ePIC Early Science with Transverse Energy Energy Correlators

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ePIC

Motivation

- Transverse Energy-Energy correlators (TEECs) can be theoretically calculated with high accuracy in DIS

- Event-shape observable sensitive to:
  - Strong coupling
  - Nuclear dynamics
  - TMD physics

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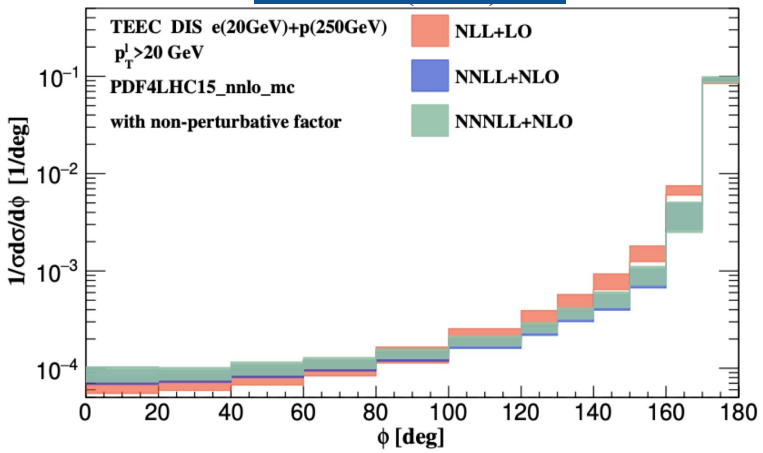

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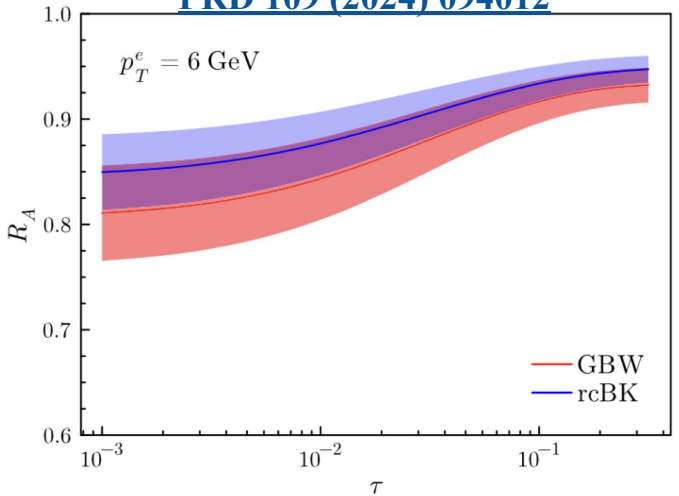

Definition

- Using simplified second equation in From Transverse Energy Energy Correlators in Deep Inelastic Scattering.
- Cancellation of Transverse Lepton Energy.
- TEEC uses P_T instead of E_T
- Middle term weighted energy fraction.
- Angular Correlation using dirac delta for difference between the scattered Lepton and produced Hadron.

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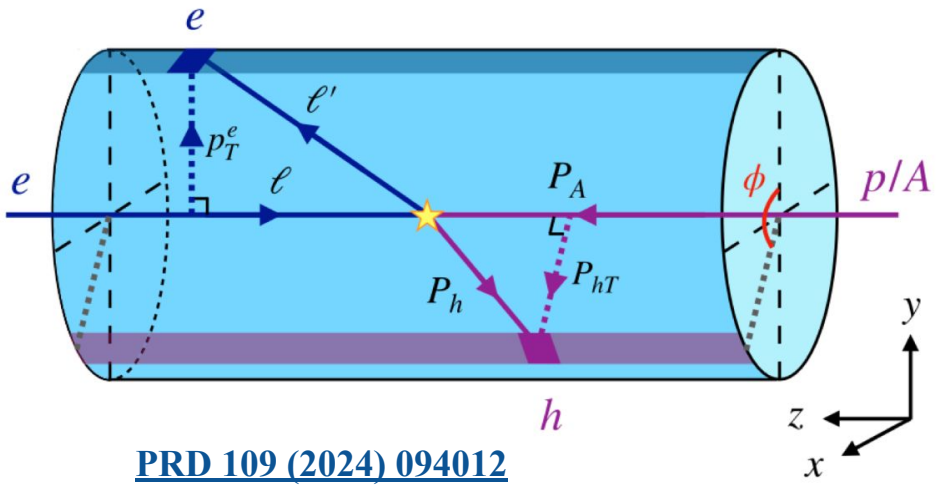
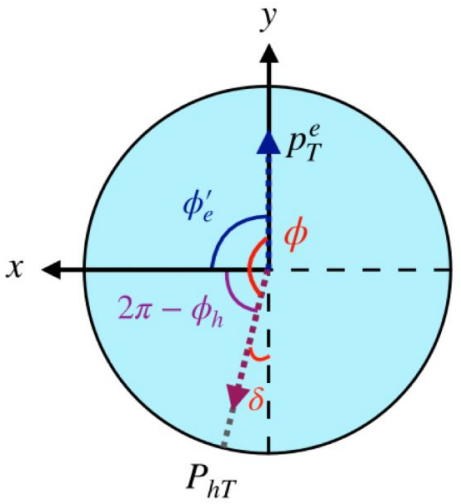
$$\begin{aligned}\mathrm{TEEC} &= \sum_a \int d\sigma_{lp\to l+a+X} \frac{E_{T,l}E_{T,a}}{E_{T,l}\sum_i E_{T,i}} \delta(\cos\phi_{la} - \cos\phi) \\ &= \sum_a \int d\sigma_{lp\to l+a+X} \frac{E_{T,a}}{\sum_i E_{T,i}} \delta(\cos\phi_{la} - \cos\phi)\,,\end{aligned} \tag{1.3}$$





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Event Selection Criteria

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Dataset Name: Pythia8 NC DIS

Specifications:

- Minimum $Q^2 > 1\ GeV^2$
- 18 x 275 GeV
- DIS - Deep Inelastic Scattering
- NC - Neutral Current
- Electron-Proton Collisions

Parameters and Methods:

- Normalization through dividing by event counts.
- Matching Between GEN and RECO to Find scattered Electron:
  - $\Delta R < 0.1$
  - $\Delta E < 3$ GeV
  - Matched to nearest negatively charged particle
  - $|\eta| < 3.5$
  - $E^e > 15$ GeV

Processed Events

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Matching Methods:

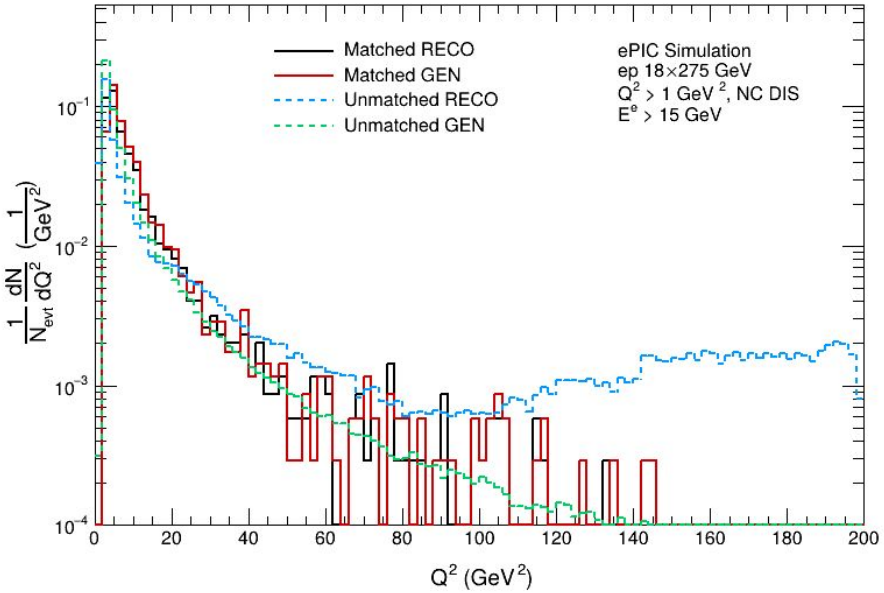
- Matching Between GEN and RECO to Find scattered Electron:
  - $\Delta R < 0.1$
  - $\Delta E < 3$ GeV
  - Matched to nearest negatively charged particle
  - $|\eta| < 3.5$
  - $E^e > 15$ GeV

Dataset	Total Events	Events in $\|\eta\| < 3.5$ Acceptance	Matched Events	Skipped Events
GEN	393,215	350,749	1,741	391,474
RECO	393,215	87,676	1,741	391,474

$|\eta| < 3.5$ Acceptance Rate:
GEN: 89.2%
RECO: 22.3%

≅0.44% of events fit matching parameters.

Matched vs Unmatched Q^2



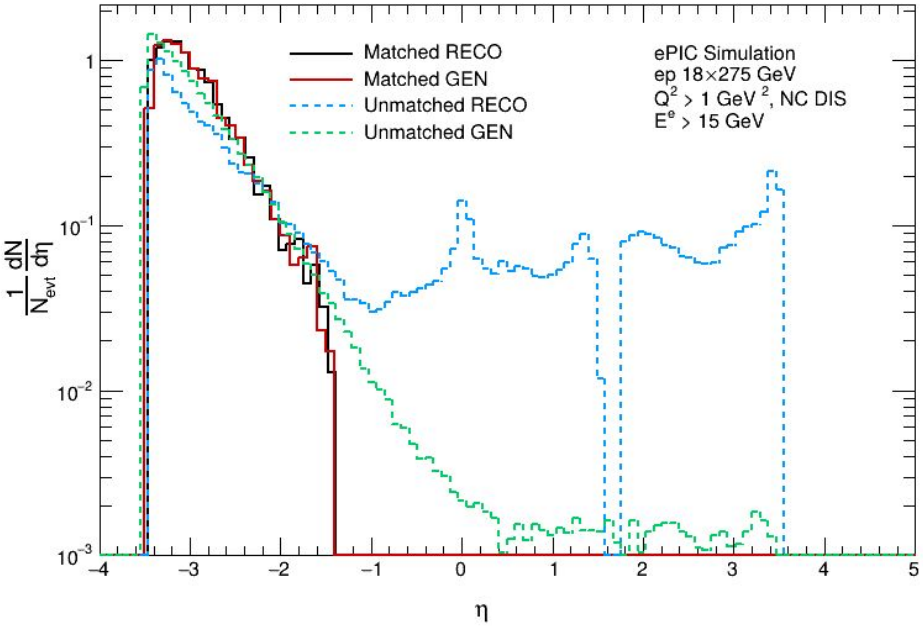
Takeaways

- Efficiency Fall Off around ~40 GeV^2
- Unmatched Tracking Diverges around ~40 GeV^2
- Matching removes RECO tail.

Conclusion

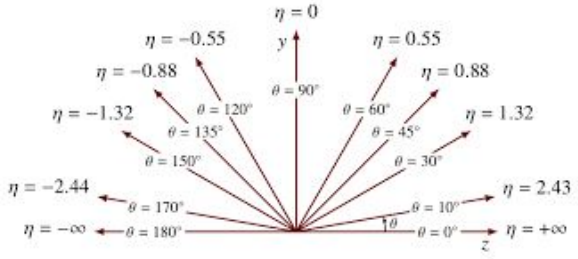
- Significant Issue Regarding Reconstructed for High Q^2 Events

Matched vs Unmatched RECO and GEN η

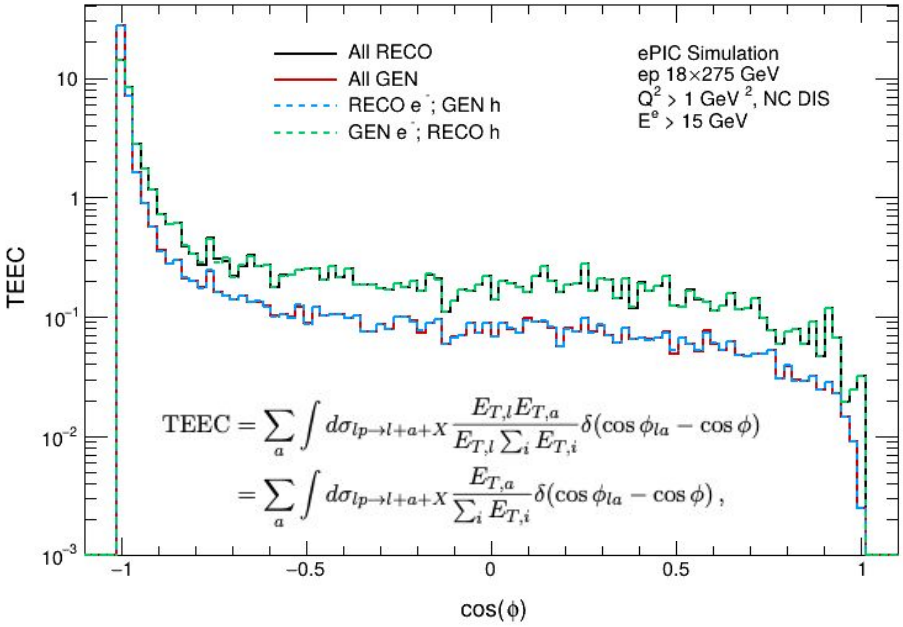


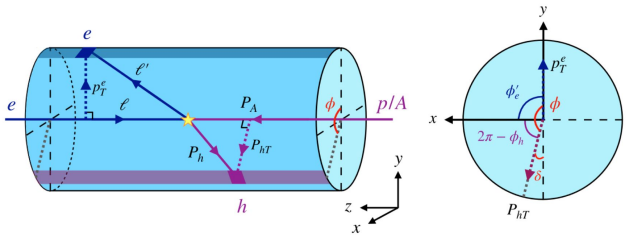
Takeaways

- Strong agreement between Matched GEN and Matched RECO in electron endcap.
- Due to the $E^e > 15$ GeV constraint, scattered electrons are confined to $-3.5 > \eta > -1.4$
- Possible misidentification of scattered electron.



All Particle TEECs





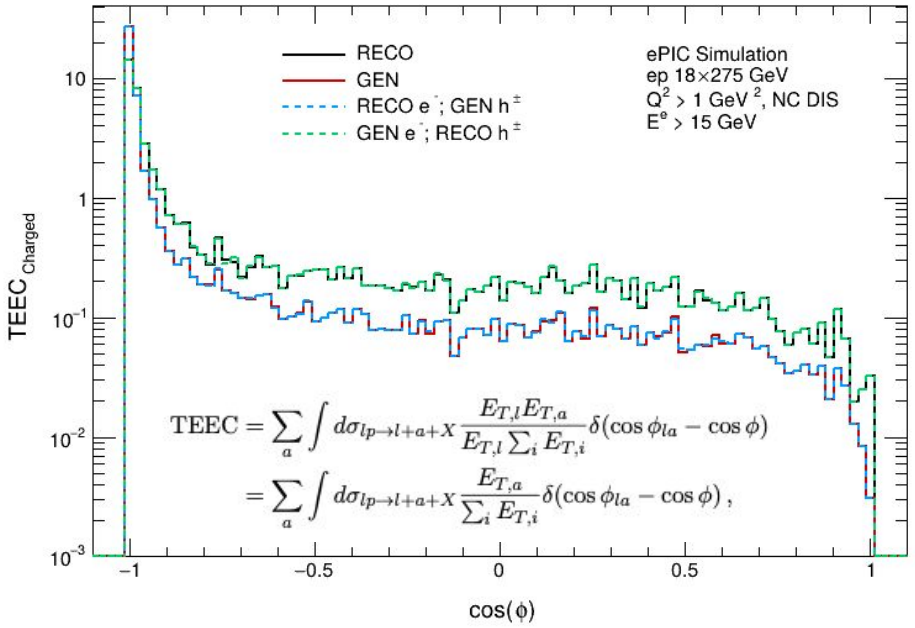
Takeaways

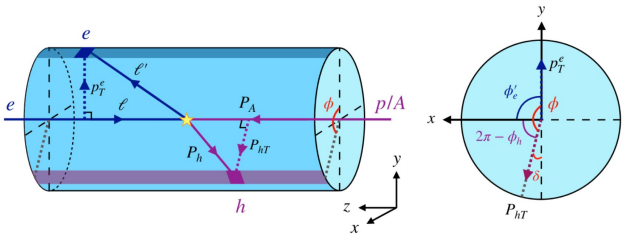
- Kinematic recoil region around -1 for the jet.
- Right side fall due to the jet's geometric and kinematic restrictions of the interaction.
- Non-closure GEN-RECO through full angular range.

Conclusion

- Energy-weighted TEEC is early science viable.

Charged Particle TEECs





Takeaways

- Kinematic recoil region around -1 for the jet.
- Charged Particles accurately mirror the total energy flow of the entire event.
- Non-closure GEN-RECO agreement.

Conclusion

- Reduced calibration dependencies:
  - Charged TEEC preserves core dynamics.

Conclusions

- TEEC is viable for early science
- Issues with electron identification
  - Used matching parameters to correct
- Recover general shape despite non-closure from reconstructed hardons
- There is a broad applicability across EIC species.

Species	Beam energy (GeV)	Integrated luminosity
e+Ag	9×115	1.0 fb^{-1}
e+D	9×130	1.5 fb^{-1}
$e + p$	9×130	1.0 fb^{-1}
$e + p$	9×275	2.5 fb^{-1}
e+Au	9×100	1.0 fb^{-1}
$e+{}^3\text{He}$	9×166	1.5 fb^{-1}

Future plans:

- Apply tracking corrections.
- Process early-science simulation datasets.
- Try to have uncertainty projections for early science paper (NIM-A issue?)