Nuclear modification of jet shape for inclusive jets and γ-jets at the LHC energies

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Abstract: With our coupled jet-fluid model, we study the nuclear modifications of full jets and jet structures for single inclusive jets and γ-jets in Pb+Pb collisions at 5.02 ATeV and 2.76 ATeV. The in-medium evolution of full jet shower is described by a set of coupled transport equations including the effects of collisional energy loss, transverse momentum broadening and medium-induced splitting process. The dynamical evolution of bulk medium is simulated by solving relativistic hydrodynamic equation with source term which accounts for the energy and momentum deposited by hard jet shower to soft medium. Our study demonstrates that the hydrodynamic medium response to jet propagation significantly enhances the broadening of jet shape at large angles and is essential for the cone-size dependence of jet energy loss and nuclear modification factor of inclusive jet production. It is also found that the nuclear modification pattern of jet shape is sensitive to jet energy but has weak dependence on the flavor of the parton that initiates the jet. Our result can naturally explain the different nuclear modification patterns of jet shape functions for single inclusive jet and γ-jet events as observed by the CMS Collaboration, and can be tested in the future by measuring the jet shape function over a wider range of jet energies in heavy-ion collisions.

Motivation:

CMS observes different modification patter for the jet shape of inclusive jets and γ-jets. Does it come from the different flavor compositions of γ-jets and single inclusive jets?

Framework: Jet evolution + Medium response

$$\frac{d}{dt}f_j(\omega_j,k_{j\perp}^2,t) = \hat{e}_j\frac{\partial}{\partial\omega_j}f_j(\omega_j,k_{j\perp}^2,t) + \frac{1}{4}\hat{q}_j\nabla_{k_\perp}^2 f_j(\omega_j,k_{j\perp}^2,t) + \sum_i\int d\omega_i dk_{i\perp}^2\tilde{\Gamma}_{i\to j}(\omega_j,k_{j\perp}^2|\omega_i,k_{i\perp}^2)f_i(\omega_i,k_{i\perp}^2,t) - \sum_i\int d\omega_i dk_{i\perp}^2\tilde{\Gamma}_{j\to i}(\omega_i,k_{i\perp}^2|\omega_j,k_{j\perp}^2)f_j(\omega_j,k_{j\perp}^2,t)$$

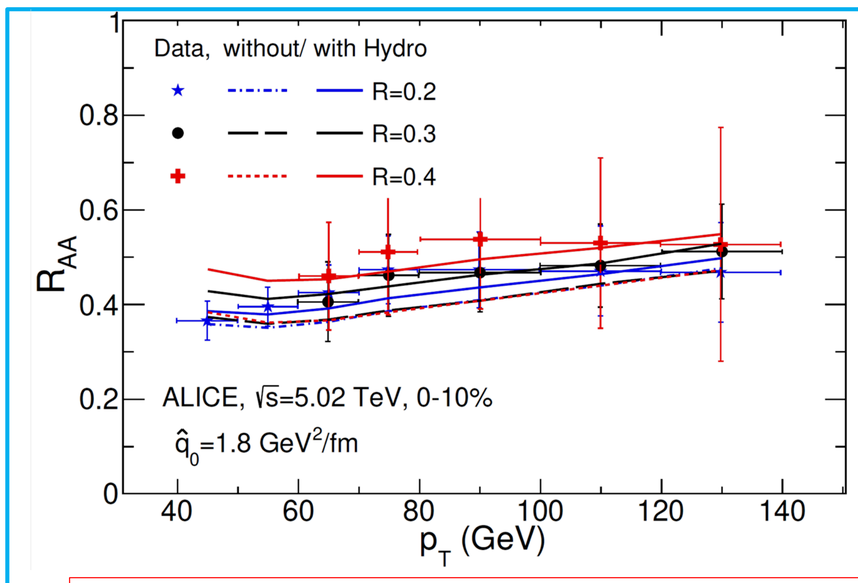
Collisional energy loss; K_T broadening; Radiation: gain, loss

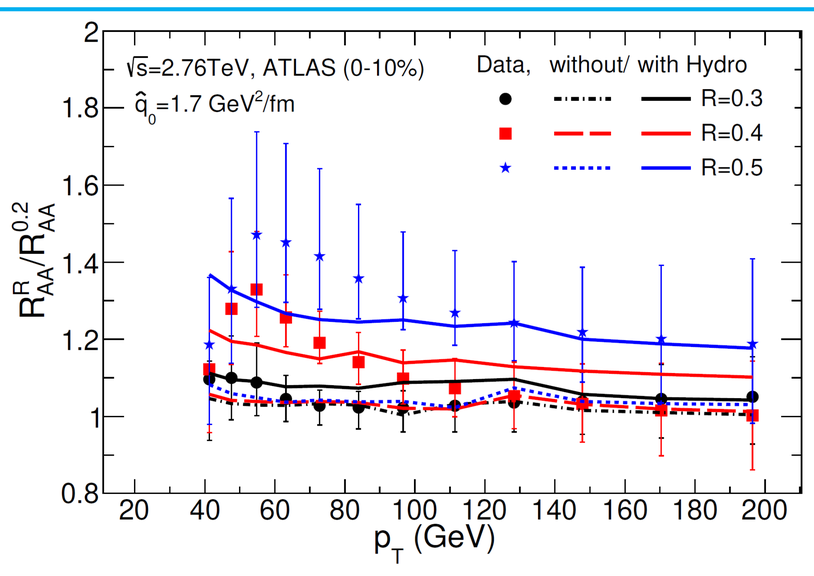
$$J^\nu(x) = -\sum_j\int d^3k_j k_j^\nu\frac{df_j(\boldsymbol{k}_j,t)}{dt}\Big|_{\text{col.}}\delta^{(3)}\left(\boldsymbol{x}-\boldsymbol{x}_0^{\text{jet}}-\frac{\boldsymbol{k}_j}{\omega_j}t\right)$$

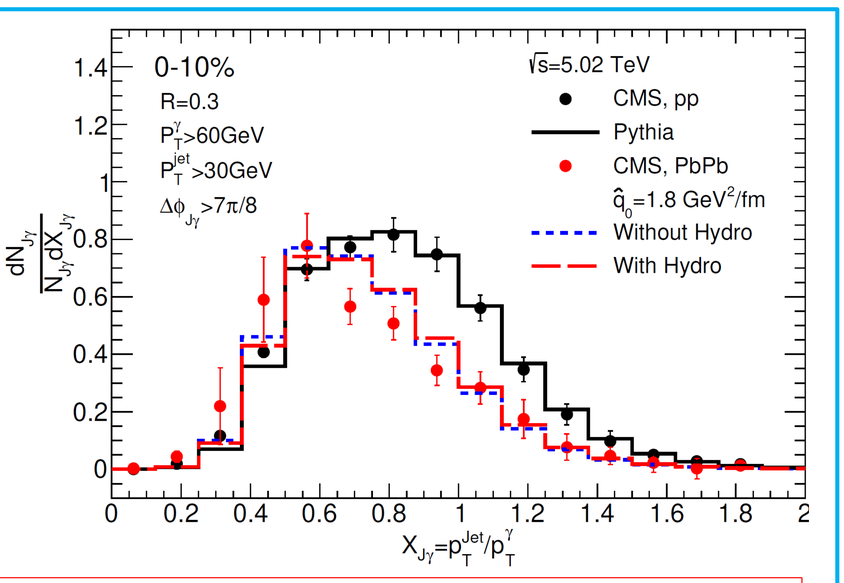
$$\partial_\mu T^{\mu\nu}_{\text{fluid}}(x) = J^\nu(x)$$

$$\frac{d\Delta N^{\text{hydro}}}{d^3p} = \frac{dN^{\text{hydro}}}{d^3p}\Big|_{\text{w/ jet}} - \frac{dN^{\text{hydro}}}{d^3p}\Big|_{\text{w/o jet}}$$

Jet Energy Loss

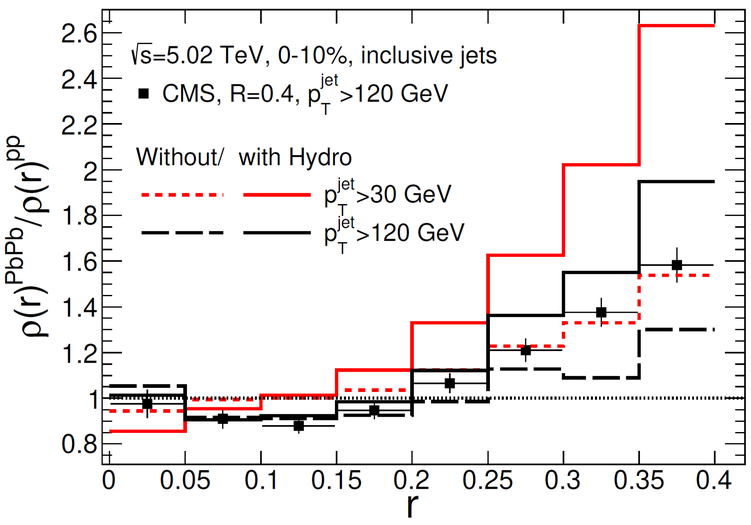


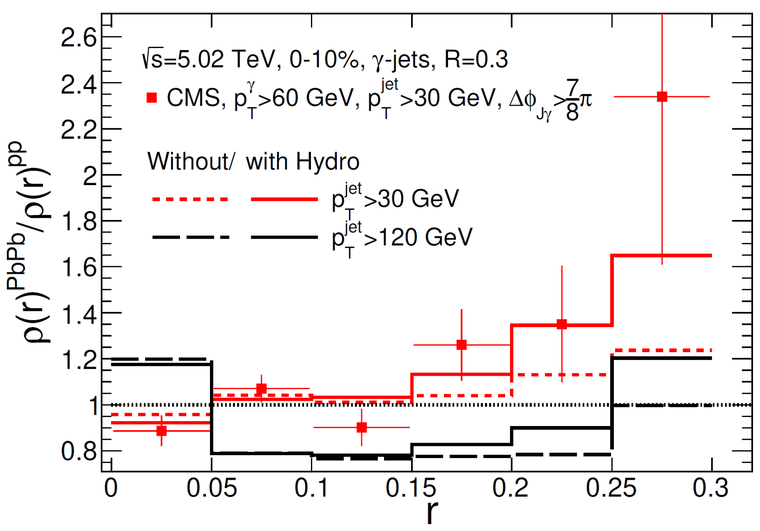




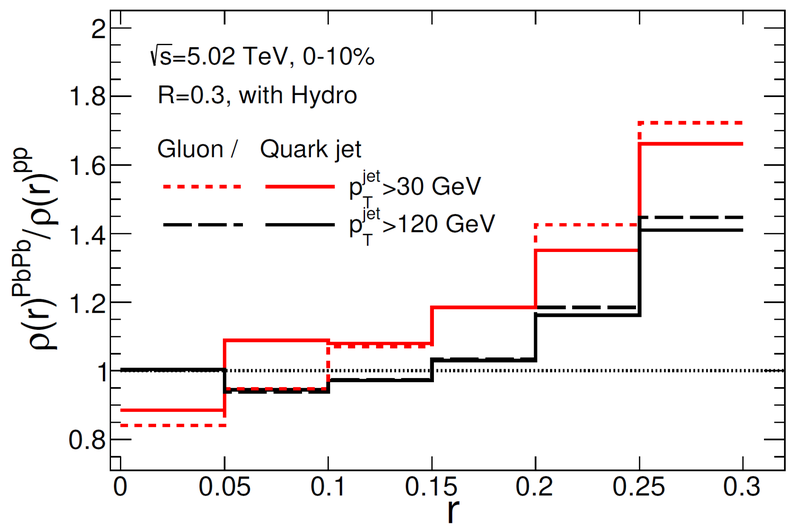
1. Describe well the experimental data of inclusive jet R_{AA} and the modification of γ-jet momentum imbalance.
2. The effect of medium response is important to the cone size dependence of inclusive jet R_{AA} .

Modification of jet shape



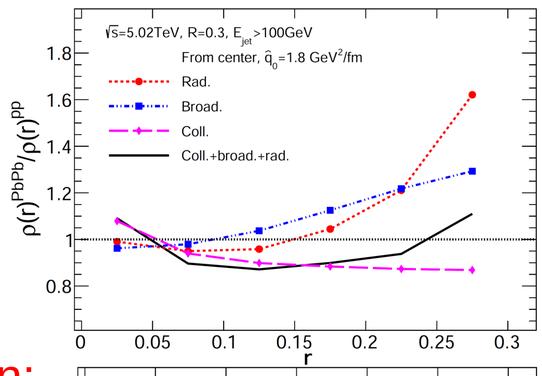


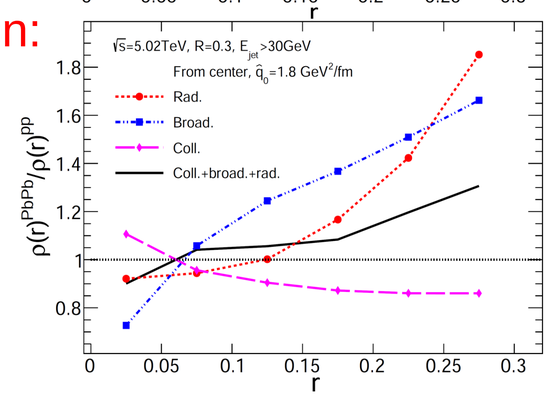
Our results describe well both the modification jet shape function for inclusive jets and γ-jets. But what's the reason?



The modification of jet shape is sensitive to jet energy, insensitive to jet flavor.

The Reason:





Conclusion:

1. Medium response feeds back some energy to the jet shower, which is important to the cone size dependence of inclusive jet R_{AA} and the jet shape modification at large r.
2. The modification pattern of jet shape is sensitive to jet energy but insensitive to the jet flavor. The energy dependence is because that partons with less energy lose more fraction of their energy via medium induced radiations, so as jet energy decreasing the inner partons are modified more which leads that the effect of Rad.+Broad. overrides the effect of Coll.. The insensitivity is attributed to the competition of the three mechanisms which makes the difference between the modification for quark jets and gluon jets diminished.
3. Our model may be tested by further experimental analysis with different jet p_T cuts, in particular, using lower p_T cut for inclusive jets and higher p_T cut for γ-jets.

References:
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3. Ning-Bo Chang, Yasuki Tachibana and Guang-You Qin, arXiv:1906.09562