3D structure of jet-induced diffusion wake in an expanding quark-gluon plasma

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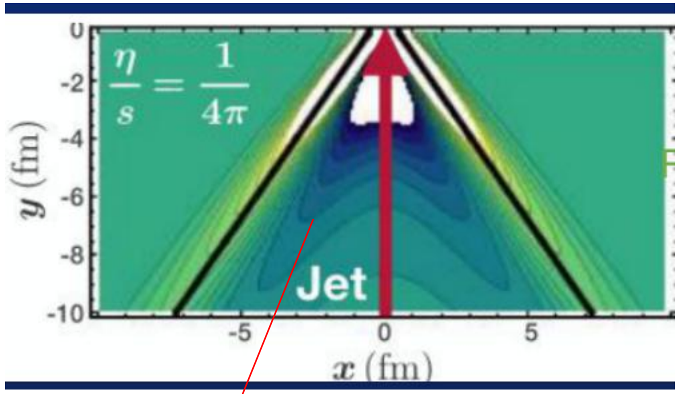
1. Motivation

Diffusion wake is an unique signal of medium response which can probe properties of quark-gluon plasma. It can be characterized by the depletion of soft hadrons in the opposite of the propagating jet.

However, this phenomenon is not clear in recent experimental data due to the initial multiple parton interaction(MPI) effect. To get this signal, we should do:

(1) substract the contribution from MPI
(2) locate initial jet position by 2D tomography

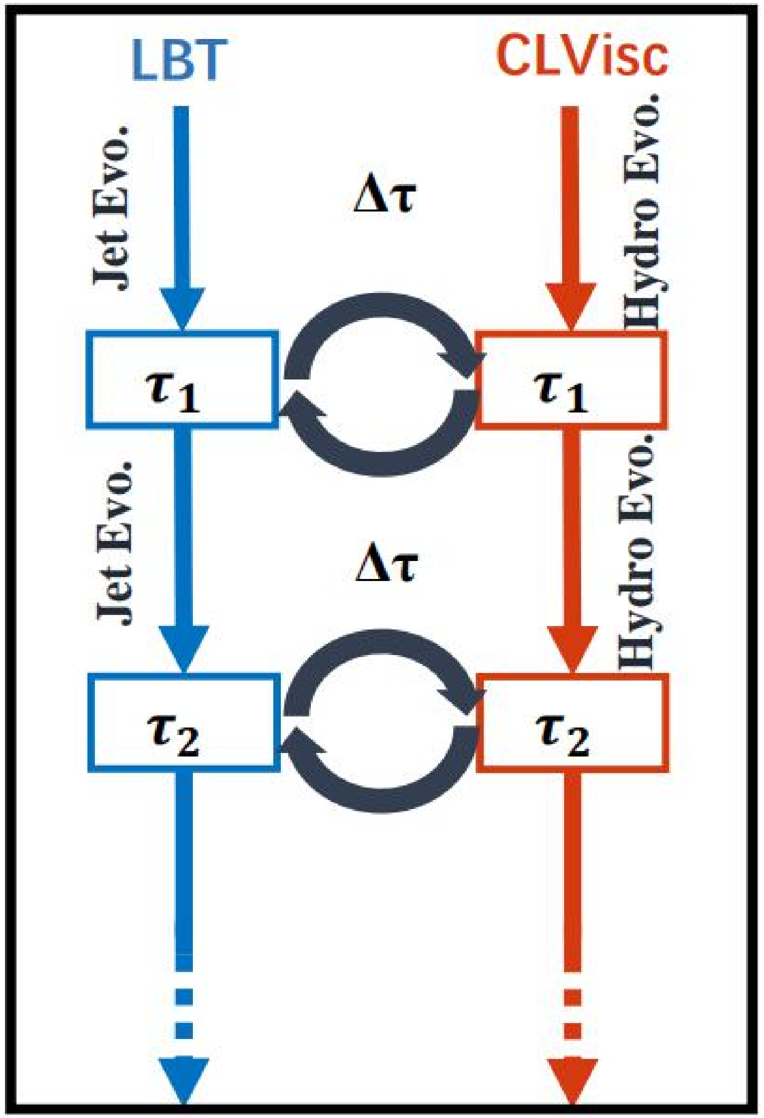
Thus, we want to explore a new signal of diffsuion wake that experimental group can also find it.



R.B.Neufeld. PRC79,054909(09')

Diffusion wake

2. CoLBT-hydro Model



$$p\partial f(p) = -C(p) \quad (p \cdot u > p^0_{cut})$$

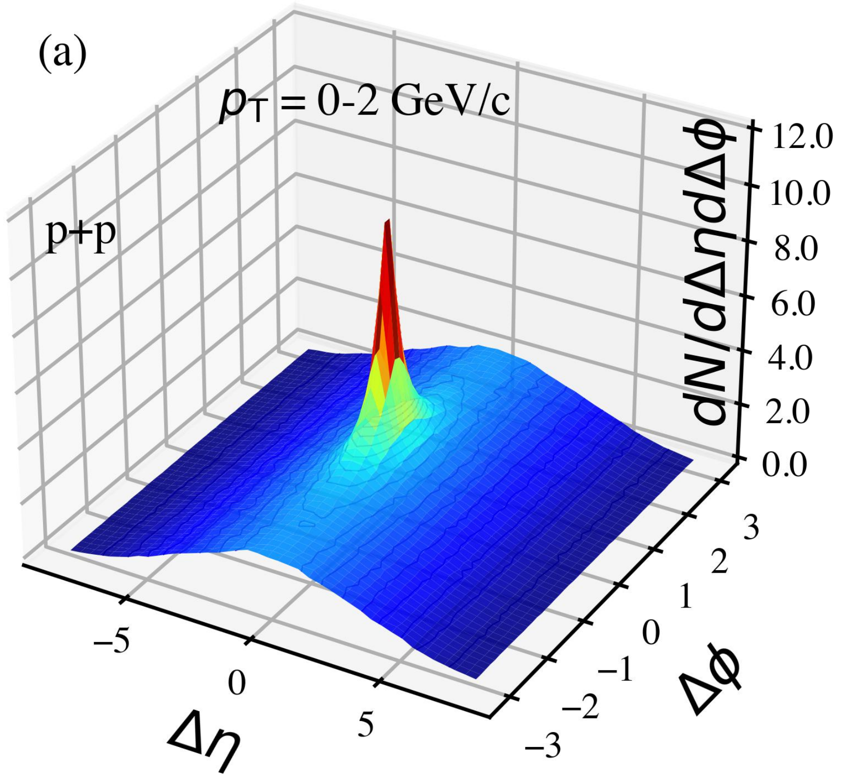
$$\partial_\mu T^{\mu\nu} = j^\nu(x)$$

$$j^\nu(x) = \sum_i p_i^\nu \delta^{(4)}(x - x_i)\theta(p^0_{cut} - p \cdot u)$$

Final hadron spectra:

1. Hadronization of hard partons within a parton recombination model.
2. Jet-induced hydro response via Cooper-Frye freeze-out.

3. 3D structure of the diffusion wake



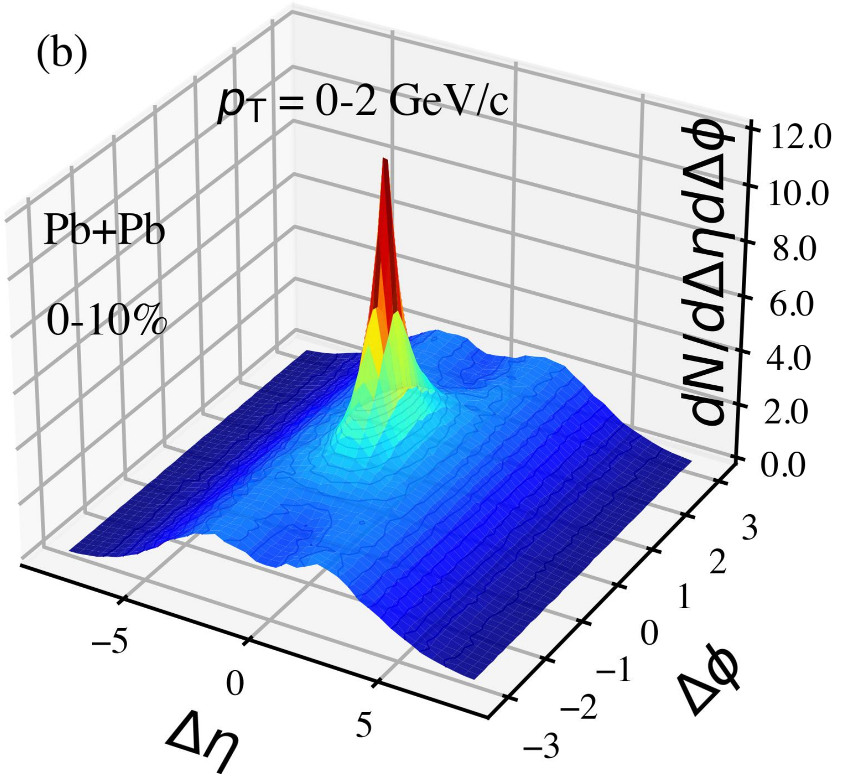
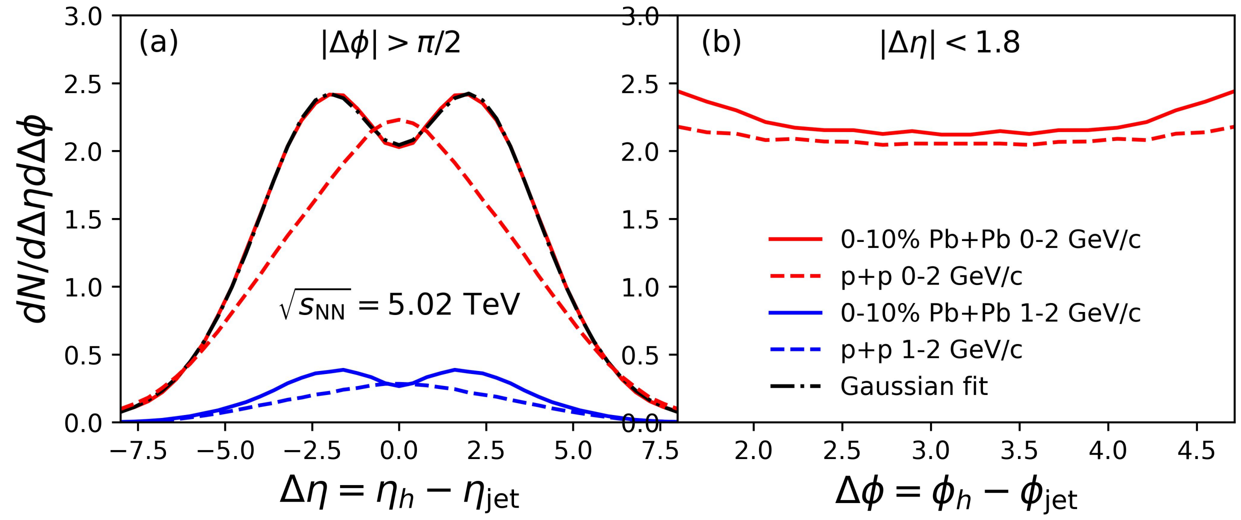
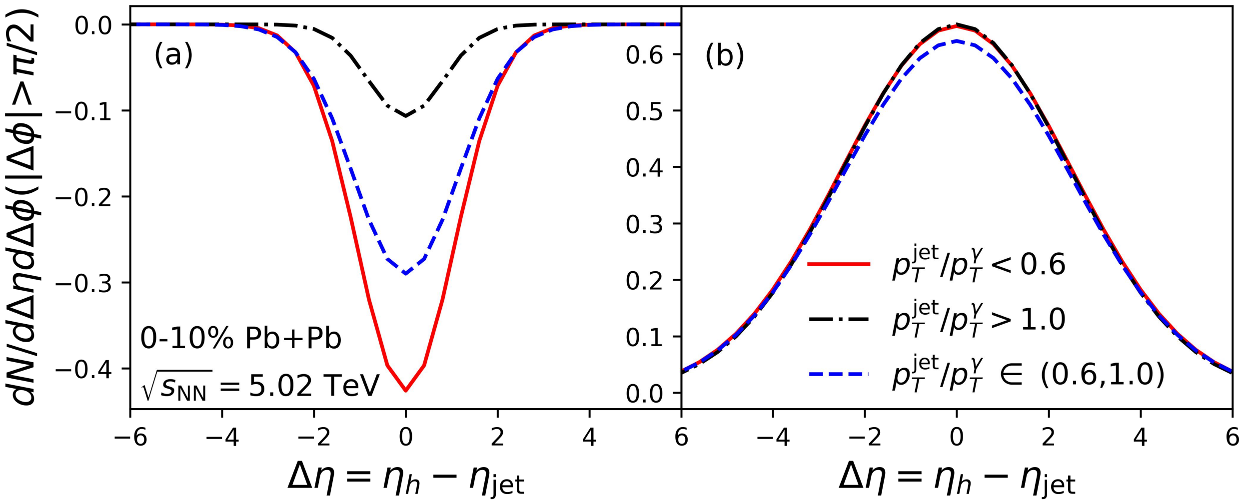


Fig.a and Fig.b are jet-hadron correlations in $\Delta\eta = \eta_h - \eta_{jet}$ and $\Delta\phi = \phi_h - \phi_{jet}$ for soft hadrons in $p_T \in (0,2) GeV/c$ in p+p and Pb+Pb collisions. We find in Pb+Pb collisions:

1. An enhancement of jet peak due to recoil and radiated partons.
2. A valley on top of MPI ridge in the opposite of jet due to the depletion of soft hadrons by diffusion wake.

4. A new signal of diffusion wake and a two-Gaussian fit method





There is a valley in $\Delta\eta$ distribution, we refer this as a new signal of diffusion wake

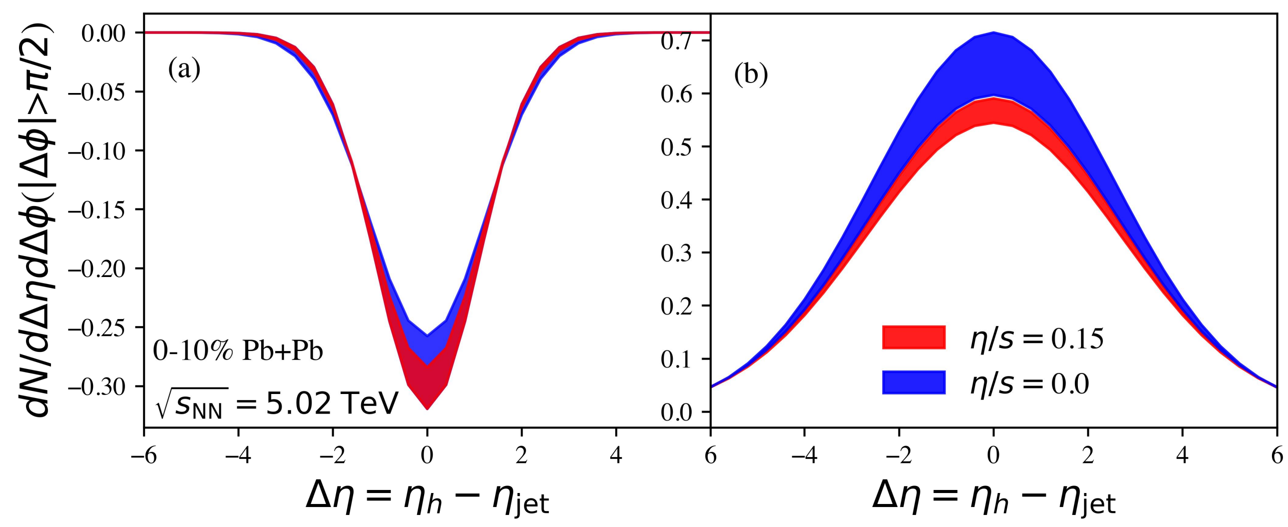
A two-Gaussian fit method:

$$F(\Delta\eta) = \int_{n_{j1}}^{n_{j2}} dn_j F_3(n_j)(F_2(\Delta\eta, \eta_j) + F_1(\Delta\eta))$$

Here $F_1(\Delta\eta) = A_1 e^{-\Delta\eta^2/\sigma^2}$ is the diffusion wake valley, $F_2(\Delta\eta, \eta_j) = A_2 e^{-(\Delta\eta+\eta_j)^2/\sigma^2}$ is the MPI ridge, $F_3(\eta_j)$ is self-normalized Gaussian-like rapidity distribution of gamma-triggered jets.

In events with small $x_{j\gamma}$ DF-valley is deeper because of longer propagation length and larger jet energy loss. But MPI ridge has a very weak and non-monotonic dependence on $x_{j\gamma}$.

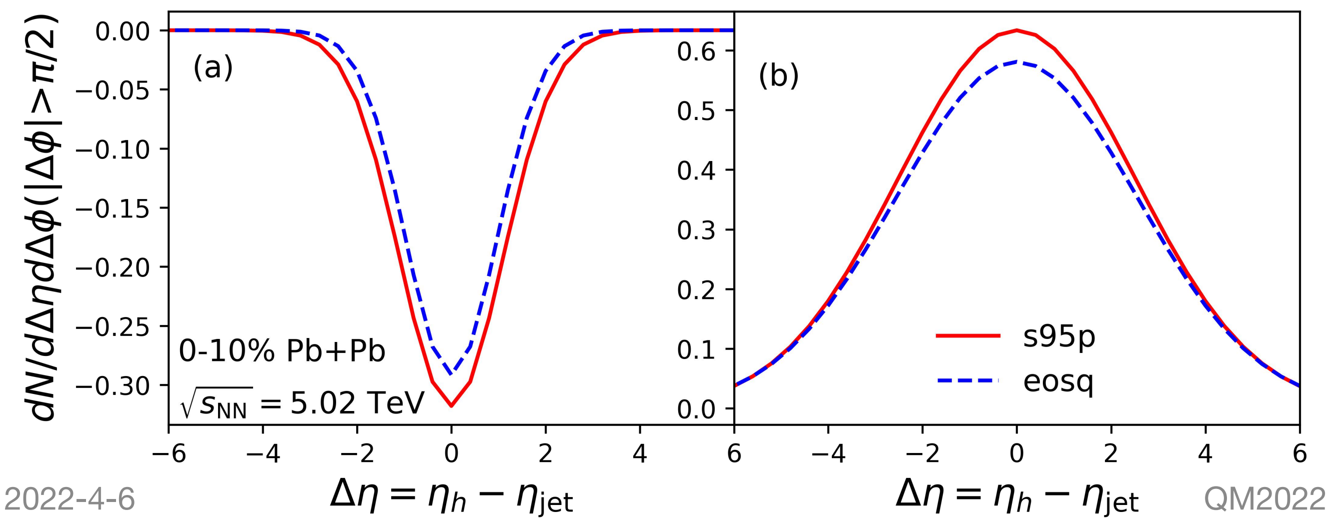
5. Sensitivity to viscosity and EoS



Sensitivity to viscosity:

(1) Competition between negative longitudinal pressure and increased radial flow leads to a slightly deeper diffusion wake valley in viscous hydro.

(2) Increased radial flow suppresses the MPI ridge of soft hadrons in viscous hydro.



Sensitivity to EoS:

A large averaged speed of sound in eosq transports energy to large angle. as a result, the diffusion wake valley is shallower and MPI ridge is smaller in the case of eosq.

6. Summary

1. We explore the 3D structure of the diffusion wake in gamma-triggered jets

2. We find the jet-hadron correlation in azimuthal angle and rapidity has a valley structure in the opposite direction of the jet.

3. We use a two-Gaussian fit to extract diffusion wake and MPI contributions to the double peak and study valley's sensitivity to jet energy loss.

4. According to our work, this valley deepens slightly with the shear viscosity and is reduced somewhat by the higher effective speed of sound.