



Institute of Particle Physics
粒子物理研究所

The elliptic wind on jet wakes in high-energy heavy-ion collisions

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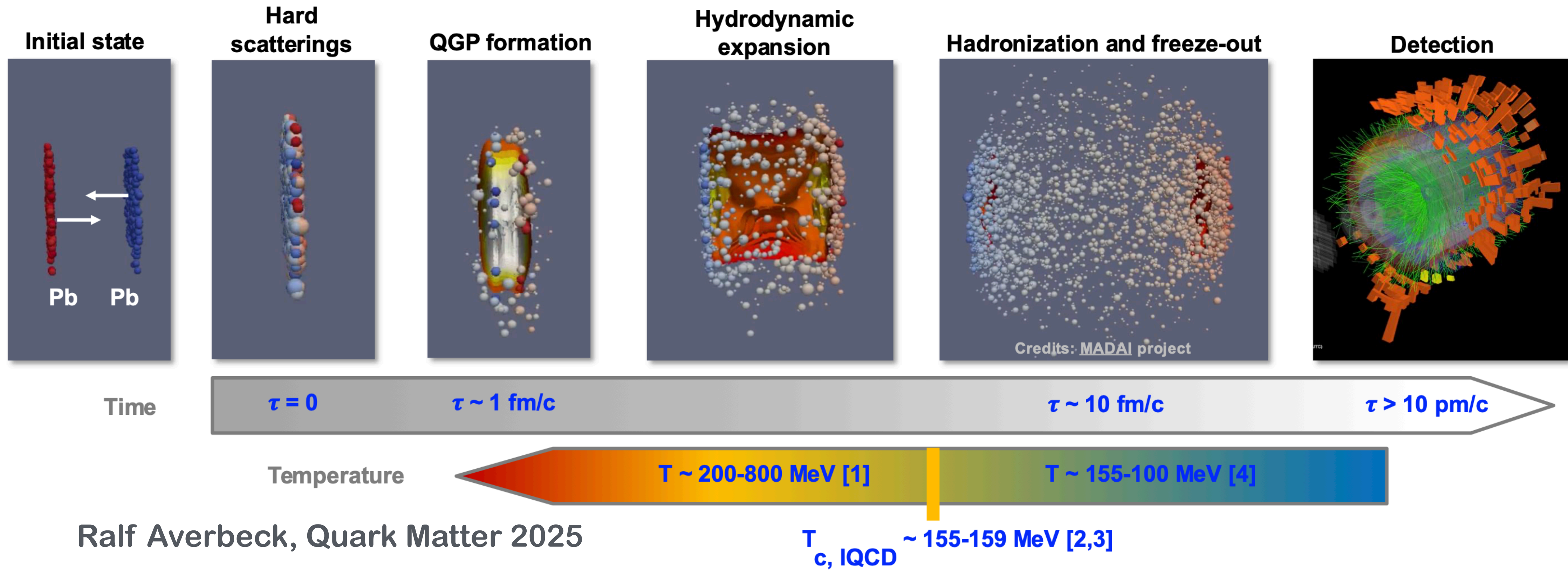
arXiv:2608.17967v2

Spicy gluon 2026 WuHan

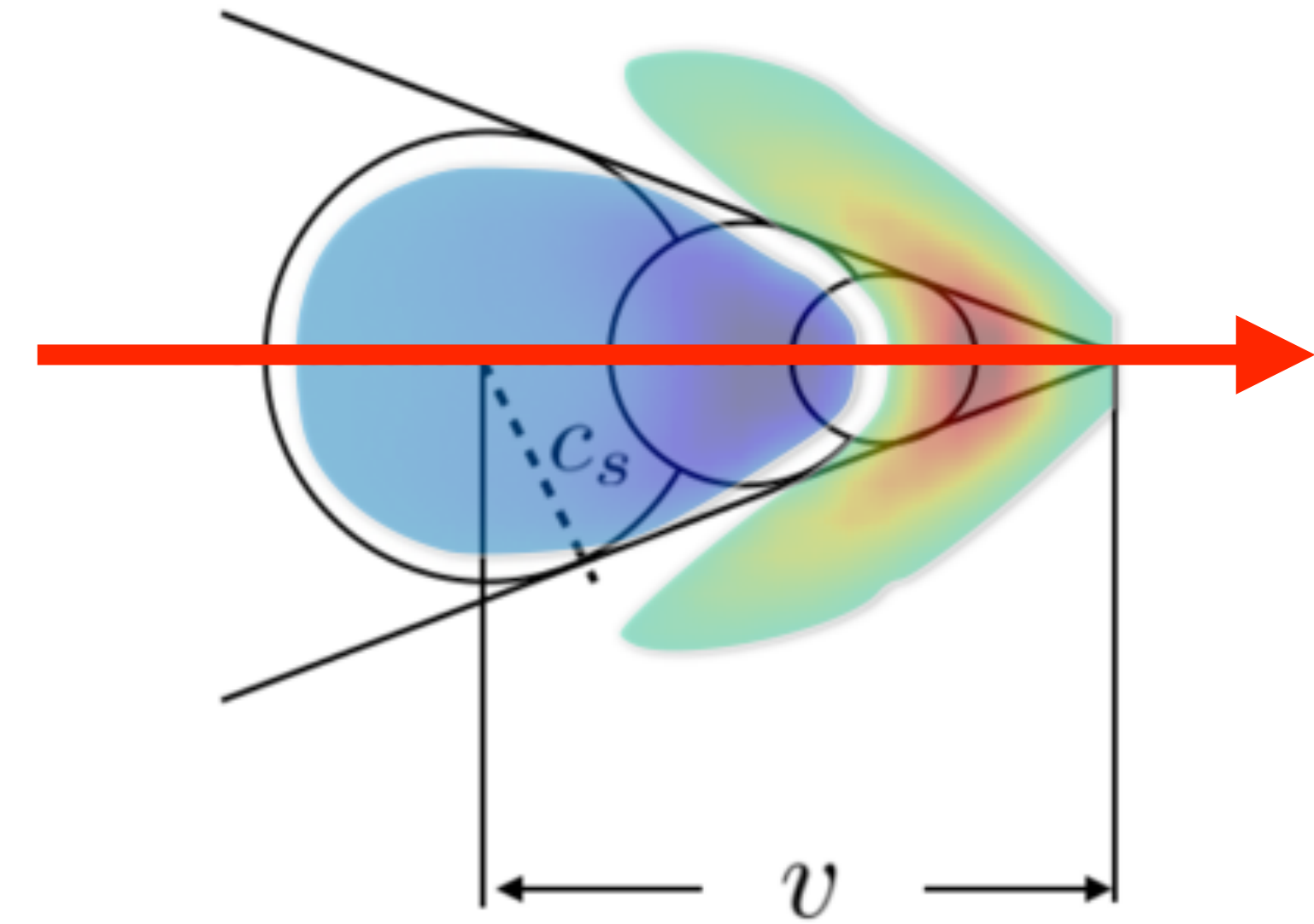
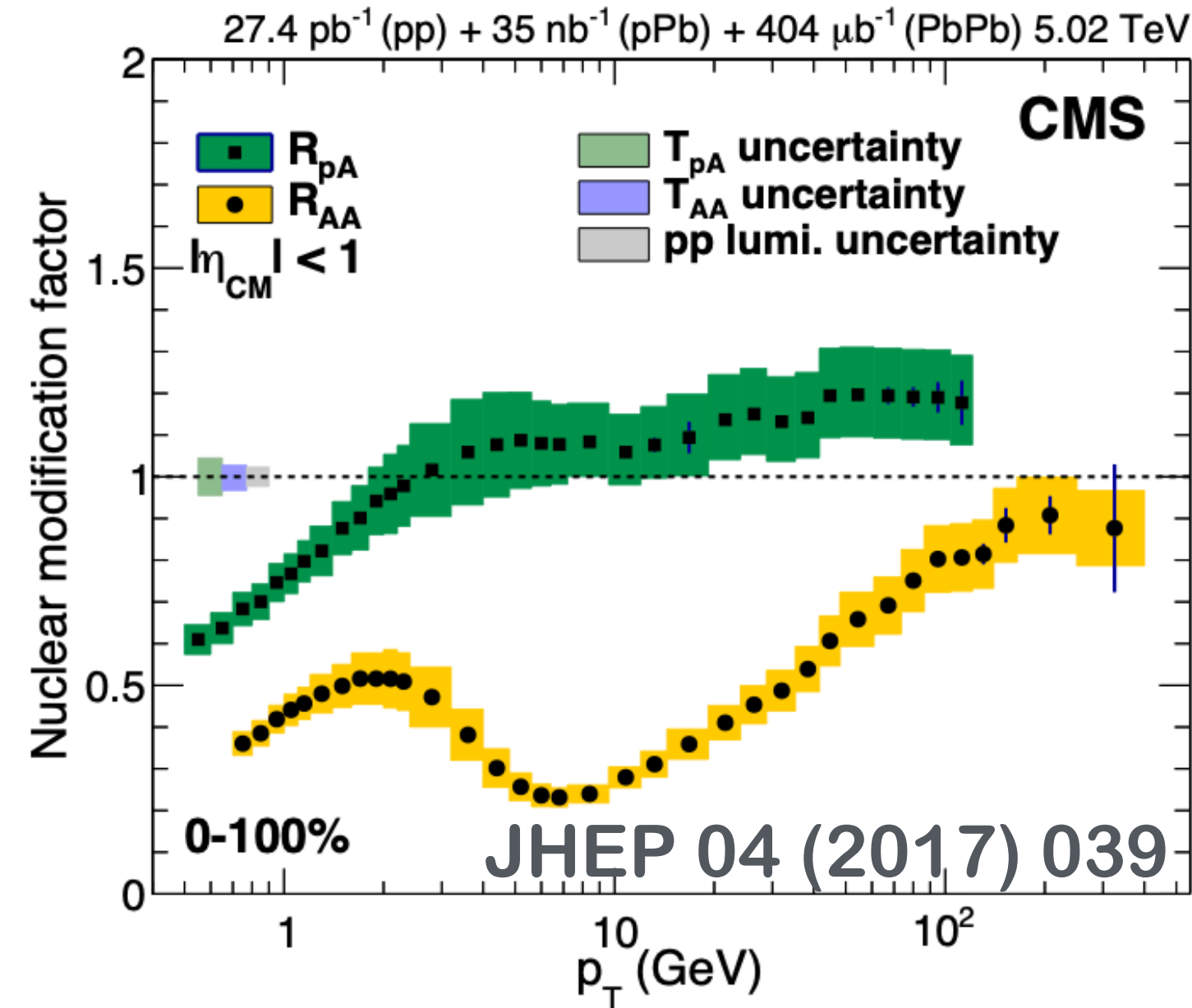
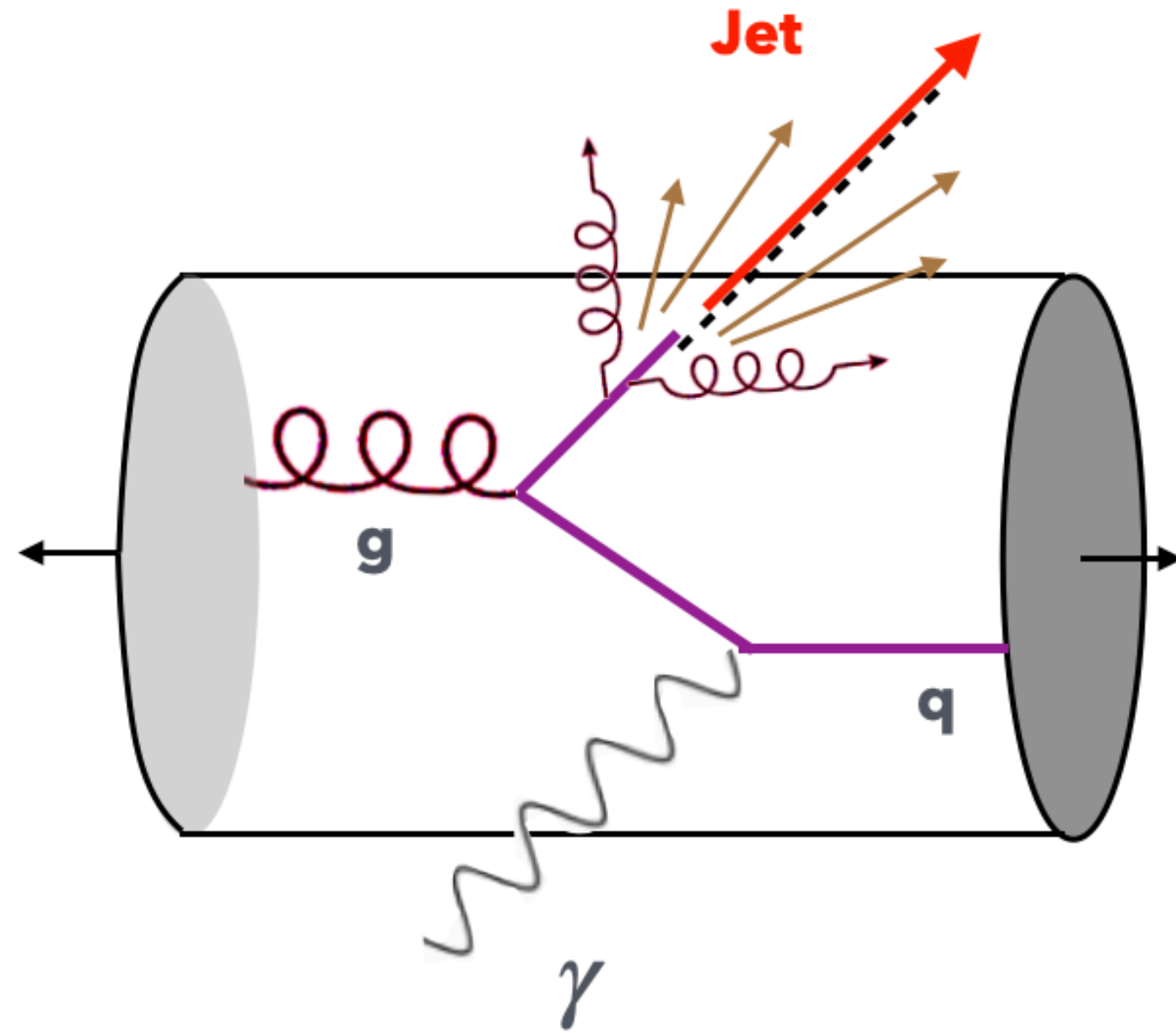
2026.10.18



High energy heavy ion Collisions



Jet quenching and medium response



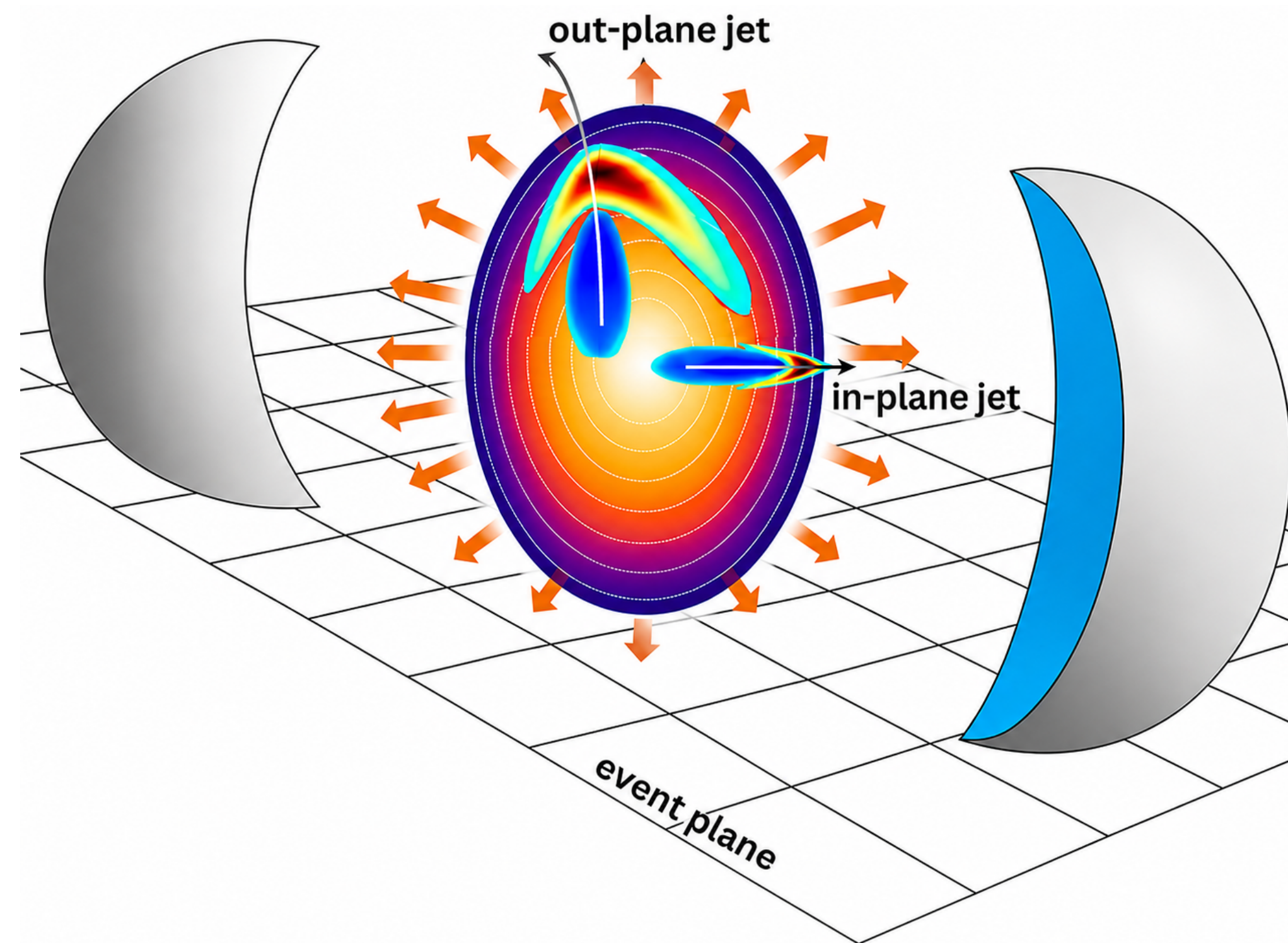
$$d\sigma_{\text{jet}} = \sum_{a,b,j,d} f_{a/p} \otimes f_{b/p} \otimes d\sigma_{ab \rightarrow jd} \otimes J_j$$

$$R_{AA} = \frac{dN_{AA}/dp_T}{\langle N_{\text{coll}} \rangle dN_{pp}/dp_T}$$

$$\cos \theta = \frac{c_s}{v}$$

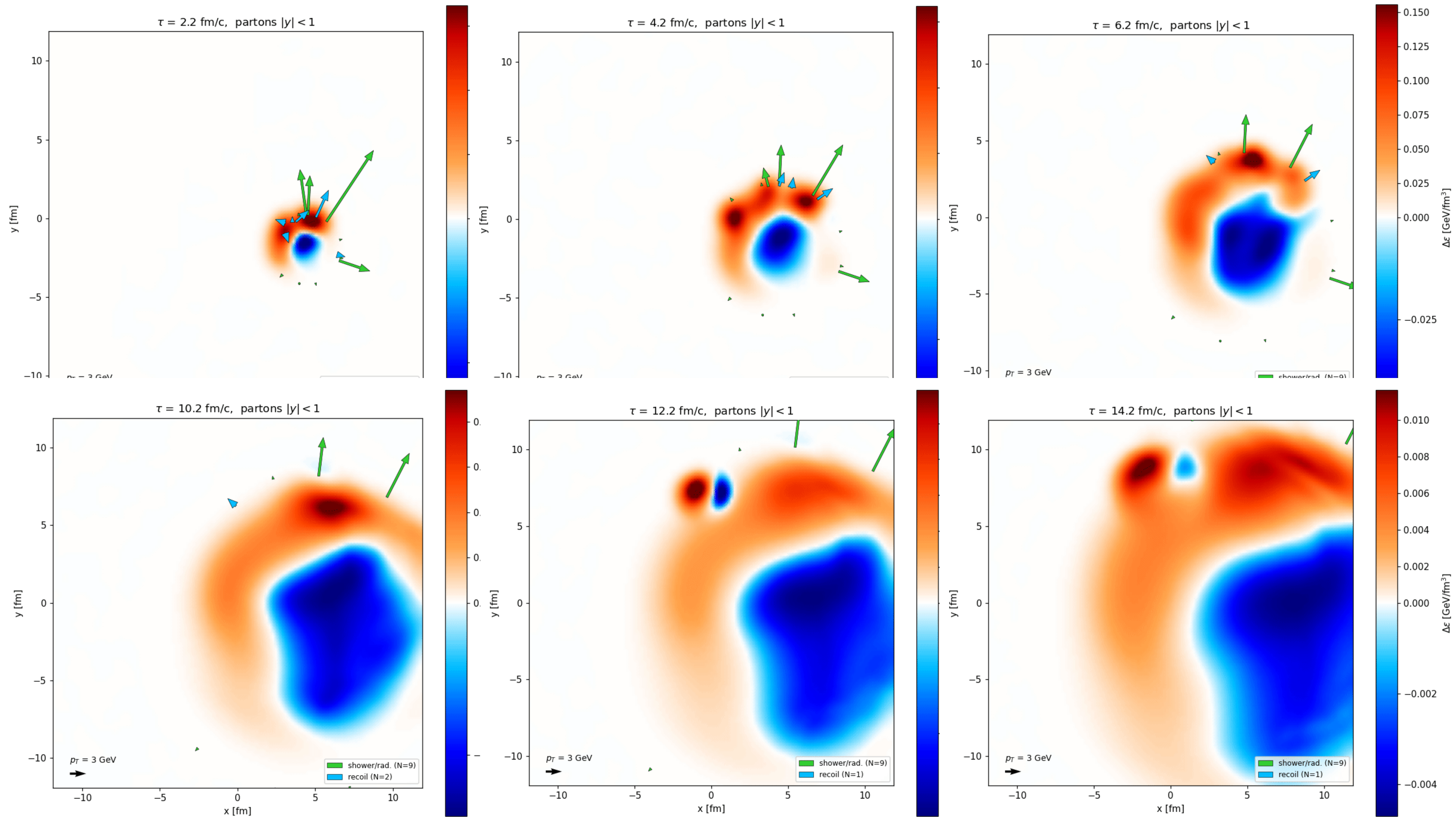
- Jet will deposit energy into QGP during propagation.
- The energy will form jet-induced medium response

Jet wakes distorted by Elliptic flow

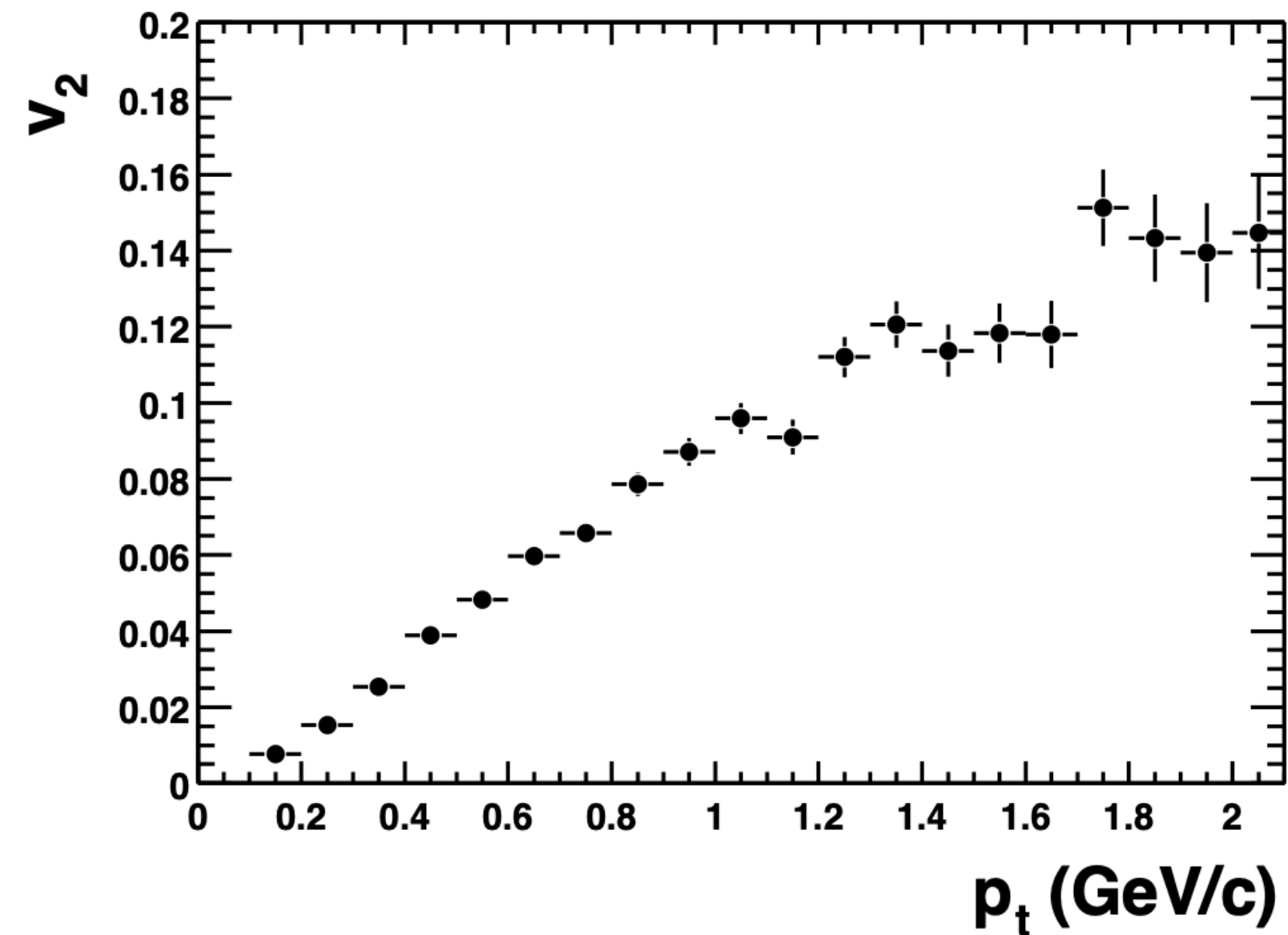
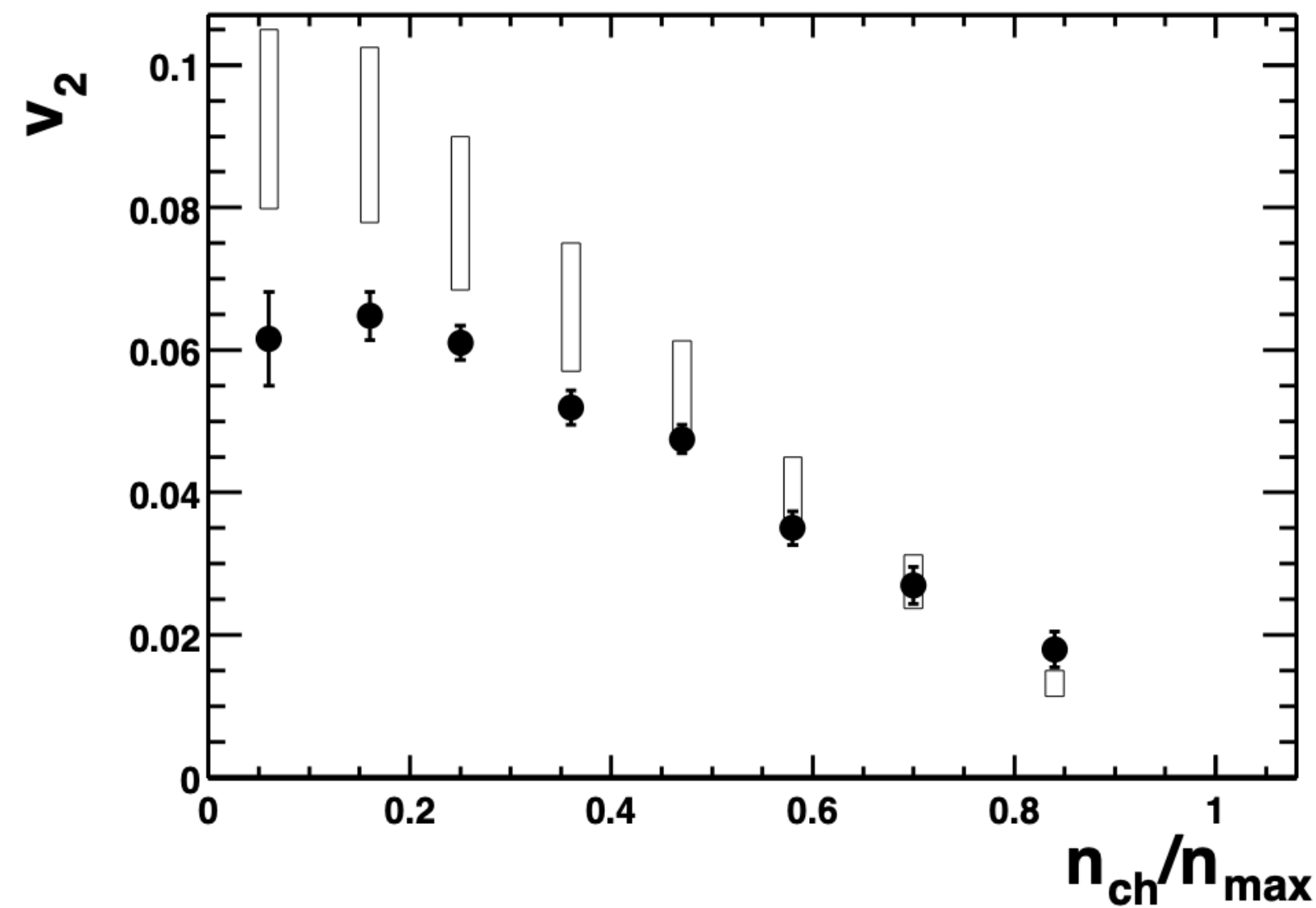


- The in-plane and out-plane jet will be distorted by elliptic flow differently
- The out-plane jet will be expended by flow.

CoLBT simulation



Elliptic flow in QGP



Physical Review Letters 86, 402–407 (2001). (STAR Collaboration)

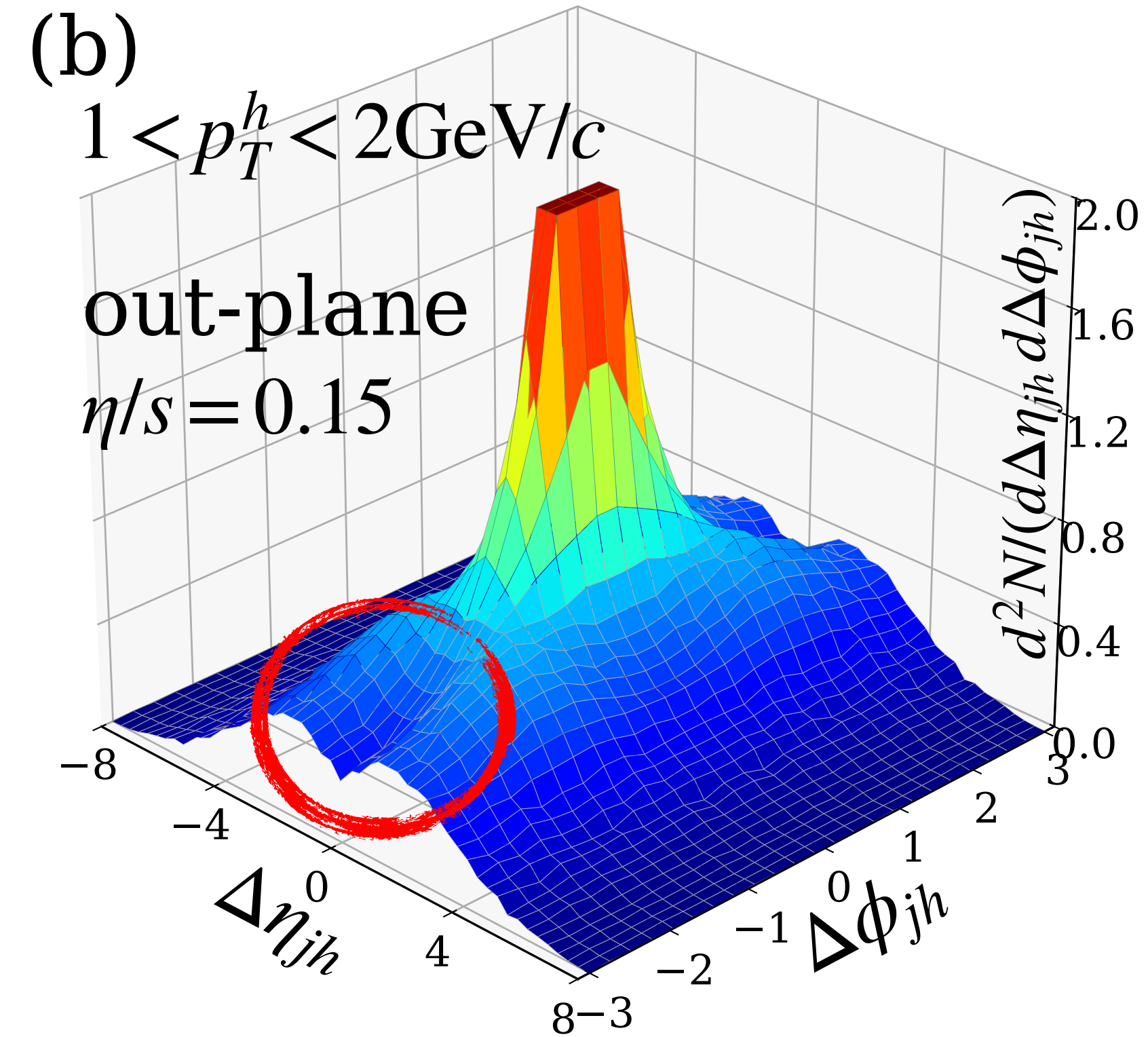
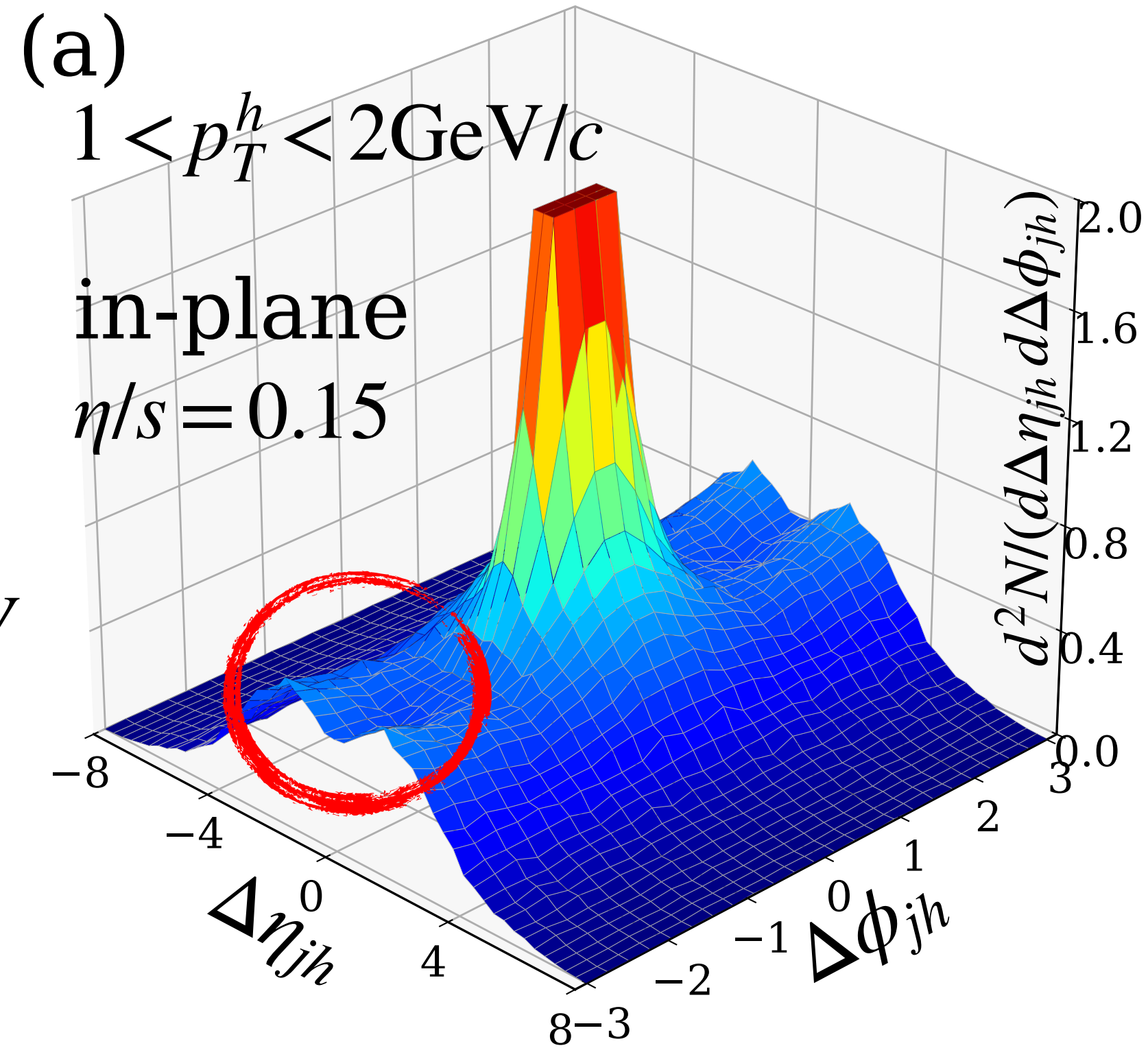
$$\frac{dN}{d\phi} = N_0[1 + 2\sum v_n \cos n(\phi - \psi_n)]$$

- v_2 comes from the pressure gradient asymmetry in in-plane and out-plane
- QGP behaves like a fluid. Collective flow affects not only soft particles but also jet shapes.

2D jet-hadron correlations

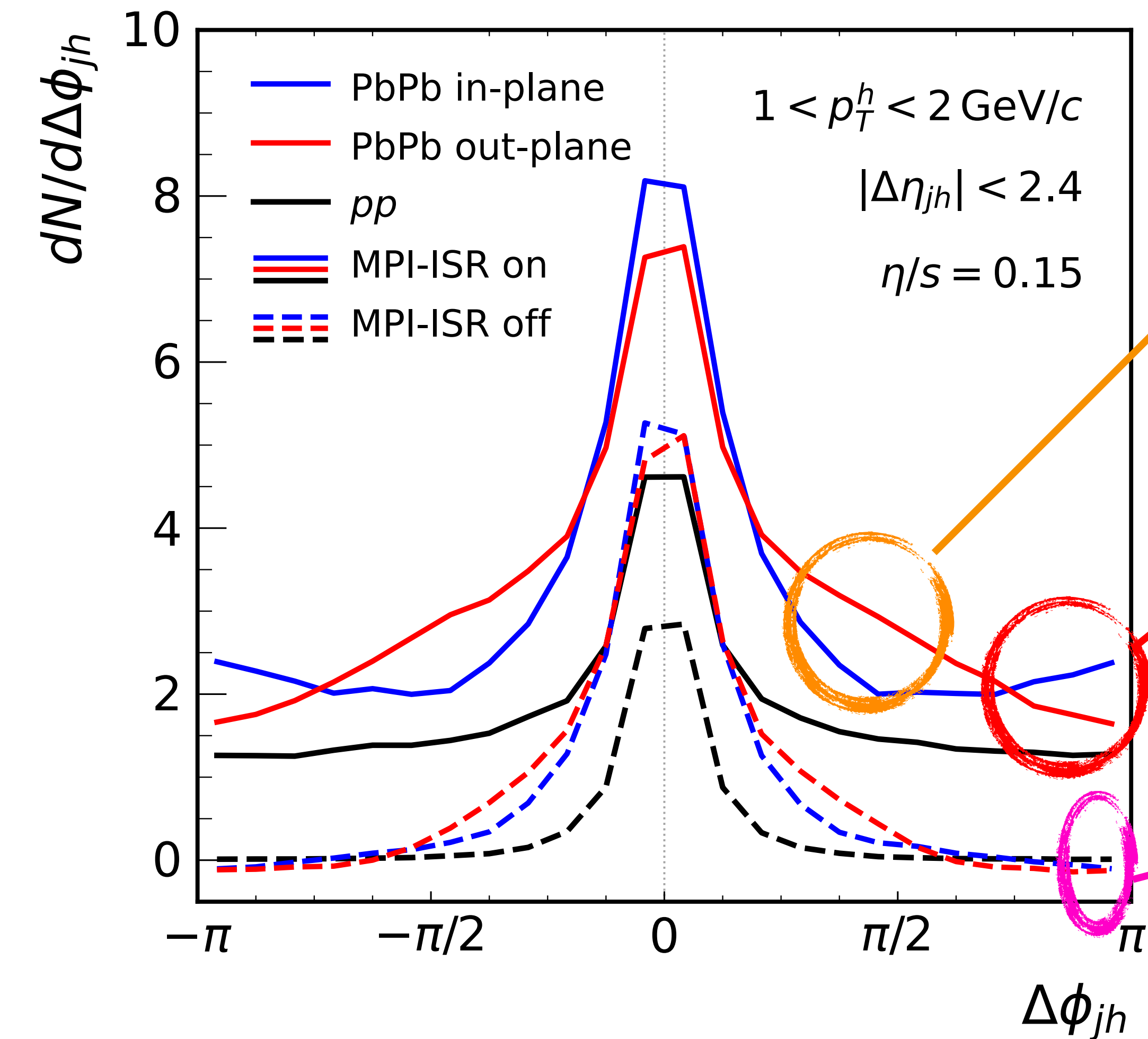
PbPb
30 – 50 %

$\sqrt{s_{NN}} = 5.02 \text{ TeV}$



- In both figures we can see the MPI-ISR ridge and diffusion wake valley
- The MPI-ISR shape will obey the elliptic flow in $\frac{dN}{\Delta\eta_{jh}}$ distribution

Jet-hadron correlations azimuthal distribution



Due to elliptic flow

- The out-plane distribution will be expended but in-plane will be gathered
- The MPI-ISR distribution can be distinguished by elliptic flow in in-plane and out-plane.
- The negative part is the diffusion wake signal if we

$$\frac{dN_{\text{MPI-ISR}}}{d\Delta\phi_{jh}} \approx N_{\text{MPI-ISR}} \left[1 + 2 \sum_{n=2,4} \tilde{v}_n \cos \left(n(\Delta\phi_{jh} - \Psi_2) \right) \right]$$

AA > pp: MPI-ISR thermalization

Double Gaussian fit for MPI-ISR ridge and diffusion wake

arXiv:2203.03683v4

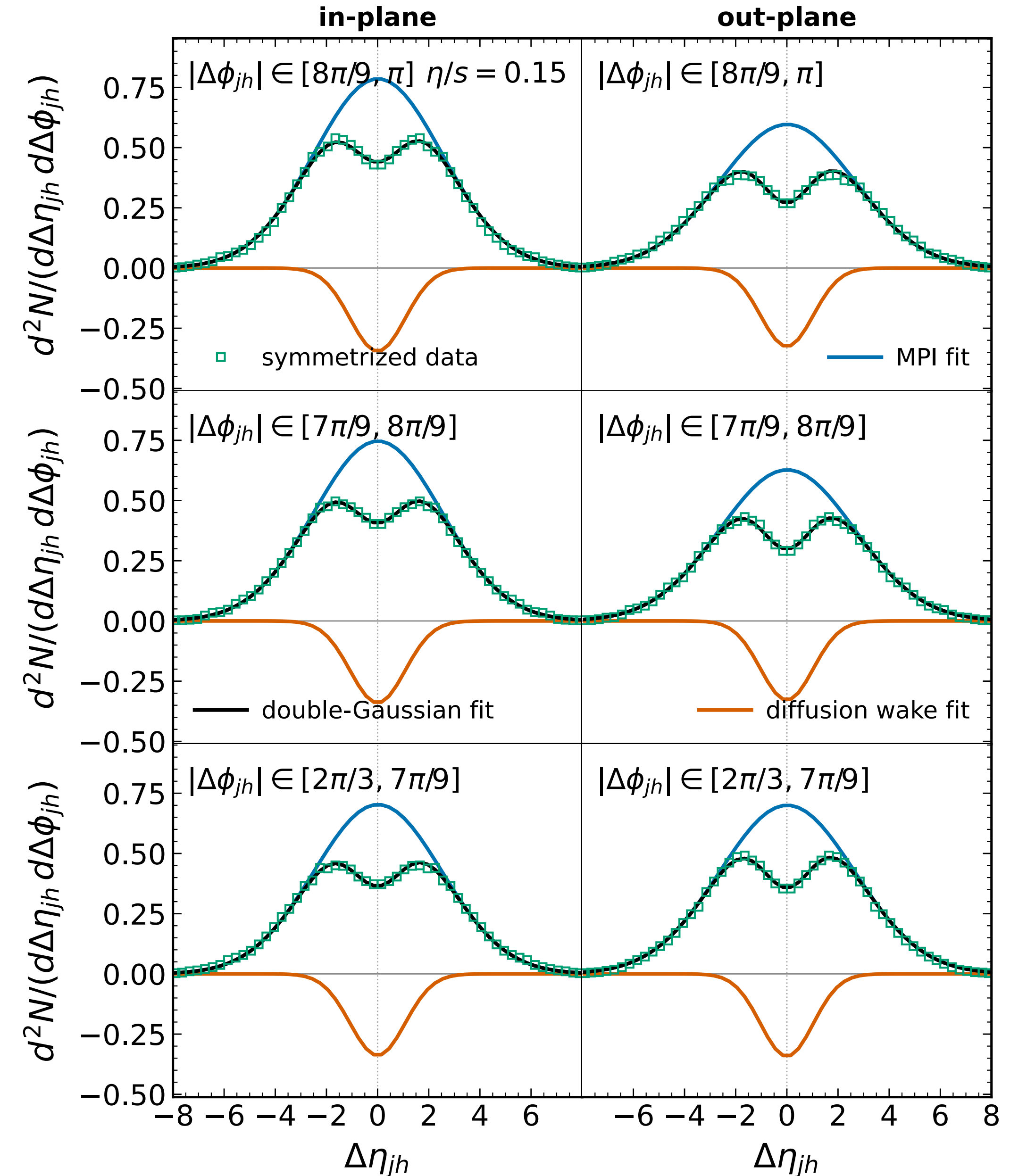
$$F(\Delta\eta) = \int_{\eta_{j1}}^{\eta_{j2}} d\eta_j F_3(\eta_j) \left[F_2(\Delta\eta, \eta_j) + F_1(\Delta\eta) \right]$$

$$F_1(\Delta\eta) = A_1 e^{-(\Delta\eta)^2/\sigma_1^2} \quad (\text{DF-wake valley})$$

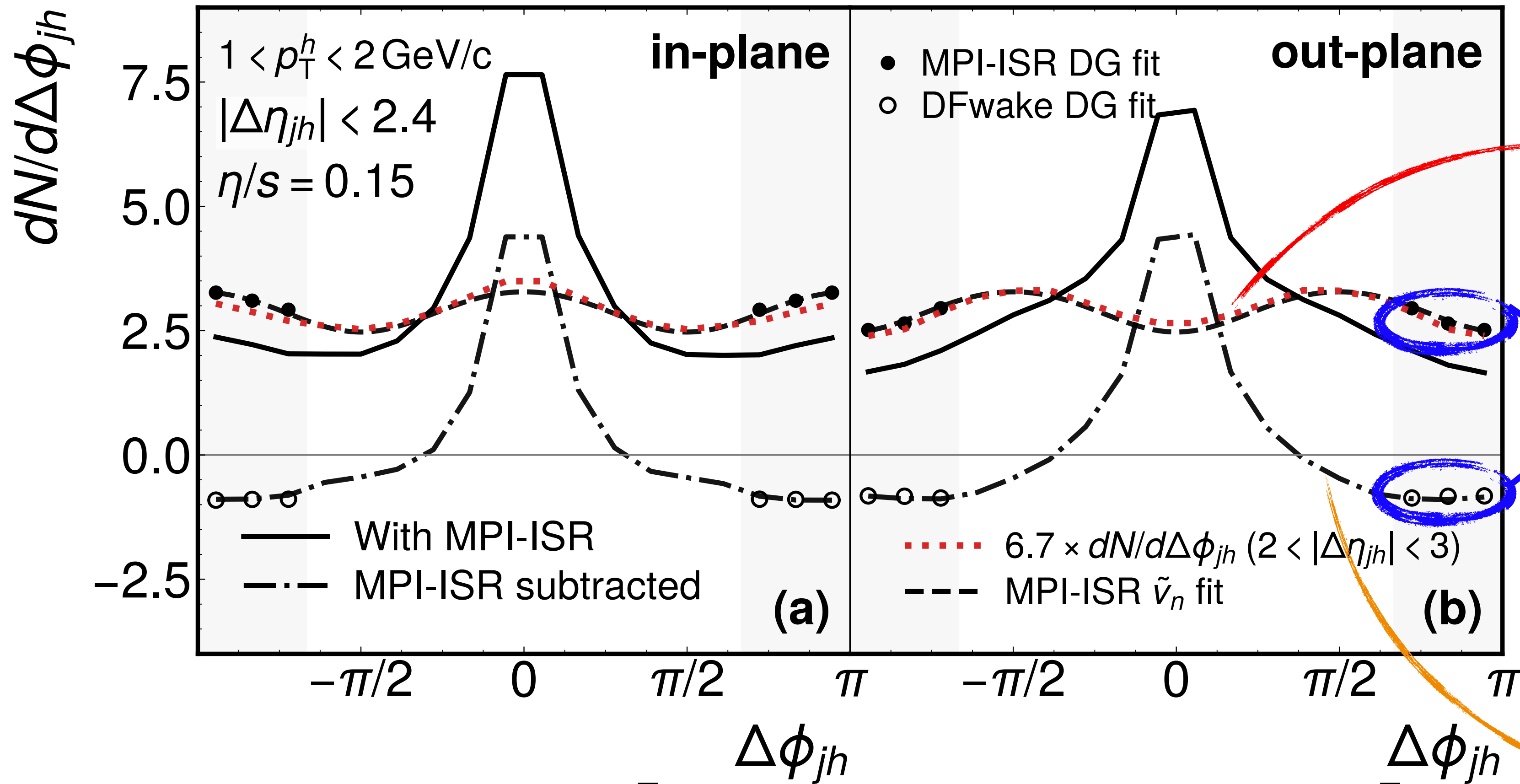
$$F_2(\Delta\eta, \eta_j) = A_2 e^{-(\Delta\eta + \eta_j)^2/\sigma_2^2} \quad (\text{MPI ridge})$$

$$F_3(\eta_j) = \frac{1}{N_{\gamma\text{-jet}}} \frac{dN_{\gamma\text{-jet}}}{d\eta_j}$$

$$\eta_j \in [\eta_{j1}, \eta_{j2}]$$



MPI-ISR fitting and subtraction



Rescaled distribution in large $\Delta\eta_{jh}$ region where the jet's reflection is small

Double Gaussian fit at the same time in each $\frac{dN}{\Delta\phi_{jh}}$ region

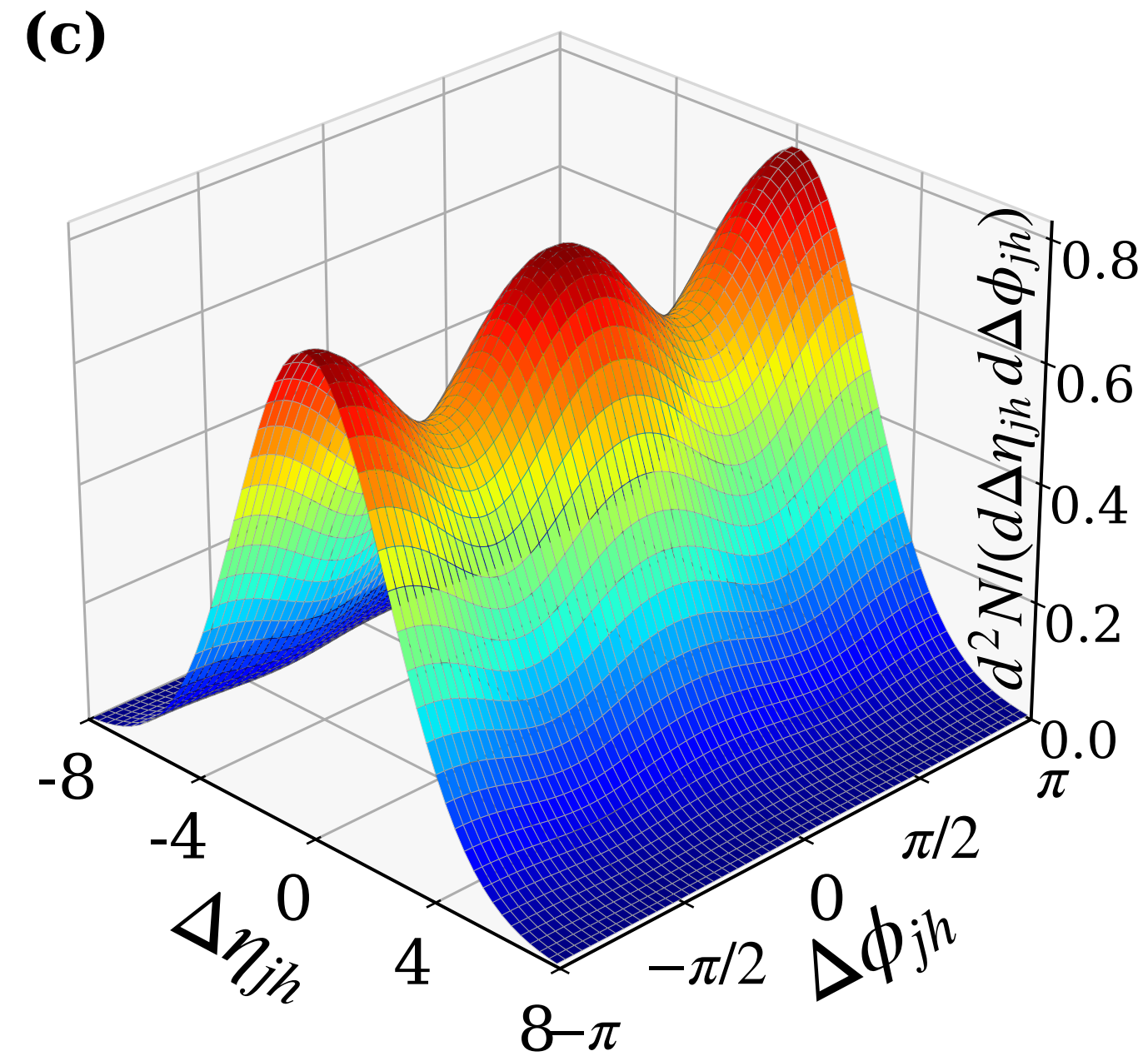
MPI-ISR subtracted

$$\frac{dN_{\text{MPI-ISR}}}{d\Delta\phi_{jh}} \approx N_{\text{MPI-ISR}} \left[1 + 2 \sum_{n=2,4} \tilde{v}_n \cos \left(n(\Delta\phi_{jh} - \Psi_2) \right) \right]$$

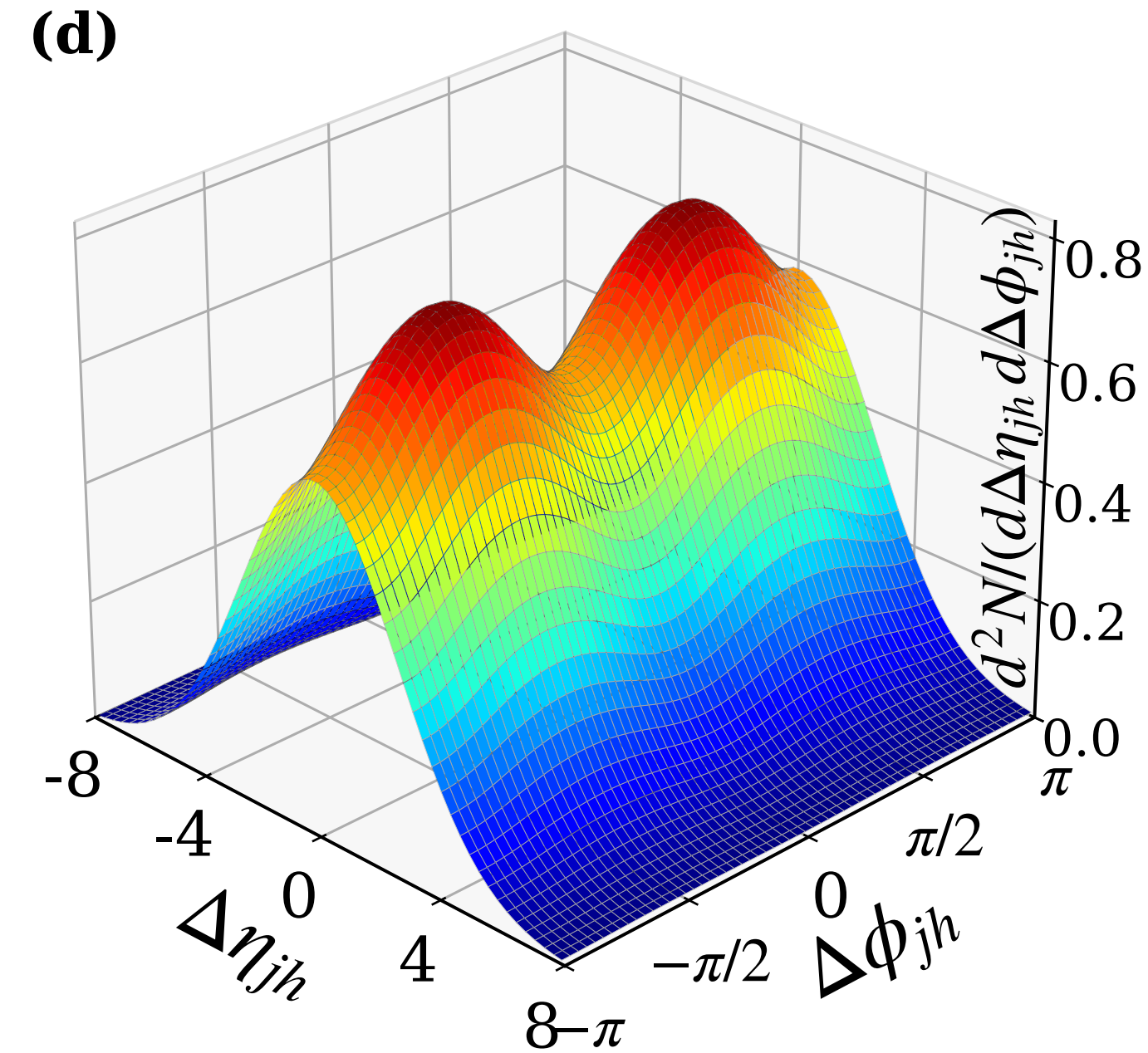
$$\tilde{v}_n = \frac{1}{n\Delta_{\text{jet}}} \sin \left(n\Delta_{\text{jet}} \right) \left\langle v_n \cos \left(n(\Psi_n - \Psi_2) \right) \right\rangle$$

MPI-ISR 3D shape inference and reconstruction

MPI-ISR — in-plane



MPI-ISR — out-plane

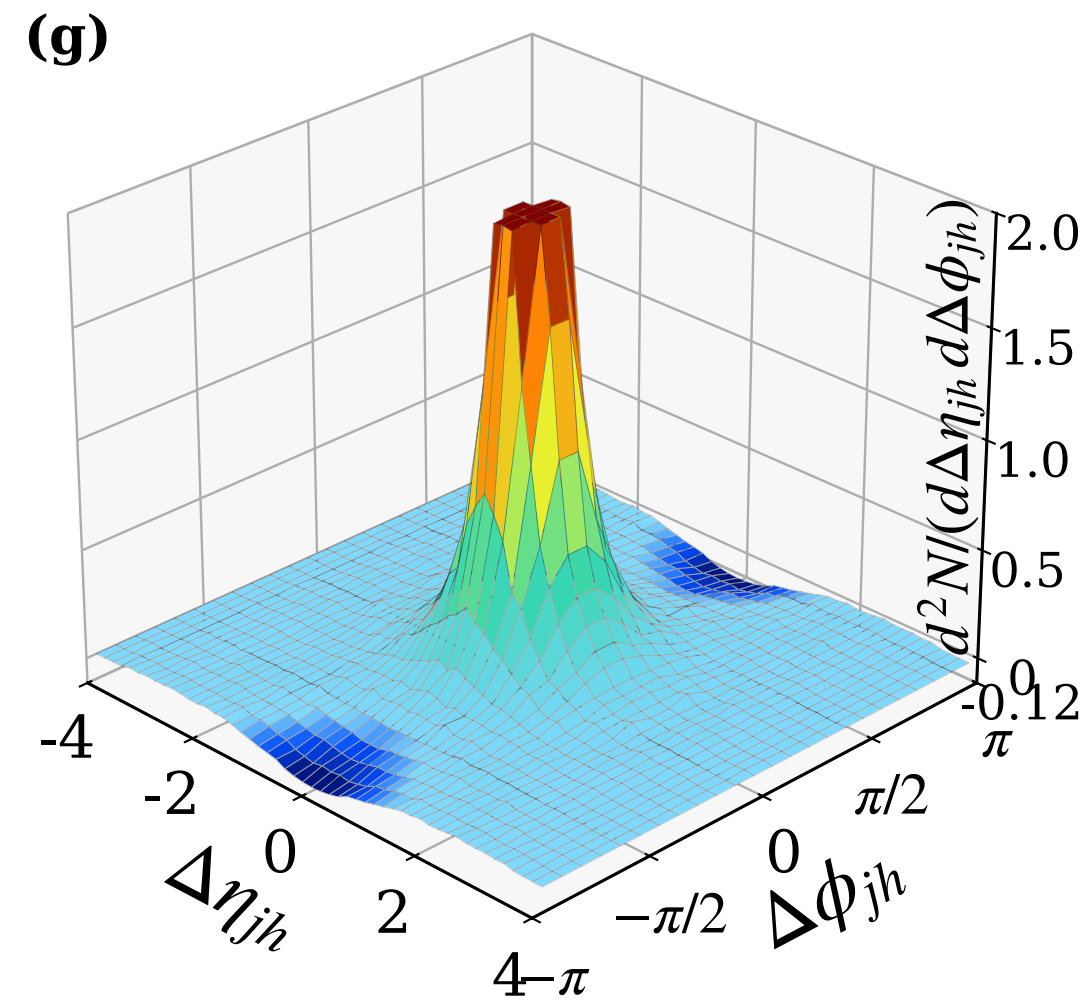


$$F_2(\Delta\eta, \eta_j) = A_2 e^{-(\Delta\eta + \eta_j)^2 / \sigma_2^2} \quad (\text{MPI ridge})$$

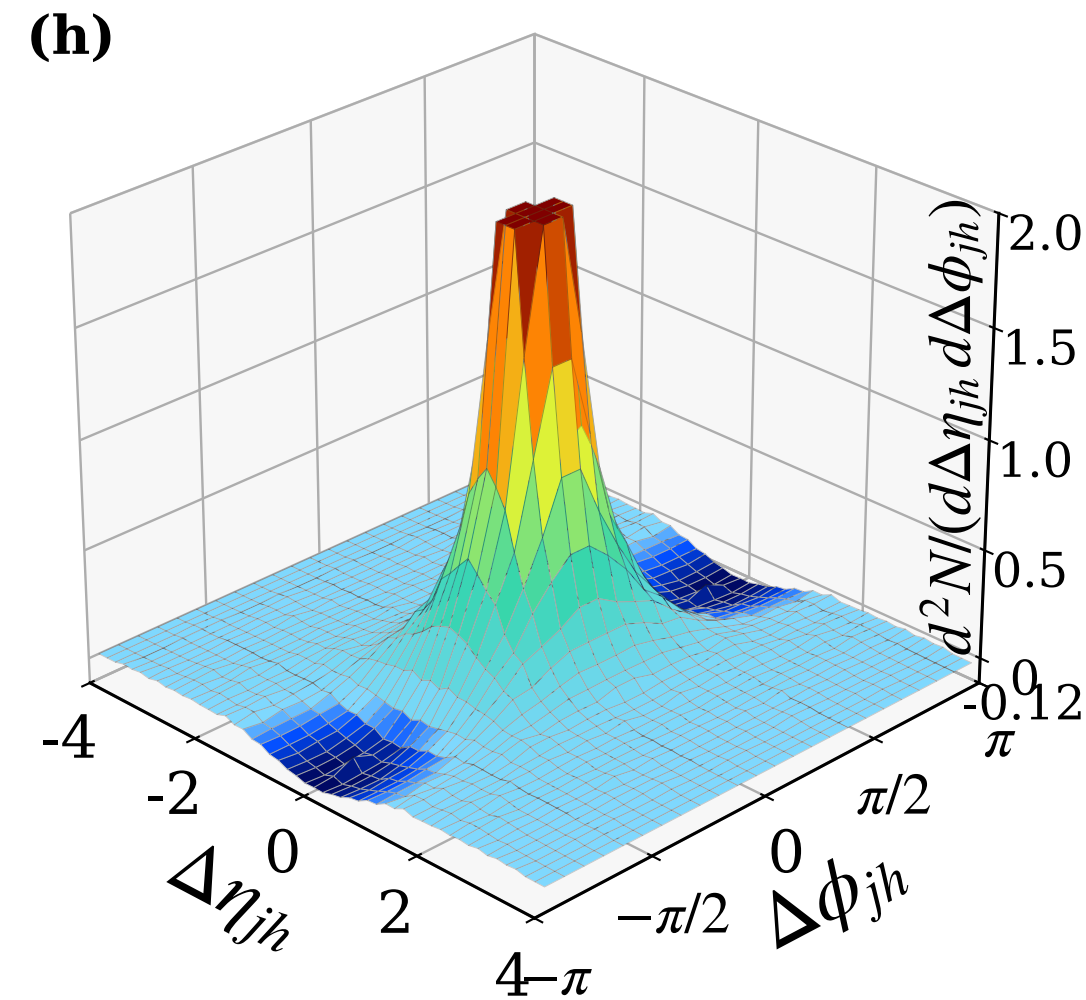
$$\frac{dN_{\text{MPI-ISR}}}{d\Delta\phi_{jh}} \approx N_{\text{MPI-ISR}} \left[1 + 2 \sum_{n=2,4} \tilde{v}_n \cos \left(n(\Delta\phi_{jh} - \Psi_2) \right) \right]$$

Comparison with MPI-ISR turned off

MPI-ISR off — in-plane



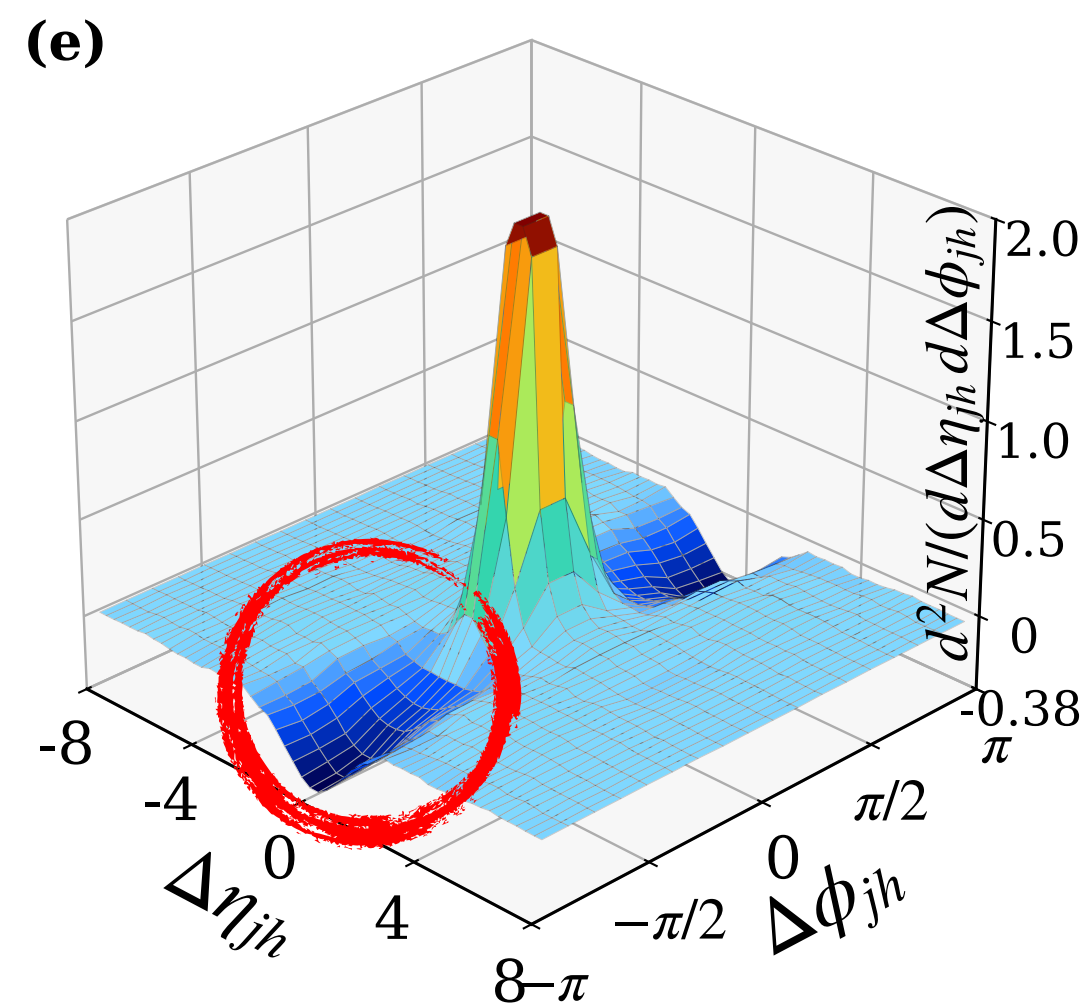
MPI-ISR off — out-plane



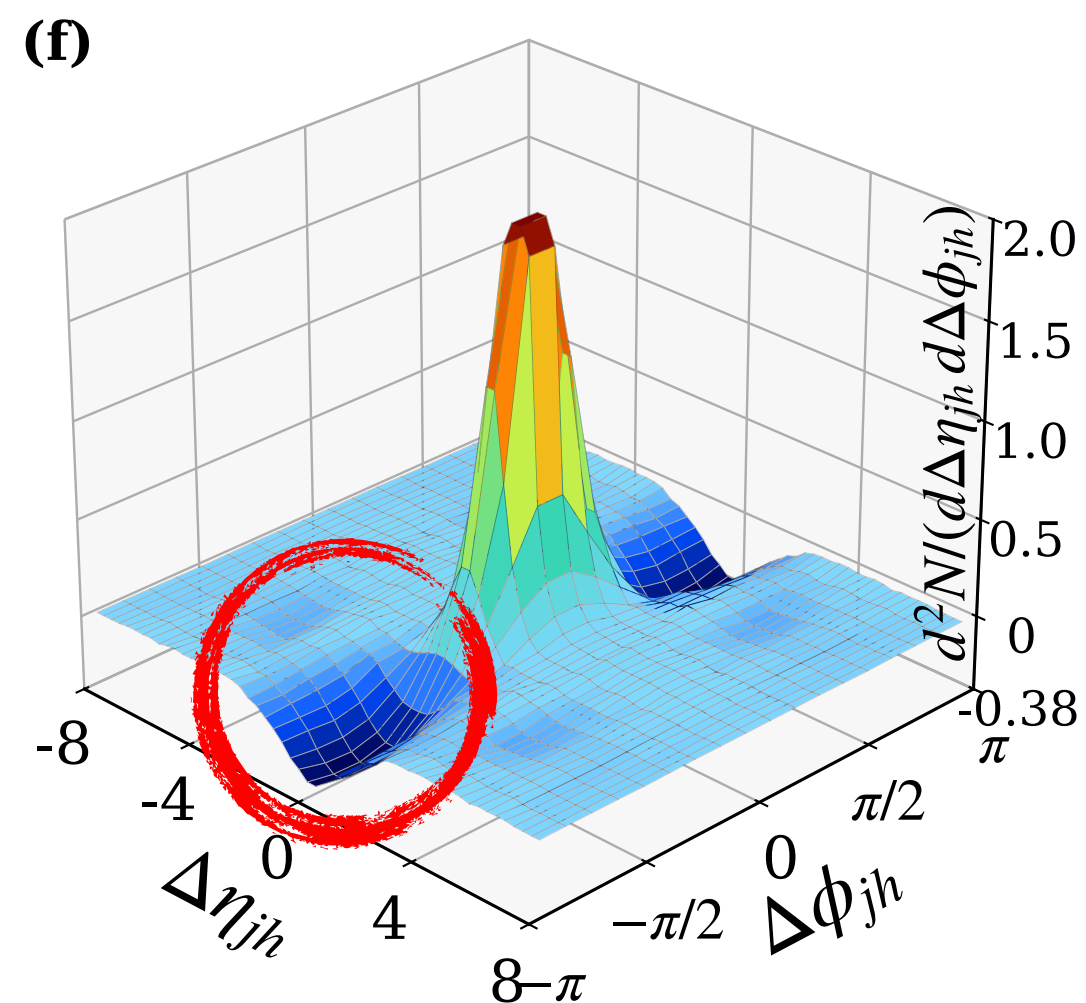
MPI-ISR off by CoLBT

The diffusion wake of out-plane will be deeper than in-plane

after MPI-ISR subtraction — in-plane



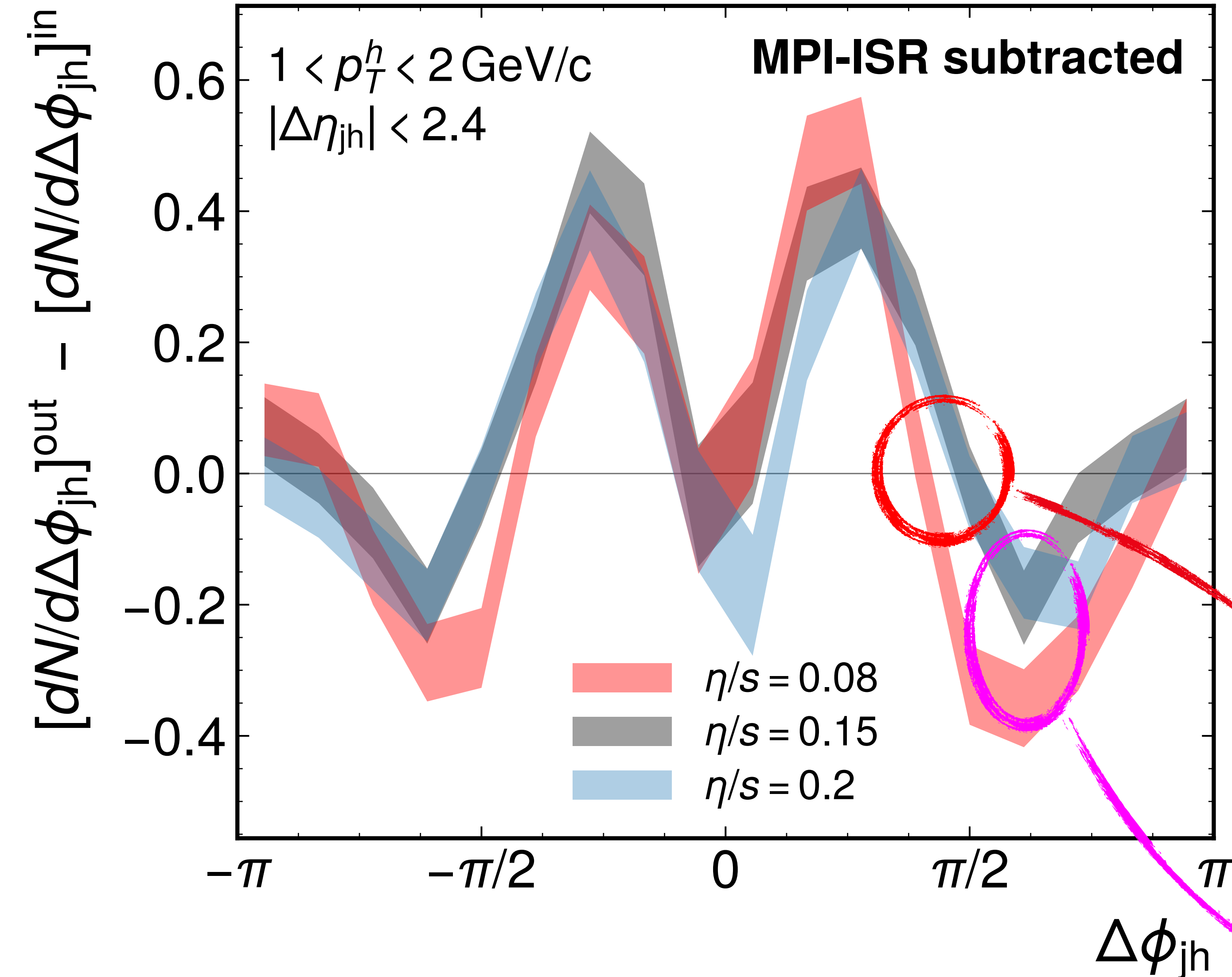
after MPI-ISR subtraction — out-plane



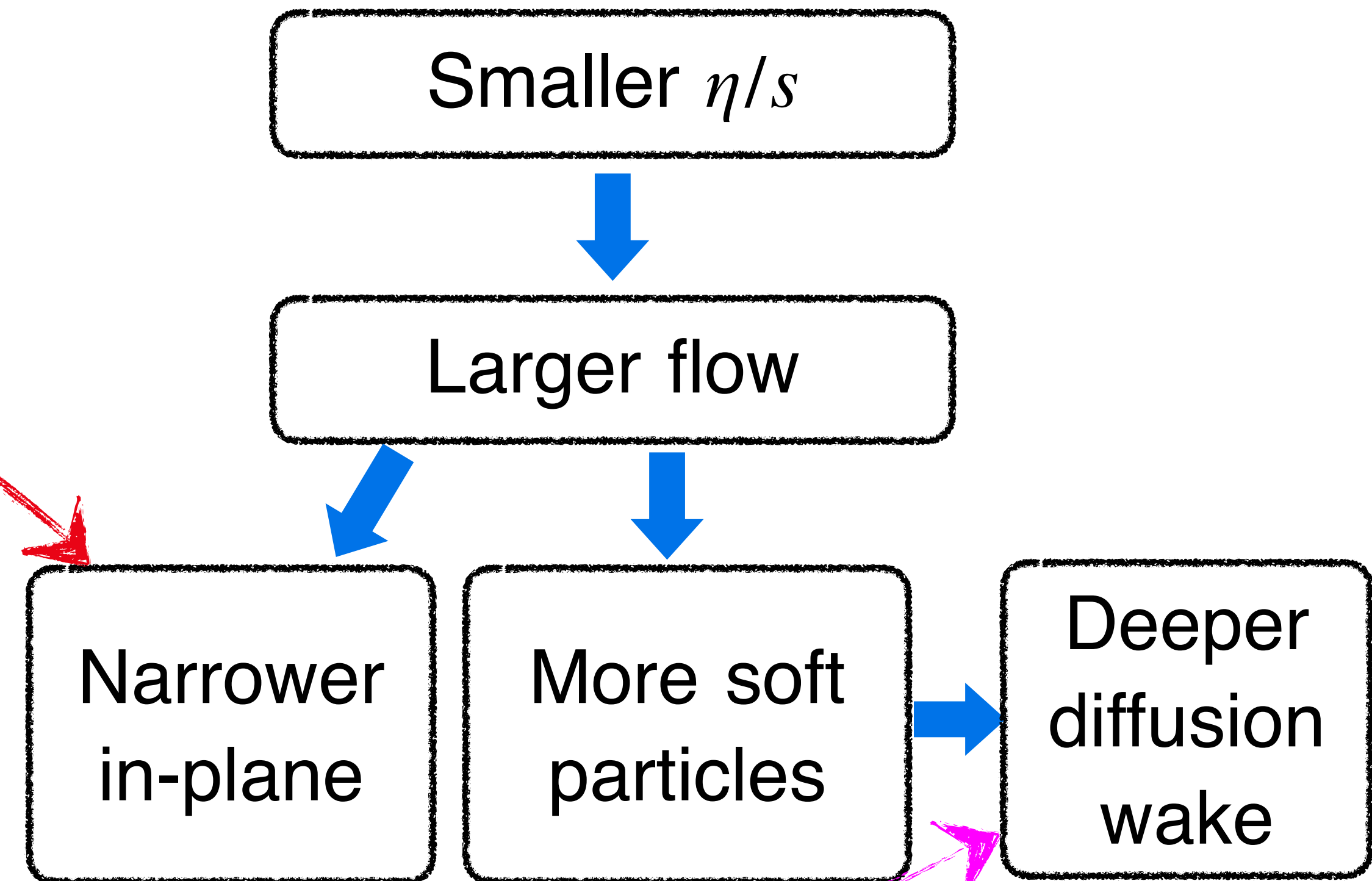
MPI-ISR subtracted

Over-sized estimation of diffusion wake and MPI-ISR ridge in both cases

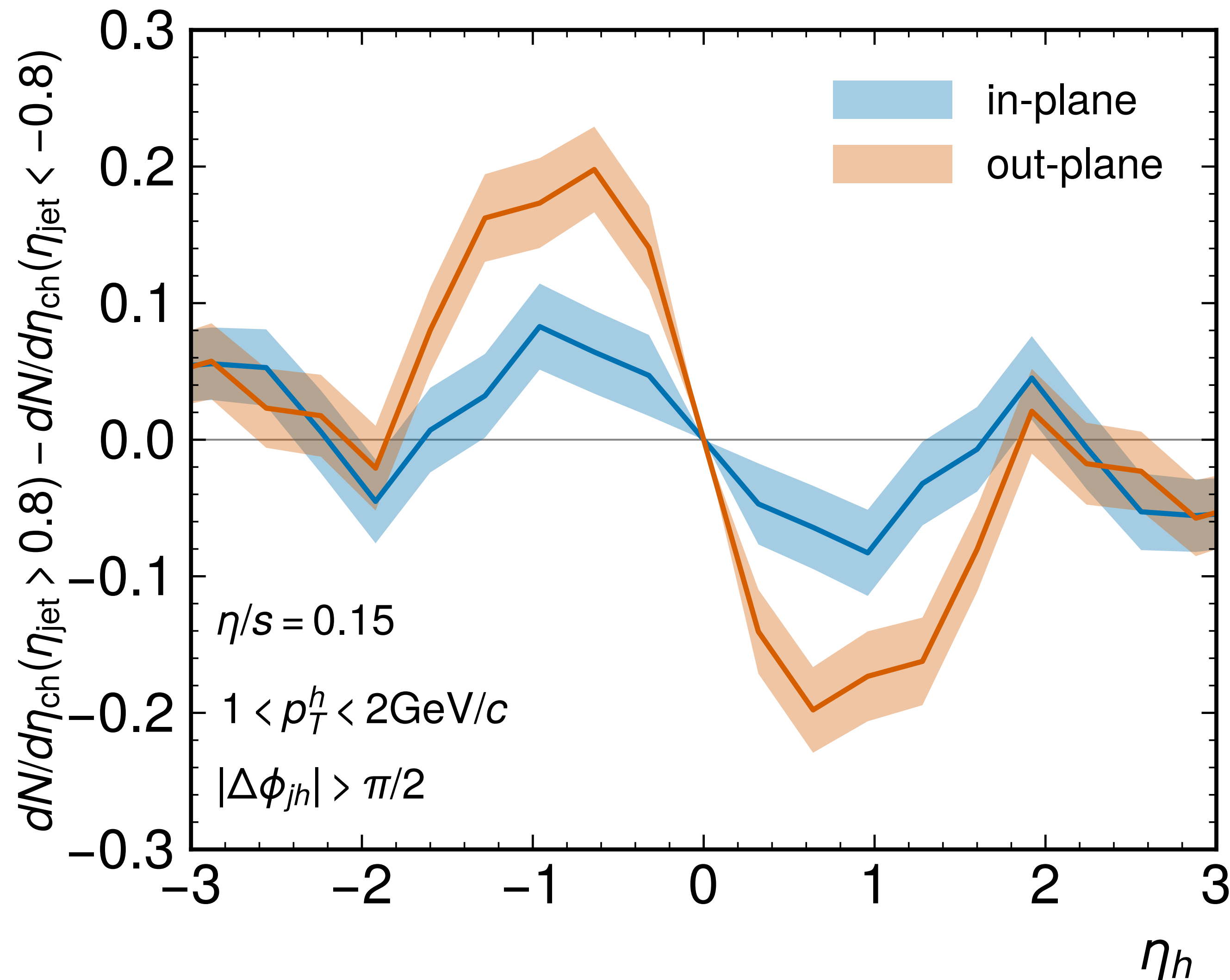
Out-plane in-plane difference



- Jet hadron correlations is expended in $|\Delta\phi_{jh}| < \pi/2$ region in out-plane



Rapidity asymmetry



$$A(\eta_h) = \left. \frac{dN_{\text{ch}}}{d\eta_h} \right|_{\eta_{\text{jet}} > 0.8} - \left. \frac{dN_{\text{ch}}}{d\eta_h} \right|_{\eta_{\text{jet}} < -0.8}$$

The out-plane jet has longer path length so the energy loss is bigger than in-plane jet



Larger front wake and diffusion wake



Larger rapidity asymmetry

Conclusion

- Elliptic flow and density gradients change the jet wake. The out-of-plane wake is broader than the in-plane wake.
- The MPI–ISR ridge also follows a flow pattern. We need to include this when we subtract the ridge. Our comparison also shows limits of the subtraction.
- Out-of-plane jets give a larger diffusion-wake asymmetry. Changing the viscosity affects the results, but the differences are modest.

Thank you