Jet-flow coupling in heavy ion collisions

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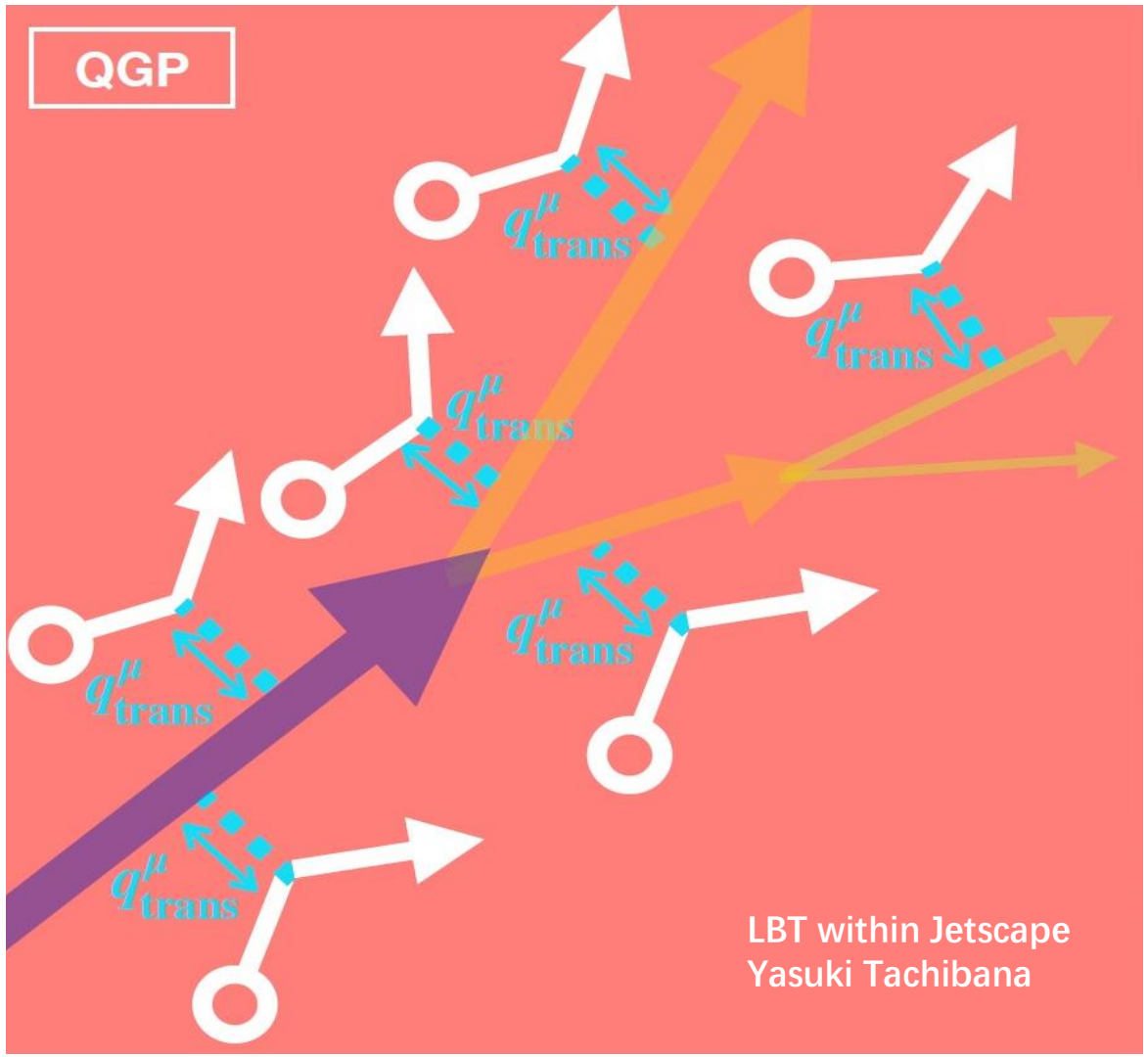
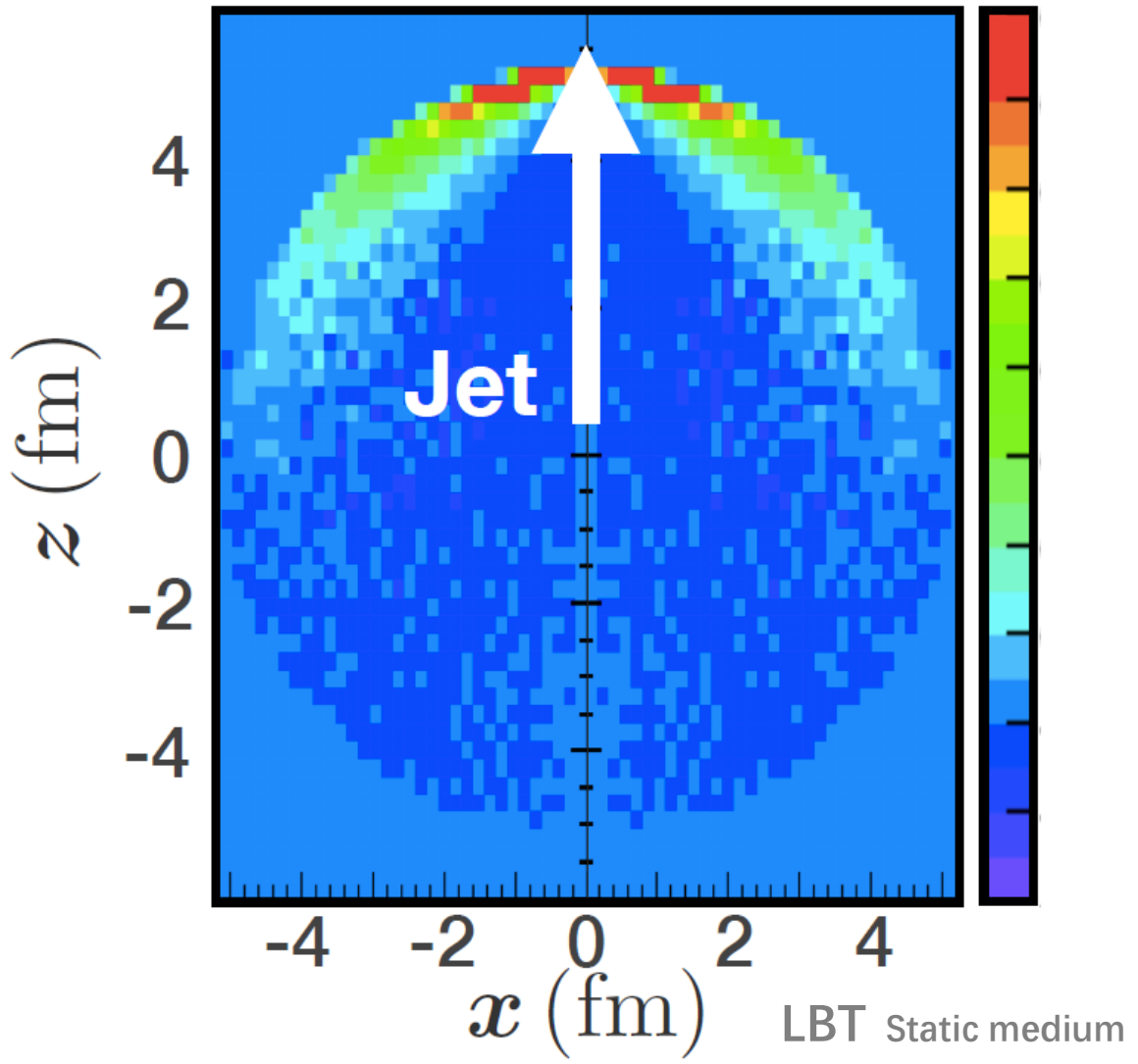
In collaboration with Yayun He, Carlos A. Salgado, Xin-Nian Wang

Jet induced medium response

Negative particle, Particle hole,
Wake, Initial thermal parton



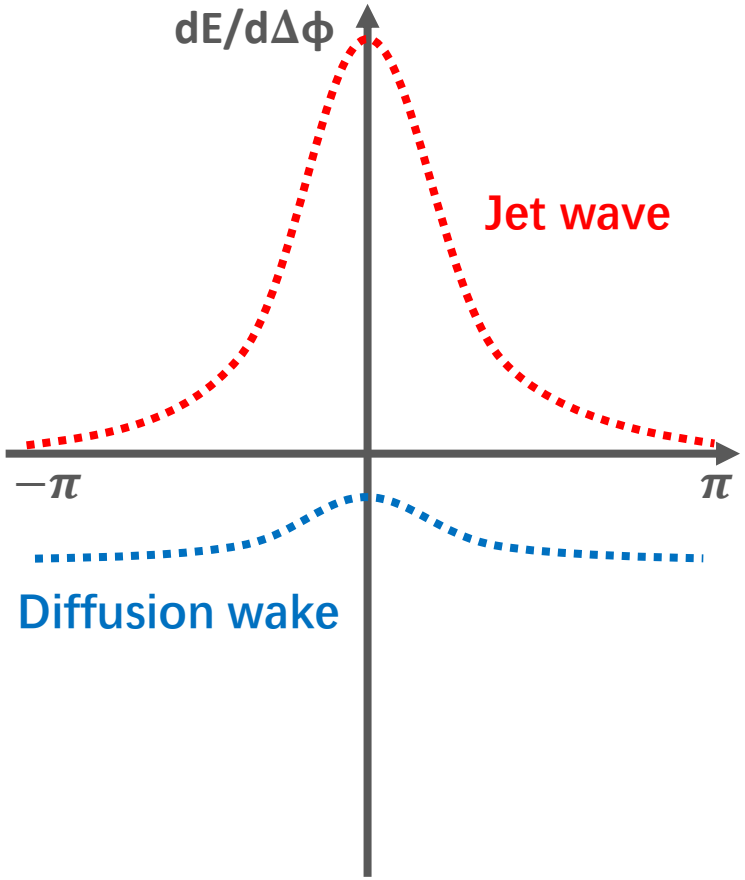
Energy-momentum conservation

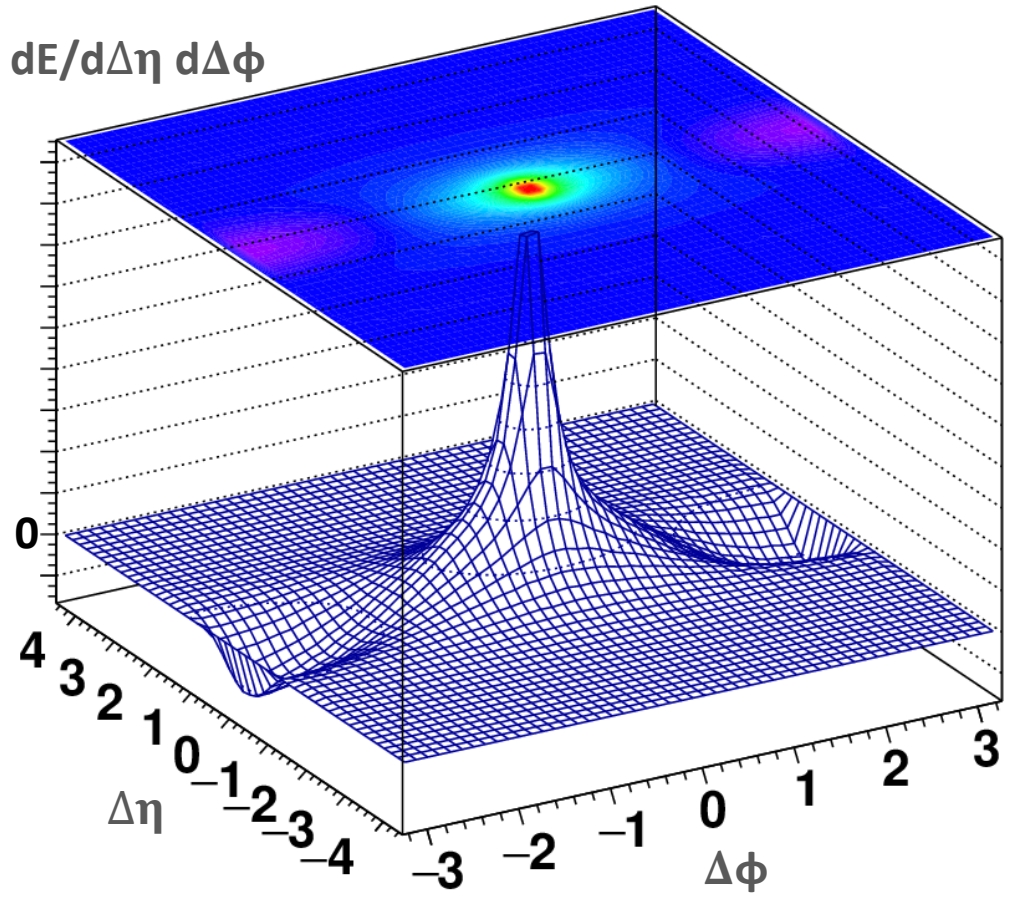


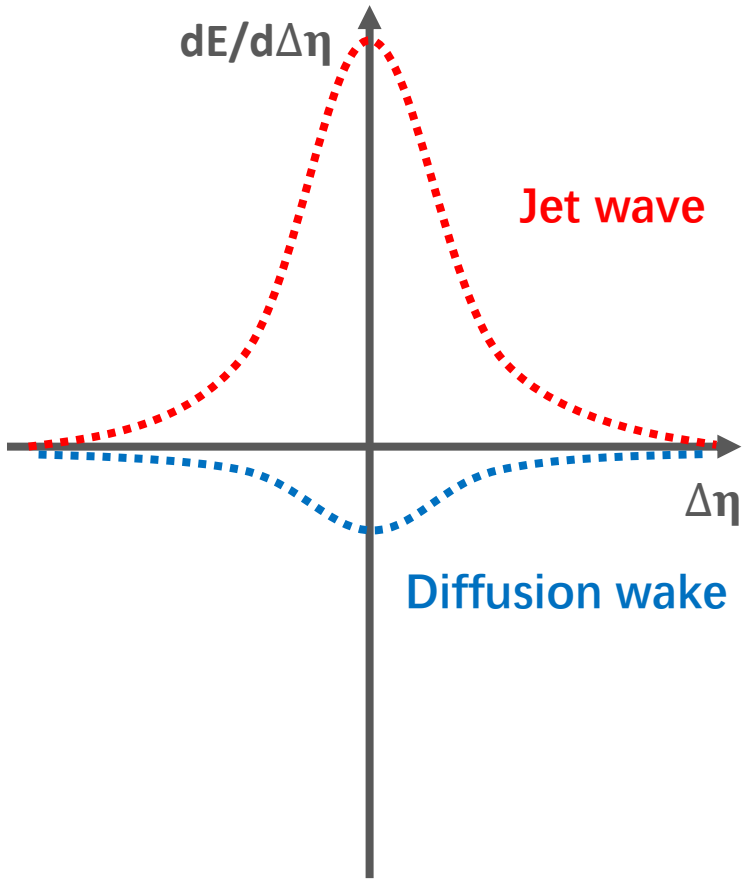
Searching for the diffusion wake

Jet induced medium response: a naive picture

- The deep in the back side of the jet (Signal of the diffusion wake).
- The induced diffusion wake is locate at the same rapidity range as the jet.

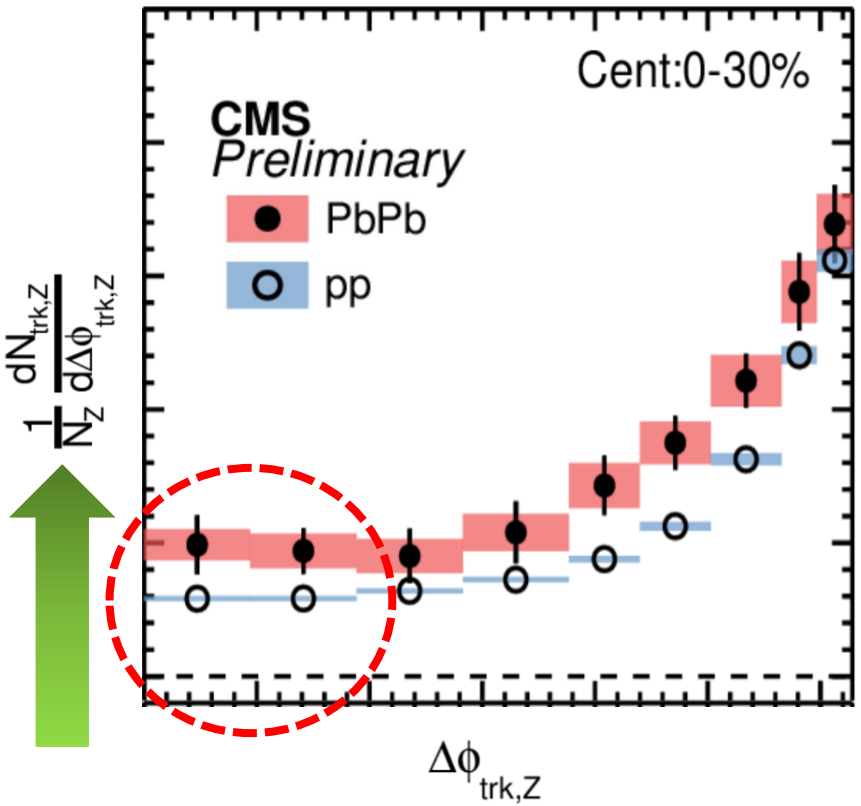


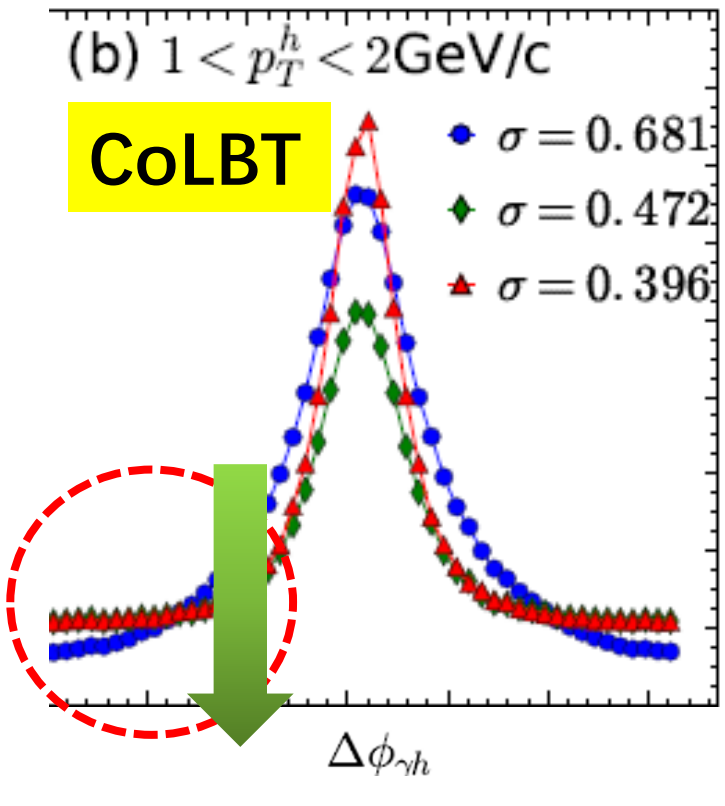


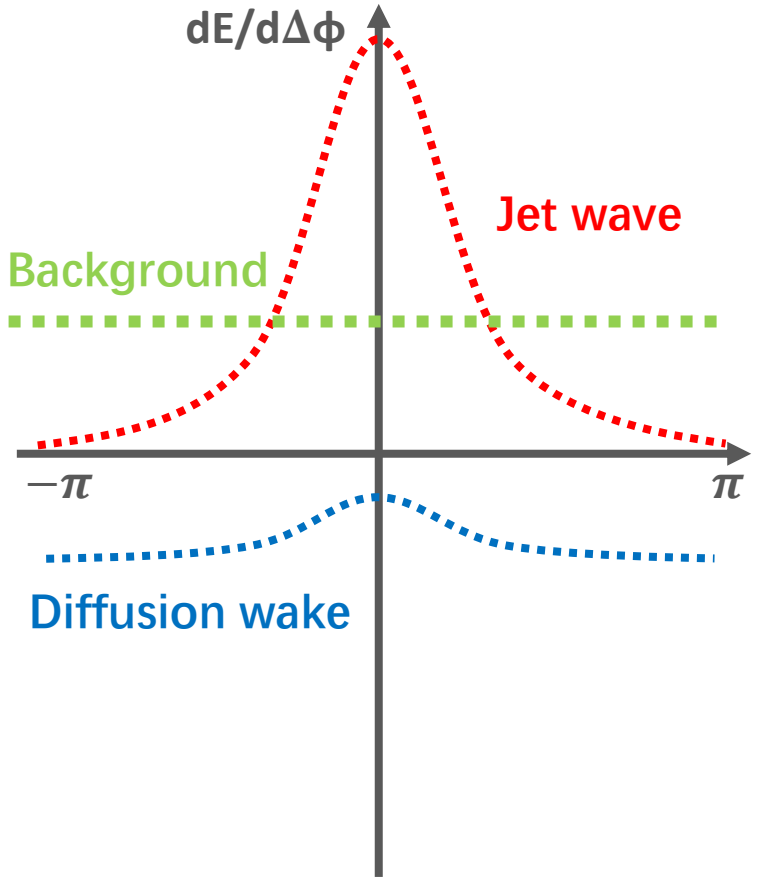


Searching for the diffusion wake: the background

- The deep in the back side of the jet (Signal in the transverse structure)
- Diffusion wake .vs. background

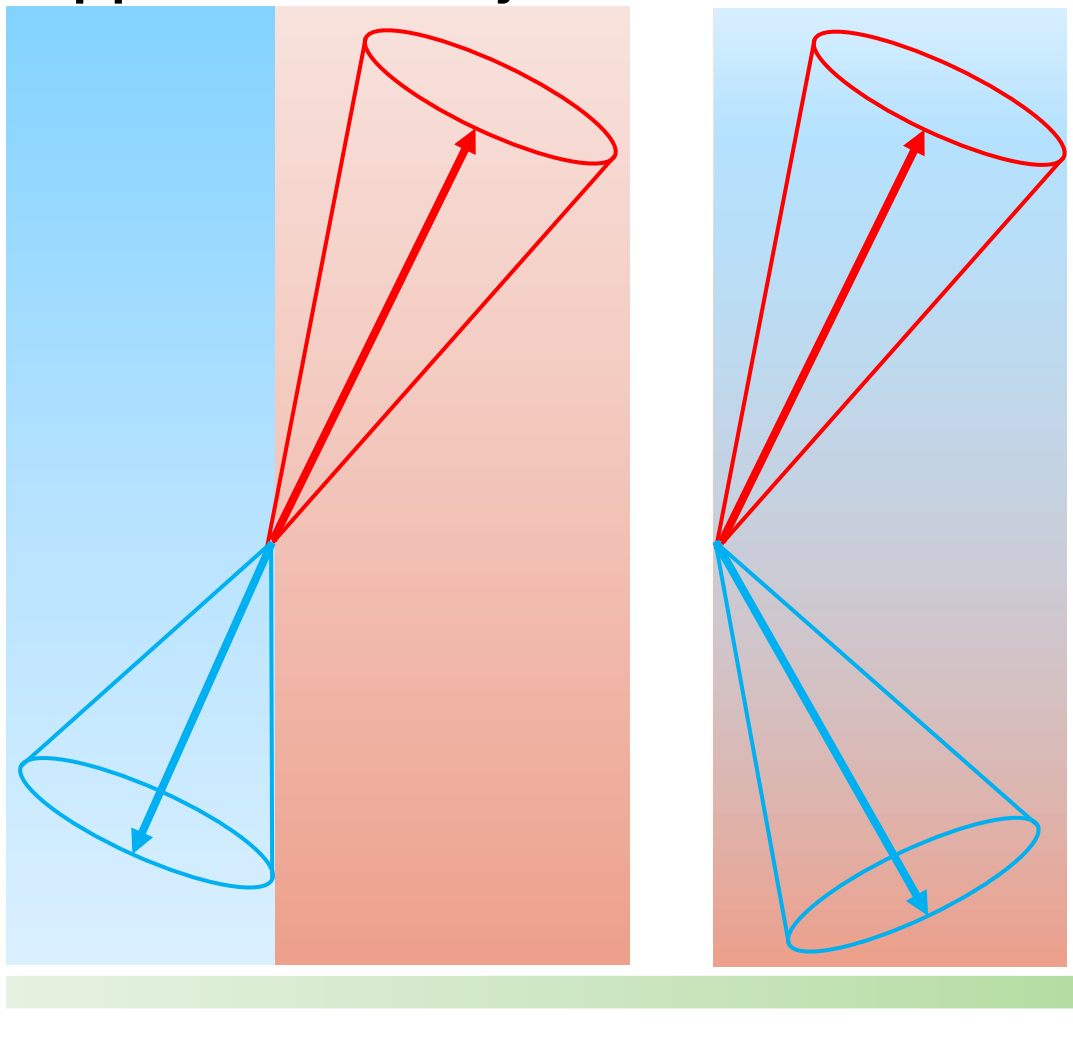






Diffusion wake in the longitudinal structure

- The effect of the diffusion wake could be observed by looking at the leading jet suppression in dijet events with different rapidity configuration.



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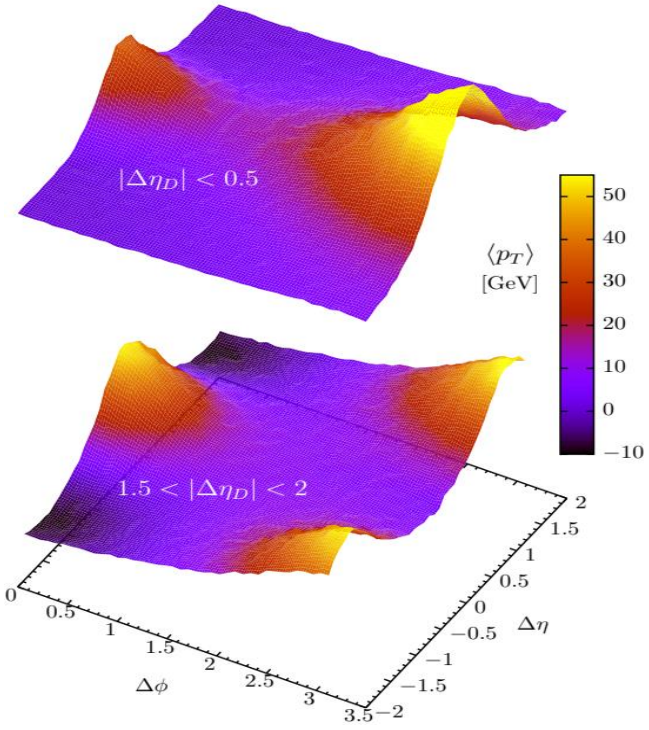
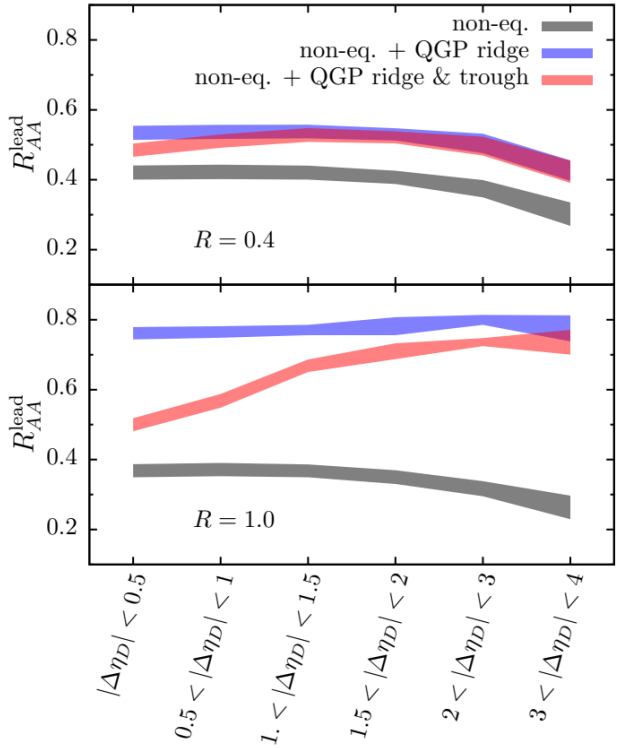
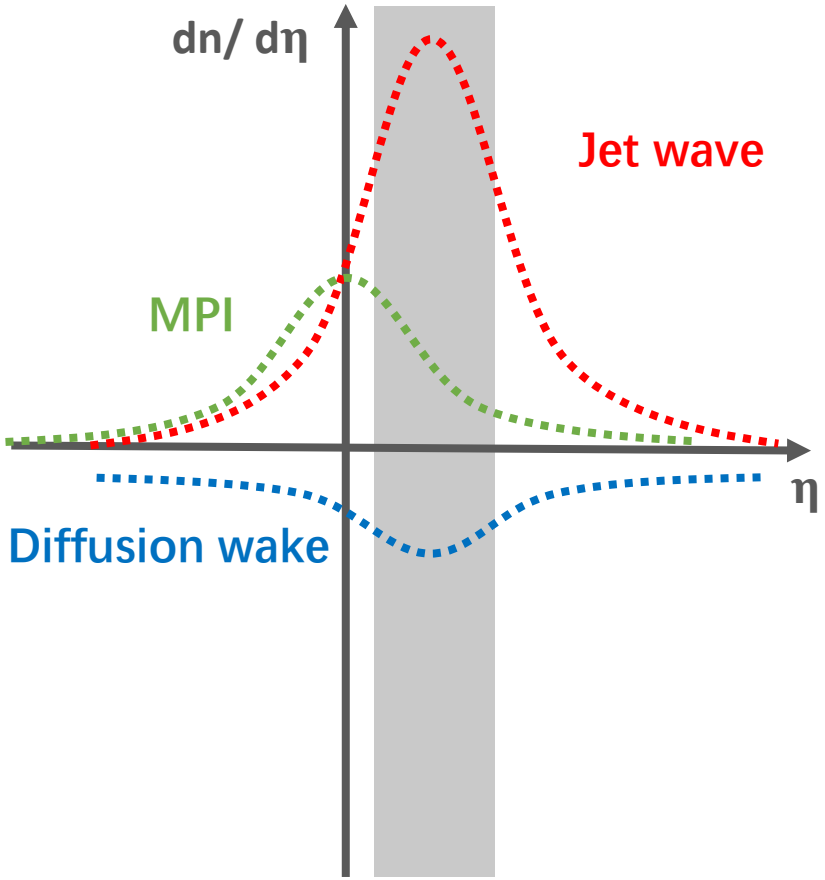


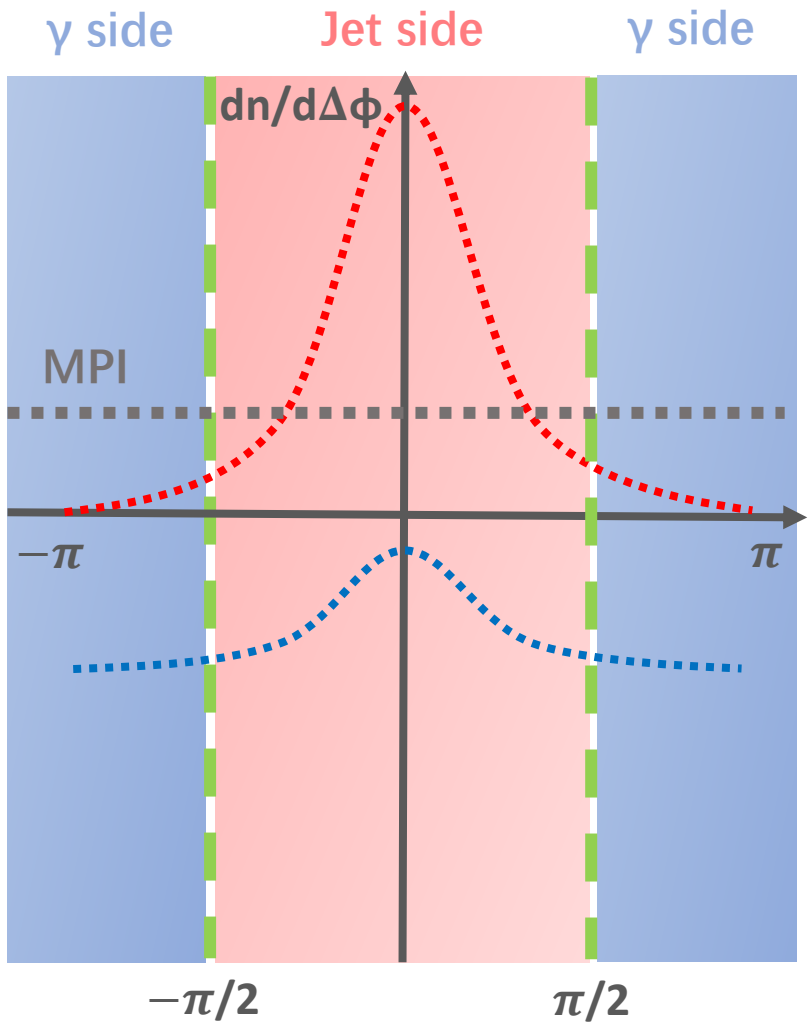


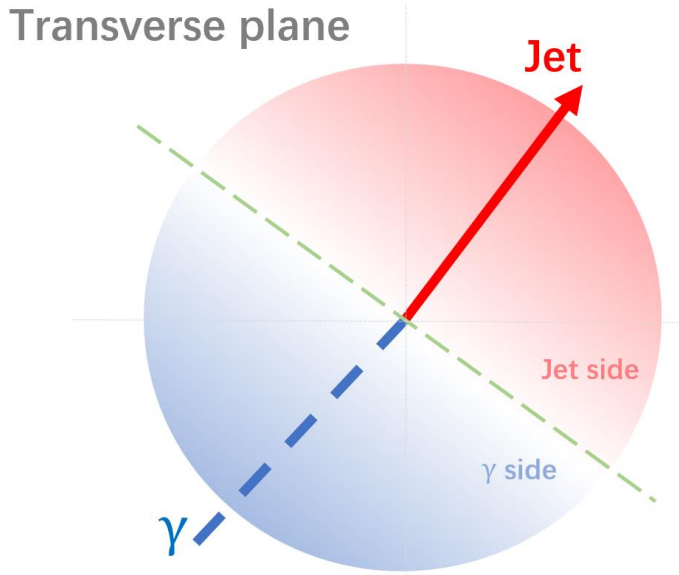
- Dijet pairs with large rapidity gap are rare. (So are many other proposed observables)

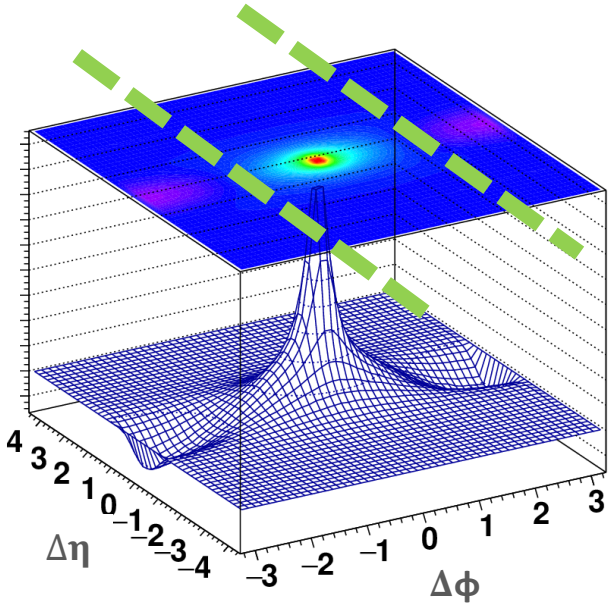
Searching for the diffusion wake

- A phase space cut in the transverse plane.
  (Jet hemisphere & γ hemisphere)



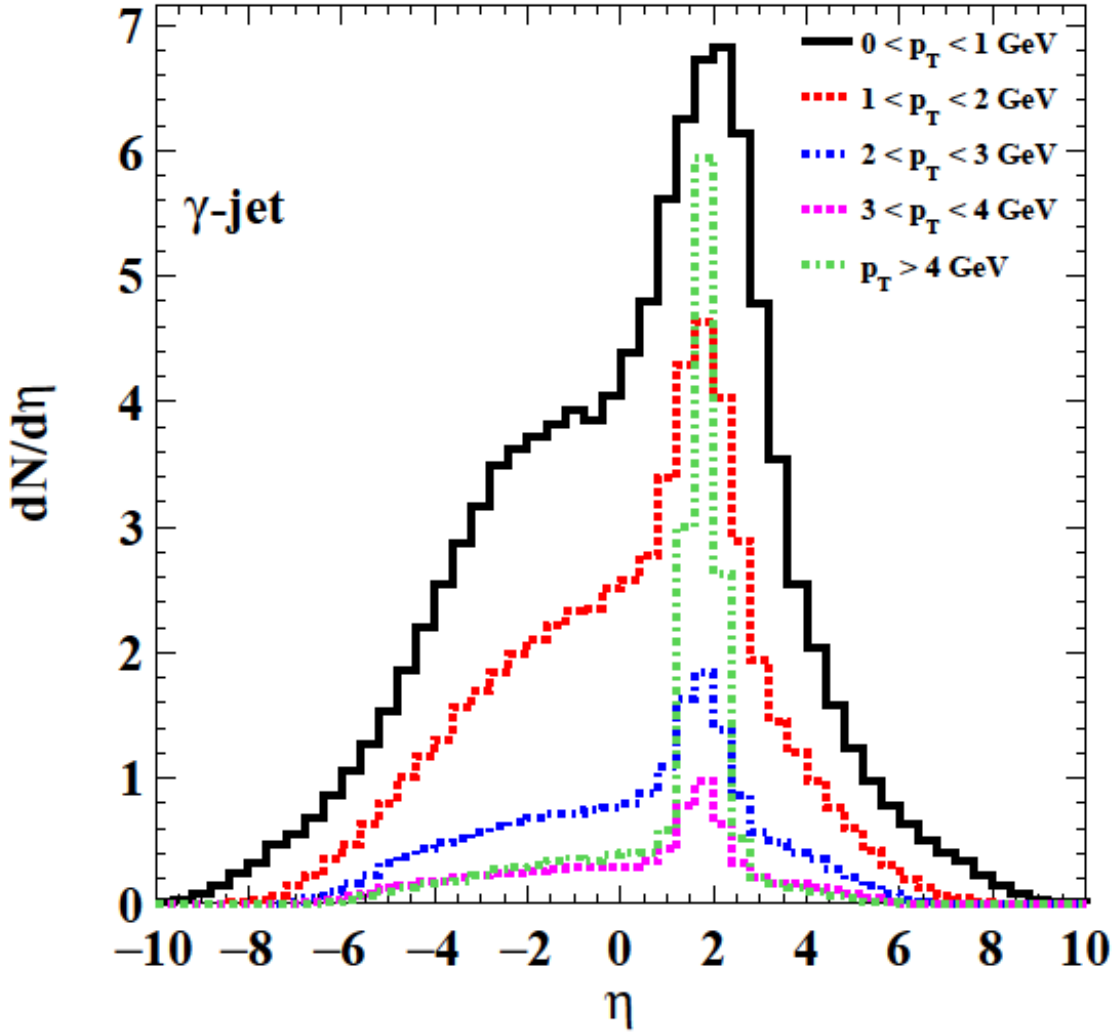




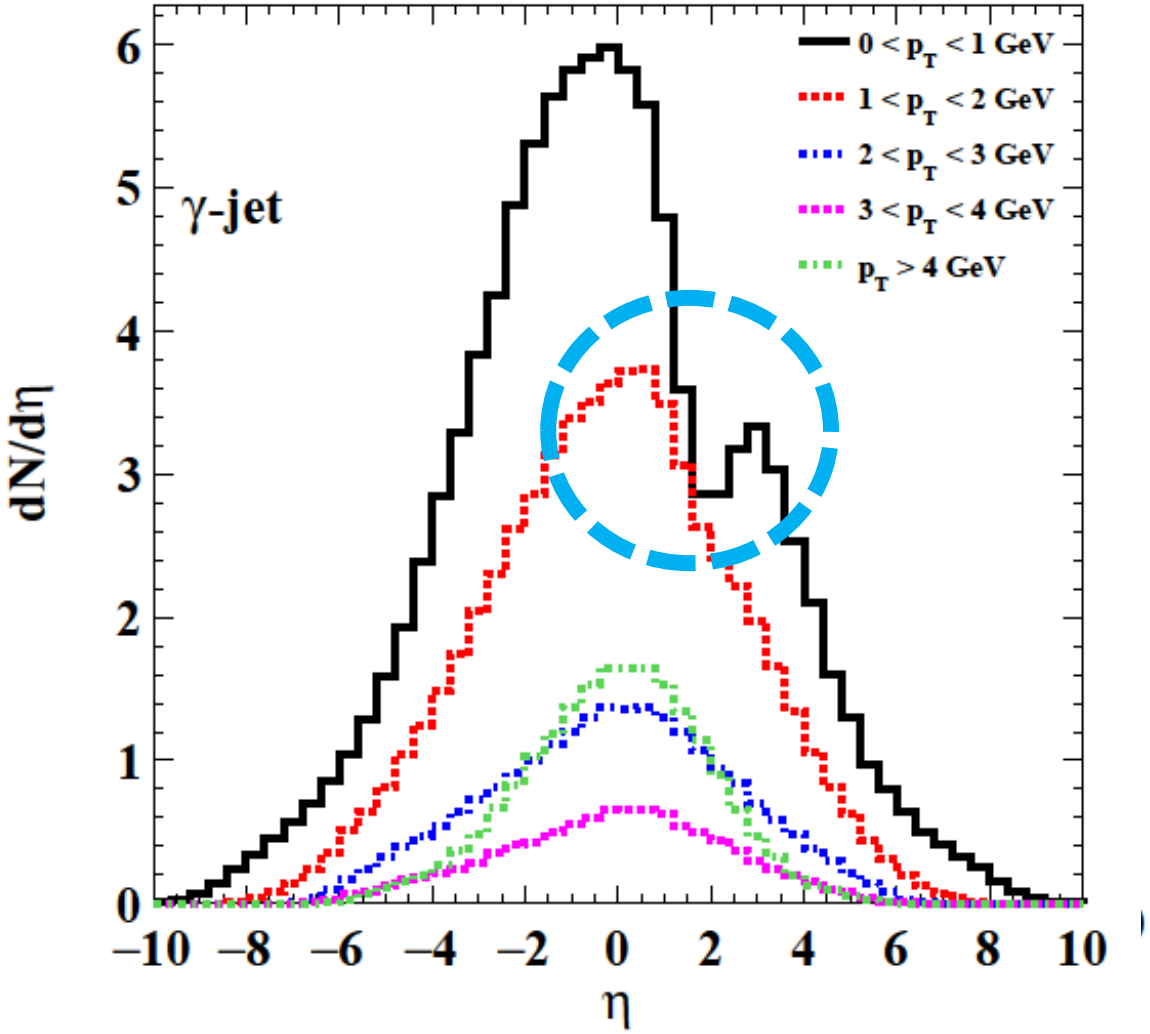


Searching for the diffusion wake

Jet side



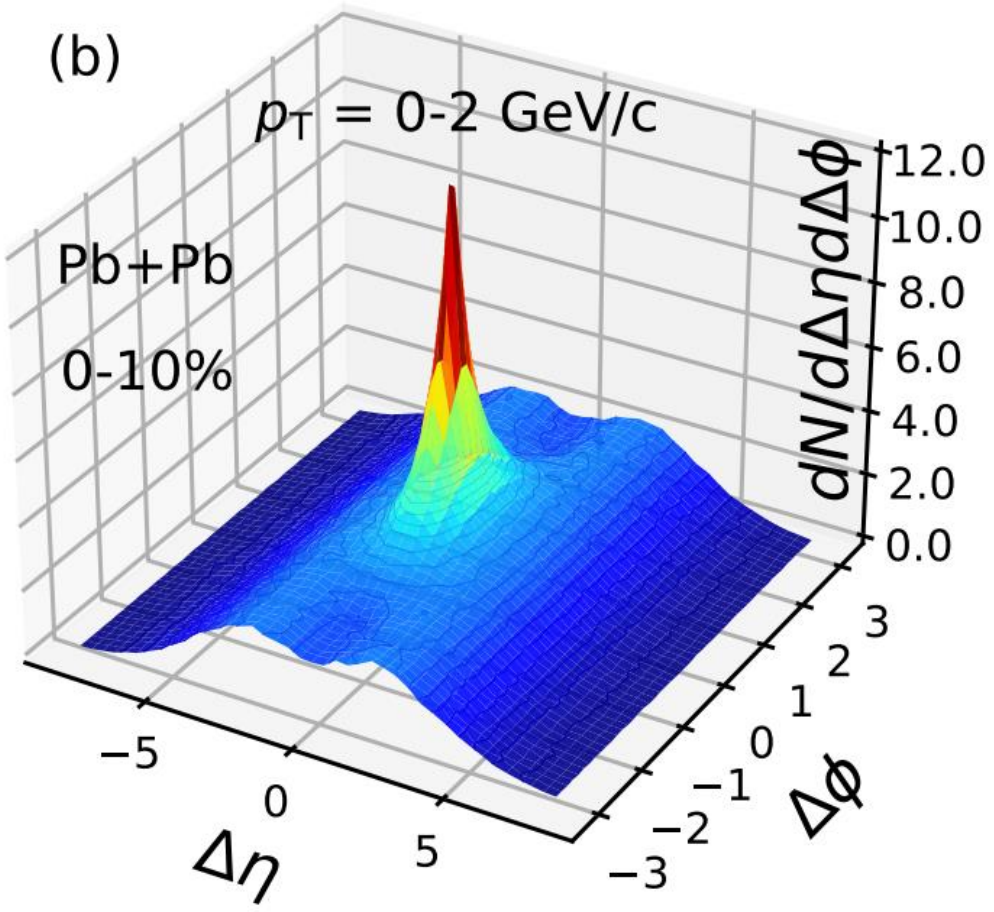
γ side

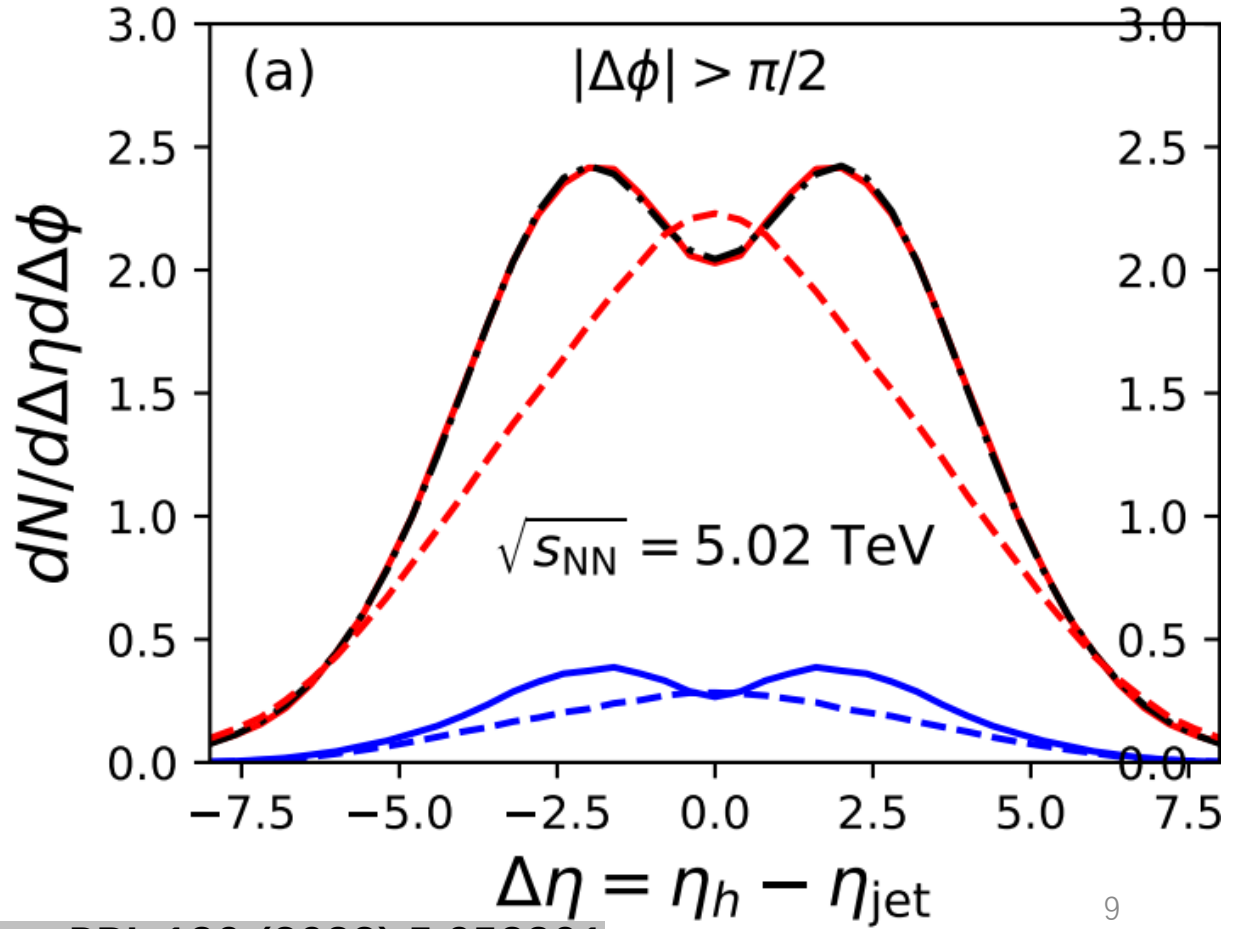


Diffusion wake in the longitudinal structure

- **MPI ridge & diffusion wake valley (γ-jet particle number distribution)**

- **Quantify the wake with Gaussian fit**

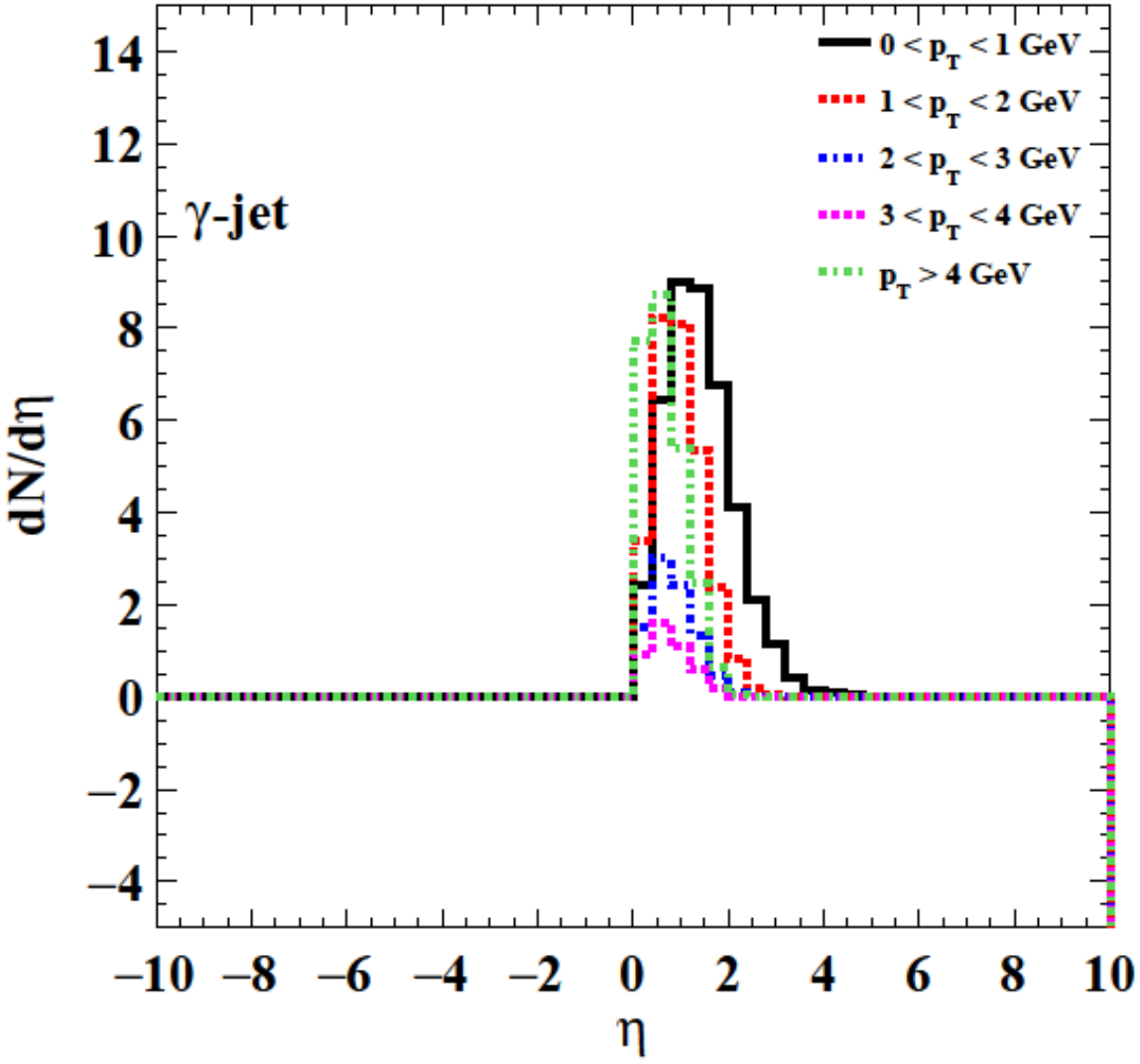




Yang, Luo, Chen, Pang, Wang, PRL 130 (2023) 5,052301

Intra-jet asymmetry (Jet winnowing)

Jet side



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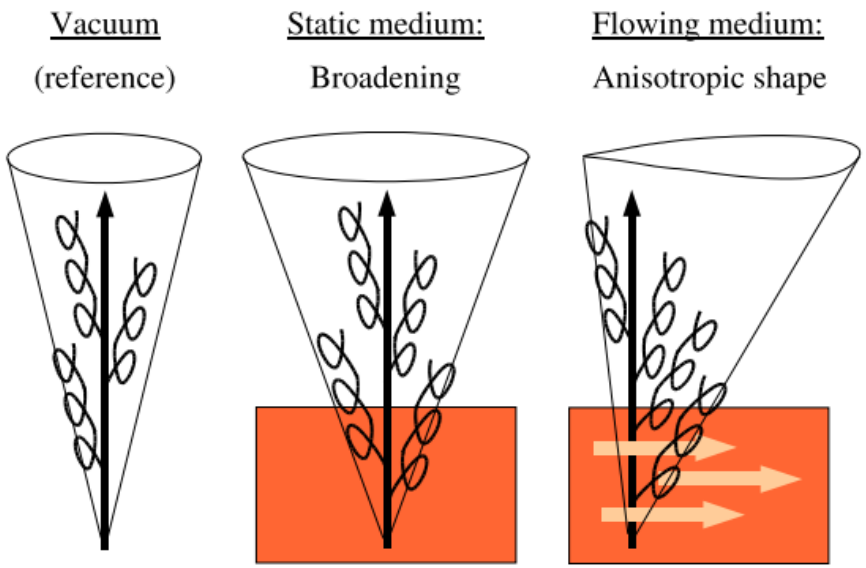
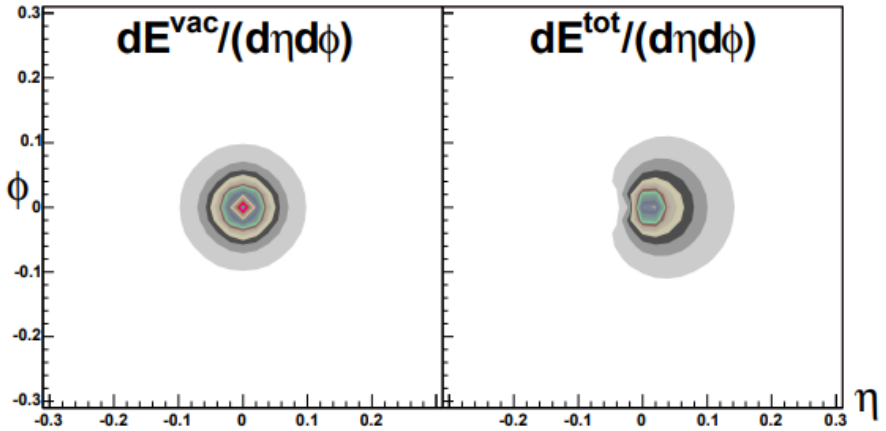
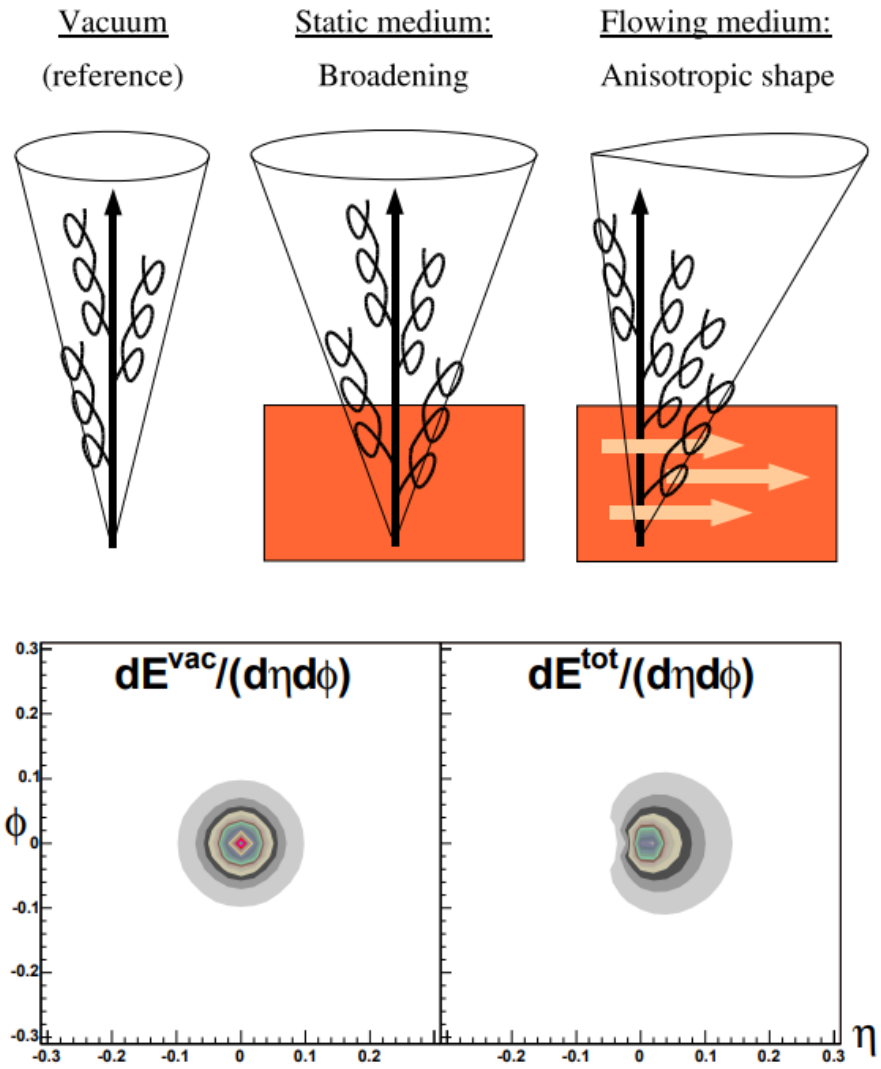
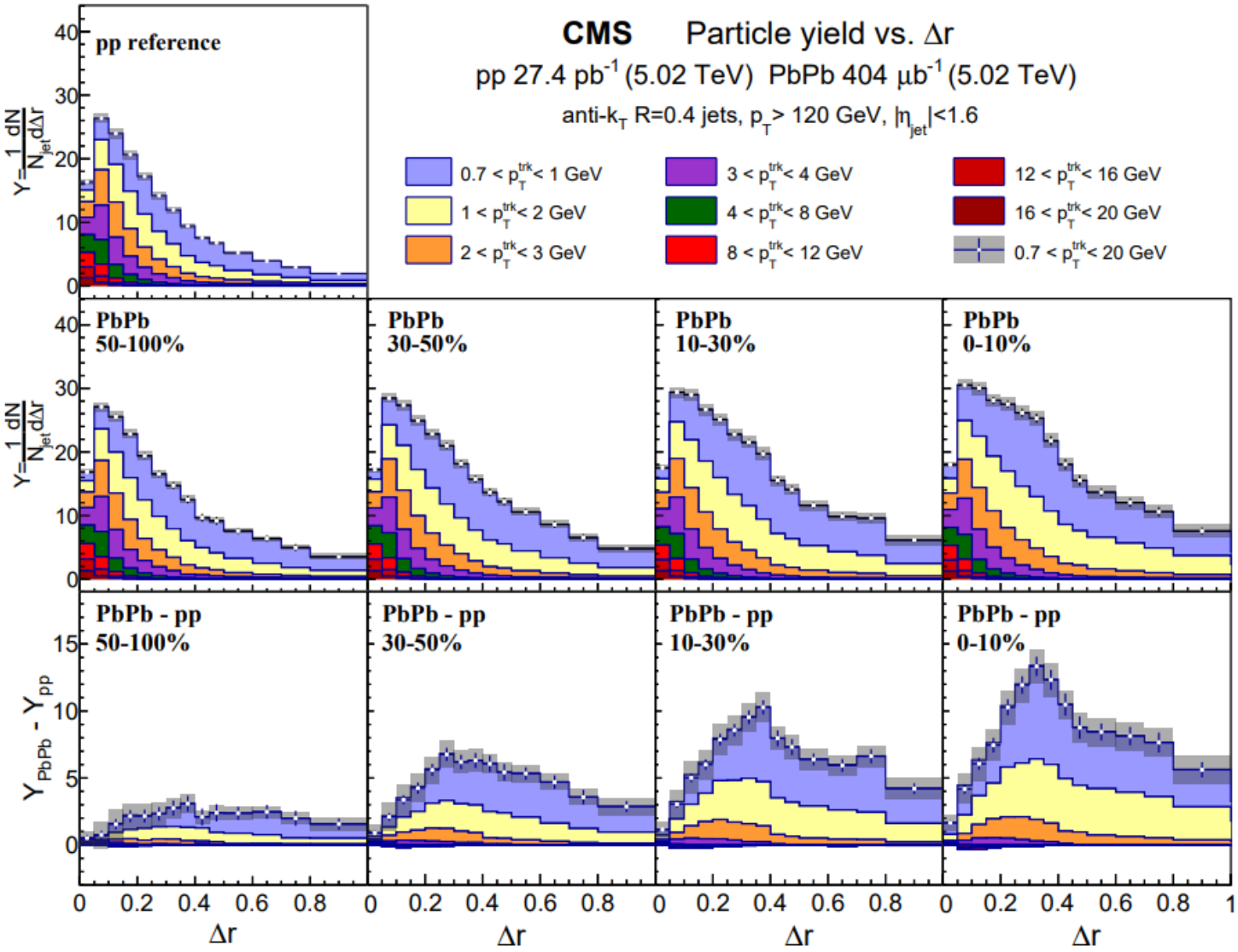




Armesto, Salgado, Wiedemann Phys.Rev.Lett.93:242301,2004

Intra-jet asymmetry (The jet-flow coupling)





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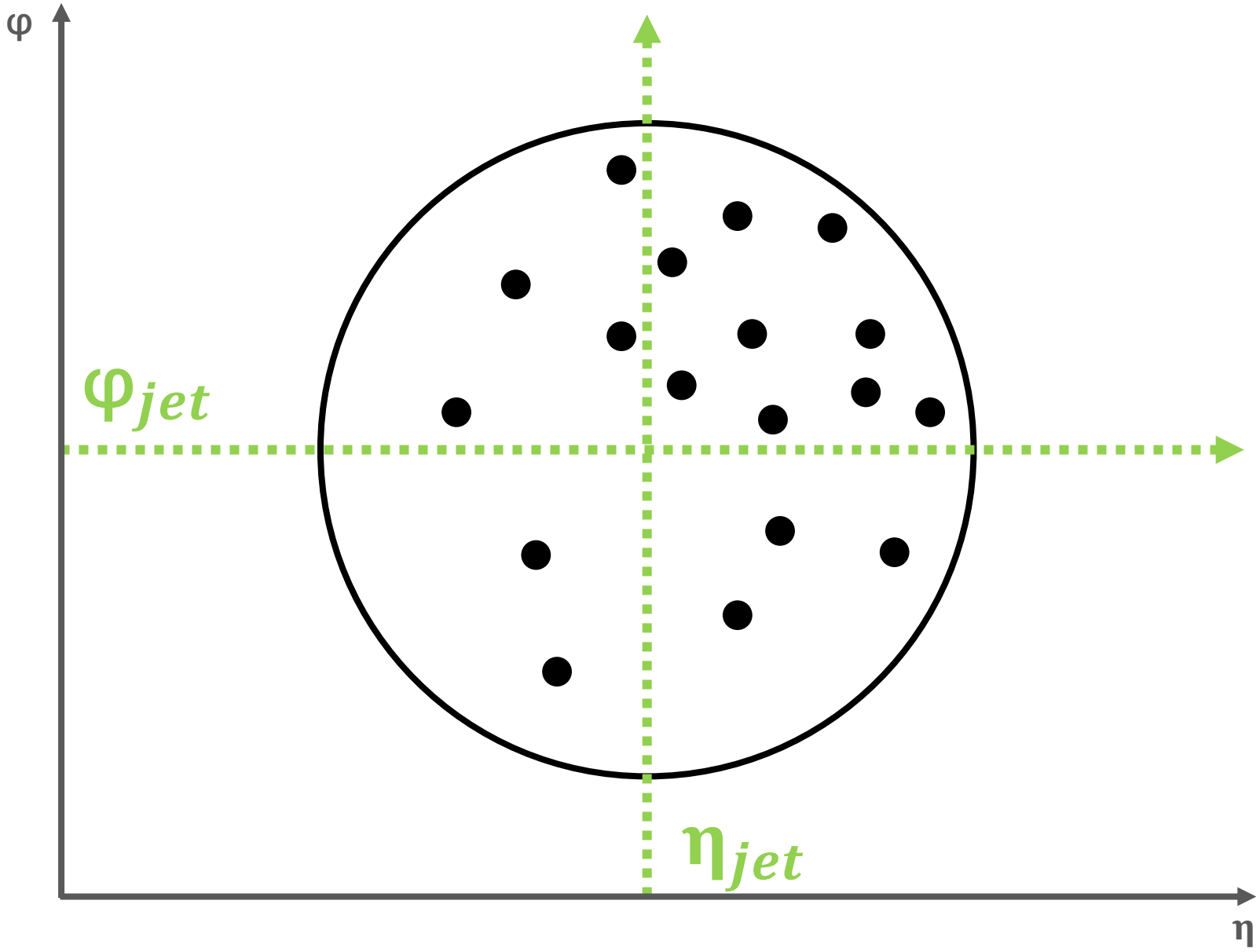
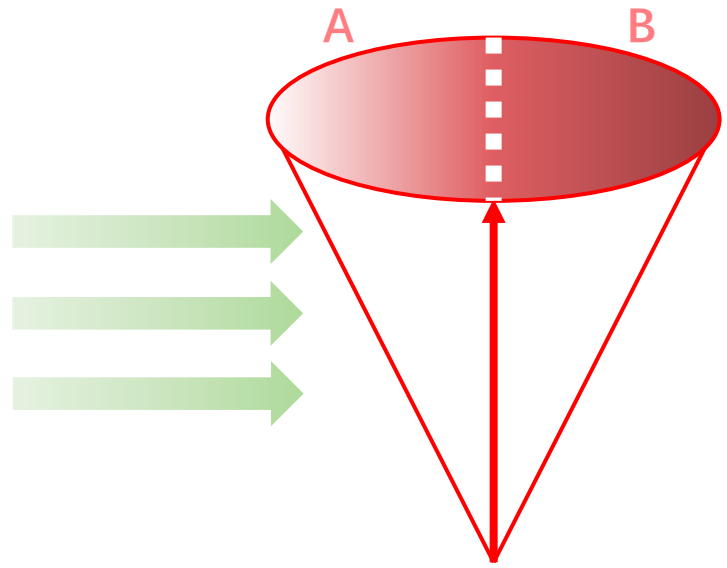


$$X = \frac{Q_A - Q_B}{Q_A + Q_B}$$

$$Q_A = \sum_{i \in A} q_i$$

$$Q_B = \sum_{i \in B} q_i$$



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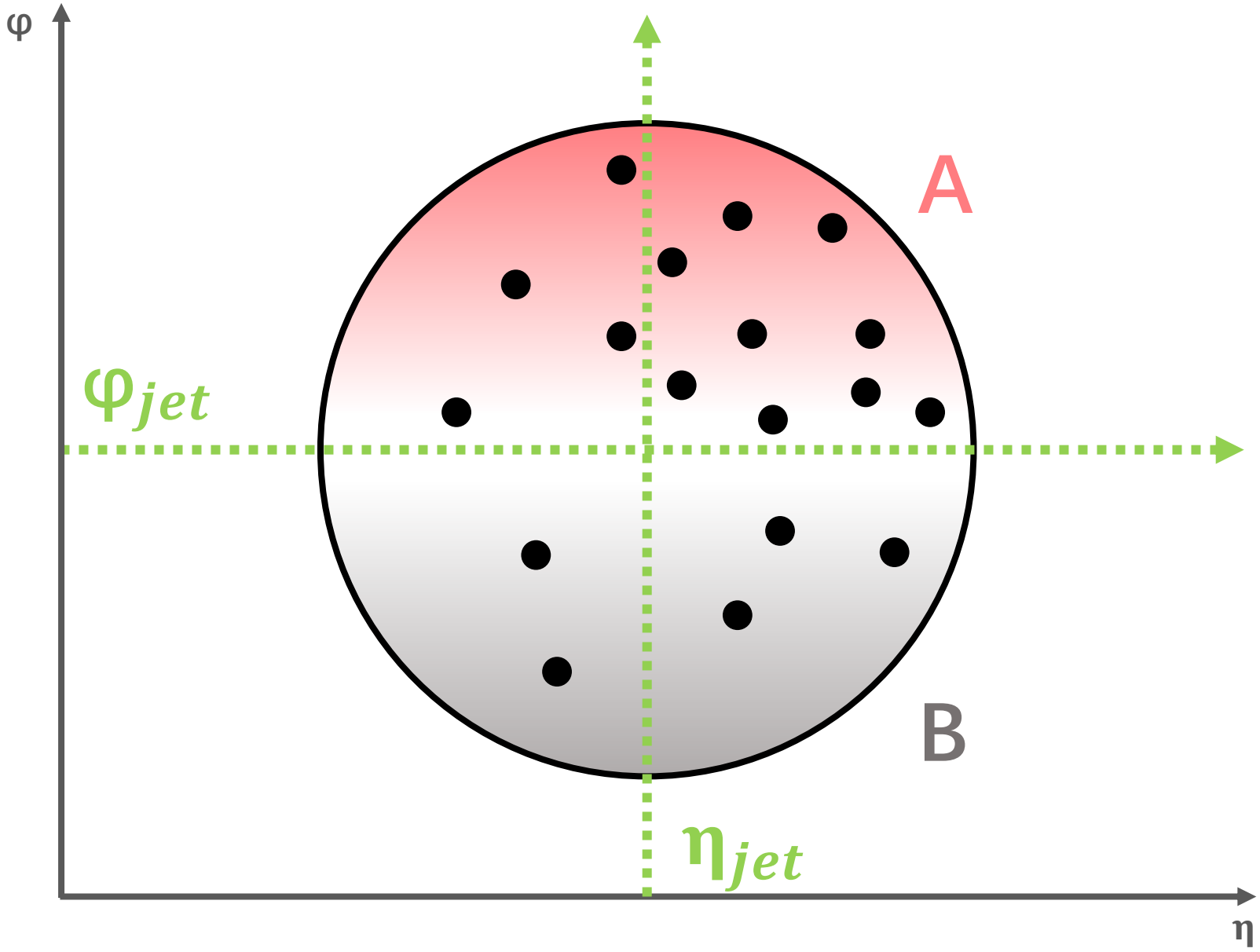

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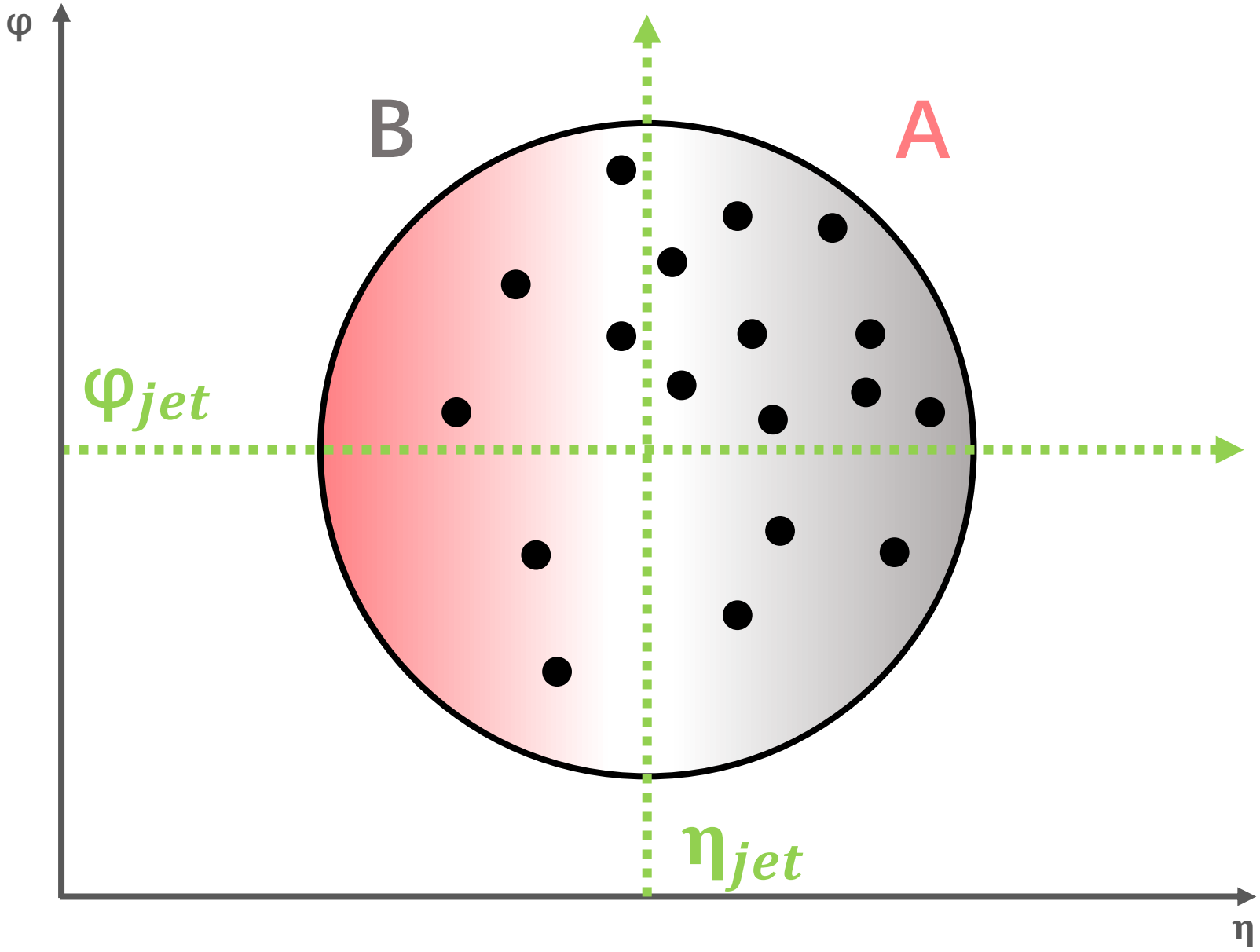
A $(\varphi_i > \varphi_{jet})$

B $(\varphi_i < \varphi_{jet})$

Intra-jet asymmetry (The jet-flow coupling)



$$X = \frac{Q_A - Q_B}{Q_A + Q_B}$$

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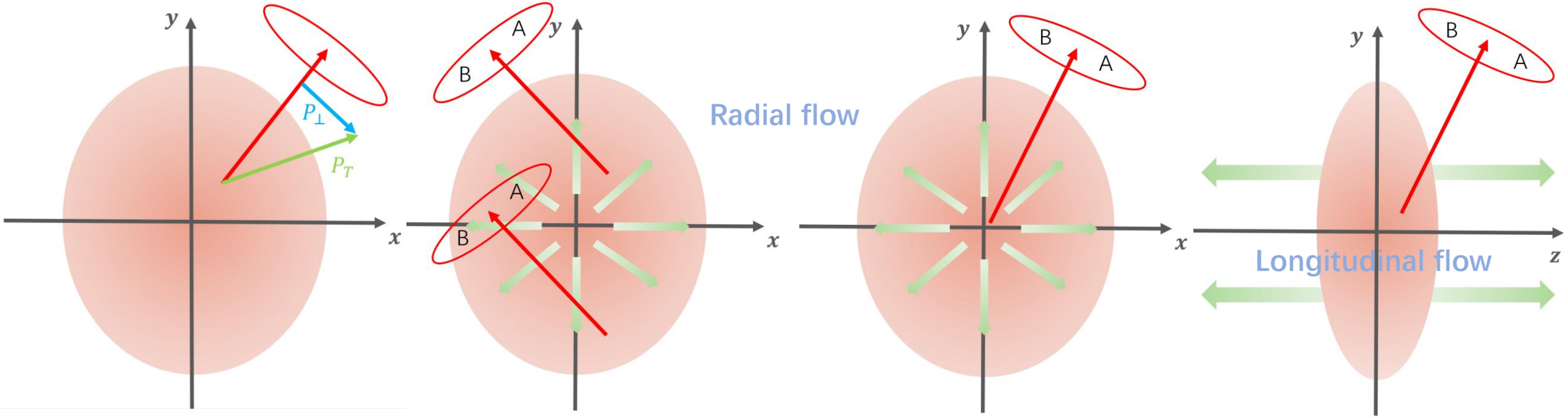
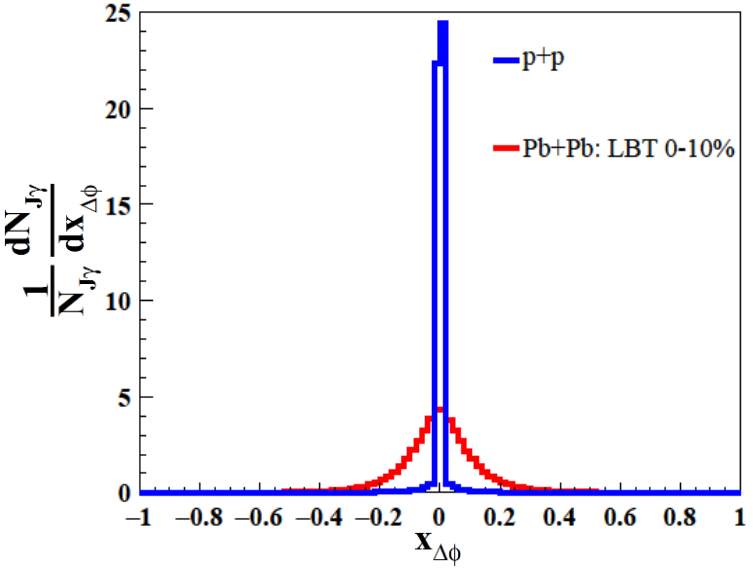
$$Q_B = \sum_{i \in B} q_i$$

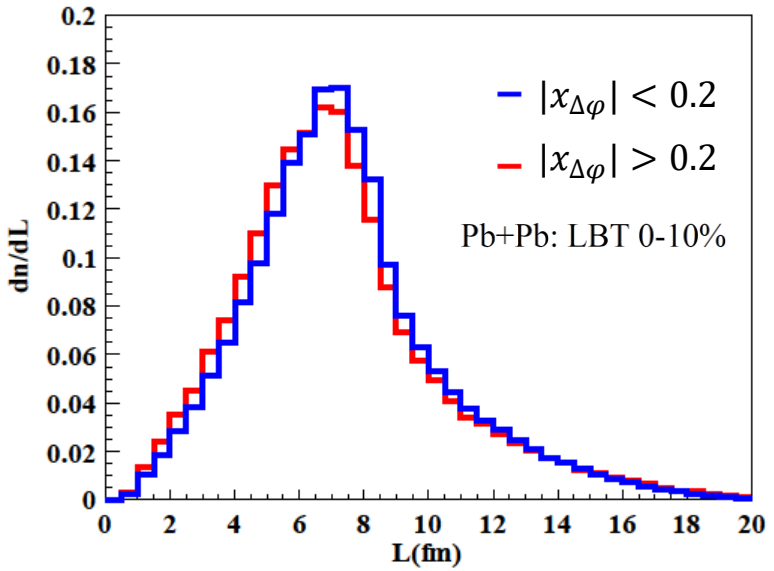
A $(\eta_i > \eta_{jet})$

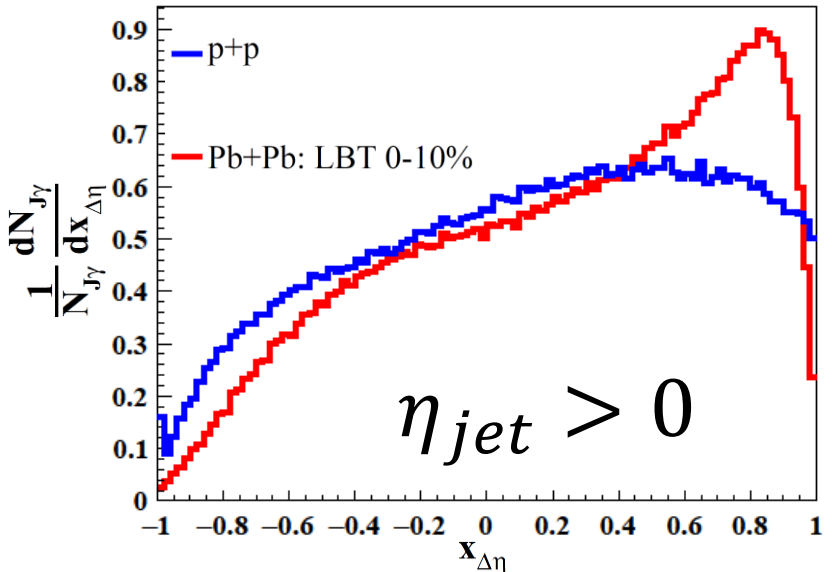
B $(\eta_i < \eta_{jet})$

Intra-jet asymmetry increase in AA collisions (γ-jet)



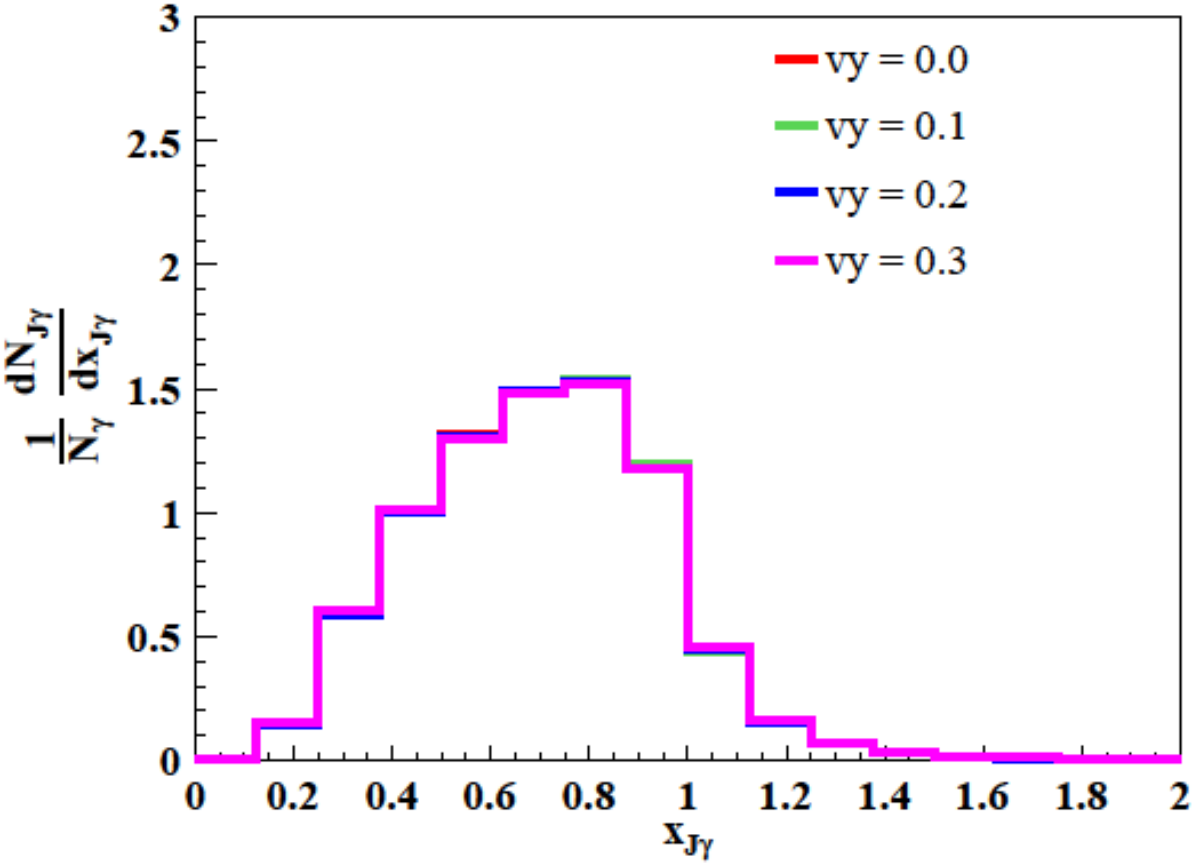


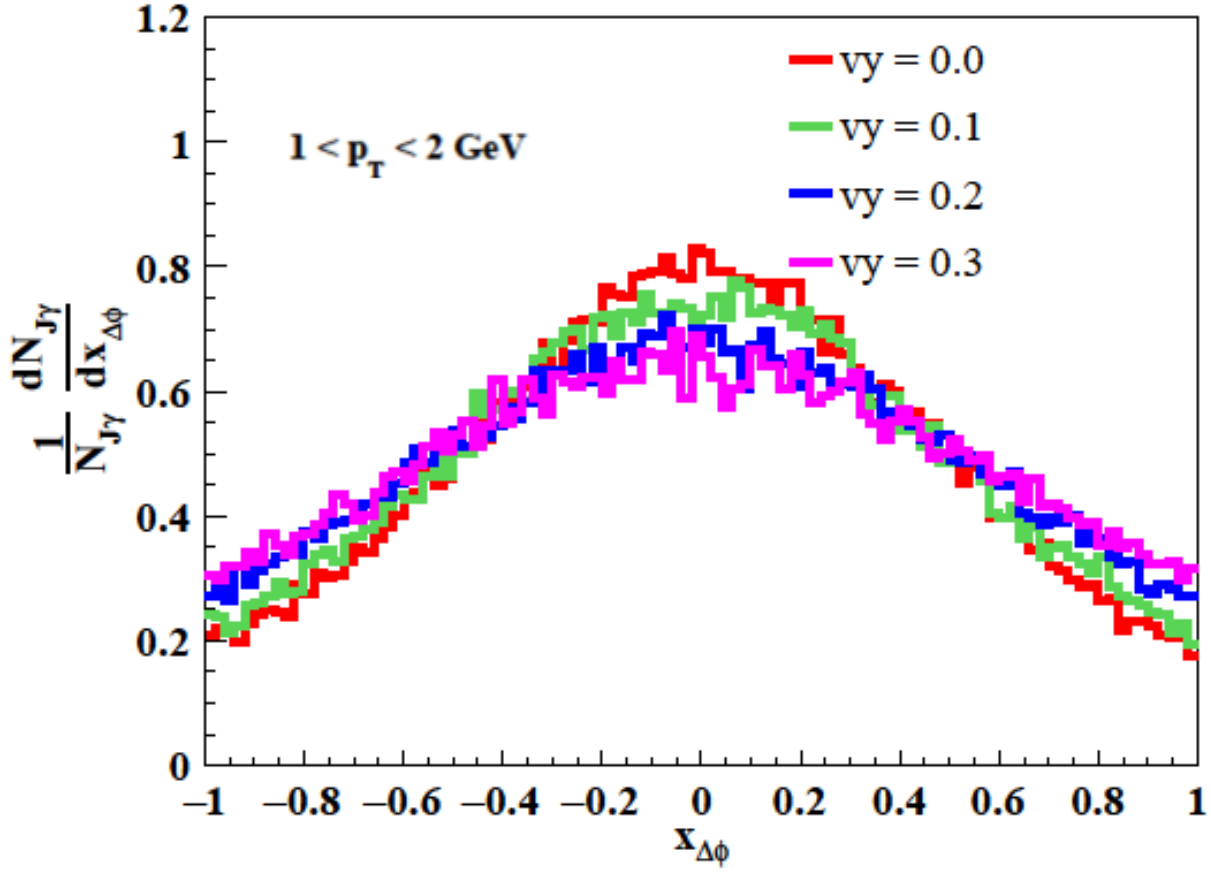




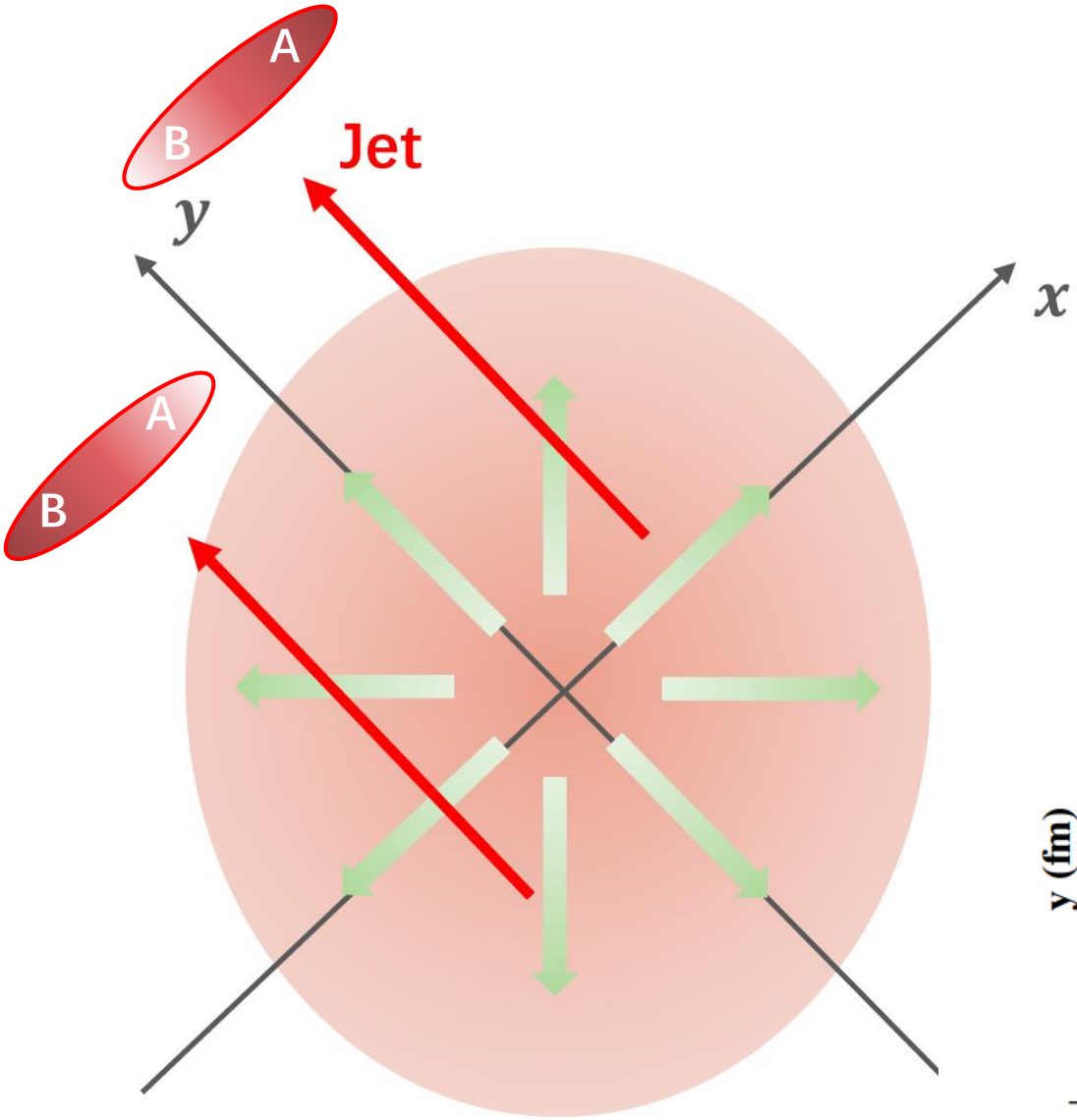
Intra-jet asymmetry & Jet-flow coupling (γ-jet)

- Jet propagation in a uniform medium with different flow velocities.
- A clear broadening of the intra-jet asymmetry with the increasing flow velocities.



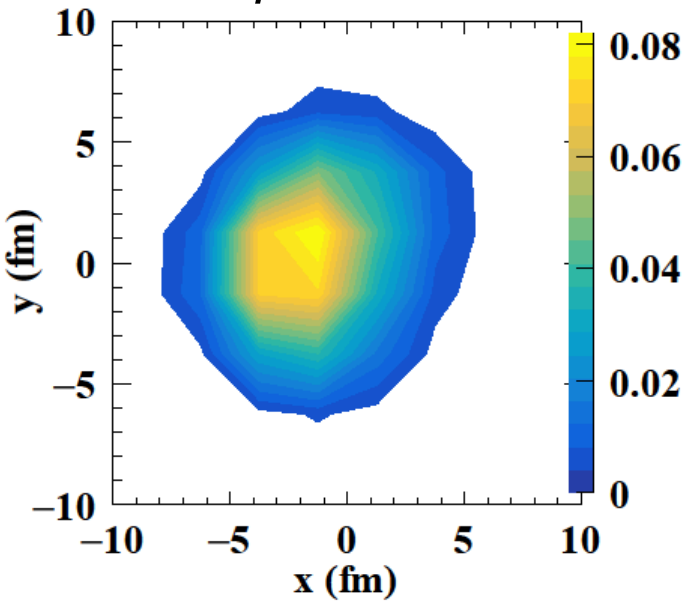


Jet localization with intra-jet asymmetry (γ-jet)

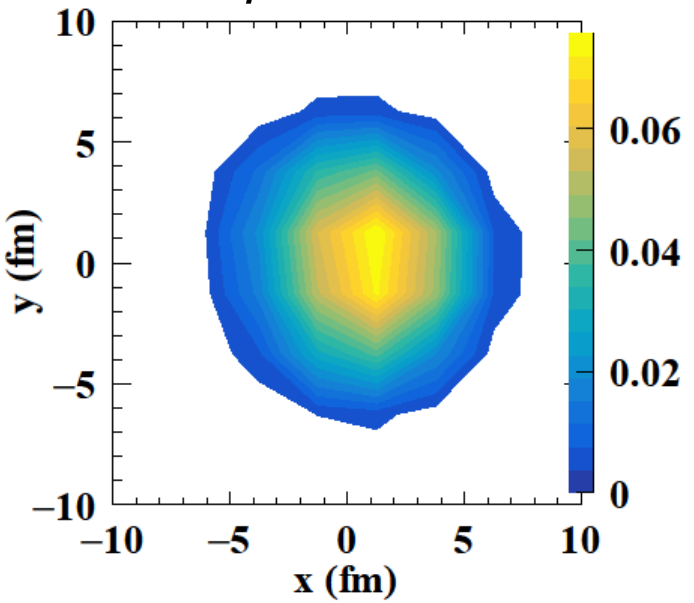


- Since the relative angle between jet and the event plane is random, we can use the jet axis as the coordinate axis y in the transverse plane.
- Better localization in multiple jets (Dijet) events?

$x_{\Delta\varphi} < -0.2$

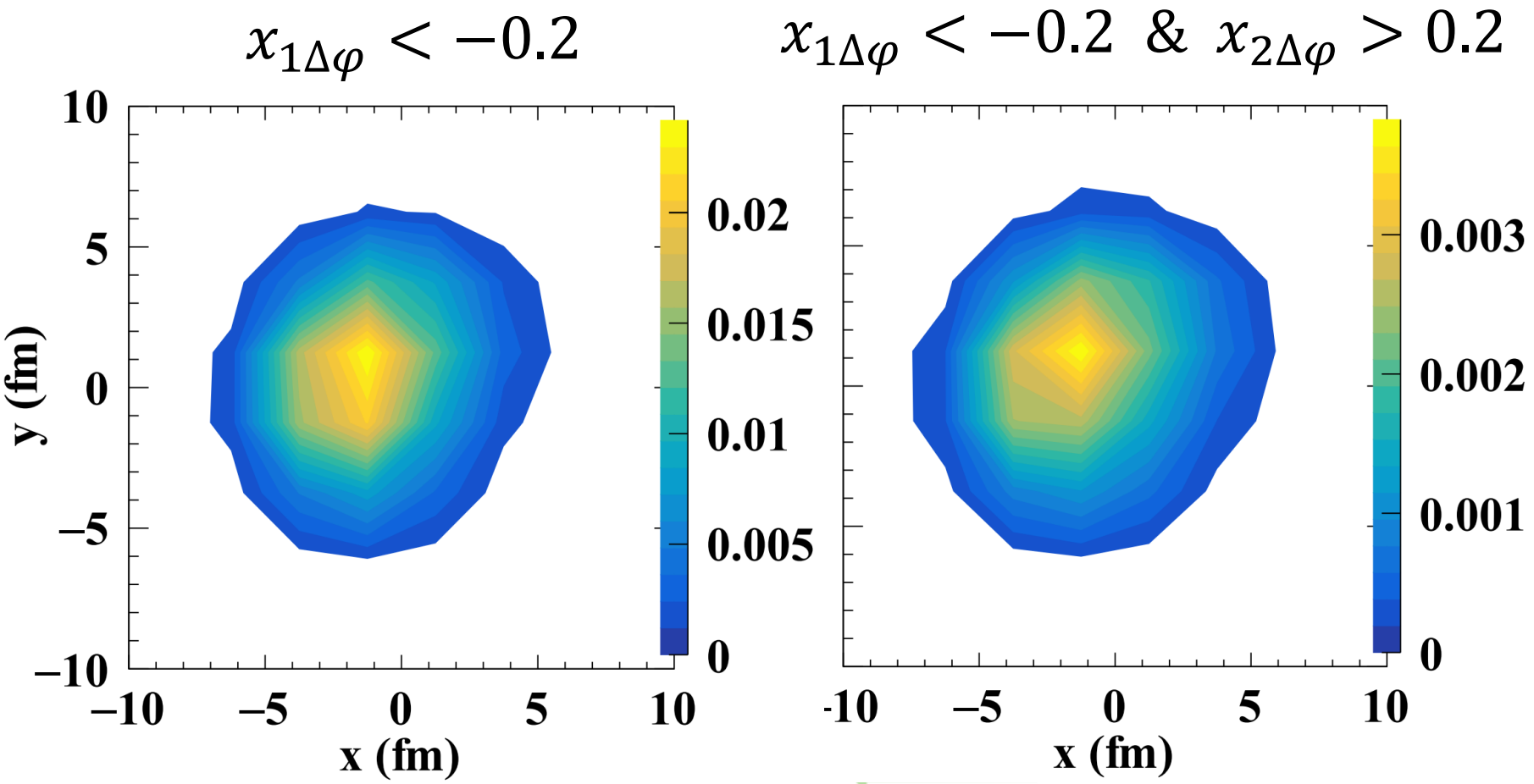


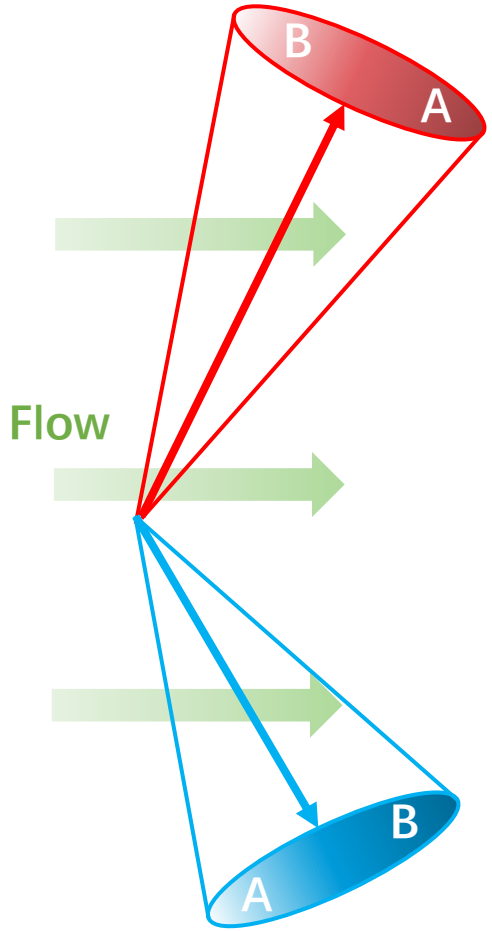
$x_{\Delta\varphi} > 0.2$



Jet localization with intra-jet asymmetry (Dijet)

- More jets, more information, better localization.
  (Interplay with the jet-induced diffusion wake)





Summary

- A new method to detect the effect of jet-flow coupling in heavy-ion collisions.
- Intra-jet asymmetry are observed at both the longitudinal and transverse direction.
- Intra-jet asymmetry can also be used in jet localization.

Outlook

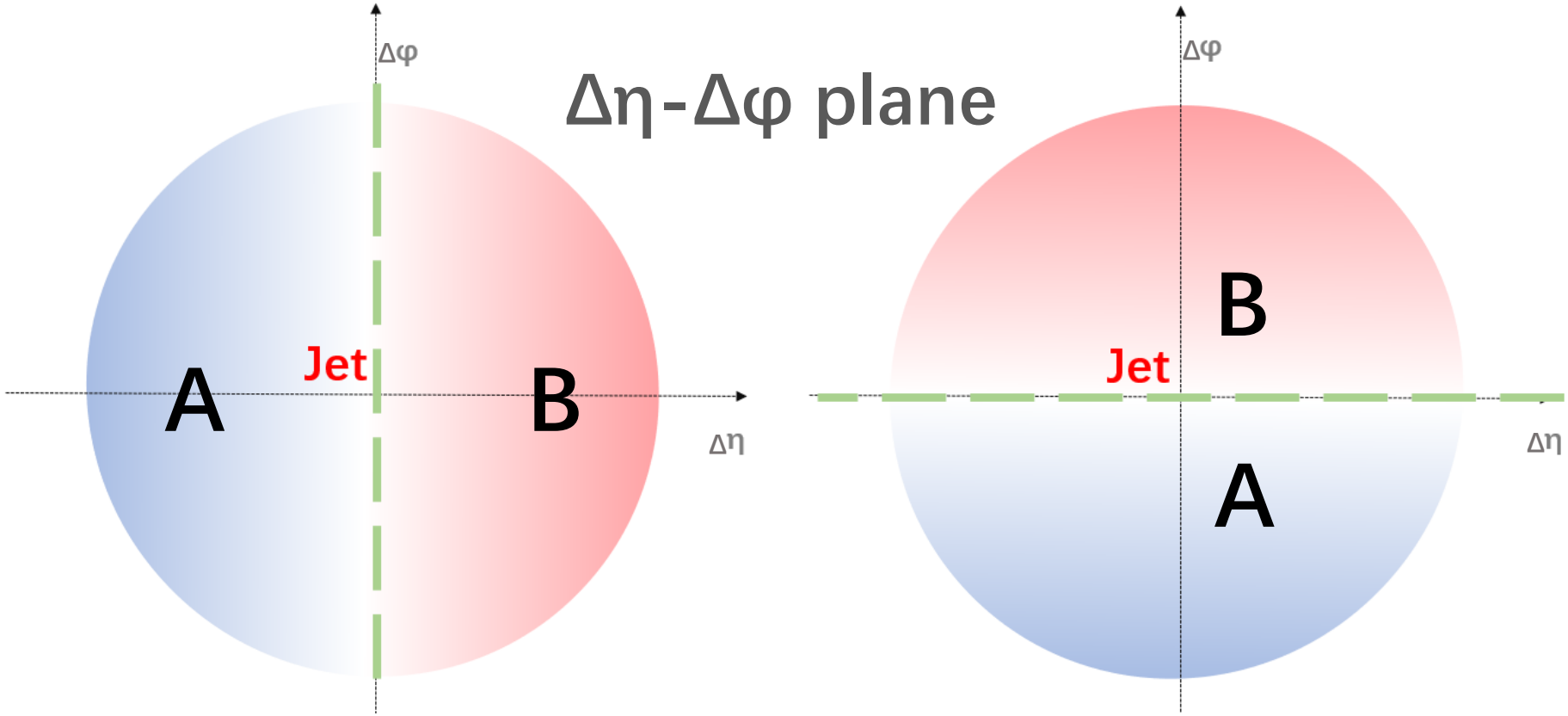
- Jet-flow coupling in QGP.
  (Medium fluctuation, Hadron cascade, Medium-induced splitting)


Thanks

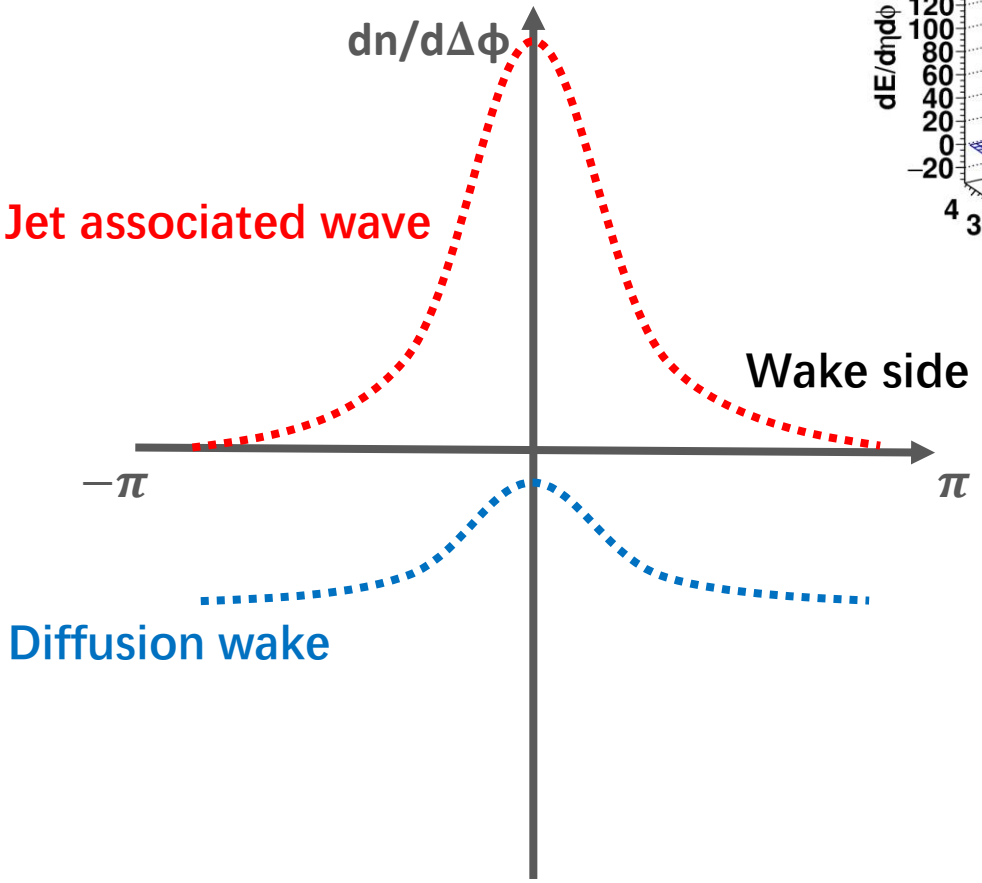
Phase-space cut and intra-jet asymmetry

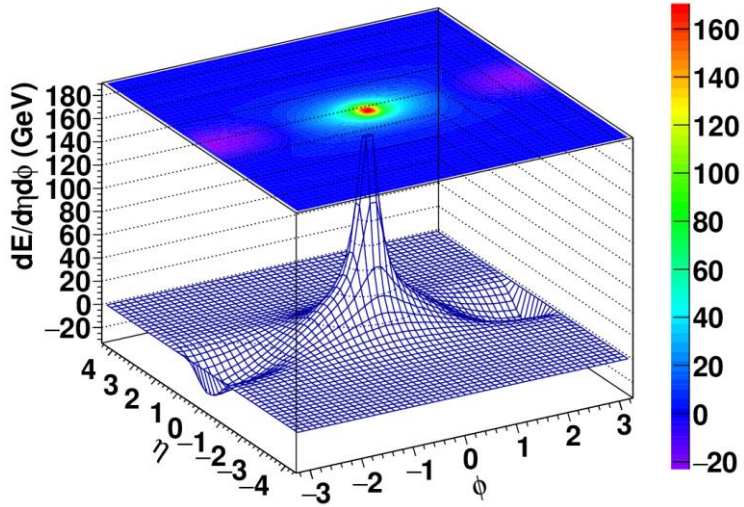
- A phase space cut inside jet cone (the Δη-Δφ plane).

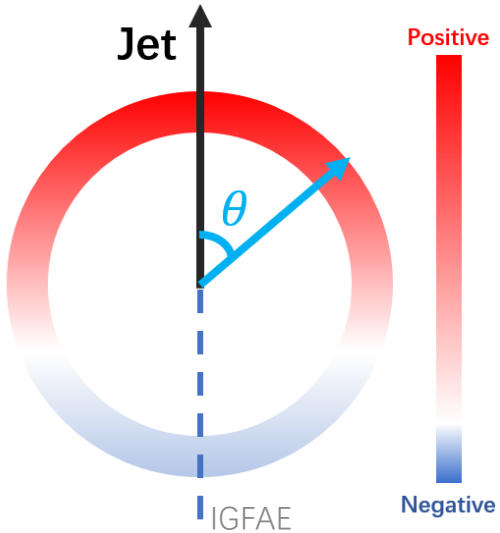
Intra-jet asymmetry $x = \frac{Q_A - Q_B}{Q_A + Q_B}$

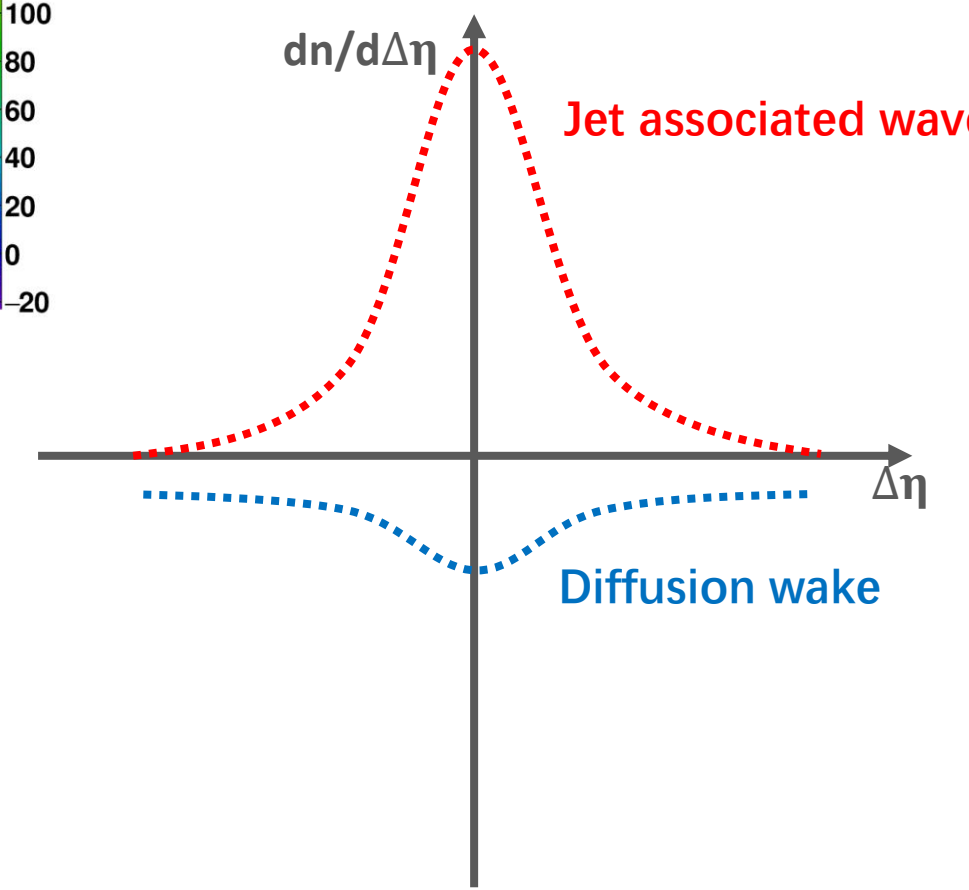


Jet induced medium response (3D structure)









A Linear Boltzmann Transport (LBT) Model

Parton shower

Pythia Sherpa

Jet propagation

$$p_1 \cdot \partial f_1(x_1, p_1) = E_1 \left(C_{elastic} + C_{inelastic} \right)$$

- **Rescattering**
  Shower-thermal & recoil-thermal
- **Back reaction**
  Track the initial thermal parton

Fragmentation Recombination

LBT
Hard

Local medium information ε T $\boldsymbol{u}$

LBT Phys.Rev.C 109 (2024) 3, 034919

Hadronic observables

Initial profile

AMPT TRENTO

Medium evolution

$$\partial_\mu T^{\mu\nu} = 0$$

Cooper Frye

CLvisc
Soft

Jet shape within LBT model

LBT Phys.Lett.B 782 (2018) 707-716