How should we plot jet observables?

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July 15th

Movitated by discussions @ INT Workshop

In the ePIC Collaboration:

- Many of us have worked on e+ p/A experiments
- Many of us are well-versed in jet physics at hadron colliders
- Very few of us have used jets in ep collisions

This means that most of us may need to spend some time thinking about the optimal kinematic variables to present our jet observables. Lots of options:

1. Q^2
2. x_B
3. Transverse momentum in the Breit frame p_T^{Breit}
4. Transverse momentum in the lab frame p_T^{Lab}
5. Dijet M_{INV}
6. …

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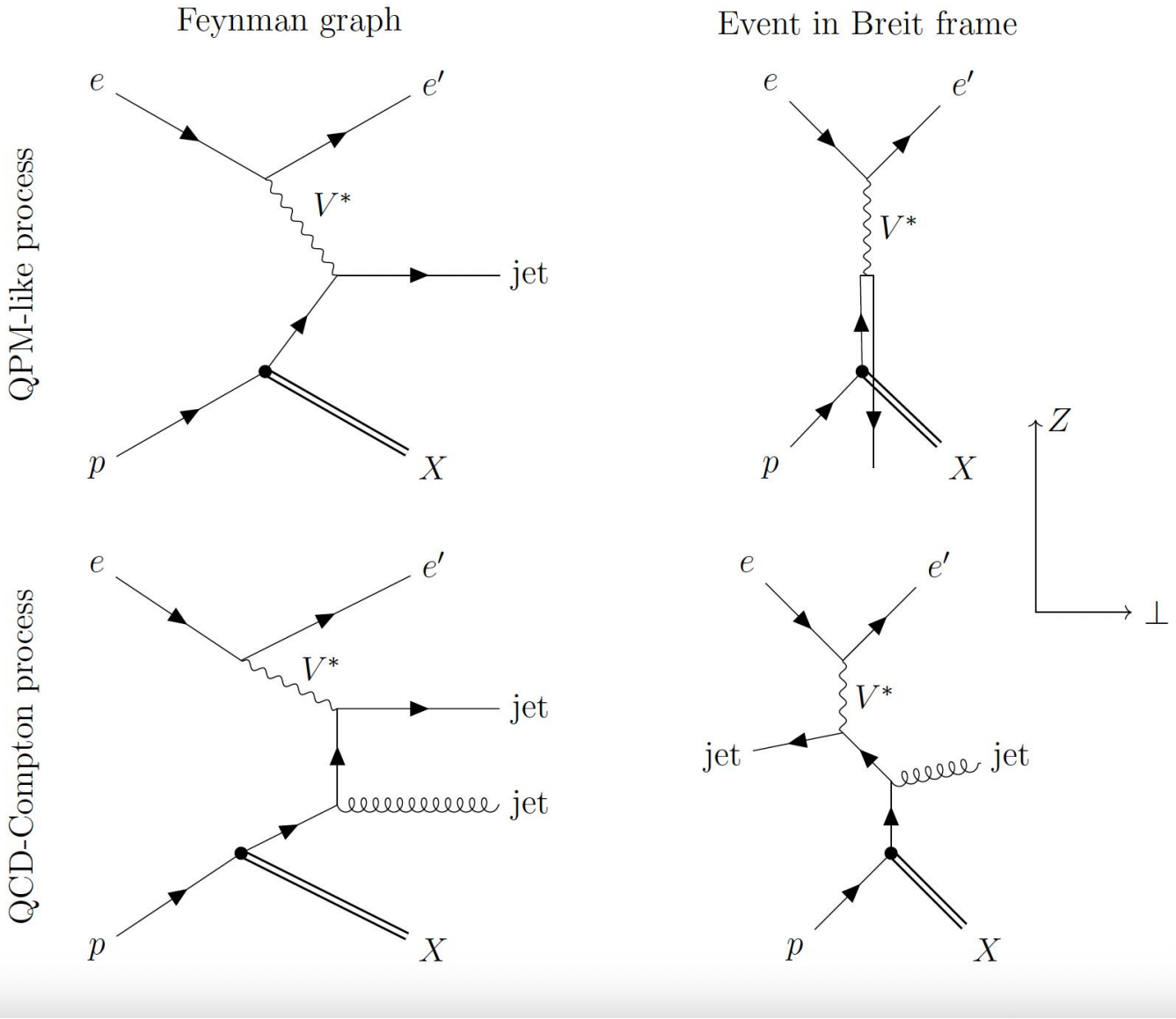
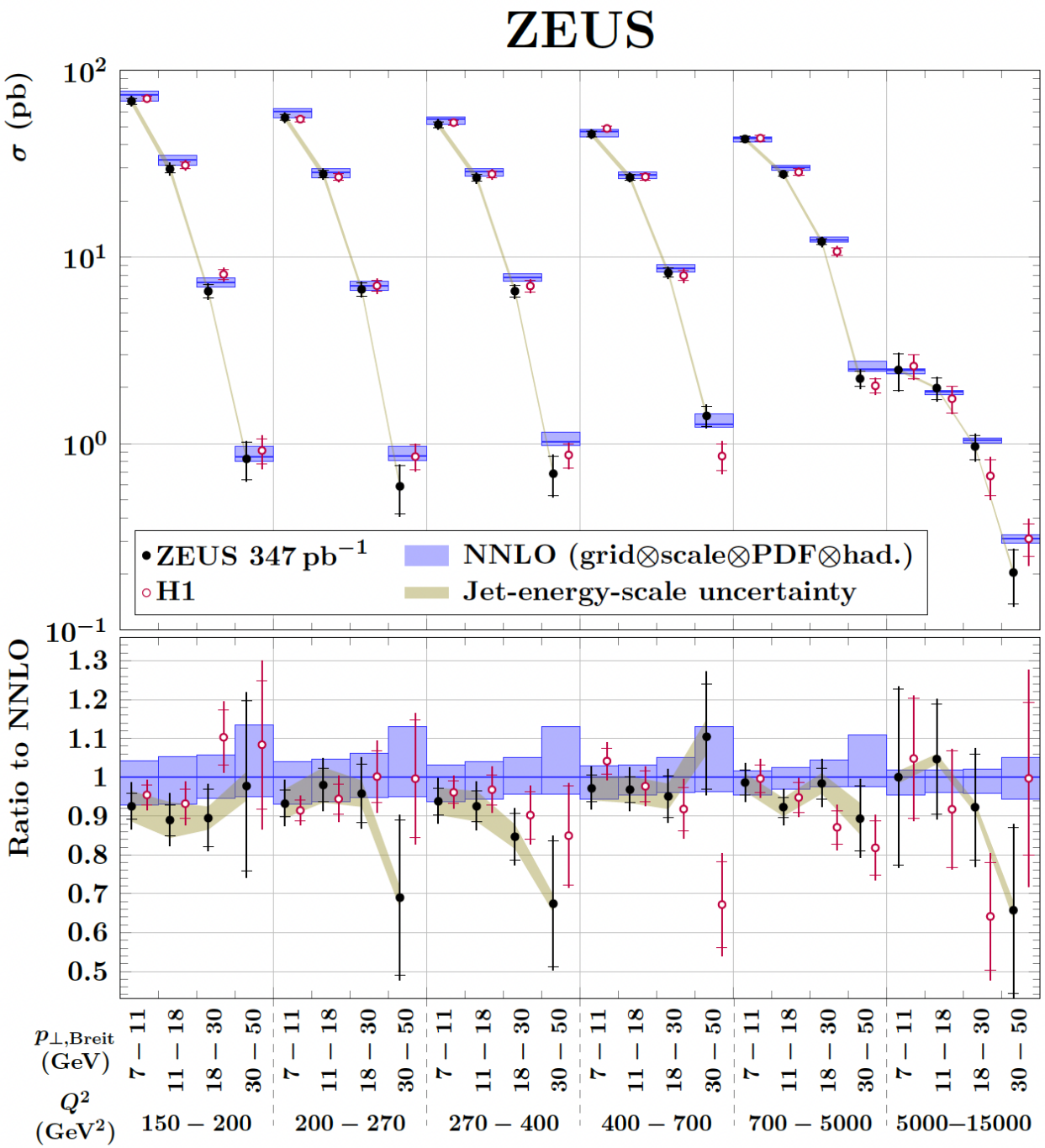
It depends on your physics goals.

Inclusive jet X-sec with ZEUS @ HERA

Eur. Phys. J. C 83, 1082 (2023)

- Proton PDFs (gluon) and extraction of α_s. Theoretical predictions available at NNLO.
- NC DIS with e detected
- Jet reconstruction in Breit frame, where exchanged virtual boson is collinear with colliding parton. Allows for clear separation of beam fragmentation and hard jets and suppression of QPM-like processes, which are 0^{th} order in α_s
- All energy deposits assigned M = 0 and boosted to Breit frame. Reconstruct with k_t algorithm with R = 1 and p_T weighted recombination scheme
- Cuts were placed in both Breit and lab frame
- Measured as a function of Q^2 and p_T^{Breit}




ZEUS
σ (pb)
10^2
10^1
10^0
10^-1
ZEUS 347 pb^-1
H1
NNLO (grid⊗scale⊗PDF⊗had.)
Jet-energy-scale uncertainty
Ratio to NNLO
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
p⊥,Breit (GeV)
7 – 11
11 – 18
18 – 30
30 – 50
Q² (GeV²)
150 – 200
200 – 270
270 – 400
400 – 700
700 – 5000
5000–15000

TSSA for inclusive jet production

arXiv:2503.16119v1

- Study origins of non-zero TSSAs within the twist-3 collinear factorization framework.
- Compare data to NLO predictions generated by 2 and 3-parton correlation functions in the initial state.
- $\ell N^{\uparrow} \to jet + X$. Several scenarios of q-g-q models are considered.
- Fix jet p_T^{Lab} and plot as a function of η^{Lab}

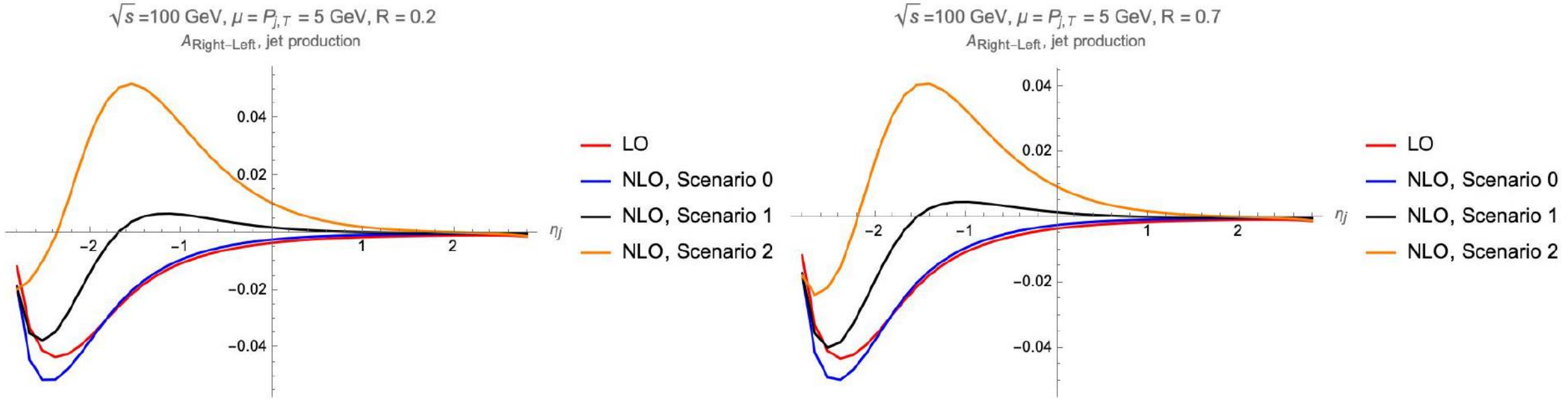
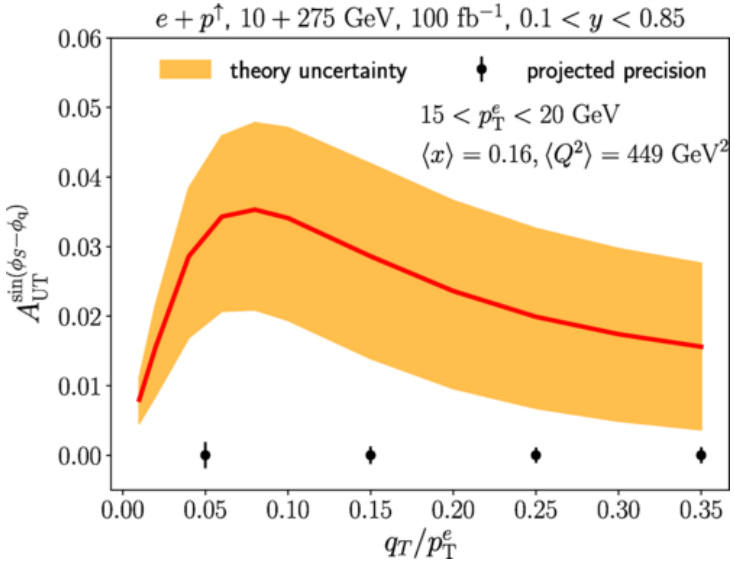


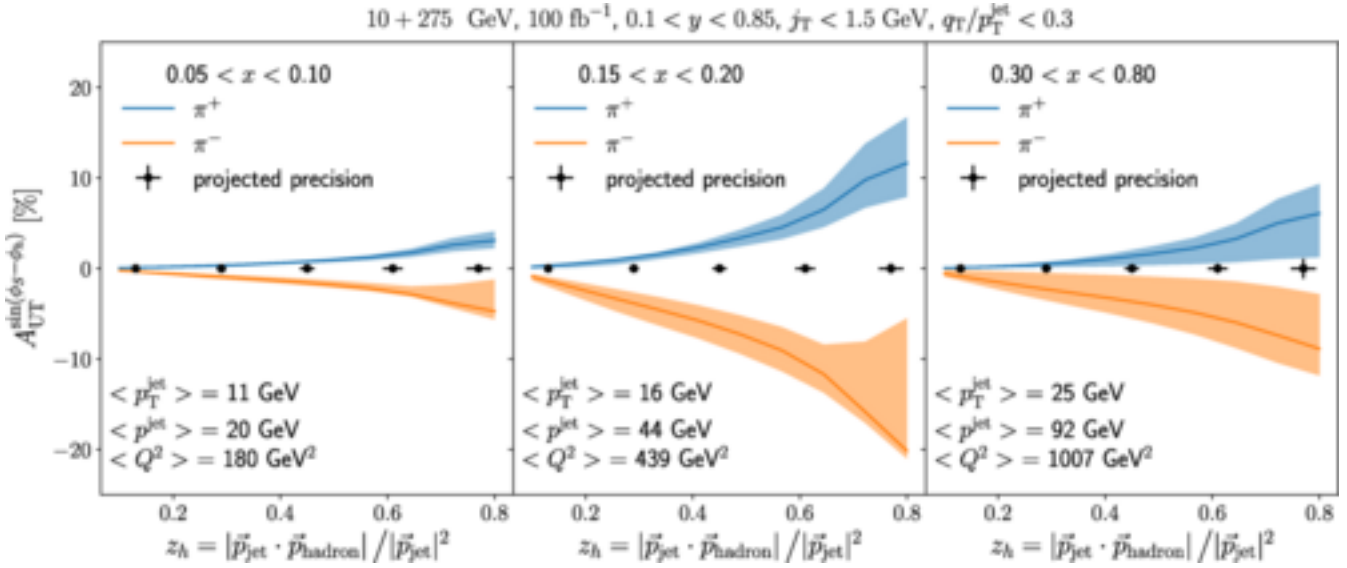
FIG. 22: Comparison of the NLO asymmetries A_{RL} computed for Scenarios 0,1,2. The asymmetries are again plotted vs. the jet's pseudorapidity η_j for jet cone radii $R = 0.2$ **(left)** and $R = 0.7$ **(right)**.

Hadron-in-Jet Collins and Sivers Asymmetries

PhysRevD.102.074015

- Isolate and study initial and final state TMDs
- back-to-back electron-jet production in the lab frame
- $\overrightarrow{q_T}$ transverse momentum imbalance between jet and scattered electron is sensitive to TMD PDFs. *Seems natural to plot in q_T, x and Q^2?*
- $\overrightarrow{j_T}$ transverse momentum of hadrons with respect to the jet axis is sensitive to the TMD FFs. Seems natural to plot in j_T, z and Q^2?





Imaging Cold Nuclear Matter with EECs arXiv : *2303.08143*

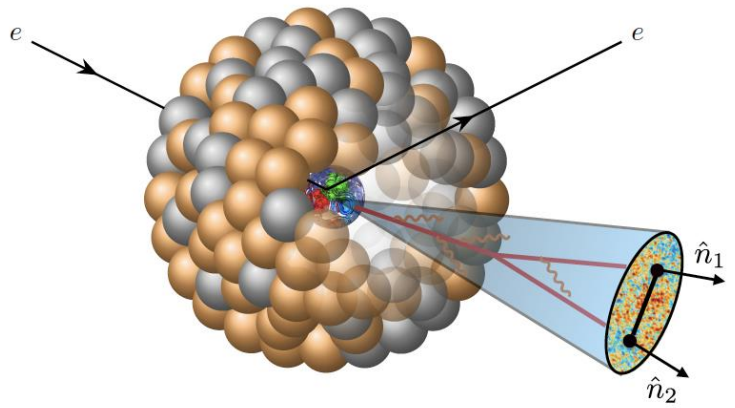
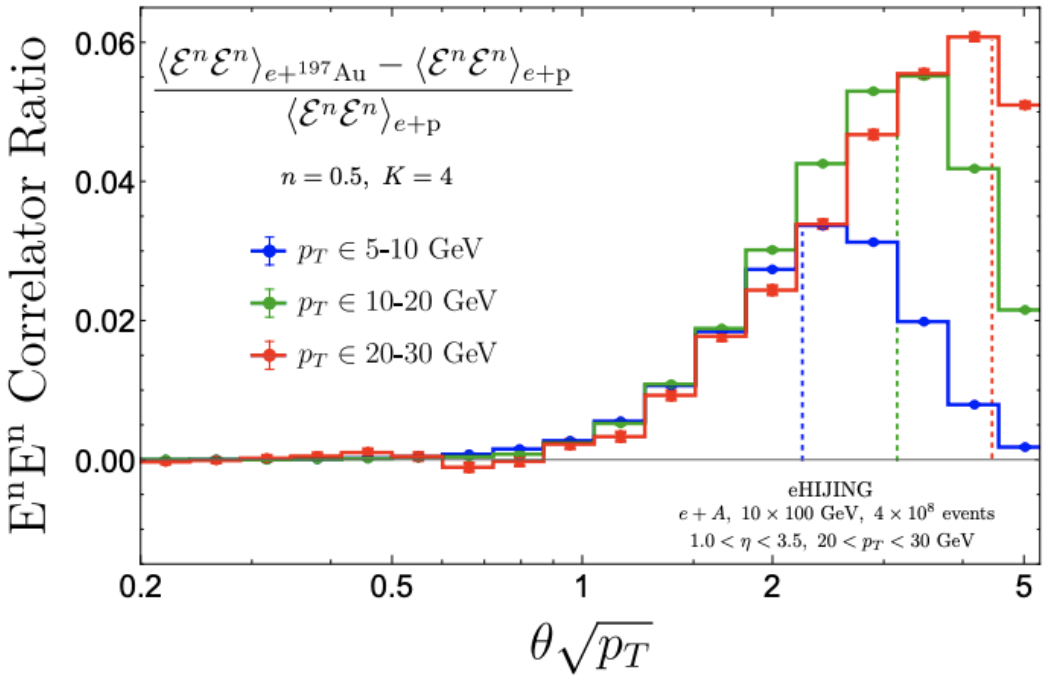


FIG. 1. A parton knocked out of a nucleon propagates a distance $\tau \sim 1/p_T\theta^2$, thereby directly imprinting nuclear time scales into angular scales of the two-point correlator in jet substructure.

- Imaging of hadronization and nuclear medium modification effects
- Plot 2-point EECs as a function of opening angle between hadrons in jets
- Directly related to formation distance **τ** which is inversely proportional to the jet p_T^{Lab}
- Measurement is a function of p_T^{lab} and θ



Jets @ the EIC

- Discussed 4 examples of jet observables at the EIC
- Optimal kinematic variables changed with example

1. Q^2, p_T^{Breit}
2. p_T^{lab}, η^{lab}
3. q_T , x_B, Q^2 and z , j_T, Q^2
4. p_T^{lab} and θ

- As always, in the end we need to choose according to the physics .. And through discussions with our theory friends.