Study of Isolated-photon and Jet Momentum Imbalance in pp and $PbPb$ Collisions - [arχiv:1803.10533]

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Sudakov Resummation

Isolated-photon jet correlations have been widely regarded as the "Golden Probe" to understand the properties of the Quark-Gluon Plasma. In this study, we employed the Sudakov resummation formalism:

$$\frac{d\sigma}{d\Delta\phi} = \sum_{a,b,c,d} \int p_{\perp\gamma} dp_{\perp\gamma} \int p_{\perp J} dp_{\perp J} \int dy_\gamma \int dy_J \int db$$

$$\times x_a f_a(x_a, \mu_b) x_b f_b(x_b, \mu_b) \frac{1}{\pi} \frac{d\sigma_{ab\to cd}}{d\hat{t}} b\, J_0(|\vec{q}_\perp| b) e^{-S(Q,b)}$$

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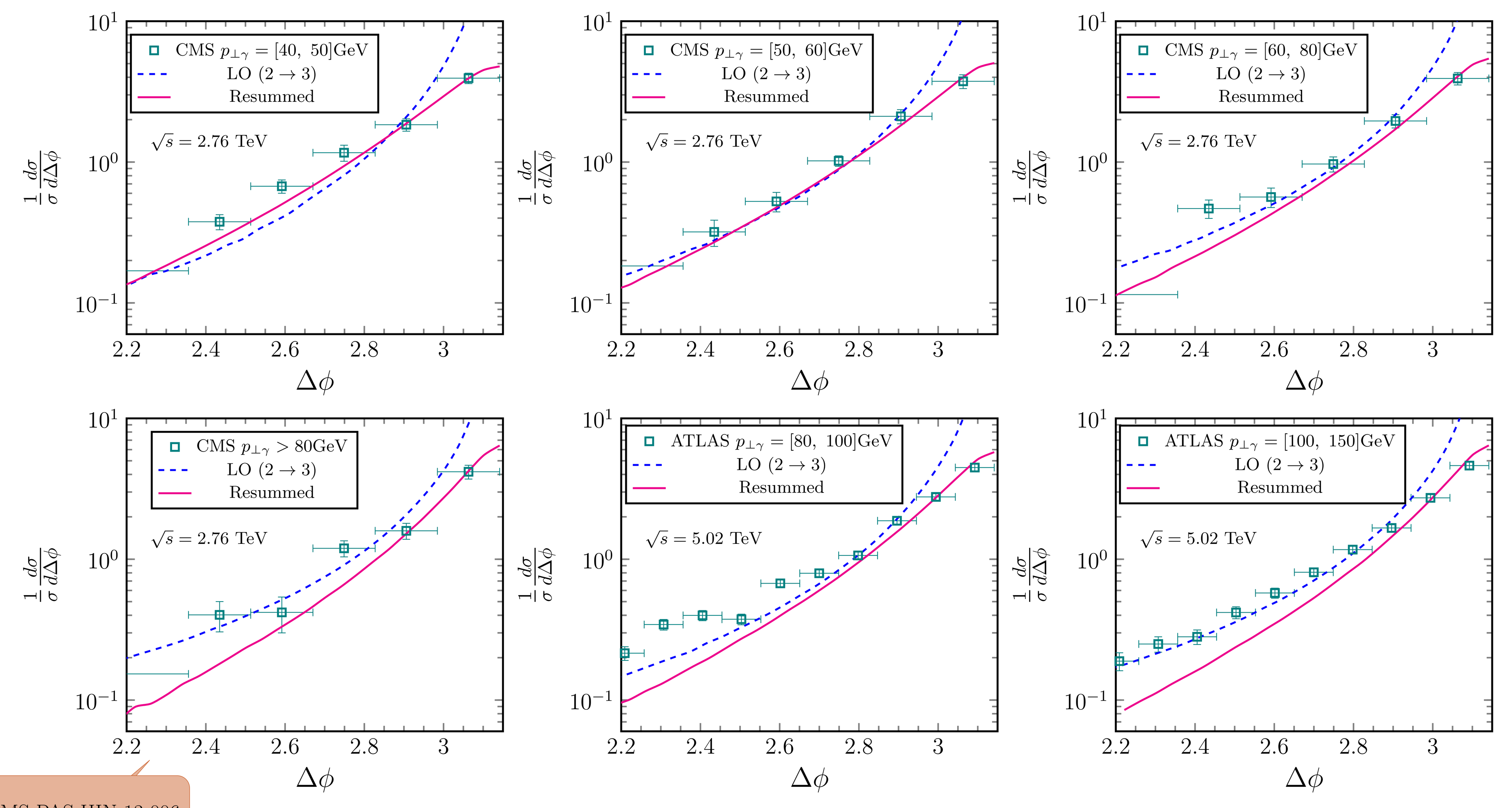
to study the angular correlation and transverse momentum imbalance between direct photon and jets, which is complementary to our previous study on dijet, dihadron and hadron-jets.
We begin by comparing the normalized angular distribution with CMS and ATLAS data. Notice that the leading-order perturbative calculation diverges near $\Delta\phi \approx \pi$ due to the large Sudakov logarithms, which were effectively resummed in the resummation formalism. Although pQCD can describe data at $\Delta\phi \ll \pi$. Thus both framework is required in order to study the entire phase-space.



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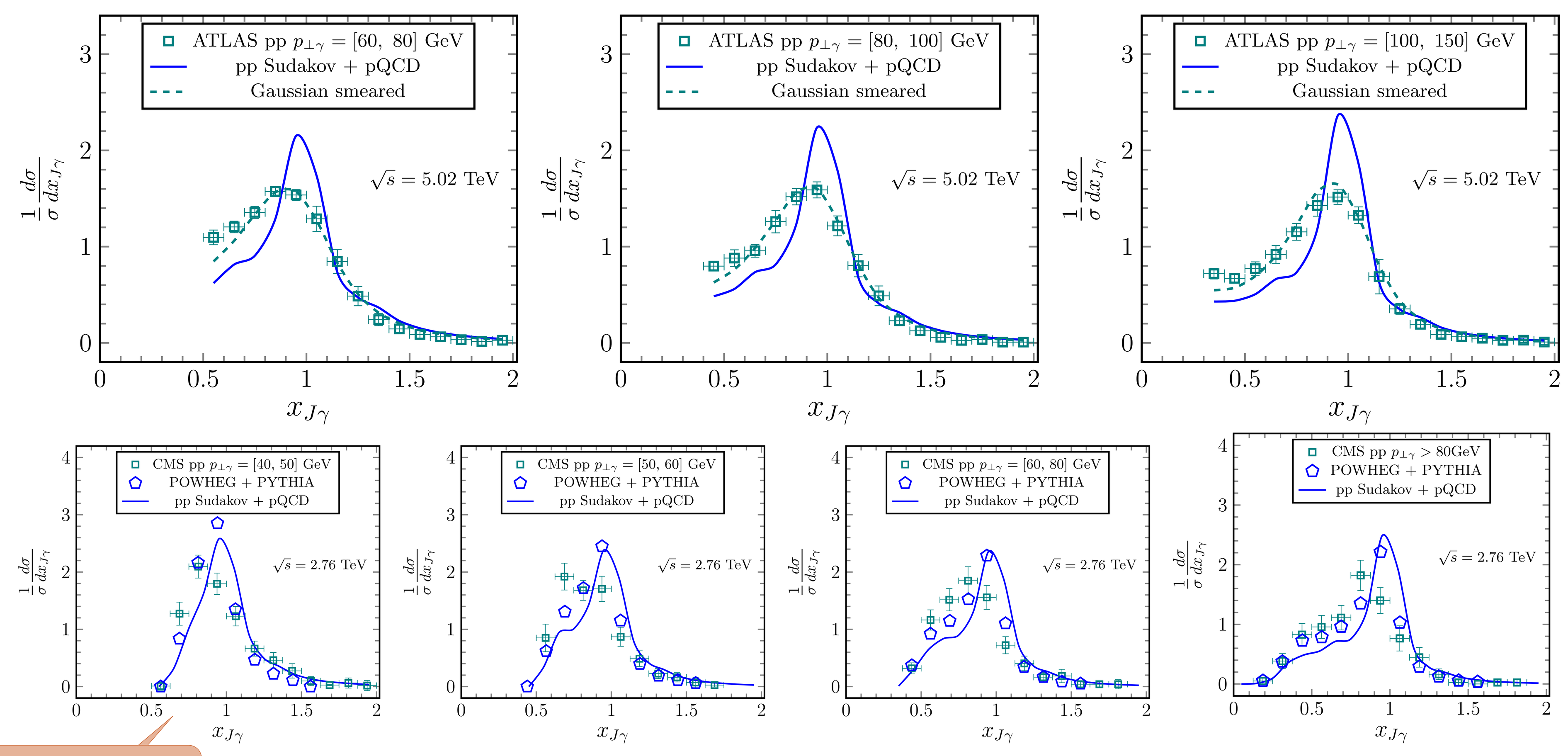
ATLAS-CONF-2016-110



JHEP 1803:081, 2018

Momentum Imbalance

We then implemented the Sudakov resummation improved pQCD approach developed in our previous study

$$\left.\frac{1}{\sigma}\frac{d\sigma}{dx_J\gamma}\right|_{\text{improved}} = \frac{1}{\sigma_{\text{pQCD}}} \left.\frac{d\sigma_{\text{pQCD}}}{dx_J\gamma}\right|_{\text{cuts}} + \frac{1}{\sigma_{\text{Sudakov}}} \left.\frac{d\sigma_{\text{Sudakov}}}{dx_J\gamma}\right|_{\text{cuts}}$$

to compare with the experimental data where the cuts are imposed on $\Delta\phi$ and $q_\perp^2$ to switch between perturbative calculation and resummation. Note that we have used a Gaussian smearing to account for the asymmetry caused by detector responses in experimental measurements.

$$\frac{d\sigma_{\text{smeared}}}{dp_{\perp J}} = \int \frac{dE}{\sqrt{2\pi}\Delta} e^{-\frac{(E-\bar{E})^2}{2\Delta^2}} \left.\frac{d\sigma}{dp'_{\perp J}}\right|_{p'_{\perp J}=p_{\perp J}+E}$$

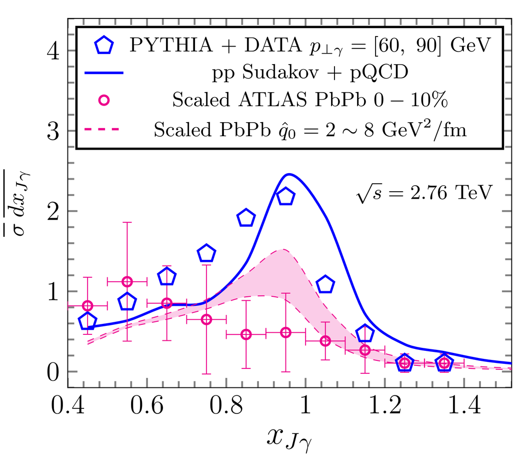
Our result agreed with both ATLAS data and POWHEG+PYTHIA monte-carlo simulations. However, we can not reproduce CMS pp data, and it is left as a future study.

Transport parameter

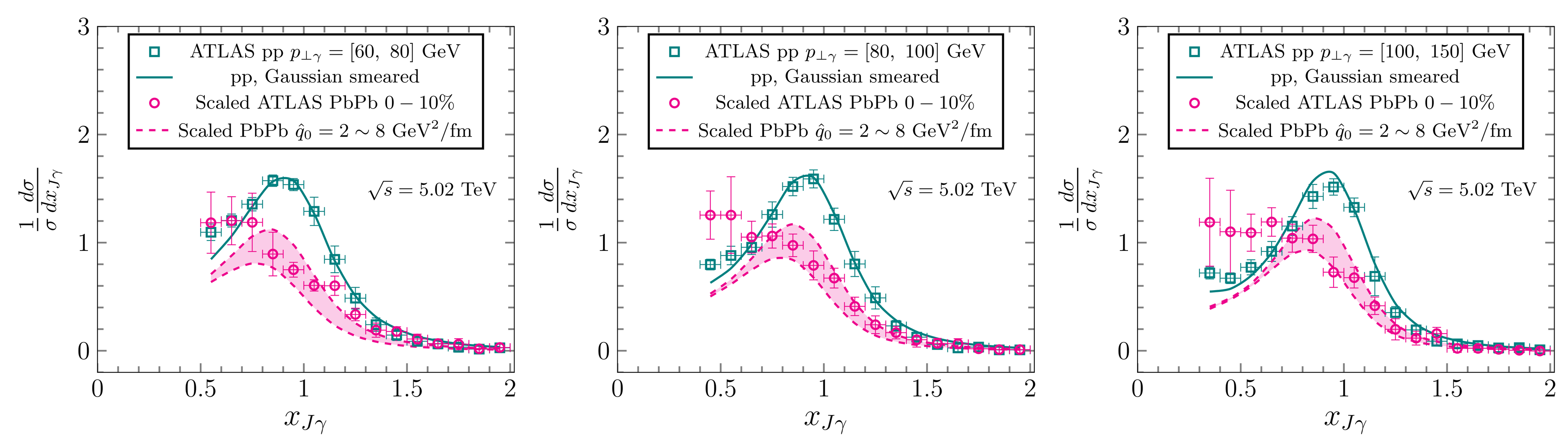
Once we have fixed our baseline calculation, we parametrized the QGP transport coefficient in the BDMPS energy-loss formalism:

$$\epsilon D(\epsilon) = \sqrt{\frac{\alpha^2\omega_c}{2\epsilon}} \exp\left(-\frac{\pi\alpha^2\omega_c}{2\epsilon}\right)$$

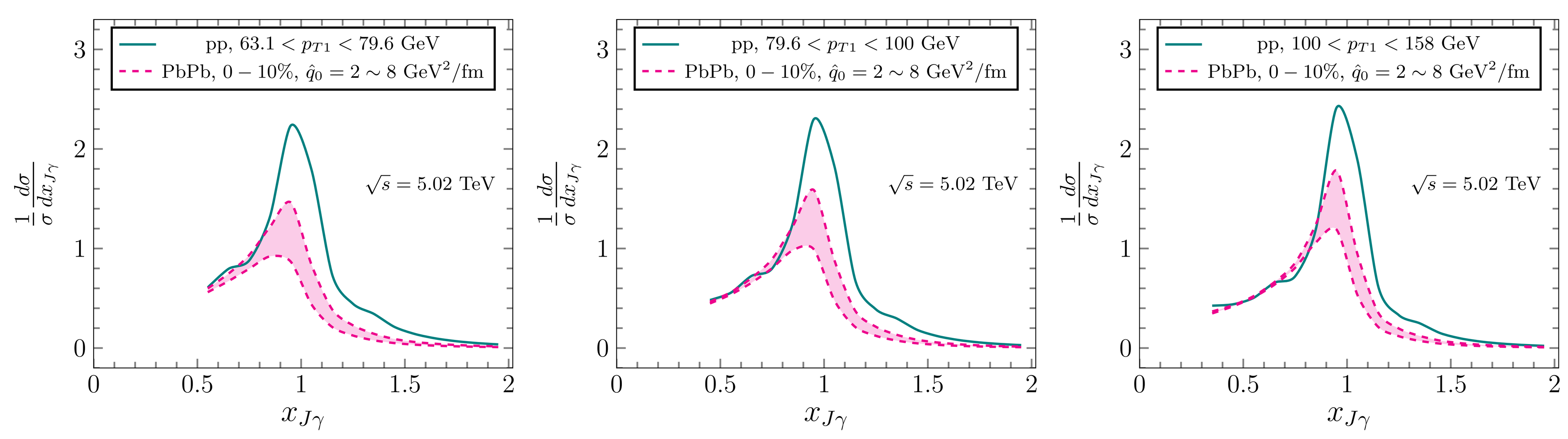
then simulated the jet propagation in the OSU 3-D viscous hydrodynamic evolution to take into account the geometric effects of the medium.
We also compare our calculation with the unfolded data from the ATLAS collaboration at $\sqrt{s} = 2.76A\ TeV$. We find that our results for pp collisions qualitatively agree with the results obtained from PYTHIA plus data overlay. The suppression in the $x_{J\gamma}$ distributions in $PbPb$ collisions also suggests a similar range for the transport coefficient $\hat{q}_0$.



Phys. Lett. B707:151, 2012



By distinguishing quark and gluon final state jets and adding different energy loss weights, we found that $\hat{q}_0 = 2 - 8GeV^2/fm$ at $\sqrt{s} = 5.02A\ TeV$, which is consistent with $\hat{q}_0 = 2 - 6GeV^2/fm$ at $\sqrt{s} = 2.76A\ TeV$ from our previous study. We see a shift towards smaller value of $x_{J\gamma}$ and an overall suppression of the distribution indicating a visible amount of energy is lost from jets due to their interaction with the medium. In addition, some of the jets after passing through the QGP medium were eliminated from the lower cuts on the jet transverse momentum, which also cause the suppression in the overall distribution.



Future predictions

Here we have provided our predictions for the $x_{J\gamma}$ distributions in both pp and $PbPb$ collisions, which can be compared directly with the unfolded ATLAS data once it becomes available. The importance of unfolding of data is that it gets rid of a lot of detector effects and make the difference between pp and $PbPb$ collisions more prominent. This can lead us to a more profound and precise understanding of the energy loss mechanisms in QGP.

Please see poster for Dijet, Dihadron and Hadron-jet correlations in resummation improved pQCD approach.