

Jet-medium interaction in heavy-ion collisions at RHIC

Nihar Ranjan Sahoo

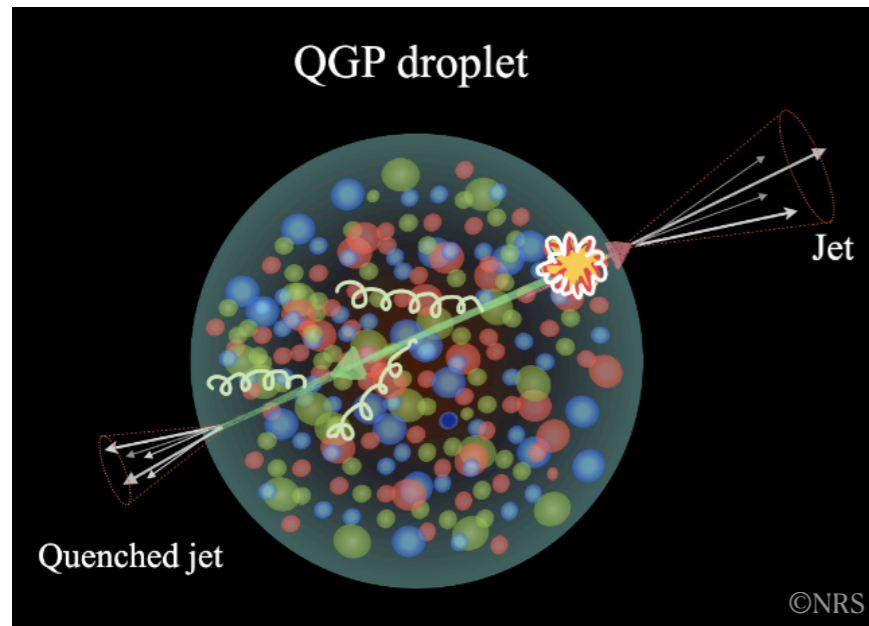
Texas A&M University, USA

National Institute of Science Education and Research, India



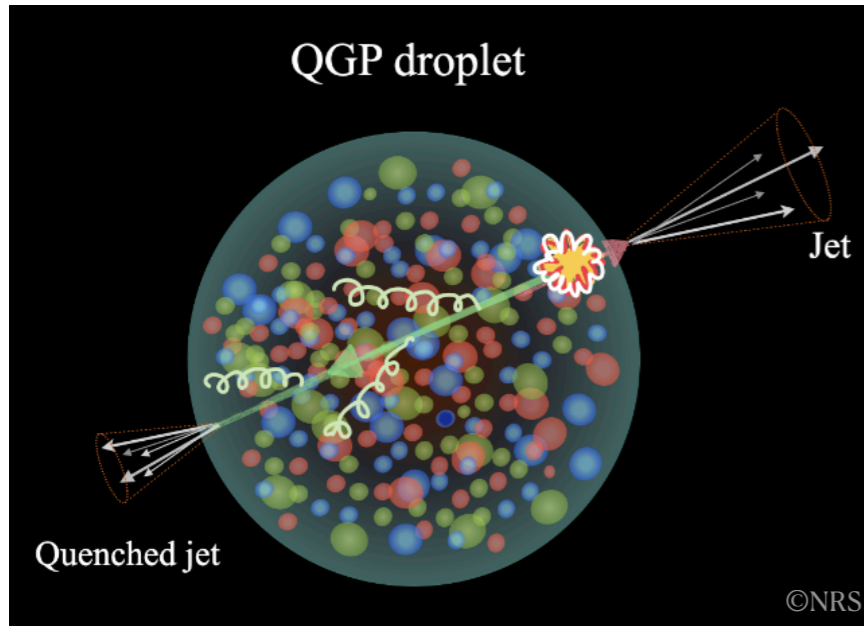
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Jet-medium interaction in heavy-ion collisions



- ## Jet quenching and early RHIC measurements
- Suppression of inclusive charged/neutral hadrons at high- p_T
 - No suppression of vector boson (γ)
 - Away-side jet suppression

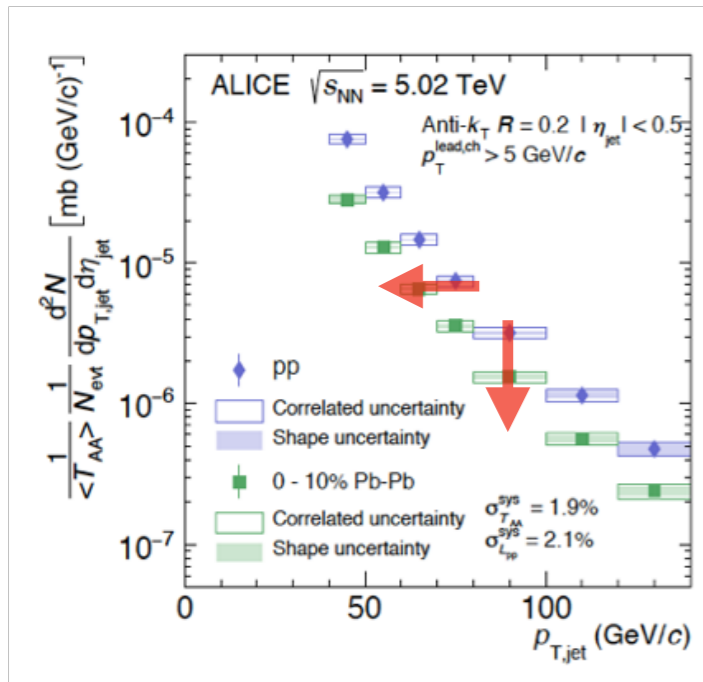
Jet-medium interaction in heavy-ion collisions



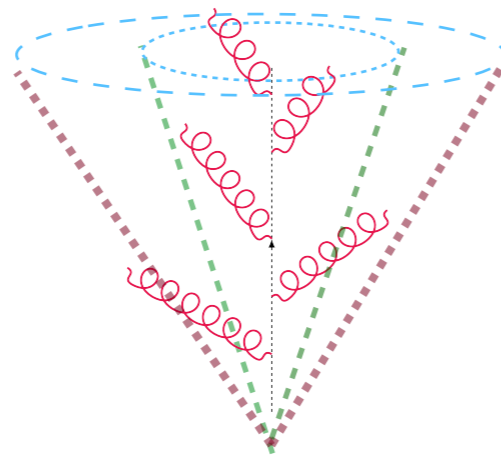
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Consequences of jet quenching

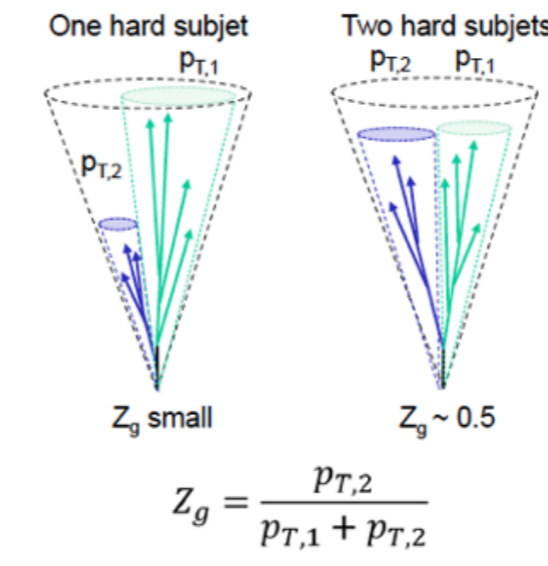
i) Energy loss



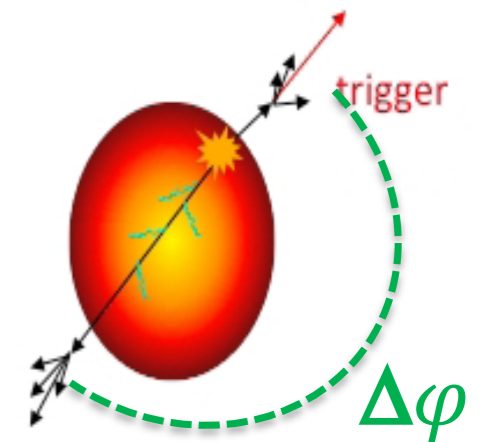
ii) Intra-jet broadening



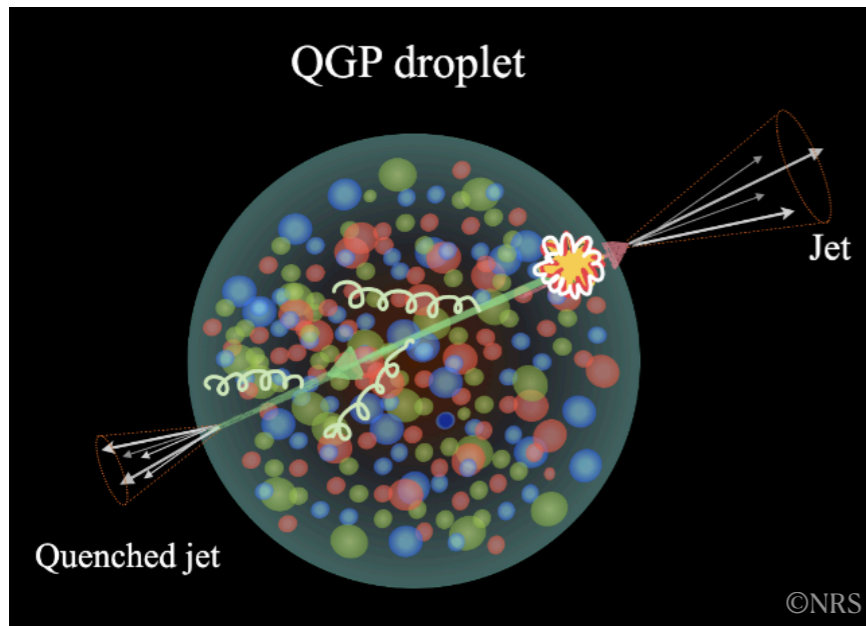
iii) jet substructure modification



iv) jet acoplanarity



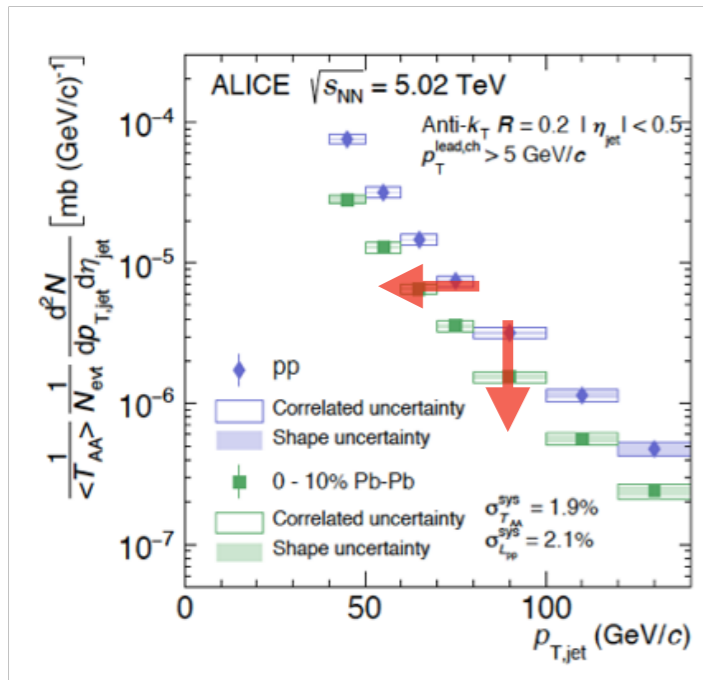
Jet-medium interaction in heavy-ion collisions



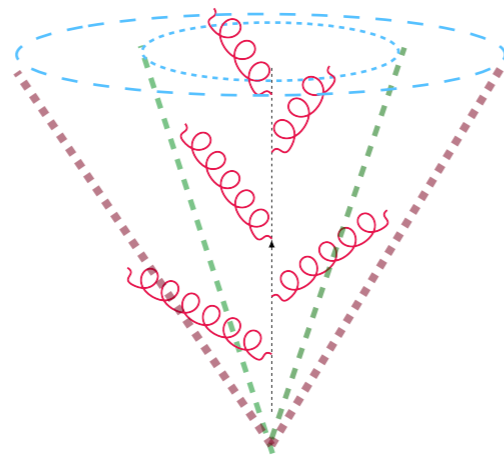
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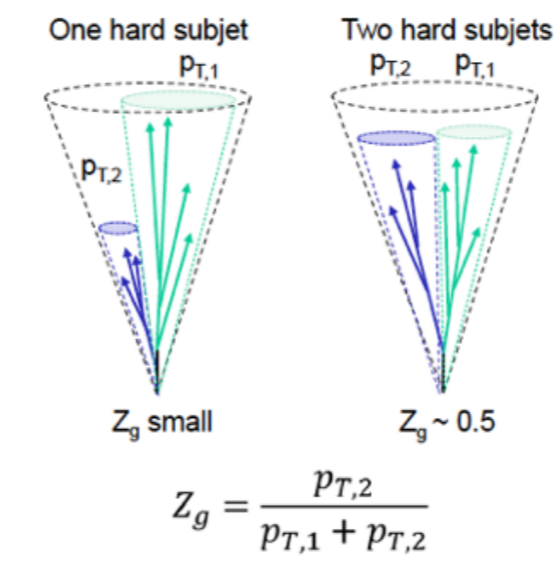
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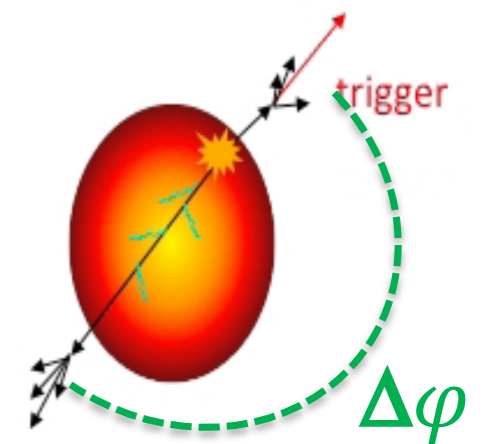
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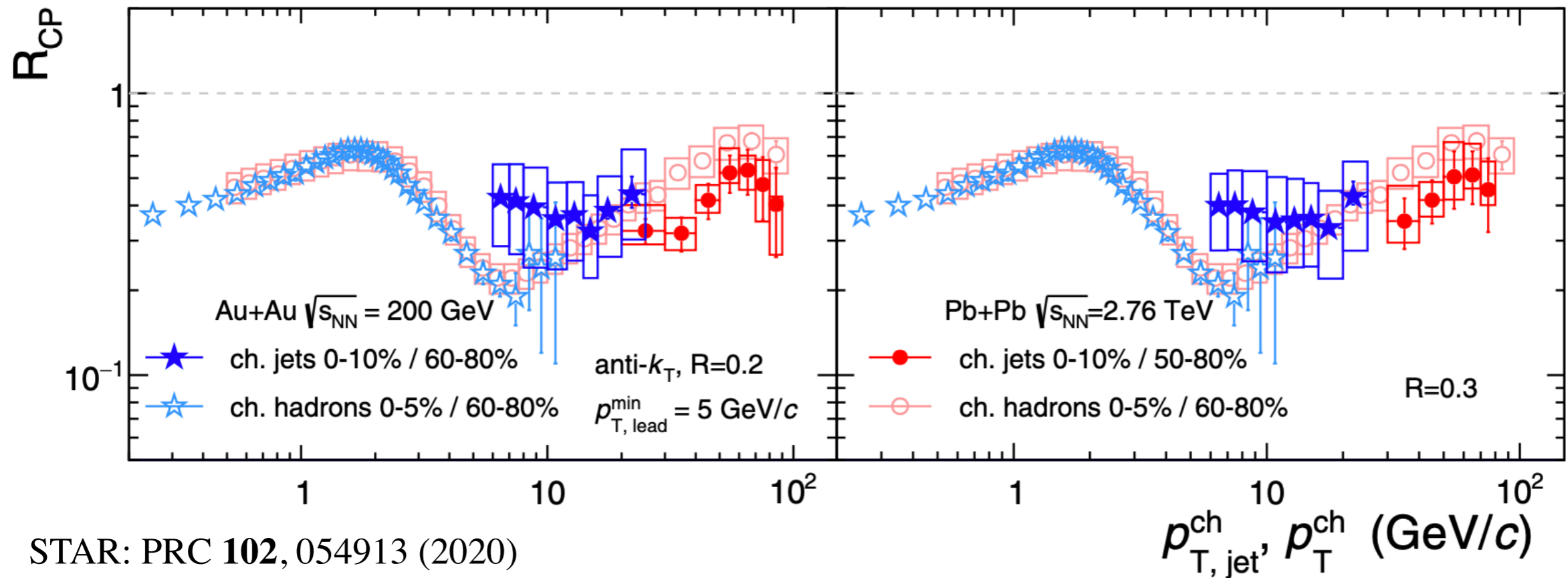
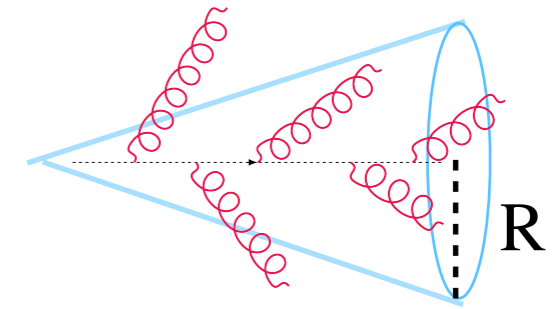
In this talk, Energy loss, intra-jet broadening and new findings on jet acoplanarity are discussed

Jet energy loss at RHIC

Inclusive jet suppression at RHIC

Jet resolution, $R = 0.2$

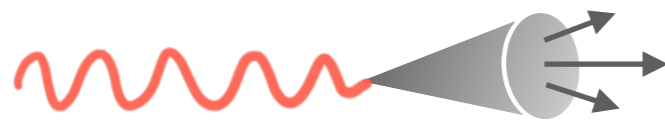
$R = 0.3$



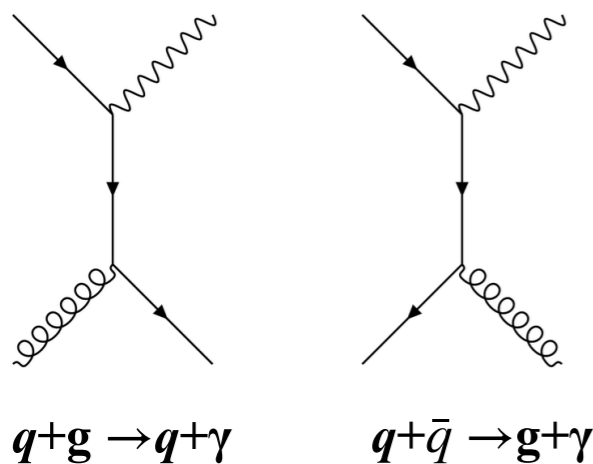
Charged-hadron R_{CP} at RHIC and LHC agrees within uncertainties

Direct photon+jet and hadron+jet measurements at RHIC

γ +jet processes:



LO QCD process for prompt photon production

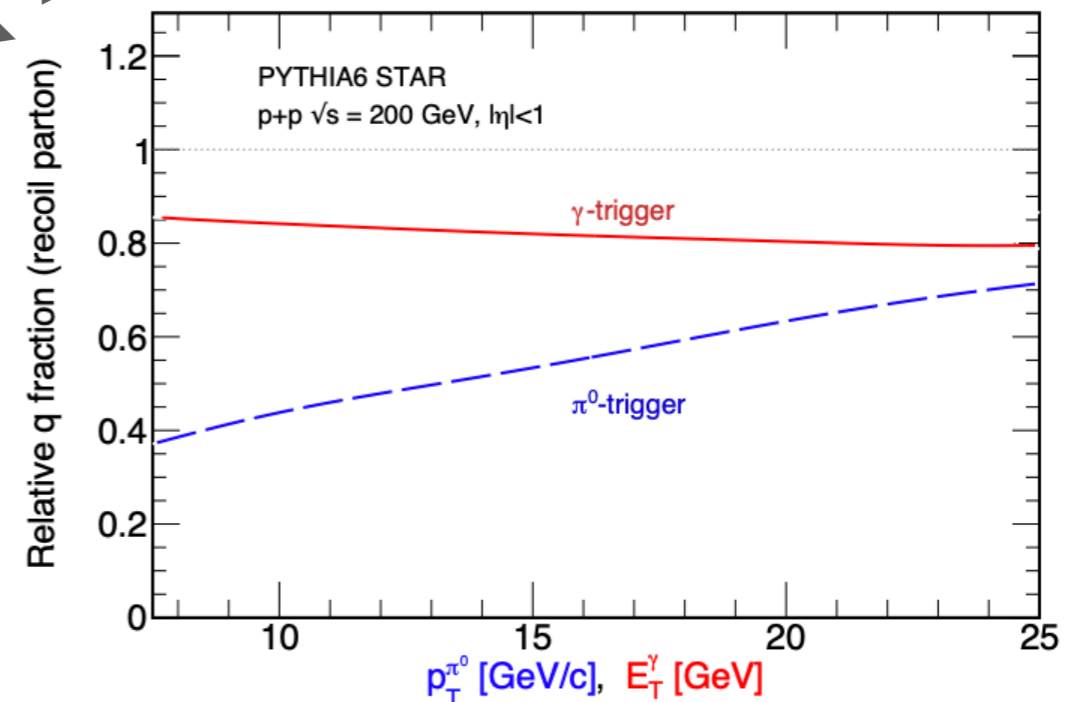


π^0 /h+jet processes:



$q+\bar{q} \rightarrow g+g$
 $q+q \rightarrow q+q$
 $q+g \rightarrow q+g$
 $g+g \rightarrow g+g$
 $g+g \rightarrow q+\bar{q}$, etc.

LO QCD process



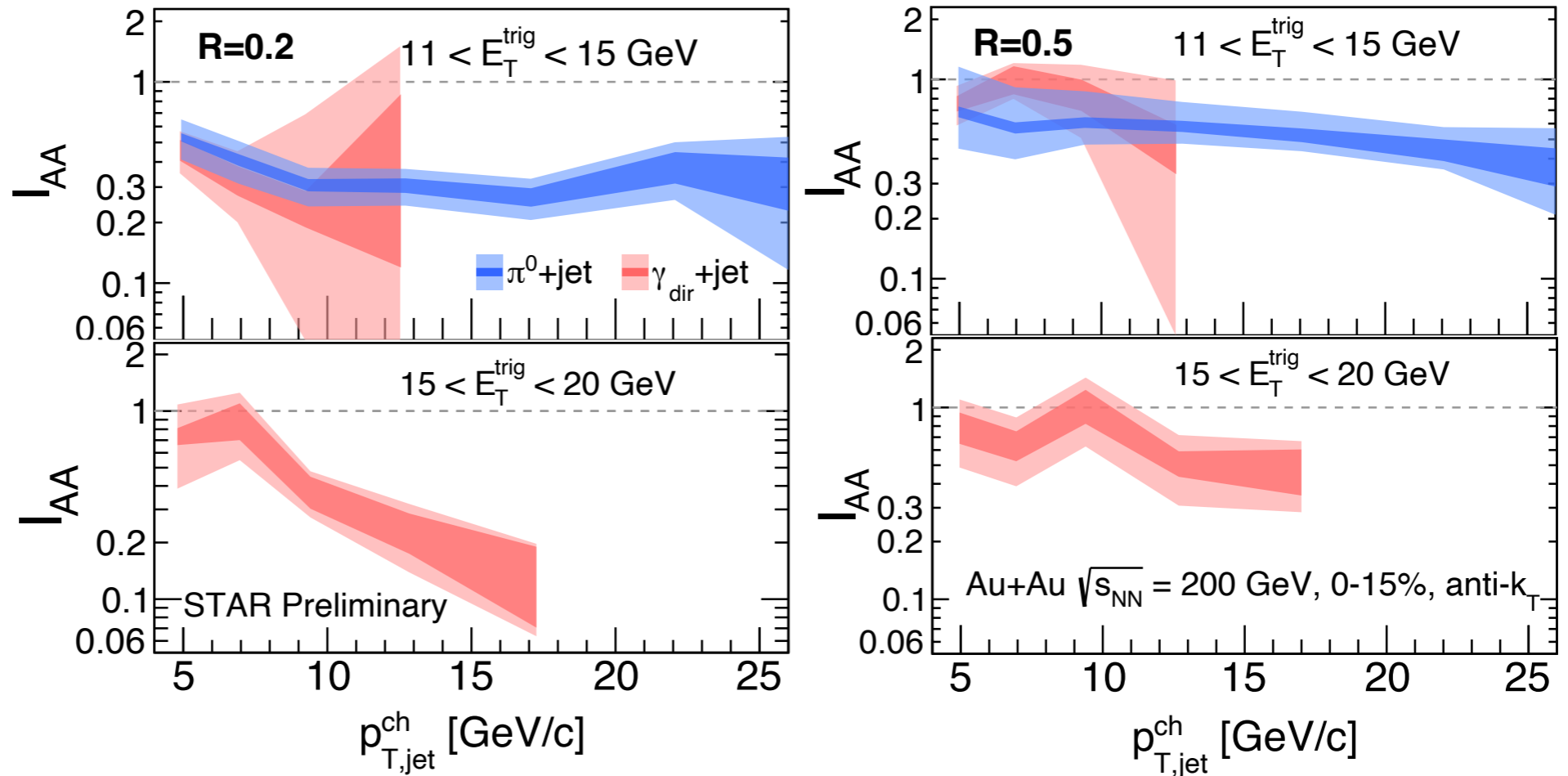
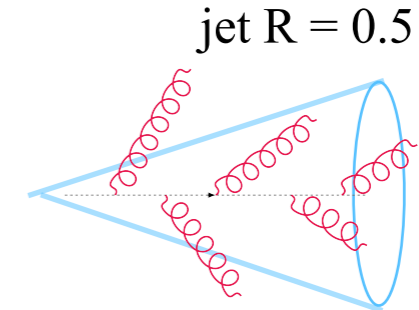
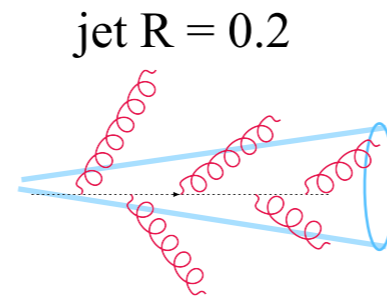
In heavy-ion collisions:

- γ does not interact strongly in QGP
 recoil jet is a “tomographic probe”
- Comparison between γ +jet and hadron+jet

Shades light on color-factor and path-length dependent parton energy loss

γ +jet and π^0 +jet suppression in Au+Au relative to p+p

$$I_{AA}(p_{T,jet}^{ch}) = \frac{Y(p_{T,jet}^{ch})^{Au+Au}}{Y(p_{T,jet}^{ch})^{p+p}}$$



Derek Anderson, QM2022

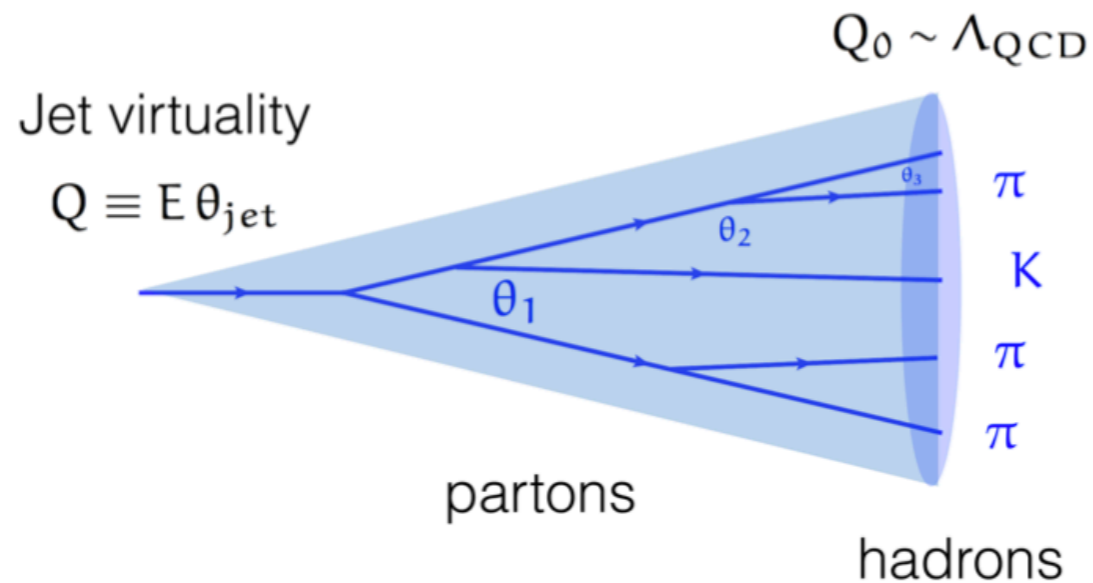
Recoil jets with smaller R more suppressed than large R

γ +jet and π^0 +jet I_{AA} are consistent within uncertainties

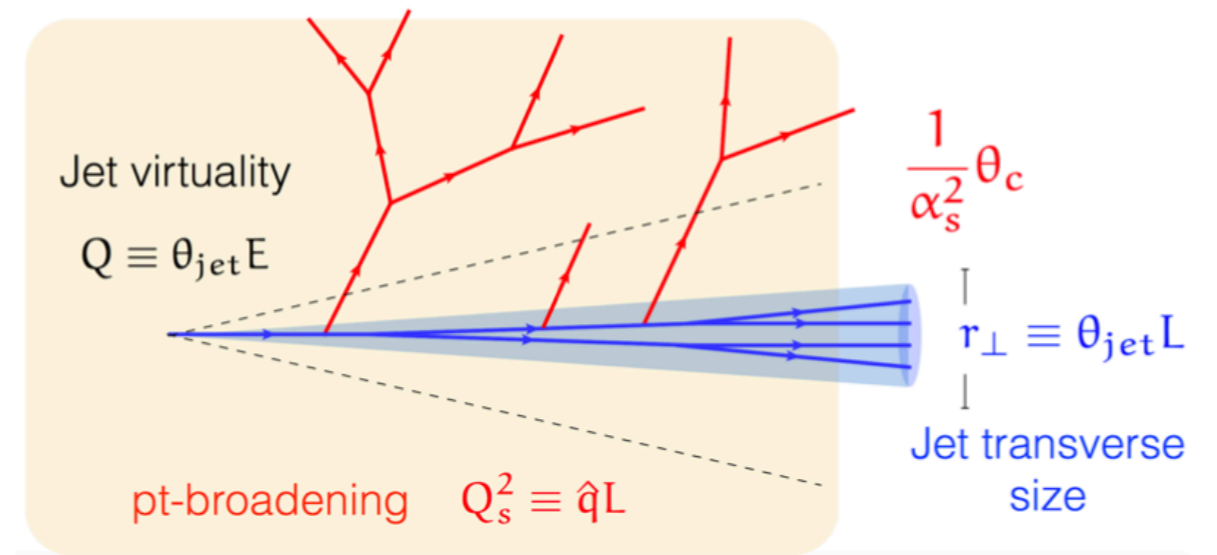
Intra-jet broadening at RHIC (STAR)

R-dependence of jet yield: Intra-jet broadening

Vacuum parton shower



Medium-induced gluon radiation



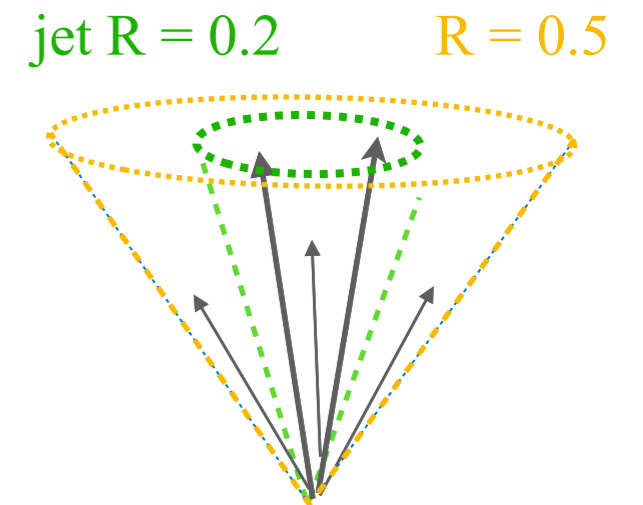
Yacine Mehtar-Tani, arXiv: 1602.01047

Simultaneous effect of vacuum shower and medium-induced gluon radiation

Jet shape: spread of energy inside a jet

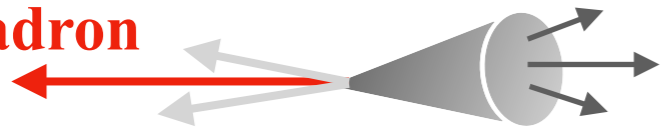
- Take jet yield ratio of smaller over large-R in the same system
- And compare with p+p and heavy-ion collisions

$$\mathcal{R}_{\frac{\text{small-R}}{\text{large-R}}} = \frac{Y(p_T^{\text{jet,ch}})^{\text{small-R}}}{Y(p_T^{\text{jet,ch}})^{\text{large-R}}}$$

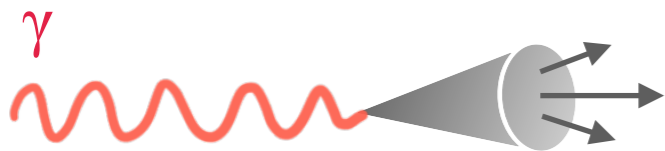


Intra-jet broadening in heavy-ion collisions

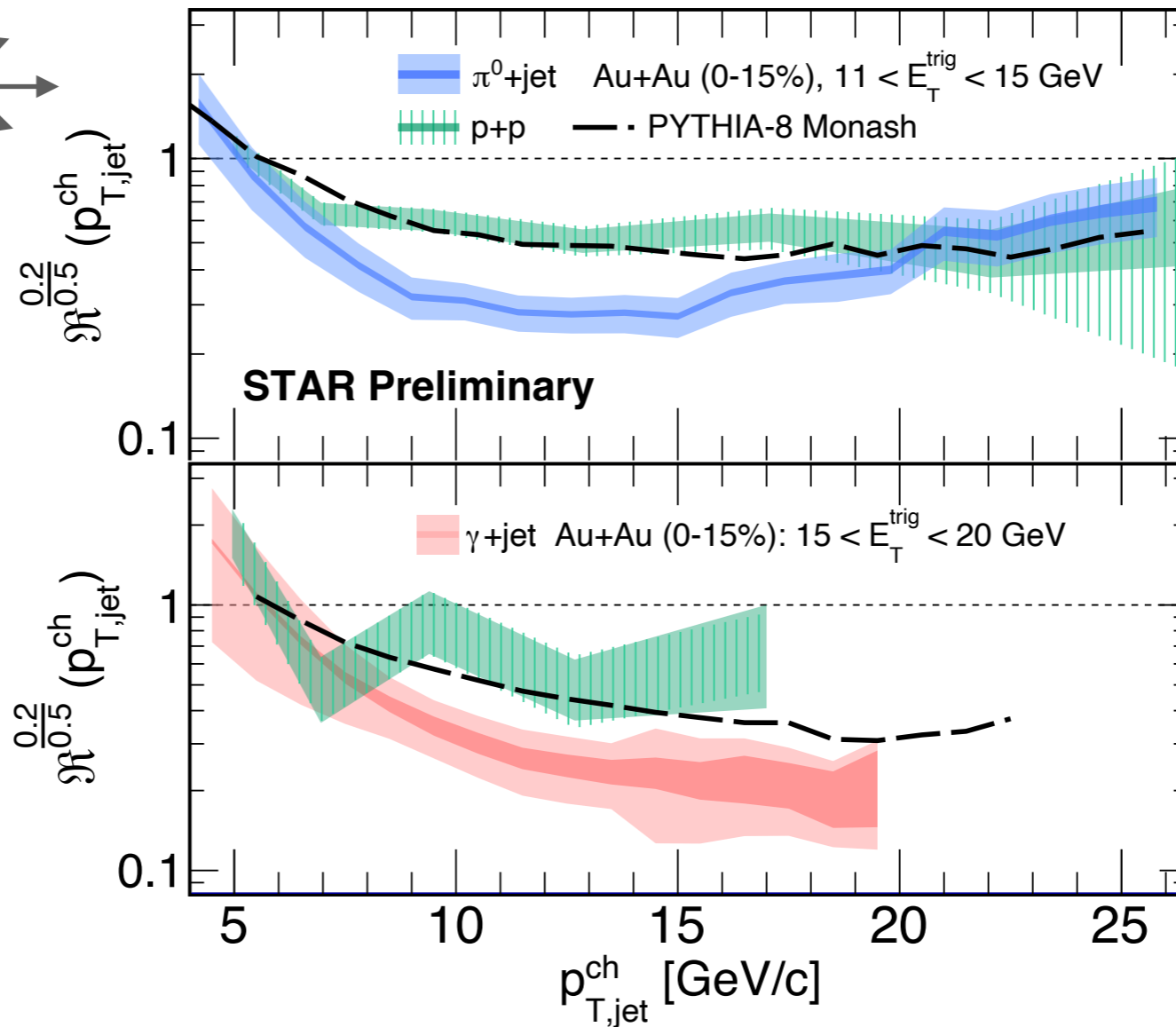
π^0 /hadron



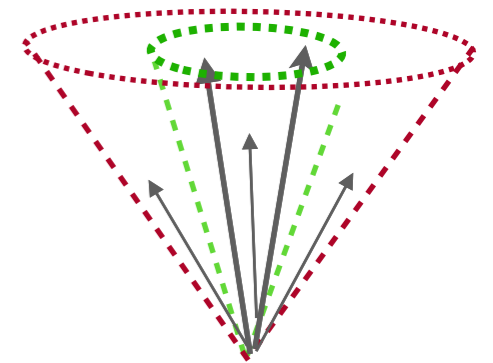
$$\mathcal{R}_{\text{large}-R}^{\text{small}-R} = \frac{Y(p_T^{\text{jet,ch}})^{\text{small}-R}}{Y(p_T^{\text{jet,ch}})^{\text{large}-R}}$$



Derek Anderson, QM2022



jet $R = 0.2$ $R = 0.5$



Intra-jet broadening due to medium induced gluon radiations at RHIC

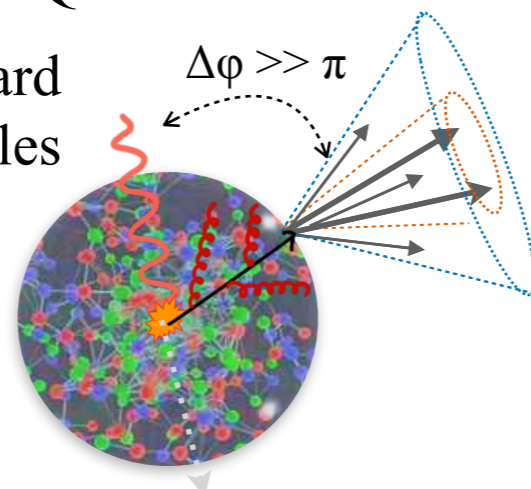
Jet acoplanarity at RHIC (STAR)

Physics mechanisms for jet acoplanarity in heavy-ion collisions

- Rutherford Scattering: Energetic parton resolves microstructure of QGP

Large-angle deflection of hard partons off quasi-particles

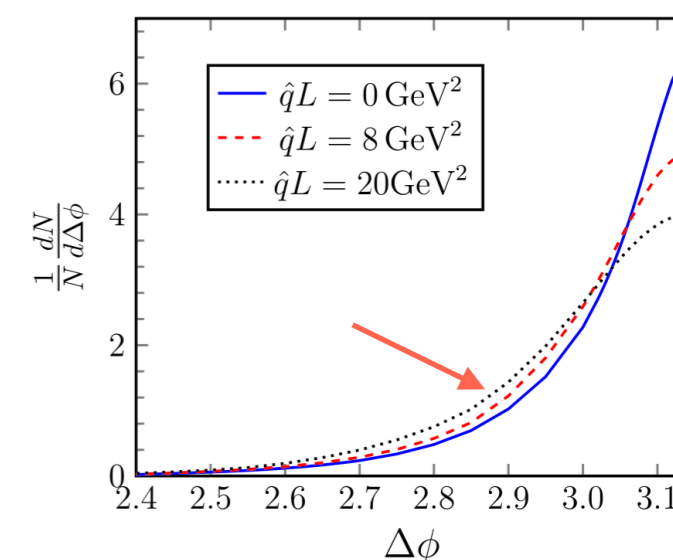
D'Eramo, Rajagopal, Yin, JHEP 01 (2019) 172;
D'Eramo, et. All, JHEP 05 (2013) 031



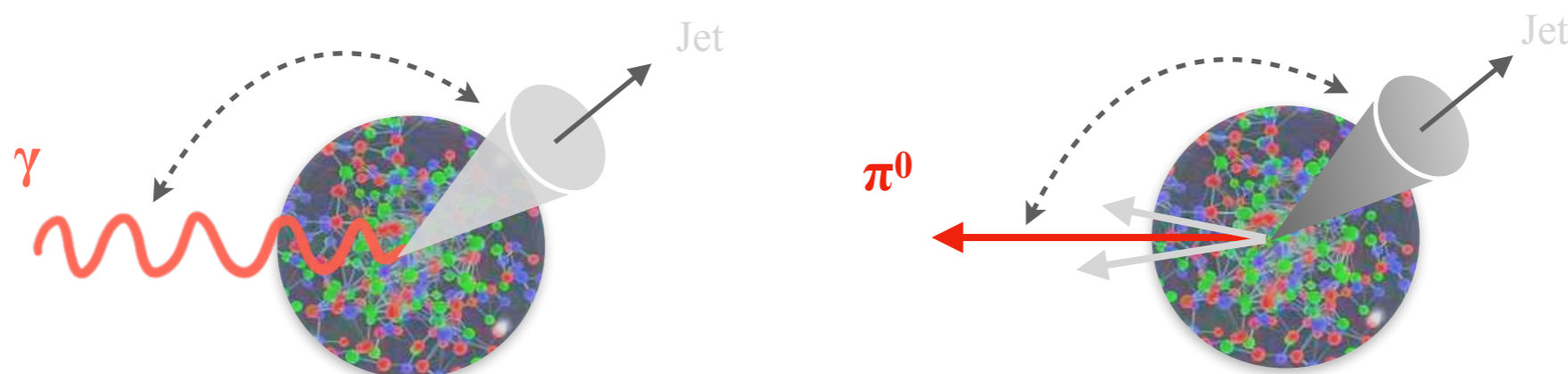
- Vacuum soft gluon radiation
- Medium effect: multiple scattering and medium induced gluon radiation

A. Mueller et al,
PLB 763 (2016) 208

Dijet Angular Correlation at RHIC



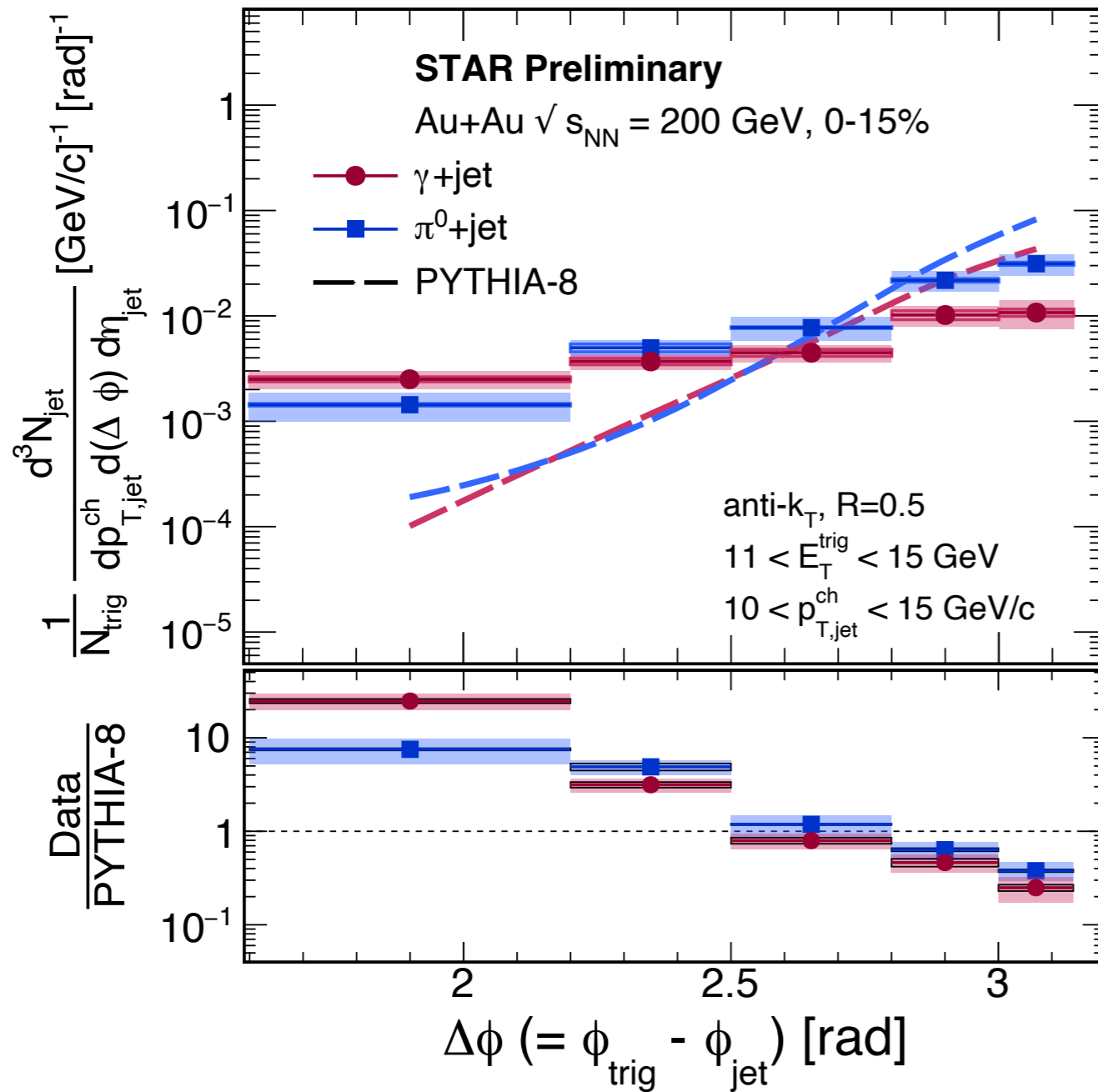
Measuring two probes in STAR experiment



Azimuthal correlations between trigger particle and recoil jet: $\Delta\phi = \phi_{\text{trig}} - \phi_{\text{jet}}$

γ +jet and π^0 +jet azimuthal correlation in Au+Au collisions

$11 < E_T^{\text{trig}} < 15 \text{ GeV}; R=0.5$



First evidence of significant medium-induced jet acoplanarity in QGP for jets with $R=0.5$

What we learnt about jet-medium interaction at RHIC?

From γ +jet and π^0 +jet measurements in heavy-ion collisions:

- **Jet cone size (R) dependence of suppression** → Encapsulation of lost energy within larger jet cone size
- **Intra-jet broadening in γ +jet and π^0 +jet** → In-medium gluon radiation due to jet-medium interaction
- **Jet acoplanarity** → another manifestation of jet-medium interaction
 - (A new observation)
 - A same observation is also seen in ALICE h+jet measurement
 - Rutherford scattering? ALICE: Rey Cruz-Torres, QM2022
 - Medium-response?
 - Important to understand in p+Au and also in e+p and e+A collisions (EIC)

Need to have detailed study on these observations at RHIC (and LHC)

Thank you!