Suppression of elliptic anisotropy inside jets: A new perspective for jet quenching

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Definition of jet coordinate frame

An individual **jet as a collision system**→ a new coordinate frame is defined by setting the longitudinal direction along the jet axis.

$\vec{p}^* = (j_T, \eta^*, \phi^*)$, where j_T and ϕ^* represent the magnitude and azimuthal angle of the transverse momentum $\vec{j}_T$, respectively, and η^* denotes the pseudorapidity characterizing the angle between particle momentum and longitudinal direction.

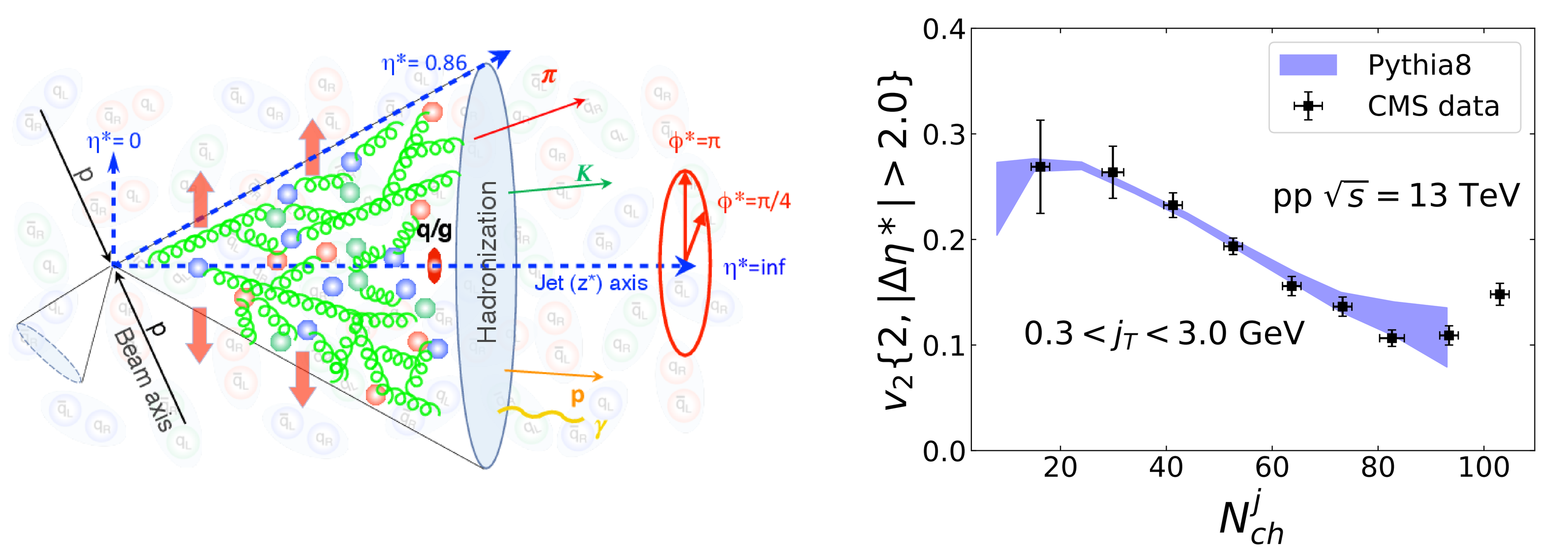

Fig. 1. Left panel: An illustration of the jet system[1]. Right panel:Elliptic anisotropies coefficient $v_2\{2, |\Delta\eta^*| > 2.0\}$ as a function of charged-particle multiplicity N^j_{ch} inside jets in pp collisions at $\sqrt{s} = 13$ TeV. Black disks represent CMS data [2].

Two-particle azimuthal-angle correlations have been successfully employed to study the possible emergence of an in-jet collectivity in hadronic collisions[2, 3]. The CMS data can be well reproduced by the PYTHIA8 calculations in most of the multiplicity regions in pp collisions as shown in the right panel of Fig.1. The high-multiplicity behavior was shown to be a possible signal of the collectivity arising from the rescatterings of the jet particles[3], which have not been taken into account in this model calculations. On the other hand, this work focuses on the nuclear modifications for the inclusive jet production in which high-multiplicity jets have negligible contributions.

Numerical Results

In this work, we perform a calculation for the inclusive in-jet v_2 as a function of the transverse momentum of jet with three cuts on the particle transverse momentum in pp collisions. Similar results for both hadronic and partonic jets can be observed in Fig.2, indicating that the **hadronization with the Lund string fragmentation in PYTHIA8 may not bring a radical change in the pattern of the elliptic anisotropy in the inclusive jets.**

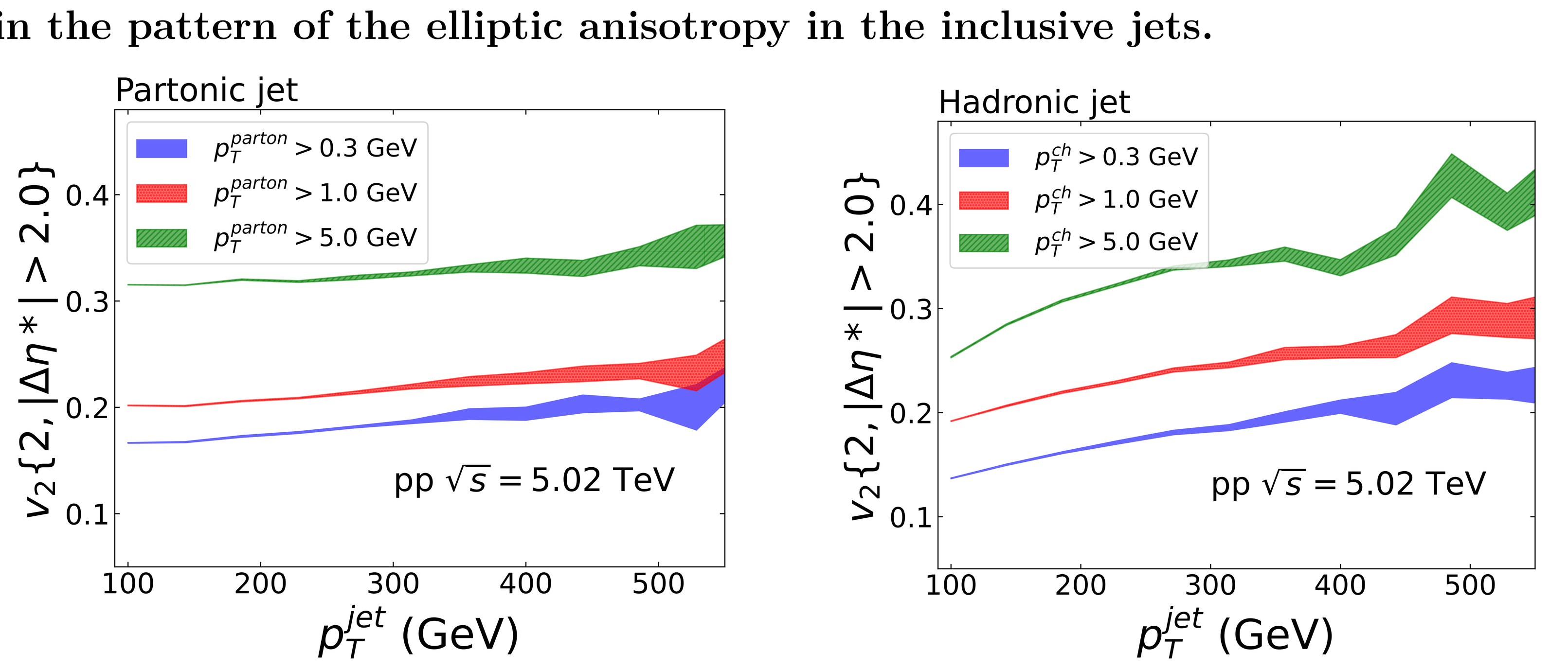

Fig. 2. Elliptic anisotropies coefficient $v_2\{2, |\Delta\eta^*| > 2.0\}$ as a function of jet transverse momentum $p_T^{\rm jet}$ for inclusive jet production in pp collisions at $\sqrt{s} = 5.02$ TeV. Anti-k_T jets with $R = 0.8$ selected in region $|\eta| < 1.6$ are used in calculations.

In this work, we employ an LBT model to simulate the in-medium evolution of the partonic-level jet events generated by PYTHIA8. Transport processes of both the jet shower partons and the jet-induced medium recoiled partons are included in LBT model, with their elastic scatterings with thermal medium and medium-induced radiations (inelastic scatterings) being tracked. Fig.3 shows that the v_2 in PbPb collisions are significantly suppressed with both $p_T^{parton} > 0.3$ GeV and $p_T^{parton} > 5.0$ GeV and the suppression becomes stronger for more central collisions.

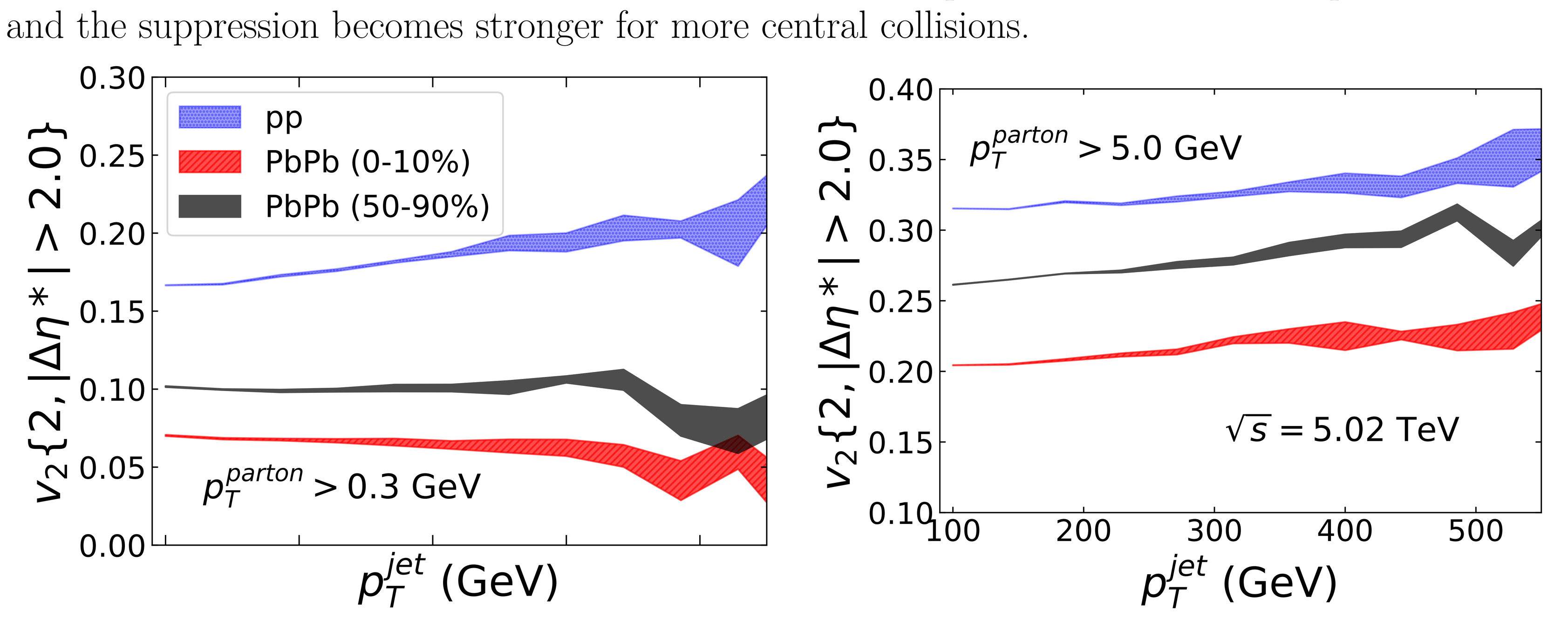

Fig. 3. Results of $v_2\{2, |\Delta\eta^*| > 2.0\}$ as a function of $p_T^{\rm jet}$ for inclusive jet production in pp and PbPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. Anti-k_T jets with $R = 0.8$ selected in region $|\eta| < 1.6$ are used in calculations. Results for two centrality classes of PbPb collisions, i.e., $0-10\%$ and $50-90\%$ are shown respectively.

To further understand such a suppression effect, we calculate the two-particle azimuthal-angle distribution inside jets in Fig.4. **A flatter distribution is observed for PbPb, indicating a de-correlation in azimuthal angle due to the jet-medium interactions, generally related to a more isotropic configuration.**

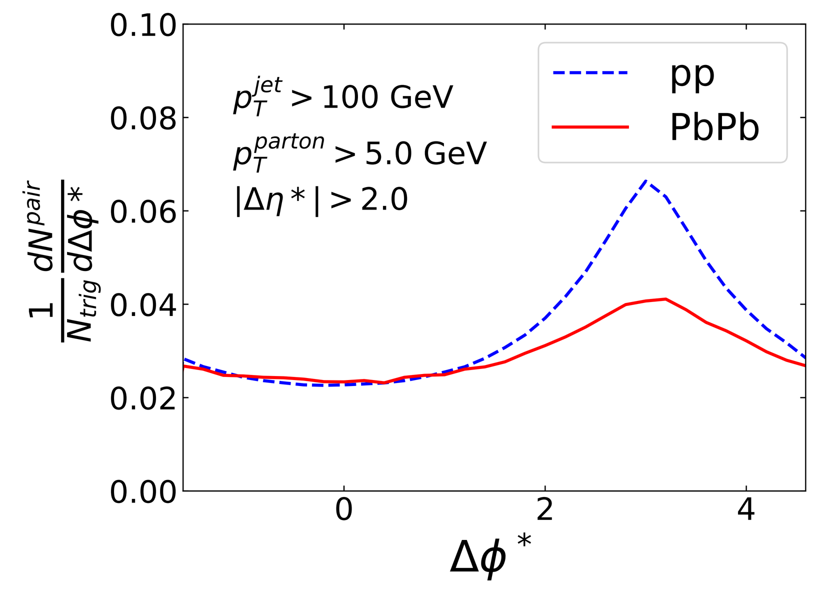

Fig. 4. Trigger-particle-normalized two-particle azimuthal-angle distribution inside jets as a function of $\Delta\phi^*$ for $|\Delta\eta^*| > 2.0$ in both pp and PbPb ($0-10\%$) collisions.

More intuitive picture:

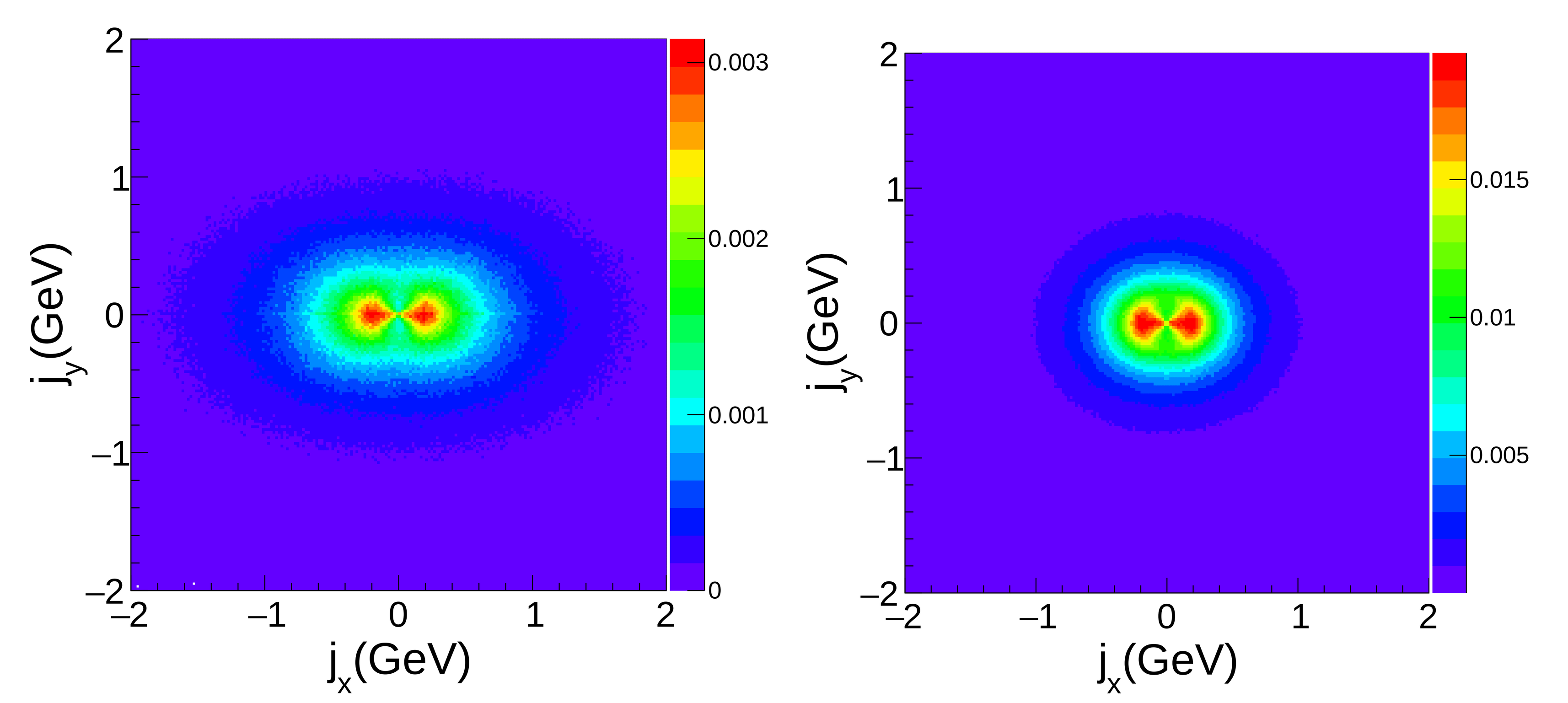

Fig. 5. Jet-particle distributions in $\vec{j}_T$ plane for inclusive jet production in both pp (left panel) and central PbPb (right panel) collisions at $\sqrt{s_{NN}} = 5.02$ TeV. Anti-k_T jets reconstructed at a partonic level with R=0.8 and $p_T^{jet} > 100$ GeV are used. Distributions are obtained by averaging over 5×10^5 collected jets with jet plane orientation in alignment.

In this calculations, the jet particles with $p_T^{\rm parton} > 0.3$ GeV are used to determine the jet plane, and for each generated jet system, the jet plane is rotated to be oriented along the j_x direction [4]. By averaging over all the collected jets, one can observe that the jets generated in pp collisions exhibit an **obvious elliptic distribution**, whereas the quenched jets in **AA** collisions becomes **more isotropic**. The elliptic anisotropy for such distributions can be evaluated with $v_2 = \langle\frac{j_x^2 - j_y^2}{j_x^2 + j_y^2}\rangle$ [5, 6], which are found to be 0.33 and 0.16 for pp and AA, respectively. Moreover, a double-peak structure can be found in both of the two distributions, indicating that such a back-to-back configuration plays an important role in the generation of elliptic anisotropy inside jets.

Summary

In this work, we study the medium-induced modifications of the elliptic anisotropy inside jets for inclusive jet production in relativistic heavy-ion collisions. By simulating the jet propagation in QGP medium with an LBT model, we observe an **obvious de-correlation in two-particle azimuthal angular distribution inside jets in AA collisions relative to that in pp collisions, leading to significant suppression of the in-jet elliptic anisotropy coefficient v_2**, which can be examined in future experiments. Since the modifications on v_2 inside jets are found to be sensitive to the medium properties, the measurement of such observables may provide new resolution power of the jets as a microscope of the structures of QCD matters.

References

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