Search for the origin of double-peak structure at RHIC by AMPT model with triggered di-jet *

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Abstract With a multi-phase transport (AMPT) model, a γ-jet with known production point and momentum is triggered to search for the origin of double-peak structure in di-hadron azimuthal correlation in central Au+Au collisions at RHIC energy. The different configurations of triggered γ-jet produce different shapes of medium responses. The key of the double-peak structure is found to be a strong shadowing effect of dense core, which is related to transverse expansion and radial flow of partonic matter.

Key words QGP, jet, flow, parton cascade, double-peak

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1 Introduction

Jet correlation is a sensitive probe to understand the new matter created by Relativistic Heavy-Ion Collider at Brookheaven National Laboratory [1]. The disappearance of back-to-back jet in central Au+Au collisions indicates that jets interact with the medium and lose energy strongly when jets pass the formed dense matter [2]. As to medium responses, an interesting double-peak structure was obseved on away-side in di-hadron azimuthal correlation in central Au+Au collisions [3]. Many possible theoretical ideas provides many mechanism candidates, but no conclusive one is drawn so far [4–8]. One of ideas was proposed by our group in 2006, we found that the double-peak structure can be produced by strong parton cascade process and further developed in hadronic rescattering process [8]. However, the detail mechanism was not clear. In this paper, we present our new results on how the double-peak structure is produced by jet and partonic medium interaction by a multi-phase transport (AMPT) model with a triggered γ-jet.

2 Model introction

A multi-phase transport (AMPT) model [9] is applied for this work. The model consists of four main processes: the initial conditions, parton cascade, hadronization and hadronic rescattering. The initial conditions, including the spatial and momentum distributions of minijet partons and soft string excitations, are obtained from HIJING model [10]. Excitations of strings melt strings into partons. Scatterings among partons are modelled by Zhang's parton cascade model (ZPC) [11], which at present includes only two-body scattering with cross section obtained from the pQCD with screening mass. Partons are converted to hadrons by coalescence or fragmentation mechanism, when they stop interactions. Dynamics of the subsequent hadronic matter is then described by A Relativistic Transport (ART) model [12]. Details of the AMPT model can be found in a review [9]. In this paper, we focus on how jet interacts with partonic medium to produce a double-peak structure. Two processes of hadronization and hadronic rescattering are ignored for the moment. In our simulation, a trigged γ-jet with known production point and momentum is embedded into the initial condition for each event, and the following process that γ-jet interacts with surrounding partonic medium is still simulated by ZPC. When partonic system freezes out, the medium responses can be obtained by parton azimuthal distribution with respect

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to triggered γ-jet. For simplicity, a γ-jet is adopted for most central Au+Au events (b=0 fm) at $\sqrt{s_{\rm NN}}$=200 GeV, since near-side γ only has ignoring electromagnetic interactions with the symmetric medium. Fig. 1 shows A schematic illustration for a triggered γ-jet inside a partonic sytem, where two parameters of VVR and θ are defined. VVR is the distance between the production point for γ-jet (the black dot in Fig. 1) and origin of coordinates O, and θ represents the angle between two directions of triggered γ ray and VVR vector going from O to the production point.

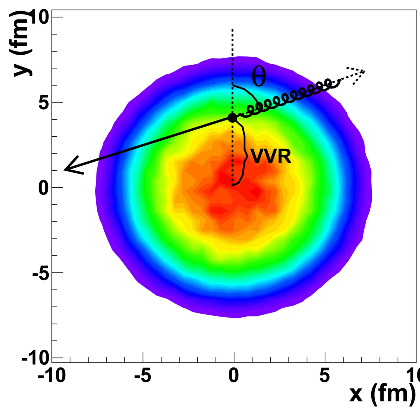

Fig. 1. (color online). A schematic illustration for a triggered γ-jet inside a partonic sytem, see text for the detail.

3 Results and discussion

3.1 Initial jets

It is very important to learn what jet looks like initially before the interactions between jet and partonic system. Fig. 2 shows the initial azimuthal parton distributions associated with triggered γ-jet for different $p_{\rm T}$ regions. One can see that jet behaves as a going packet which contain low and high $p_{\rm T}$ jet partons in our model.

3.2 Medium response

Let us look at how the medium responses to the triggered γ-jet after parton cascade. Fig. 3 shows azimuthal parton distributions ($0 < p_{\rm T}^{\rm asso} < 1$ GeV/c) associated with triggered γ-jet after parton cascade. The production points of γ-jets are required to be close to the surface by setting VVR >4 fm. Three types of γ-jet have been divided by θ angle. The cases of (1)-(3) represent the tangential, middle, pouch-through case respectively. For case (1) ($-90° < \theta < -54°$): as the one shown in Fig. 1, away-side jet axis

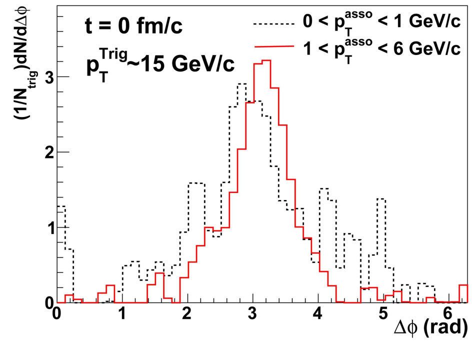

Fig. 2. (color online). The azimuthal parton distributions associated with triggered γ-jets without parton cascade. The two curves represents different $p_{\rm T}^{\rm asso}$ regions.

pass through the partonic medium tangentially. The conditions are different for two parts of jet partons around jet axis. Jet partons meet different conditions for two parts around jet axis. For the right part of jet axis, jet partons go outwards and push medium out easily, since its trajectory is close to the surface. For the left part of jet axis, jet partons go inwards and meet a big resistance, because the dense core and the expansion of whole system can result in a strong shadowing effect. Therefore, it is difficult for left part of jet partons to push medium. As a result, a single peak is found to locate at the left of π position, corresponding to the right part. It looks like a deflected-jet shape. For case (2) ($-54° < \theta < -18°$): the axis of away-side jet go through the medium in a middle way between the previous case (1) and next

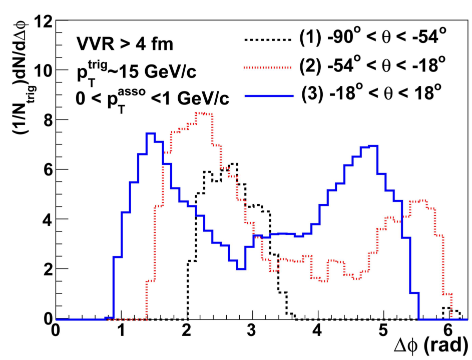

Fig. 3. (color online). The azimuthal parton distributions associated with triggered γ-jets after parton cascade. The different types of curves represent three cases of γ-jet with different θ angles.

case (3), a unsymmetric double-peak is presented because some of left part can avoid the shadowing effect sideways. For case (3) ($-18° < \theta < 18°$), the axis of away-side jet pouches through the center region of partonic medium. Jet partons only are able to push medium sidewards due to the shadowing effect of the dense core, which produces a cone-like shape with symmetric double-peak. Therefore medium response is very sensitive to the geometry of jet probe inside partonic medium. However the experimental case must consists of all kinds of cases. And our previous paper have already shown our model can well describe the data [8].

3.3 Discussions

To explore the origin of shadowing effect in AMPT model, the transverse expansion of system is switched off. Fig. 4 (a) shows no double-peak structure is observed for any of three cases expect a broaden single peak, if no transverse expansion. It implies that the transverse expansion play a key role for the shadowing effect in our model. On the other hand, the expansion rate, i. e. radial flow, is tuned by selecting different partonic interaction cross sections. Fig. 4 (b) presents the radial flow of system as a function of radius for 10 mb and 3 mb. We can see more bigger partonic interaction cross section can produce more stronger radial flow. It is consistent with our previous results that the splitting amplitude and magnitude of double-peak structure increases with partonic interaction cross section [8]. Therefore, the transverse expansion or radial flow contributes to the shadowing effect of dense core to a certain extent.

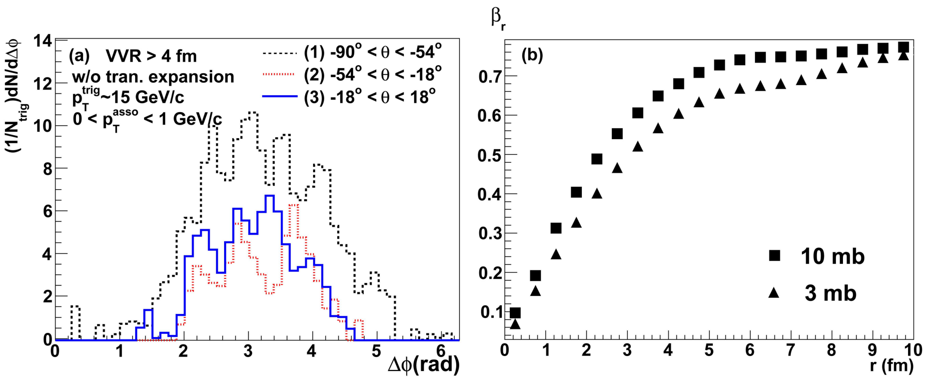

Fig. 4. (color online). (a) the azimuthal parton distributions associated with triggered γ-jets, but without transverse expansion. (b) the radial flow as a function of radius for partonic system with different partonic interaction cross sections.

4 Summary

A γ-jet with known production point and momentum has been triggered in a multi-phase transport model. By implementing the jet tomography on partonic medium dynamically, we found that different configurations produce different shapes of medium responses. The strong shadowing effect of dense partonic core is found to be the key reason of the formation of the double-peak structure in central Au+Au collisions at RHIC. The transverse expansion and strong radial flow of system contribute to the shadowing effect.

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