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Search for medium response to jet quenching via hadron chemistry around the quenched jets

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Abstract.
We present a unique signal of medium response to jet quenching: the enhancement of baryon-to-meson ratios for associated particles at intermediate transverse momentum around the triggered quenched jets. Since the lost energy from the jets can diffuse to large angles, we expect that such baryon-to-meson enhancement is stronger for larger distance with respect to the jet axis. Our prediction can be tested by future experiments.

1 Introduction

Jet-medium interaction provides an important tool to study the properties of quark-gluon plasma (QGP) produced in high-energy heavy-ion collisions [1]. The interaction of jets and medium can not only cause the energy loss of jet partons, but also lead to medium excitations, such as the Mach cone induced by supersonic partons passing through the QGP [2–4]. The detailed structure of medium excitation can provide much information on the probed medium, such as its equation of state and shear viscosity, etc. Unfortunately, the direct detection of jet-induced Mach cone in relativistic heavy-ion collisions is extremely difficult due to the fact that the medium is rapidly expanding and both jet and medium evolutions fluctuate from event to event. It is currently still a hot topic to search for the decisive signal of jet-induced medium excitation in high-energy nuclear collisions. Here we present a unique signature of medium response: the ratios of jet-induced baryons to mesons at intermediate transverse momentum (p_T) around the triggered jets are enhanced in heavy-ion collisions relative to proton-proton collisions [5]. Since the deposited energy by the quenched jets can flow to large angles in the medium, such jet-induced baryon-to-meson enhancement around jets are found to be stronger for larger values of the relative distance $\Delta r = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$ with respect to jet direction.

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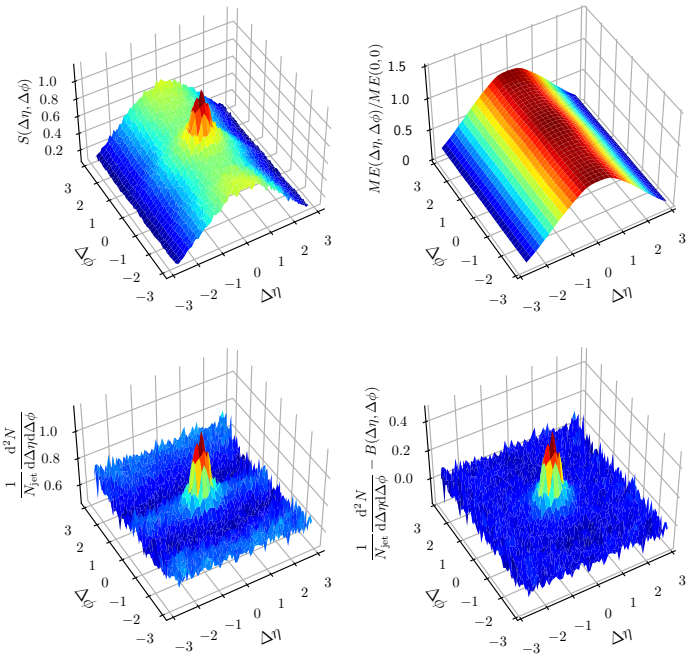

Figure 1. Illustration of jet-particle correlations for associated particle $p_T = 2 - 3$ GeV in central Pb+Pb collisions at the LHC. The upper-left, upper-right, lower-left, lower-right plots are the signal pair distribution, the normalized mixed-event pair distribution, the acceptance-corrected jet-triggered distribution, and the final jet-triggered yield after background subtraction, respectively.

2 Framework

We use the jet-particle correlation method [6] to compute the relative rapidity and azimuth $(\Delta\eta, \Delta\phi)$ distribution of jet-induced identified particle yields with respect to jet direction in Pb+Pb and p+p collisions at the LHC via the AMPT model [7]. The mixed-event and side-band methods are used to correct the limited acceptance and subtract the background for computing the final jet-induced particle yields. In the analysis, we take the reconstructed jets with $p_T^{\rm jet} > 120$ GeV, $R = 0.4$ and $|\eta_{\rm jet}| < 1.6$ and associated particles with $|\eta| < 2.4$.

Figure 1 illustrates how to construct the $(\Delta\eta, \Delta\phi)$ distributions of the associated particle around the triggered jets in heavy-ion collisions. First, we use the FASTJET package to reconstruct the full jets [8]. Then, we construct the signal pair distribution $S(\Delta\eta, \Delta\phi)$ using the associated particles around the jets, as shown by the upper-left plot. Next, we estimate the effect of limited acceptance by pairing the triggered jet and the particles from other events to construct the mixed-event distribution $ME(\Delta\eta, \Delta\phi)$, as shown by the upper-right plot. The acceptance-corrected distribution for associated particles per trigger jet is shown by the lower-left plot. Finally, the side-band method is used to subtract the uncorrelated and correlated background. The lower-right plot shows the final corrected jet-particle correlations.

3 Result

Figure 2 shows jet-induced identified particle (π, K, p, Λ) yields in the region $\Delta r < 1$ around the triggered jets as a function of associated particle p_T in p+p (left) and central Pb+Pb

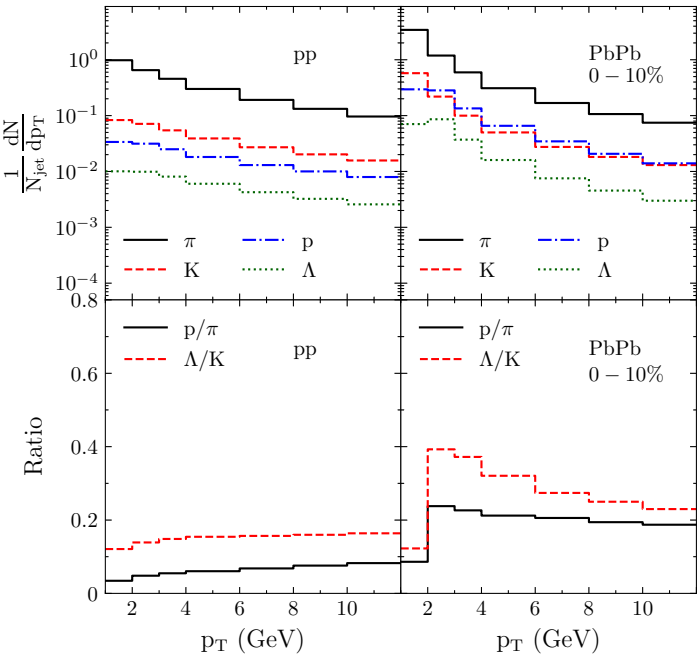

Figure 2. Upper: Jet-induced π, K, p and Λ yields in the region $\Delta r < 1$ around the triggered jets as a function of associated particle p_T for p+p and central Pb+Pb collisions at the LHC. Lower: p/π and Λ/K ratios in p+p and central Pb+Pb collisions as a function of associated particle p_T.

(right) collisions at the LHC, as calculated from the AMPT model. One can see that the low p_T particles in central Pb+Pb collisions are enhanced compared to p+p collisions. This indicates that the lost energy from the jets is carried by soft particles. The lower panels show the baryon-to-meson ratios (p/π, Λ/K) around the jets as a function of associated particle p_T. One can clearly see that jet-induced baryon-to-meson ratios (p/π, Λ/K) at intermediate p_T (2 − 6 GeV) around the quenched jets show strong enhancement in central Pb+Pb collisions compared to p+p collisions. This can be easily understood. Since the lost energy from jets is deposited to medium partons, the production of baryons relative to mesons at intermediate p_T region is more enhanced due to parton coalescence [9, 10].

Figure 3 focuses on the intermediate p_T region ($p_T = 2 - 6$ GeV) for the associated particles, and shows the enhancement of baryon-to-meson ratios (p/π, Λ/K) around the triggered jets as a function of the relative distance Δr in Pb+Pb collisions relative to p+p collisions at the LHC. We observe that the jet-induced baryon-to-meson enhancement is stronger in central collisions as compared to peripheral collisions. Another important result is that the jet-induced baryon-to-meson enhancement is more pronounced for larger values of relative distance Δr. One may understand this as follows. Since the lost energy from the quenched jets can diffuse to large angles with respect to the jet axis, the production of baryons relative to mesons at intermediate p_T via parton coalescence is more enhanced at larger Δr.

4 Summary

We study how jet-induced medium response change the hadron chemistry around the jets in heavy-ion collisions. Due to coalescence of jet-excited medium partons, the ratios of induced

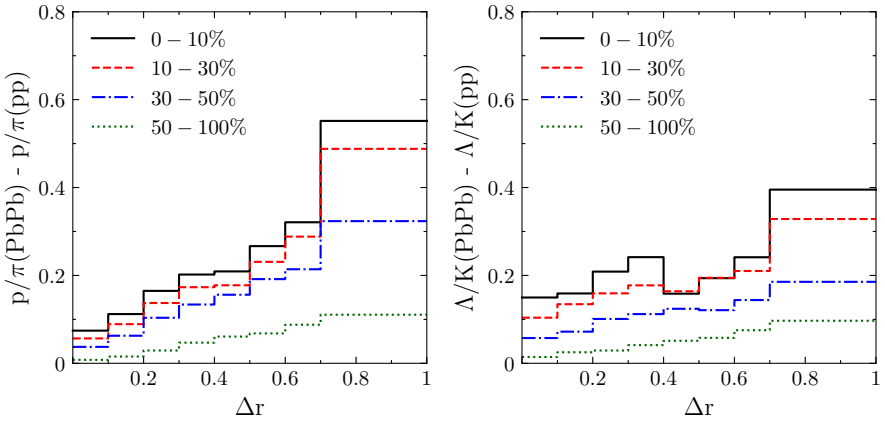

Figure 3. Enhancement of baryon-to-meson ratios (p/π, Λ/K) around the jets for associated particle $p_T = 2 - 6$ GeV as a function of Δr in Pb+Pb collisions relative to p+p collisions at the LHC.

baryons to mesons at intermediate p_T around the jets in Pb+Pb collisions are found to be significantly enhanced compared to p+p collisions. Since the lost energy from jets can flow to large angles, we further predict that jet-induced baryon-to-meson enhancement is stronger for larger relative distance Δr. Our finding, once experimentally confirmed, will provide an unambiguous evidence for the medium response to jet quenching in heavy-ion collisions.

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