# Hard Probes, 2016

## Probing Transverse Momentum Broadening via Dihadron & Hadron-jet Angular Correlations

### Shu-yi Wei (CCNU)

In collaboration with L. Chen, G.Y. Qin, B.W. Xiao & H.Z. Zhang arXiv:1607.01932

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## Introduction

Sudakov Resummation

☑ Extract  $\hat{q}$  from dihadron & hadron-jet correlations ☑ Summary

# CENTRA NORMALITY

### Jet-medium interaction

✓ k⊥ broadening
✓ Energy loss
Two sides of the same coin.



### **BDMPS** approach

Jet transport parameter  $\hat{q} = \frac{\Delta k_{\perp}^2}{L}$   $-\frac{dE}{dx} = \frac{\alpha_s N_c}{4} \hat{q}L$ 

 $\mathbf{V} \hat{q}$  reflects the density of QGP

Baier, Dokshitzer, Mueller, Peigne, and Schiff NPB 483 (1997), 484 (1997), 531 (1998).

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# Introduction

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## Energy loss - Single hadron R<sub>AA</sub>



Angular decorrelation - New and complimentary method

 $\mathbf{V}$  Extract  $\hat{q}$  via angular decorrelation in the back-to-back region.



## Dihadron Angular decorrelation @ RHIC

back-to-back region



Yield suppression
 Angular decorrelation: quantitative calculation is lacking

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# Introduction



### ATLAS [PRL 105, (2010)] & CMS [PRC 84, (2011)]



peripheral

Energy imbalance increases: Energy Loss
 No clear sign of angular decorrelation

**Qin, Muller, PRL 106 (2011)** Is  $\hat{q} \simeq 0$ ?

central

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**Puzzle**: Large Energy Loss, Small *p*<sub>T</sub> Broadening?



### Dijet angular correlation in *pp*



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## Central rapidity back-to-back dijet production



Picture: Inertia

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Kinematic region:  $|\vec{q}_{\perp}| = |\vec{p}_{1T} + \vec{p}_{2T}| \ll |\vec{p}_{1T}| \simeq |\vec{p}_{2T}|$  small angle

Back-to-back correlations are very sensitive to the soft gluon radiations.





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## Dijet angular correlation in AA



Vacuum Sudakov Effect » Medium Broadening Effect

This explains why the LHC did not observe the angular decorrelation.

Mueller, Wu, Xiao, Yuan, arXiv:1604.04250

### Dijet angular correlation in AA



Vacuum Sudakov Effect ~ Medium Broadening Effect

Decrease the center of mass energy or measure small  $p_{\rm T}$  jet.

Mueller, Wu, Xiao, Yuan, arXiv:1604.04250





### Dihadron correlations in pp - Establish Baseline



- ☑ For the first time we can describe the back-to-back angular correlation.
- Established a baseline to study the angular decorrelation in AA collisions.



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### *pp* collisions + *AA* collisions



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### Normalized $q_{\perp}$ distributions

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## $q_{\perp AA}^{*2} \simeq q_{\perp pp}^{*2} + \langle \hat{q}L \rangle$

Large  $p_T$  events are not sensitive to the medium induced  $k_T$  broadening, since the vacuum Sudakov effect is too large.



$$S_{AA}(Q,b) = S_{pp}(Q,b) + \frac{\langle \hat{q}L \rangle b^2}{4}$$

 $\langle \hat{q}L \rangle_{\rm tot} = 14^{+42}_{-14} \ {\rm GeV}^2$ 

larger than the value,  $\hat{q} = 1.2 \pm 0.3 \text{ GeV}^2/\text{fm}$ extracted from single hadron  $R_{AA}$  by JET Collaboration

Radiative correctionEffective length





- ☑ For the first time we can describe the back-to-back dihadron/hadron-jet angular correlation measured at RHIC & LHC.
- The dijet, dihadron and hadron-jet angular correlations can provide a new gateway to quantify the medium induced k<sub>T</sub> broadening.
- $\checkmark$  We extracted that  $\langle \hat{q}L \rangle_{\text{tot}} = 14^{+42}_{-14} \text{GeV}^2$  for a quark jet at RHIC energy.

# Outlook

☑ Energy loss.

**M**Dihadron per trigger yield.

 $\mathbf{\underline{M}}A_{\mathrm{J}}$  distribution.

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- ☑ For the first time we can describe the back-to-back dihadron/hadron-jet angular correlation measured at RHIC & LHC.
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The End