In the calculation, the parameter α_x is used to characterize the expansion extent of the source in the p_x direction and the parameter

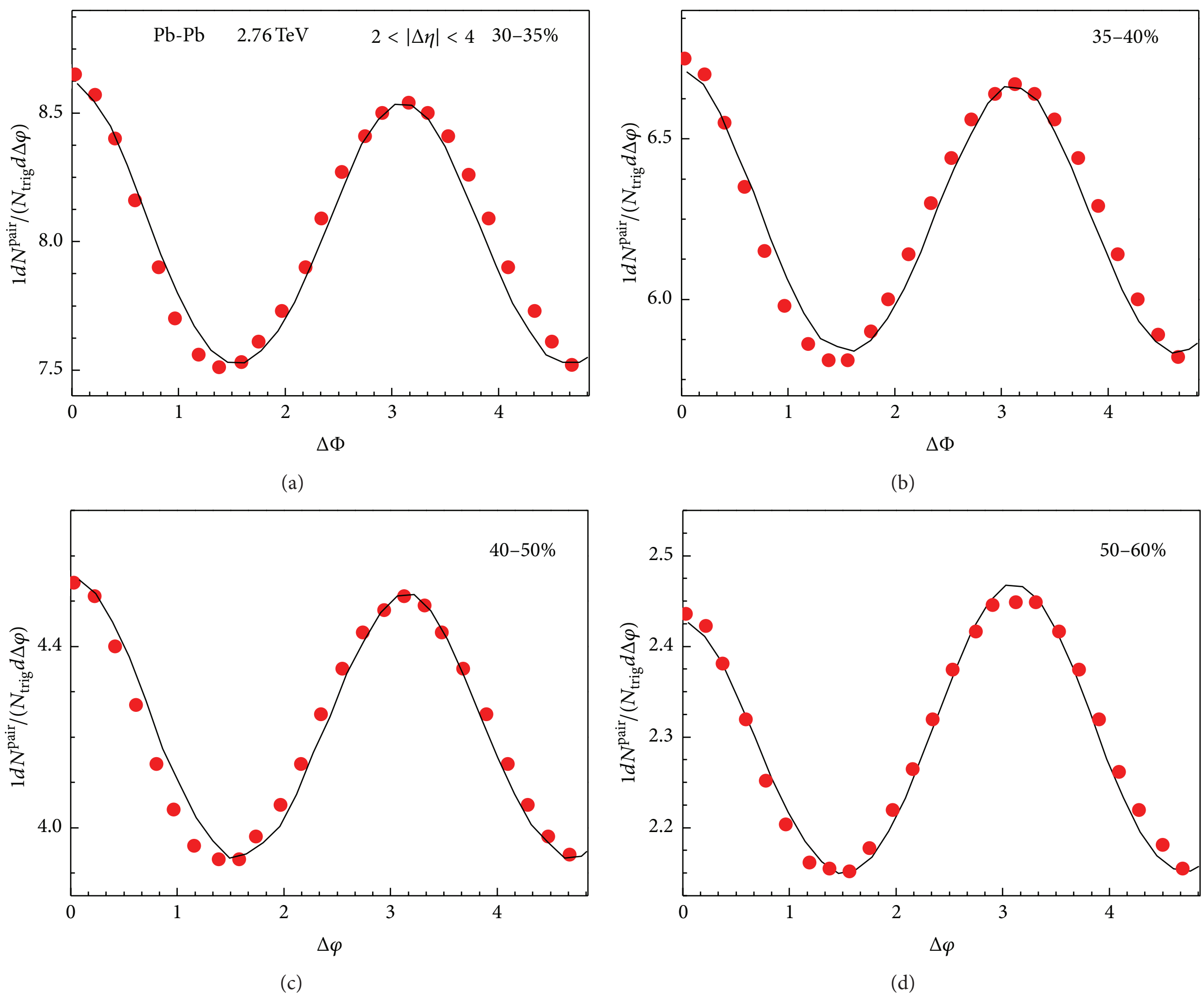

FIGURE 4: The same as Figure 3, but for 30–35%, 35–40%, 40–50%, and 50–60%.

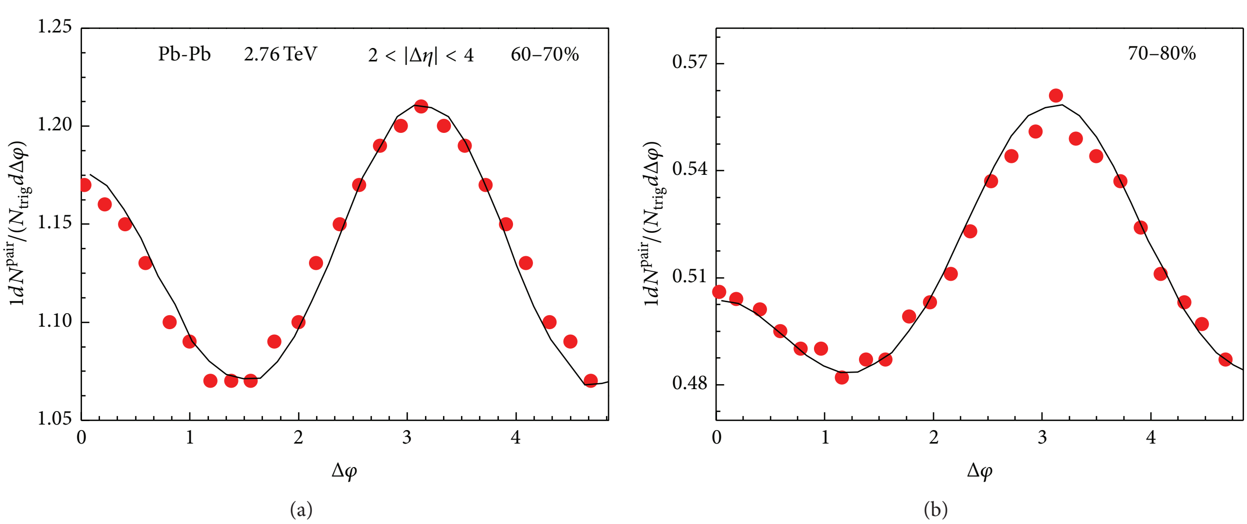

FIGURE 5: The same as Figure 3, but for 60–70% to 70–80%.

β_x is used to characterize the source movement along the positive or negative p_x direction for the different centralities. The p_x amplitude of the source is magnified, and the source translates along the p_x direction. In most cases, the value of α_x increases with the increase of the centrality in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV. Moreover, a single-peak structure has been seen in all the figures.

For a dihedron, the "trigger" and "associated" particles at final state are projected from the two coordinates in single or two sources formed in the collisions. The interaction between the two emission coordinates leads to the dihadron azimuthal correlation. In the high-energy collisions, the model has successfully described a variety of observables spectra at final state [9, 10, 13, 14], which reveal a multisource phenomenon in the colliding process. Further discussions on the dihadron azimuthal correlations of other different colliding systems using the model will be of interest.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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References

[1] L. Adamczyk, J. K. Adkins, G. Agakishiev et al., "Energy dependence of moments of net-proton multiplicity distributions at RHIC," *Physical Review Letters*, vol. 112, Article ID 032302, 2014.

[2] G. Antchev, P. Aspell, I. Atanassov, and et al, "Double diffractive cross-section measurement in the forward region at the LHC," *Physical Review Letters*, vol. 111, Article ID 262001, 2013.

[3] B. Abelev, J. Adam, D. Adamová (ALICE Collaboration) et al., "Centrality dependence of $\boldsymbol{\pi}, \mathbf{K}$, and $\mathbf{p}$ production in Pb-Pb collisions at $\sqrt{S_{NN}} = 2.76$ TeV," *Physical Review C*, vol. 88, Article ID 044910, 2013.

[4] A. Adare, S. Afanasiev, C. Aidala et al., "Cross section and double helicity asymmetry for η mesons and their comparison to π^0 production in $p + p$ collisions at $\sqrt{s} = 200$ GeV," *Physical Review D*, vol. 83, p. 032001, 2011.

[5] N. Armesto, C. A. Salgado, and U. A. Wiedemann, "Measuring the collective flow with jets," *Physical Review Letters*, vol. 93, no. 24, Article ID 242301, 2004.

[6] P. Bożek and W. Broniowski, "Collective dynamics in high-energy proton-nucleus collisions," *Physical Review C*, vol. 88, Article ID 014903, 2013.

[7] K. Werner, I. Karpenko, and T. Pierog, "'Ridge' in proton-proton scattering at 7 TeV," *Physical Review Letters*, vol. 106, Article ID 122004, 2011.

[8] M. Petran and J. Rafelski, "Universal hadronization condition in heavy ion collisions at $\sqrt{s_{NN}} = 62$ GeV and at $\sqrt{s_{NN}} = 2.76$ TeV," *Physical Review C*, vol. 88, Article ID 021901(R), 2013.

[9] B.-C. Li, Y.-Y. Fu, L.-L. Wang, and F.-H. Liu, "Dependence of elliptic flows on transverse momentum and number of participants in Au+Au collisions at $\sqrt{S_{NN}} = 200$ GeV," *Journal of Physics G: Nuclear and Particle PhysicsEmail alert RSS feed*, vol. 40, no. 2, Article ID 025104, 2013.

[10] F.-H. Liu, T. Tian, H. Zhao, and B.-C. Li, "Extracting chemical potentials of quarks from ratios of negatively/positively charged particles in high-energy collisions," *The European Physical Journal A*, vol. 50, p. 62, 2014.

[11] Y. H. Zhu, Y. G. Ma, J. H. Chen, G. L. Ma, S. Zhang, and C. Zhong, "Nonflow contribution to dihadron azimuthal correlations in 200 GeV/c Au + Au collisions," http://arxiv.org/abs/1212.0192.

[12] S. Chatrchyan, V. Khachatryan, A. M. Sirunyan et al., "Centrality dependence of dihadron correlations and azimuthal anisotropy harmonics in PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV," *The European Physical Journal C*, vol. 72, article 2012, 2012.

[13] F.-H. Liu, T. Tian, J.-X. Sun, and B.-C. Li, "What can we learn from (Pseudo) rapidity distribution in high energy collisions?" *Advances in High Energy Physics*, vol. 2014, Article ID 863863, 10 pages, 2014.

[14] B.-C. Li, Y.-Z. Wang, and E.-Q. Wang, "Meson production in high energy p+p collisions at the RHIC energies," *Advances in High Energy Physics*, vol. 2013, Article ID 486476, 7 pages, 2013.

[15] T. A. Trainor and D. J. Prindle, "Two-component model of 2D trigger-associated hadron correlations on rapidity space $y_{ta} \times y_{tt}$ derived from 1D p_t spectra for p–p collisions at $\sqrt{s} = 200$ GeV," *Physical Review D*, vol. 88, Article ID 094018, 2013.

[16] K. Dusling, F. Gelis, T. Lappi, and R. Venugopalan, "Long range two-particle rapidity correlations in A + A collisions from high energy QCD evolution," *Nuclear Physics A*, vol. 836, no. 1-2, pp. 159–182, 2010.

[17] A. Adare, S. Afanasiev, C. Aidala et al., "Spectra and ratios of identified particles in Au+Au and d+Au collisions at $\sqrt{s_{NN}} = 200$ GeV," *Physical Review C*, vol. 88, Article ID 024906, 2013.

[18] B. G. Zakharov, "Nuclear suppression of light hadrons and single electrons at the RHIC and LHC," *Journal of Physics G*, vol. 40, Article ID 085003, 2013.

[19] F.-M. Liu, "A theoretical review of centrality-dependent direct photon pt spectra in Au+Au collisions at $\sqrt{SNN} = 200$ GeV," *Nuclear Physics A*, vol. 855, no. 1, pp. 355–358, 2011.

[20] L. Adamczyk, J. K. Adkins, G. Agakishiev et al., "System-size dependence of transverse momentum correlations at $\sqrt{s_{NN}} = 62.4$ and 200 GeV at the BNL Relativistic Heavy Ion Collider," *Physical Review C*, vol. 87, Article ID 064902, 2013.