Recent Results on Reconstructed Jets from PHENIX at RHIC

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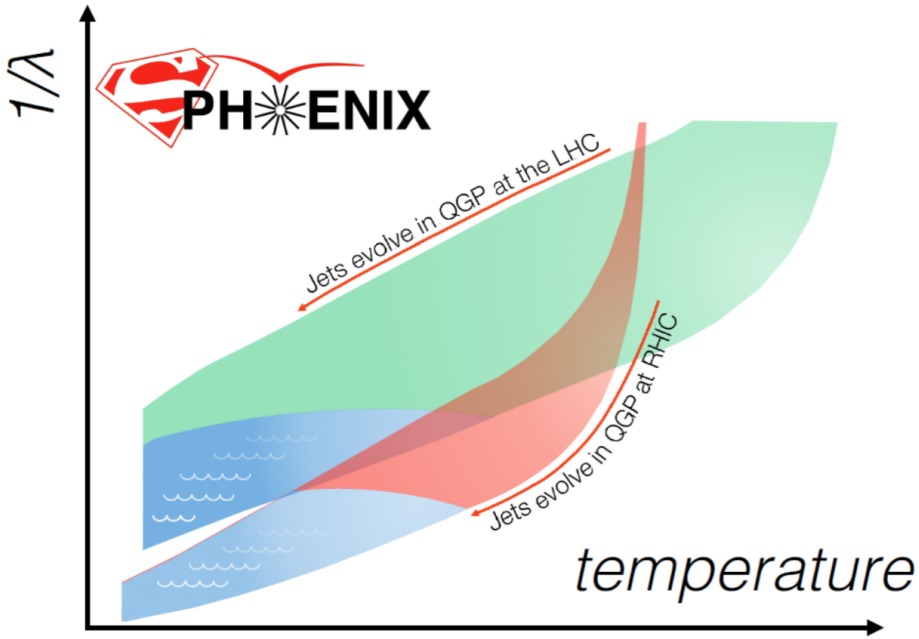
The Physics of Jets



- Jets in A+A probe the QGP

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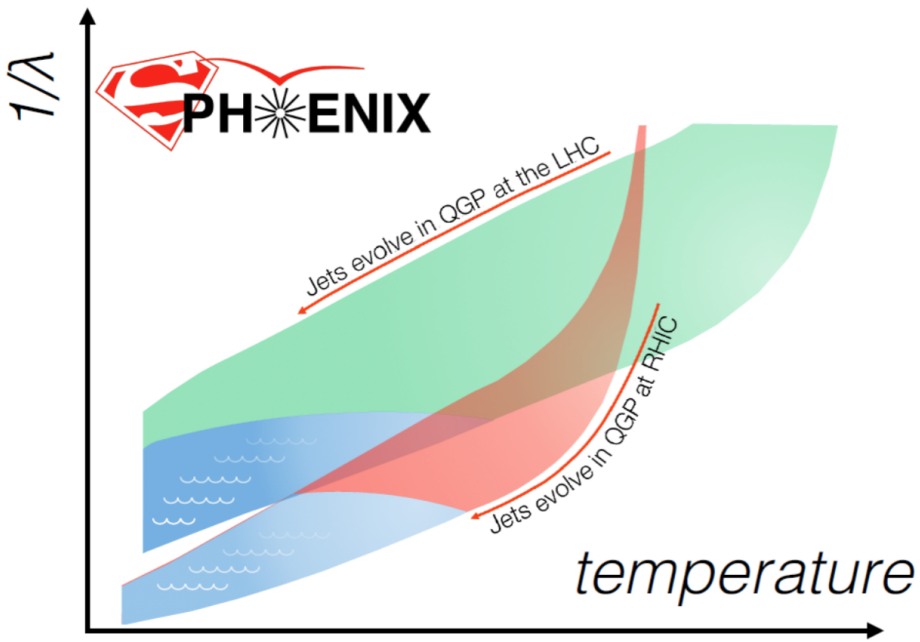

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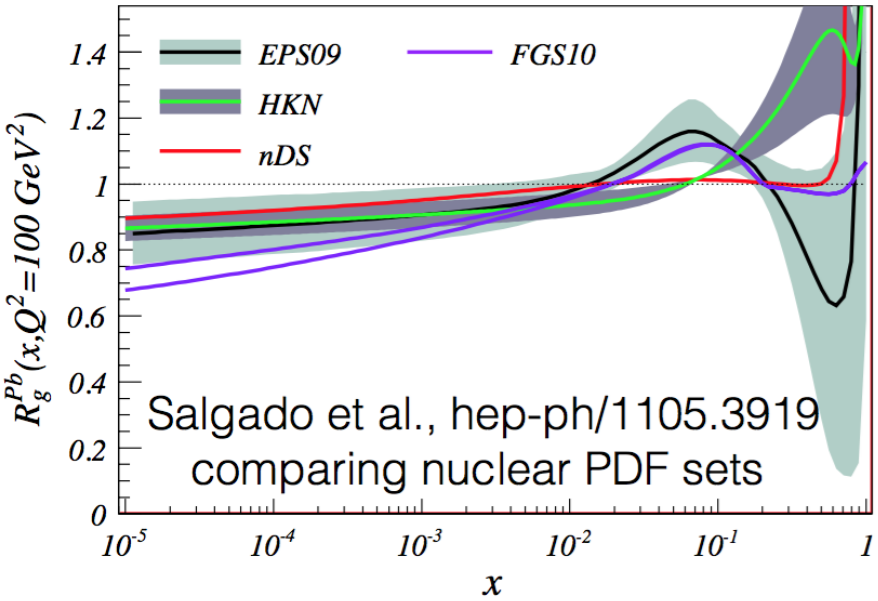
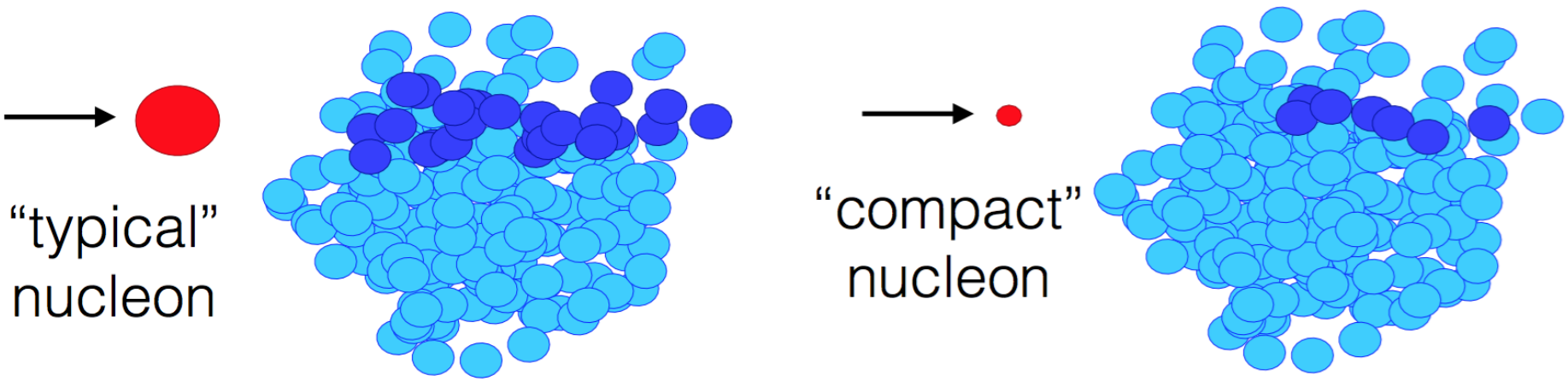


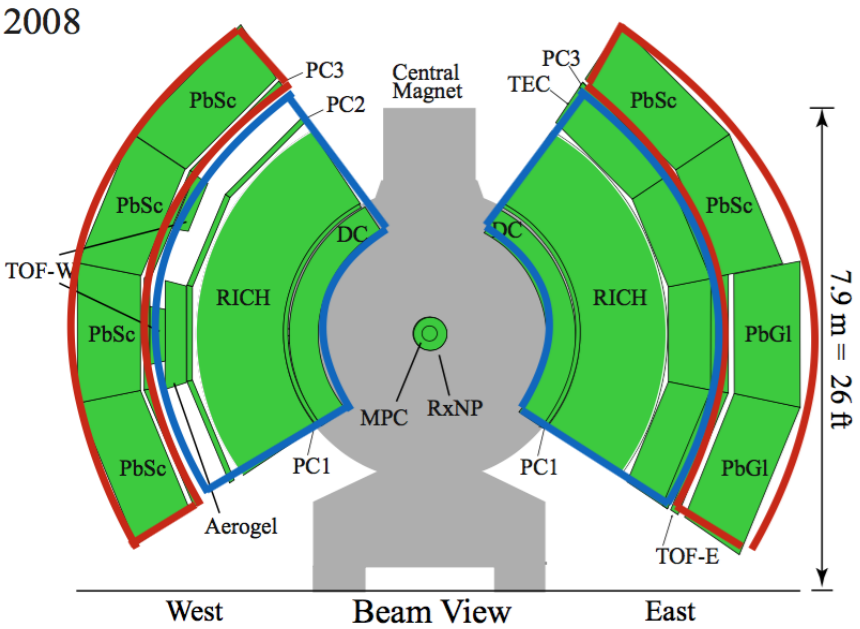
- p+A jets expected to be sensitive to nPDFs

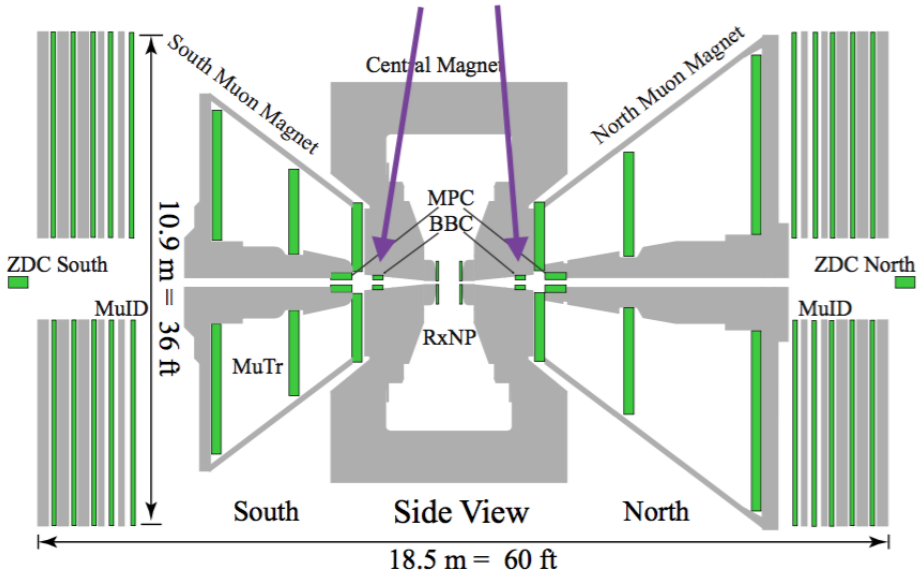
The Physics of Jets



- But, maybe the nucleus probes the structure of the nucleon in p+A?

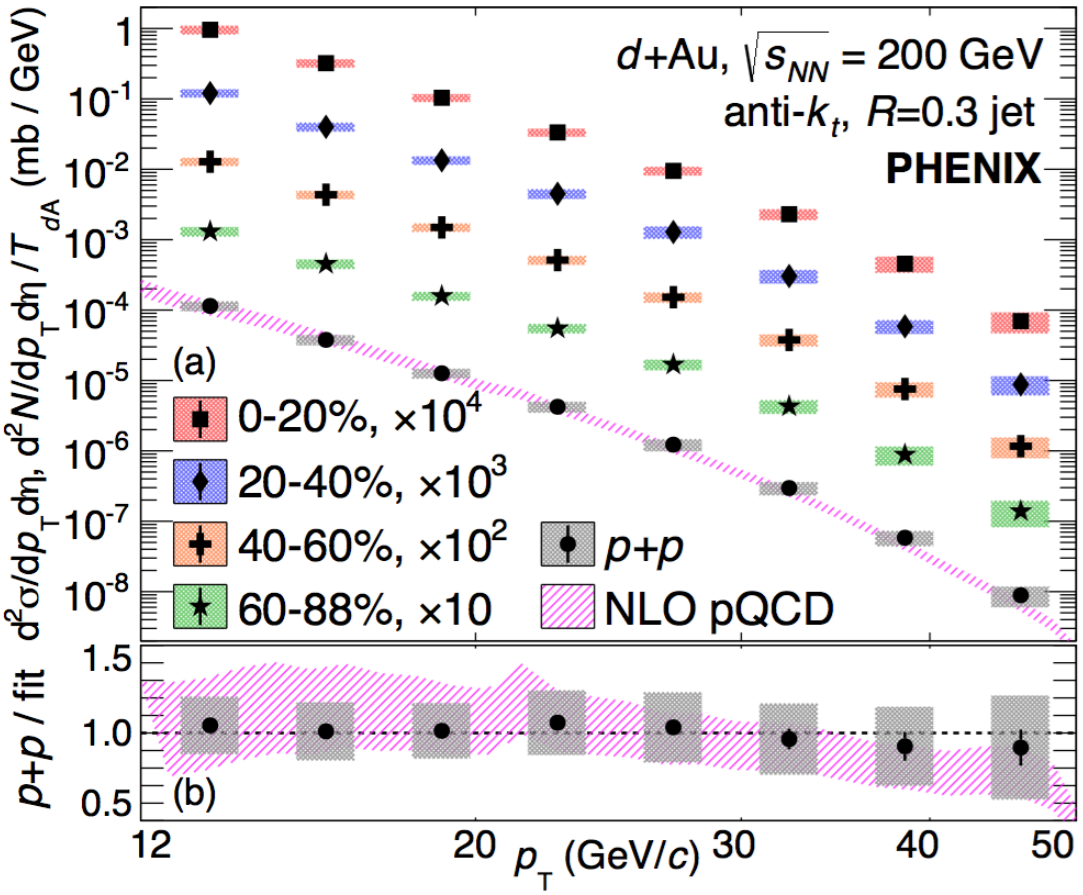
PHENIX Jet Detection





- Tracking chambers for hadrons, EM calorimetry for photons.
- Jet results are for Anti-k_T algorithm using combinations of EM energy and track p_T.
- Results unfolded to true jet p_T scale using SVD using PYTHIA to construct the response matrix.

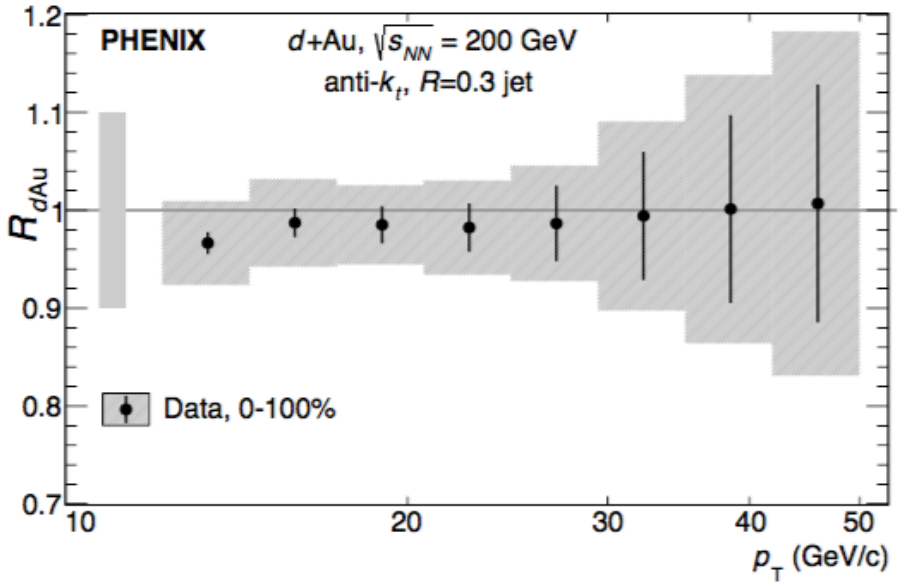
Jets in $p + p$ and d+Au



- $p + p$ consistent with NLOJET++ w/ NNPDF2.3 and hadronization corrections from Pythia.
- d+Au measured in several different centralities.

Phys. Rev. Lett. **116** (2016) 122301

Jets in $p + p$ and d+Au



- Min bias d+Au jets N_{coll} scales – not terribly surprising.

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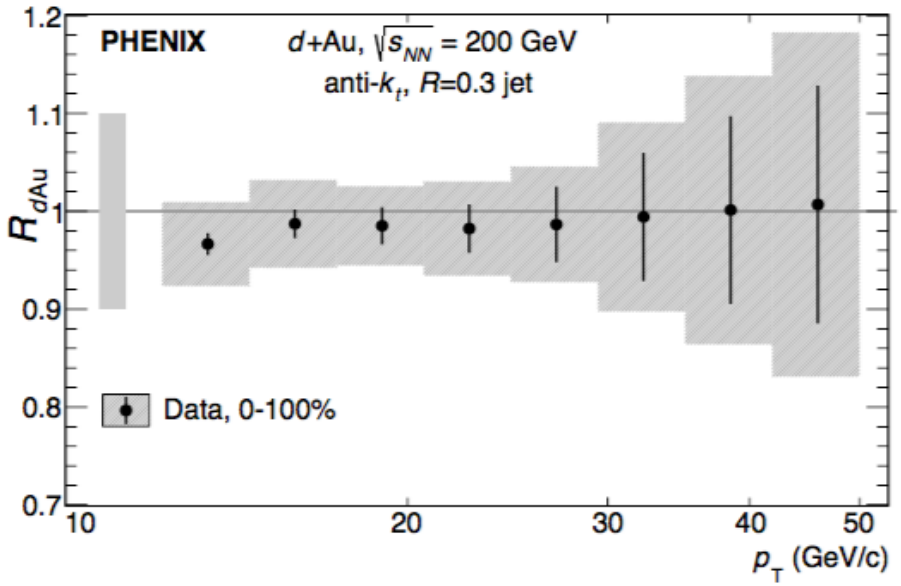

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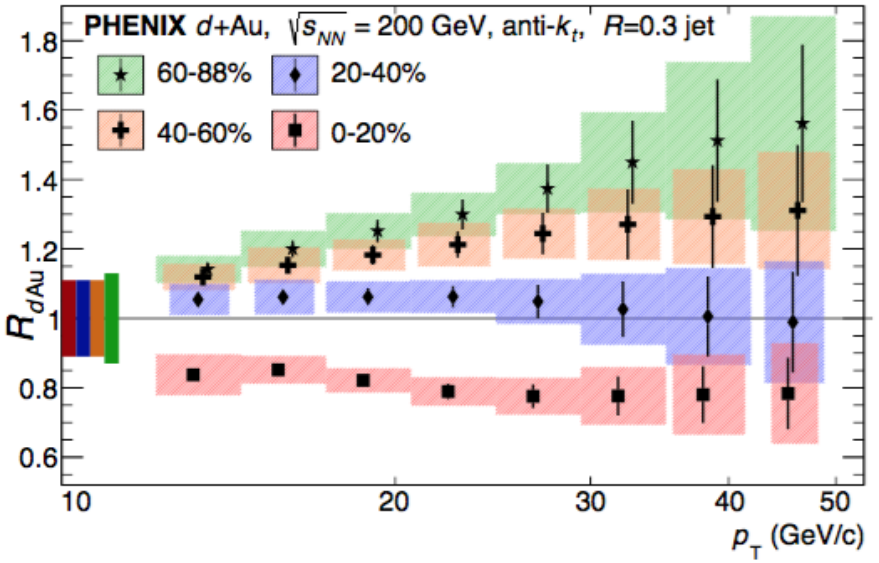
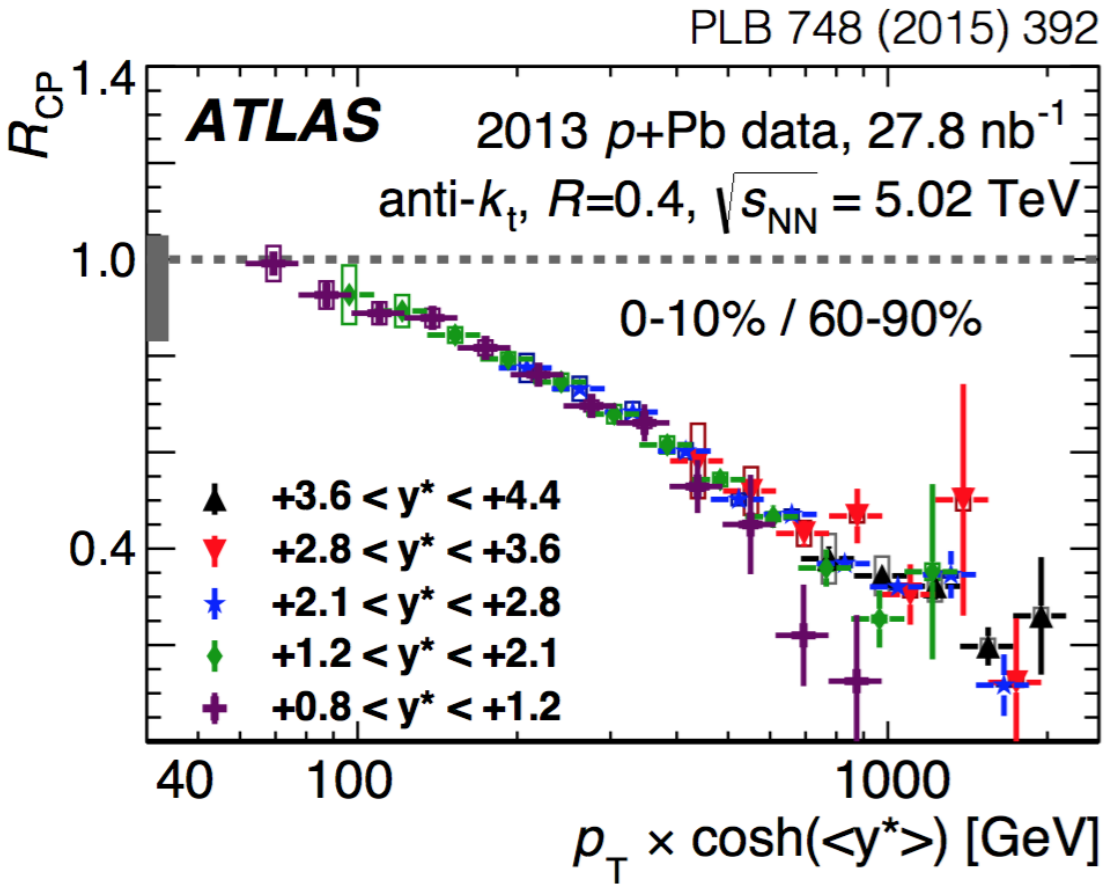


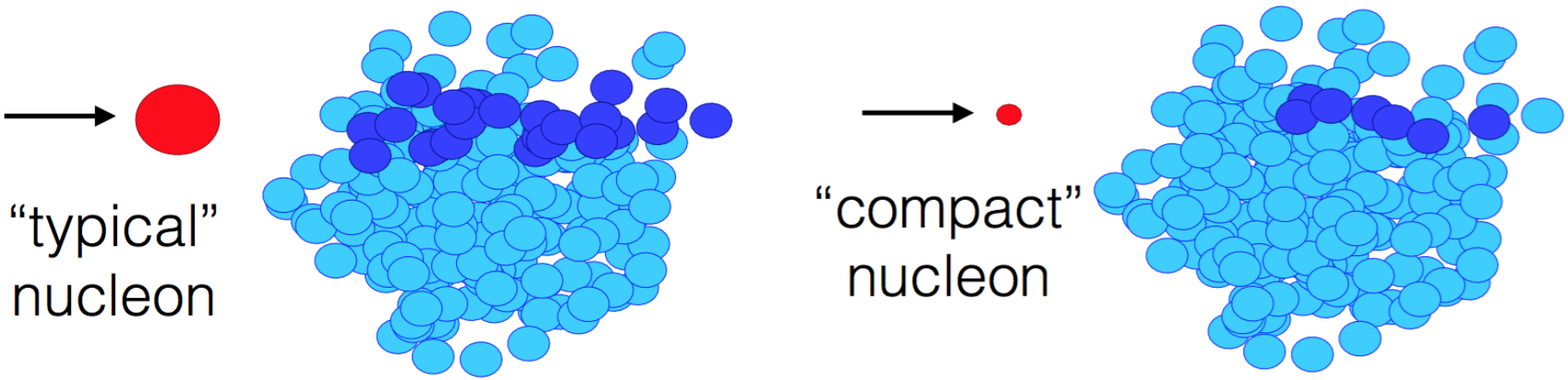
- But centrality dependence is quite surprising.

Probing the Nucleon



- Similar results from ATLAS
- R_{CP} scales with proton x

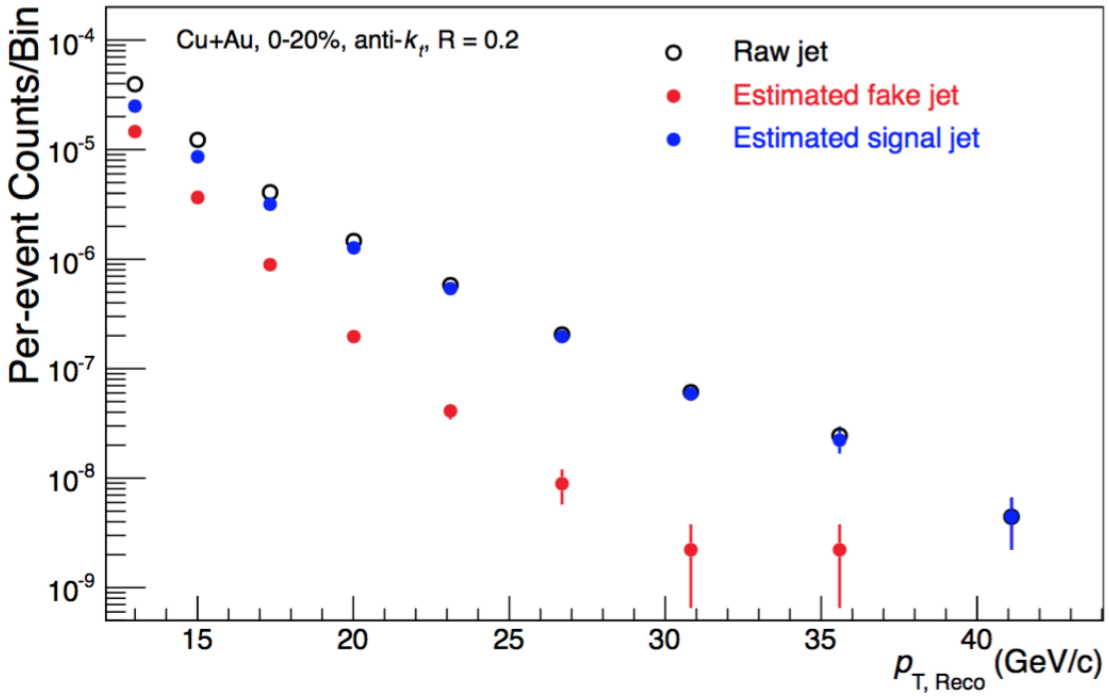
Probing the Nucleon



- A proton with a high-x parton will be "smaller" that average and strike fewer protons.
- Smaller N_{coll} than average causing R_{dA} to be greater than 1.
- Several theoretical efforts in this area: Perepelitsa, Cole and Strickman (PRC 93 (2016) 011902), Bzdak et al. hep-ph/1408.3156, Armesto et al. PLB 747 (2015) 441

Jets in Cu+Au

- Anti-k_T R=0.2 to reduce affect of underlying event.
- Data-driven underlying event determination
  - Reconstruct jets from randomly shuffled tracks and clusters.
  - Fake rate ∼30% at 15 GeV and drops to 5% by 25 GeV.



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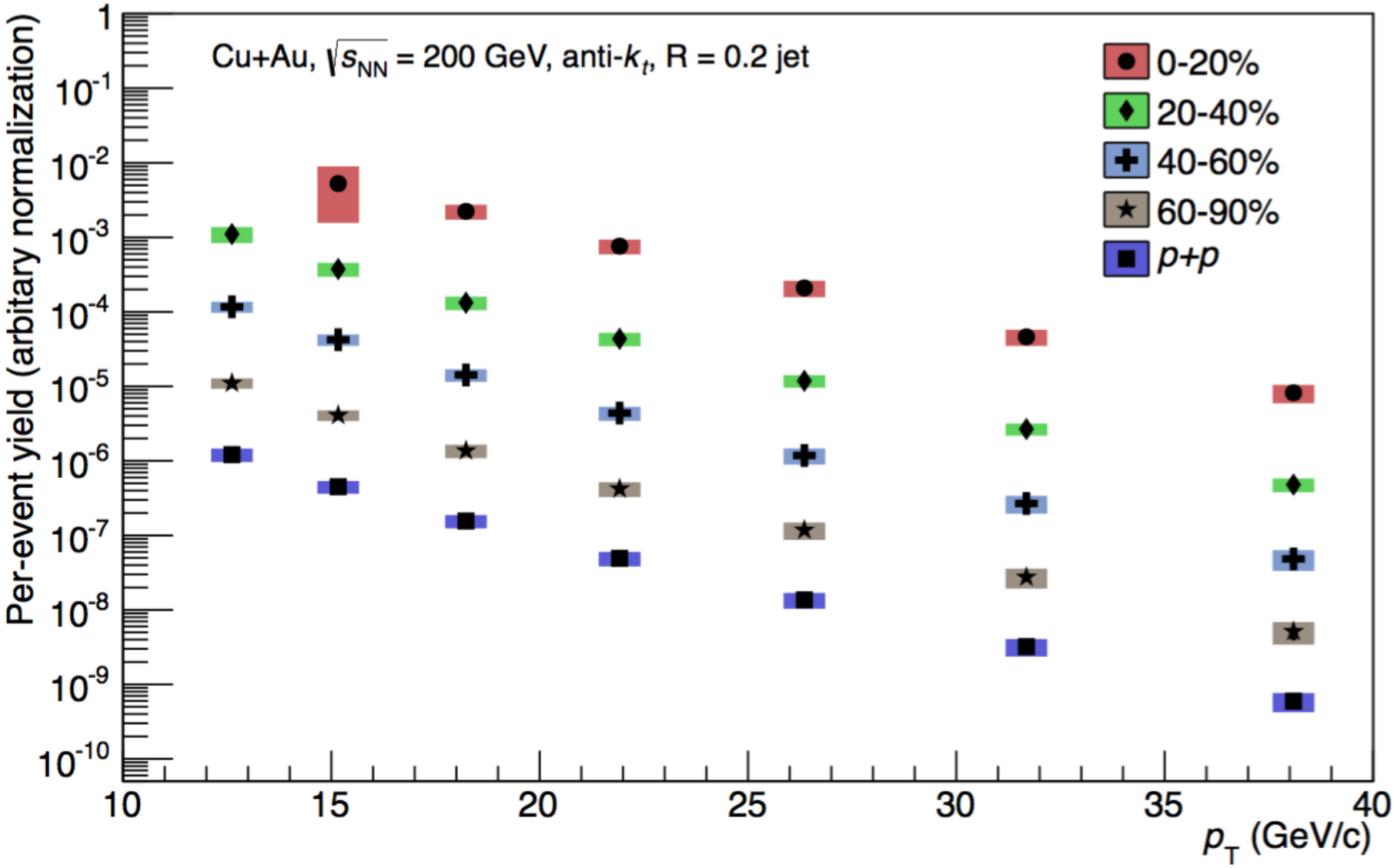
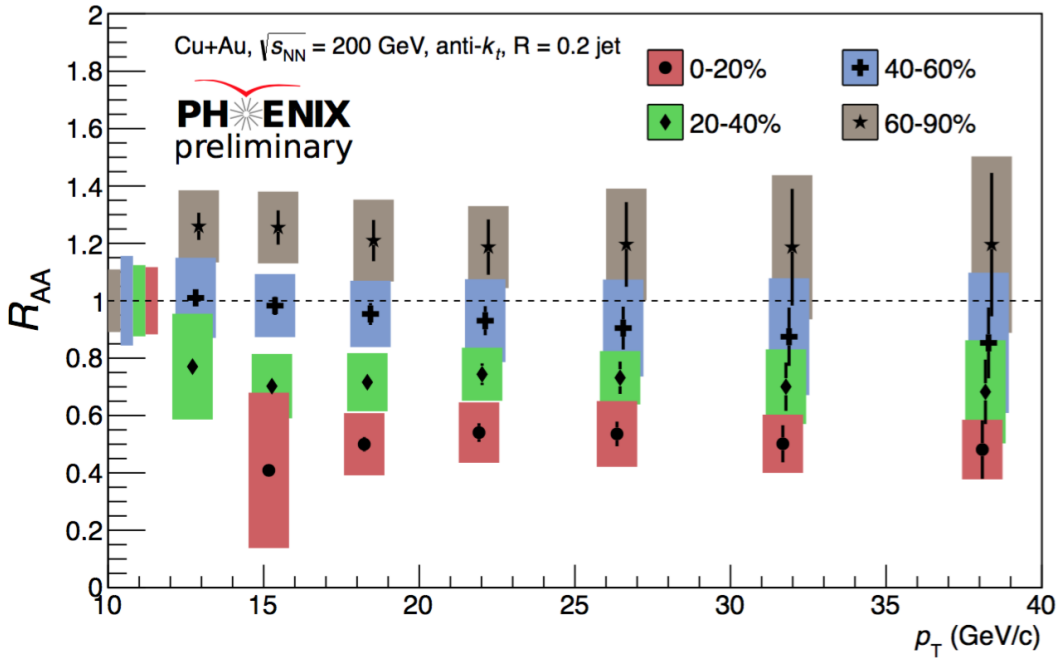

Cu+Au, $\sqrt{s_{NN}}$ = 200 GeV, anti-k_t, R = 0.2 jet
0-20%
20-40%
40-60%
60-90%
p+p
Per-event yield (arbitary normalization)
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10
15
20
25
30
35
40
p_T (GeV/c)

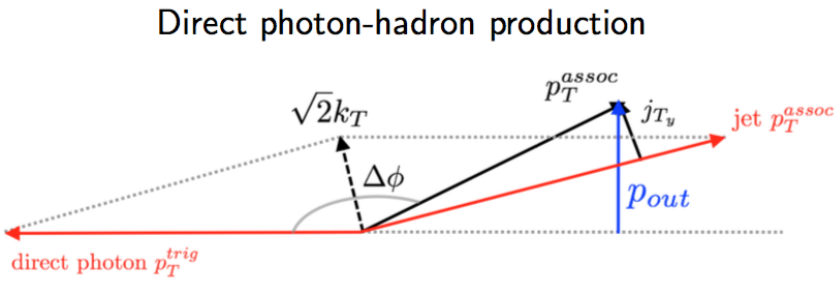
Jets in Cu+Au

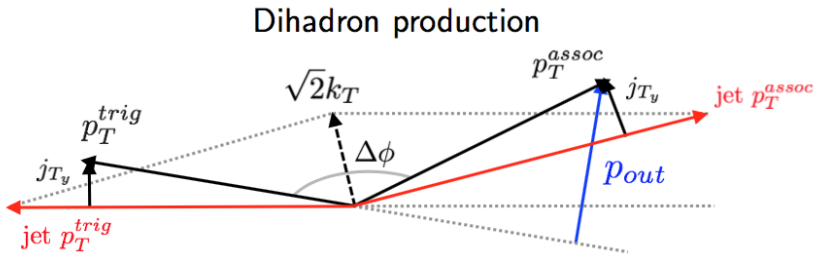
- $R_{AA} \sim 0.5$ in central
- Hint of $R_{AA} > 1$ in peripheral.



$$R_{AA} = \frac{\text{Yield}_{\text{Cu+Au}}}{\langle N_{coll} \rangle \text{Yield}_{p+p}}$$

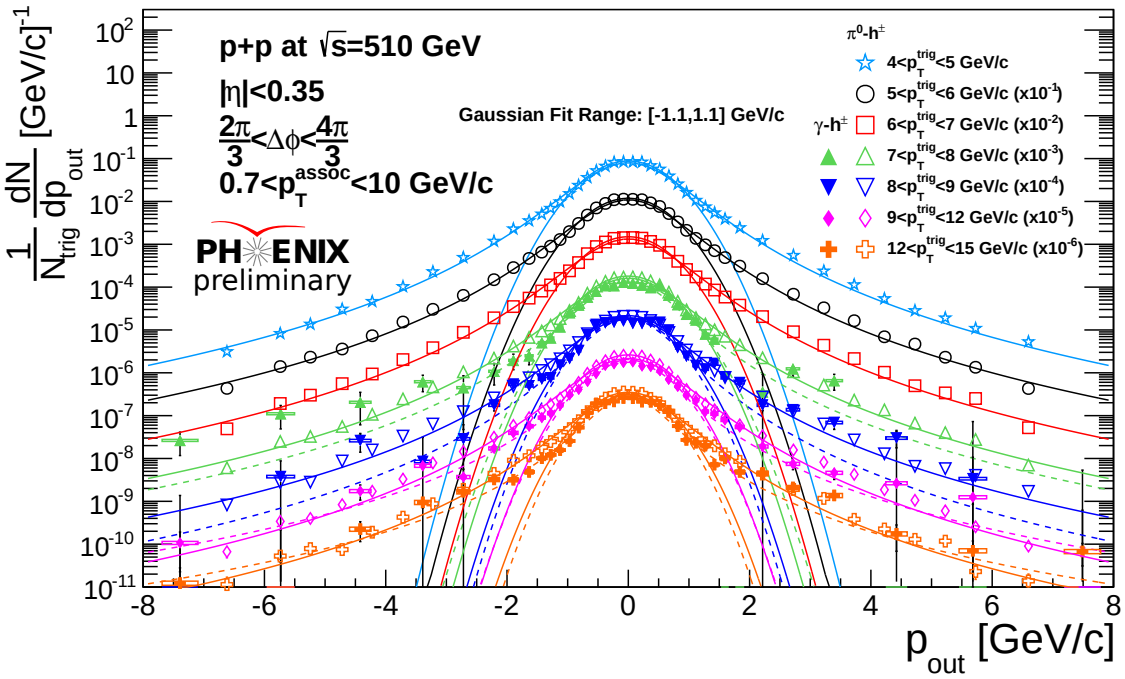
Probing the Nucleon Transverse Structure



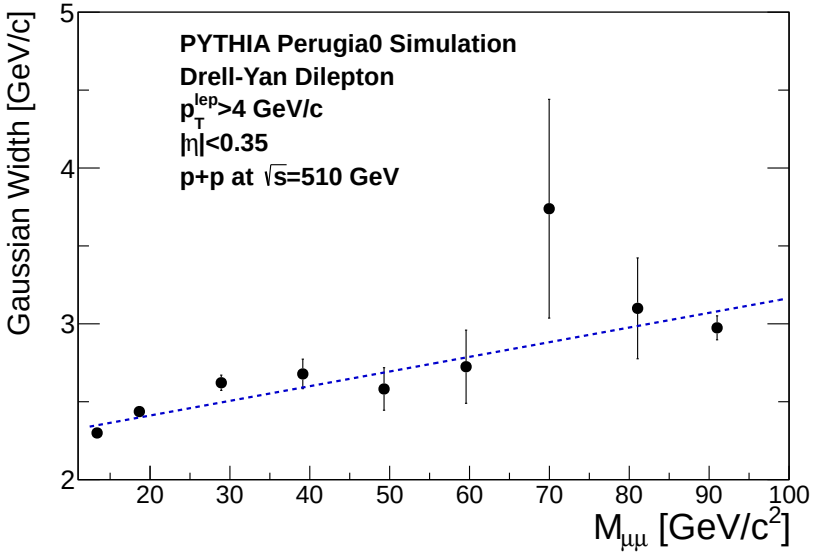


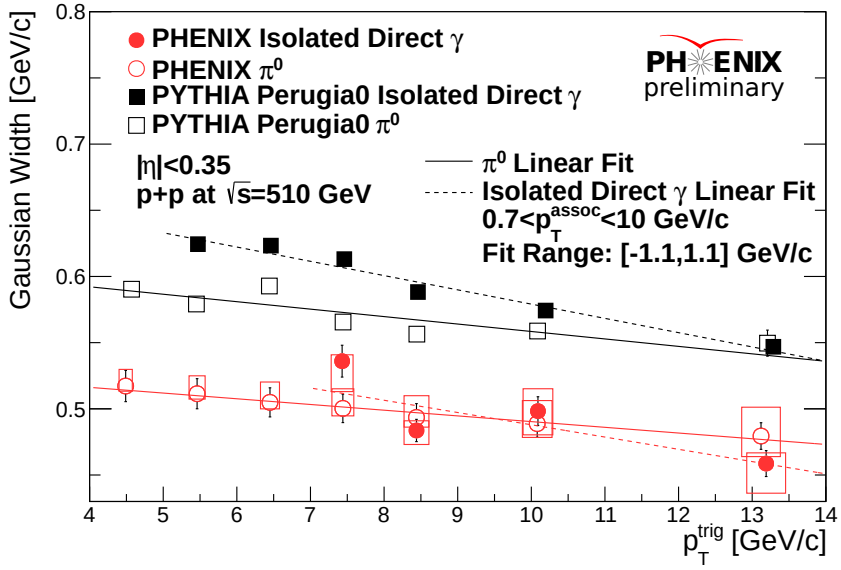
$$p_{out} = p_T^{assoc} \sin \Delta\phi$$

- p_{out} core Gaussian from intrinsic k_T.
- Power-law tail due to hard gluon radiation.



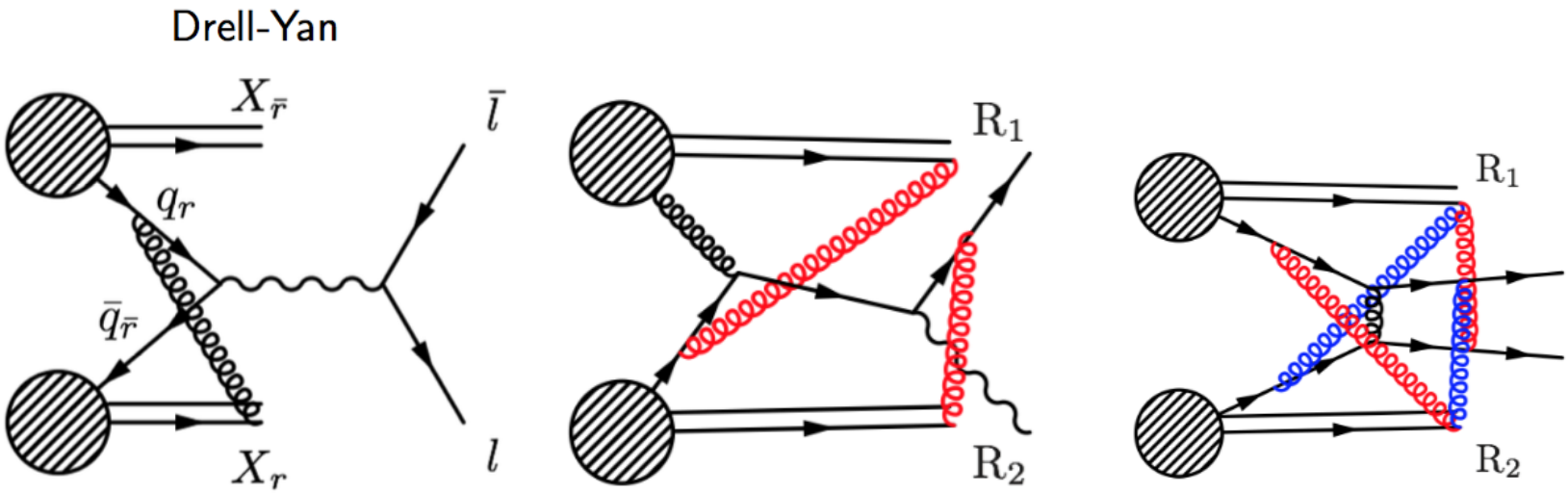
Probing the Nucleon Transverse Structure





- PYTHIA produces opposite sign slopes for p_{out} Gaussian widths in Drell-Yan events compared to γ-jet and di-jet events.
- PYTHIA magnitude doesn't match the magnitude of the data but matches the magnitude of the slope.

Probing the Nucleon Transverse Structure



- Interactions with remnants can be handled in transverse momentum-dependent (TMD) PDFs for the Drell Yan case.
- Rogers and Mulder Phys. Rev. **D81**,094006 (2010) predict breakdown of factorization (i.e. separation of PDF, hard cross section and fragmentation) in a TMD framework for di-hadron events in hadronic collisions.

Summary and Conclusions

- PHENIX has measured Anti-k_T jets in $p+p$, d+Au and Cu+Au collisions.
- Cu+Au suppression of jets in most central events.
- d+Au R_{dA} for different centrality may be interpreted as evidence of the nucleus probing the nucleon.
- Direct γ-hadron and di-hadron correlations in $p+p$ are also sensitive to the transverse structure of the nucleon in very fundamental ways.