

# Pion and Kaon Form Factors at the EIC

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Exclusive, Diffractive, & Tagging Meeting

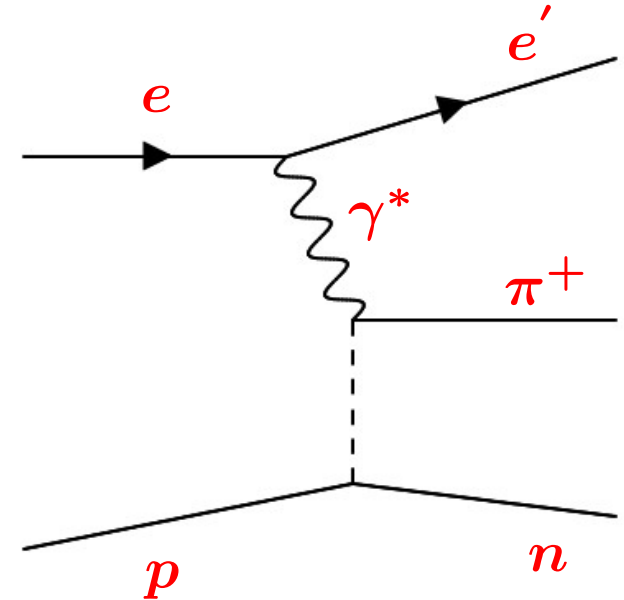
29/01/2024

# ePIC simulations for exclusive reactions

- Feasibility studies of exclusive **pion and kaon electroproduction reactions** through ePIC simulations.
- Utilized **DEMPgen** to generate files for both reactions, passed  $\pi^+$  files through the latest ePIC simulations.
- Begin with  **$\pi^+$  electroproduction** reaction.

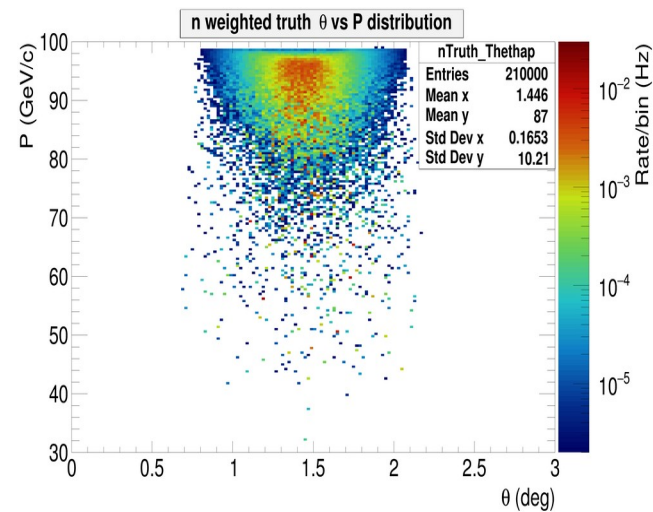
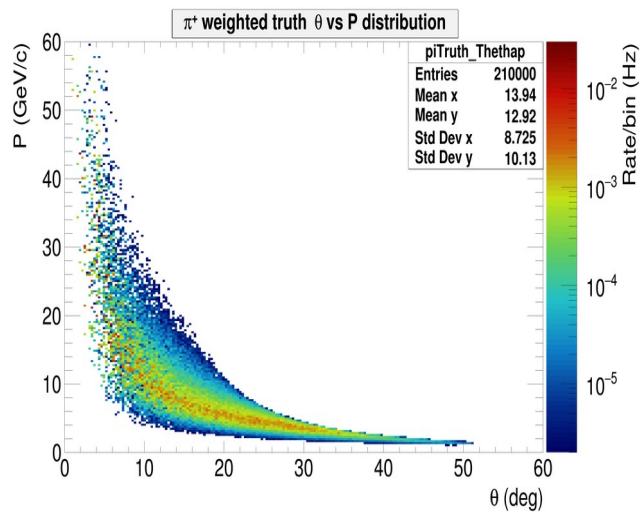
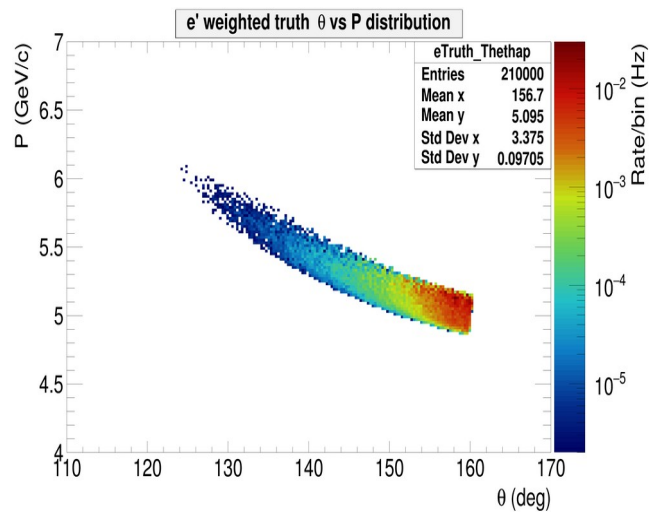


- Indirectly use the “pion cloud” of the proton via the  $p(e, e' \pi^+)n$  process.
- Identification involves **reconstructing all final state particles**.



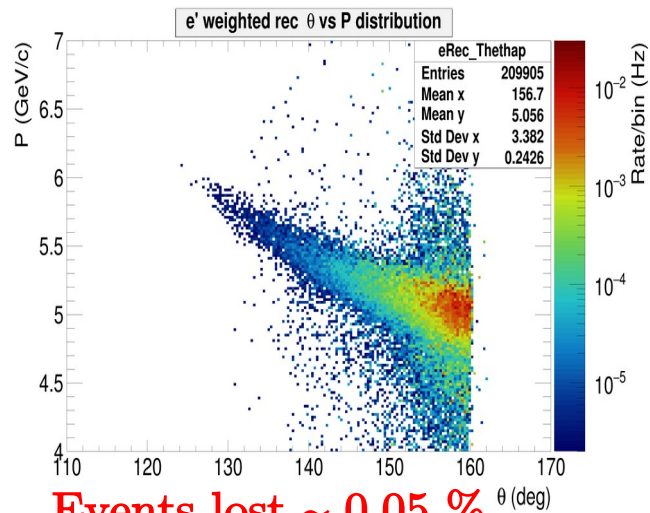
# Spatial topology of weighted truth variables at ePIC detector

- Simulated 210k events for 5(e) on 100(p) GeV collisions, 25 mrad crossing angle.
- For  $5 < Q^2 \text{ (GeV}^2\text{)} < 35$ ,  $2 < W \text{ (GeV)} < 10.2$ , and  $0 < -t \text{ (GeV}^2\text{)} < 1.3$ .
- Events weighted by cross-section.
- $e'$ ,  $\pi^+$  hits the central detector, n hits far-forward detectors (mainly ZDC).

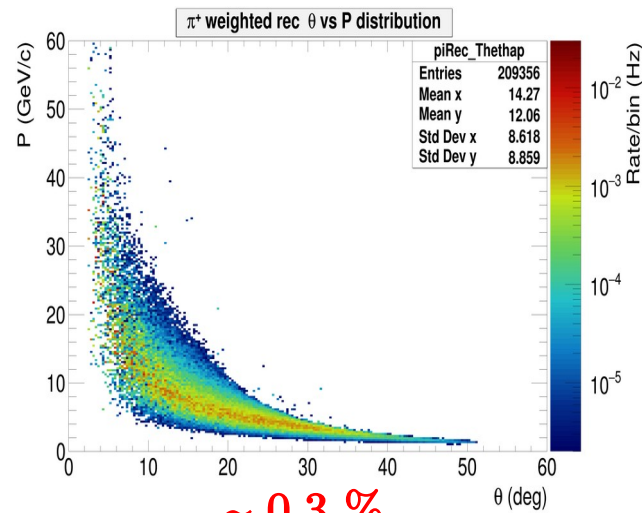


# Spatial topology of weighted rec variables at ePIC detector

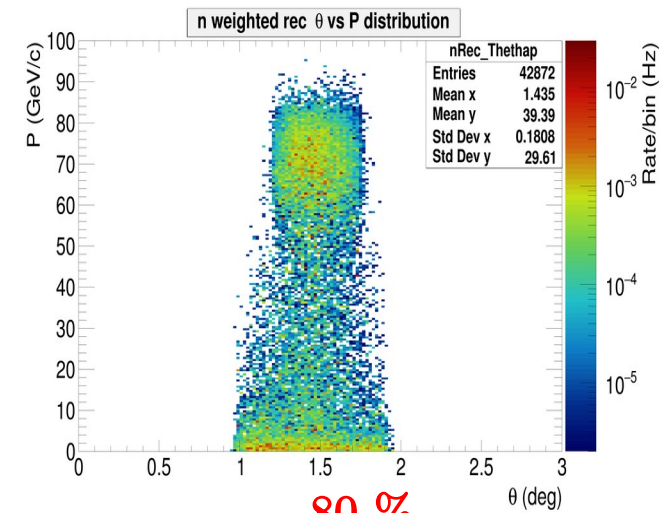
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Events lost  $\sim 0.05 \%$



$\sim 0.3 \%$



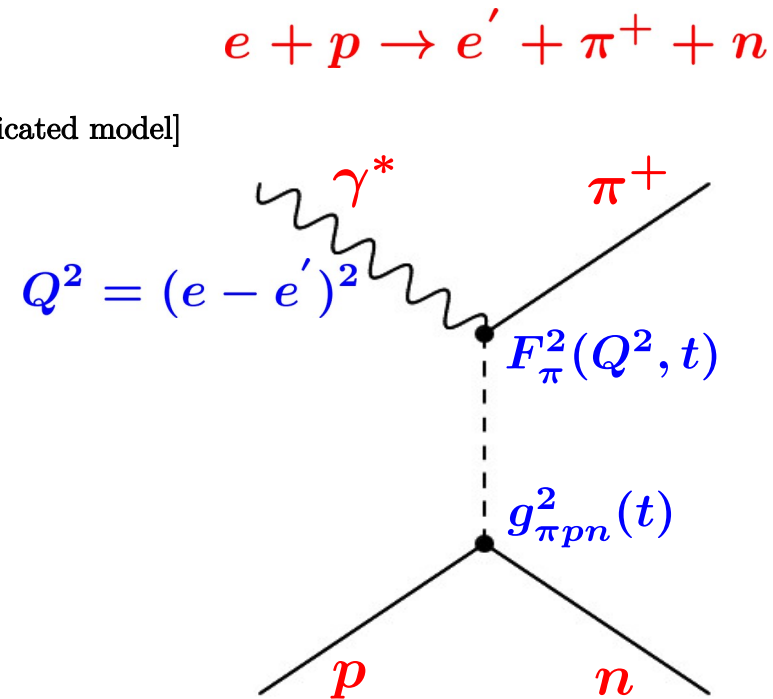
$\sim 80 \%$

# Accessing form factor through $\pi^+$ electroproduction

- Measure  $e'\pi^+n$  triple coincidence events.
- At small  $-t$ , the pion pole process dominates  $\sigma_L$ .
- In the Born model,  $F_\pi^2$  appear as [In practice one uses a more sophisticated model]

$$\frac{d\sigma_L}{dt} \propto \frac{-tQ^2}{(t-m_\pi^2)^2} g_{\pi pn}^2(t) F_\pi^2(Q^2, t)$$

- Different approaches to measure  $-t$ .



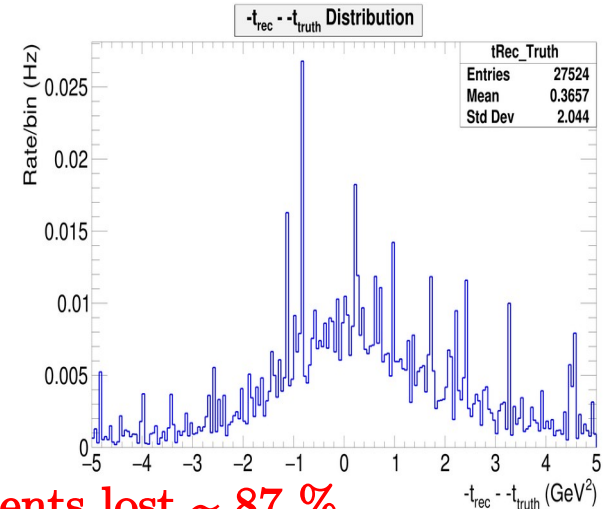
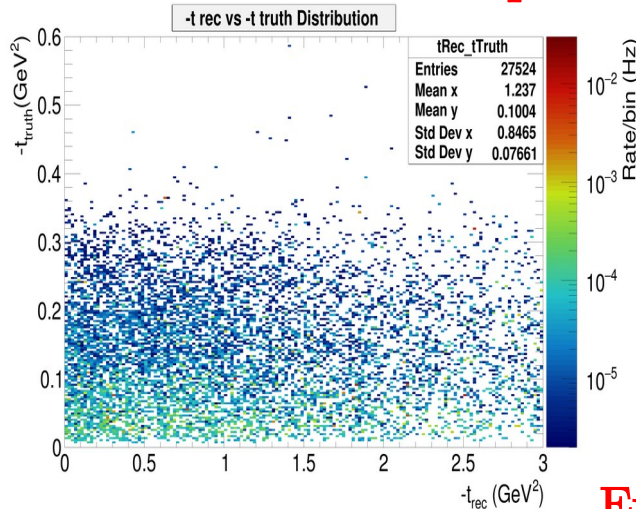
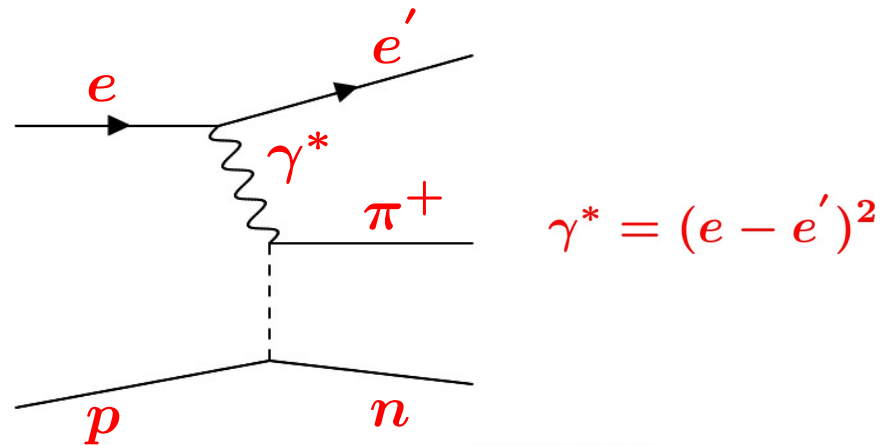
# -t reconstruction using lepton-meson vertex (Method - 1)

- $e'\pi^+n$  triple coincidence events.
- $-t_{\text{truth}}$  corresponds to truth information.

$$-t_{\text{truth}} = -(\gamma^* - \pi^+)^2$$

- $-t_{\text{rec}}$  corresponds to reconstructed information.

$$-t_{\text{rec}} = -(\gamma^* - \pi^+)^2$$



Events lost ~ 87 %

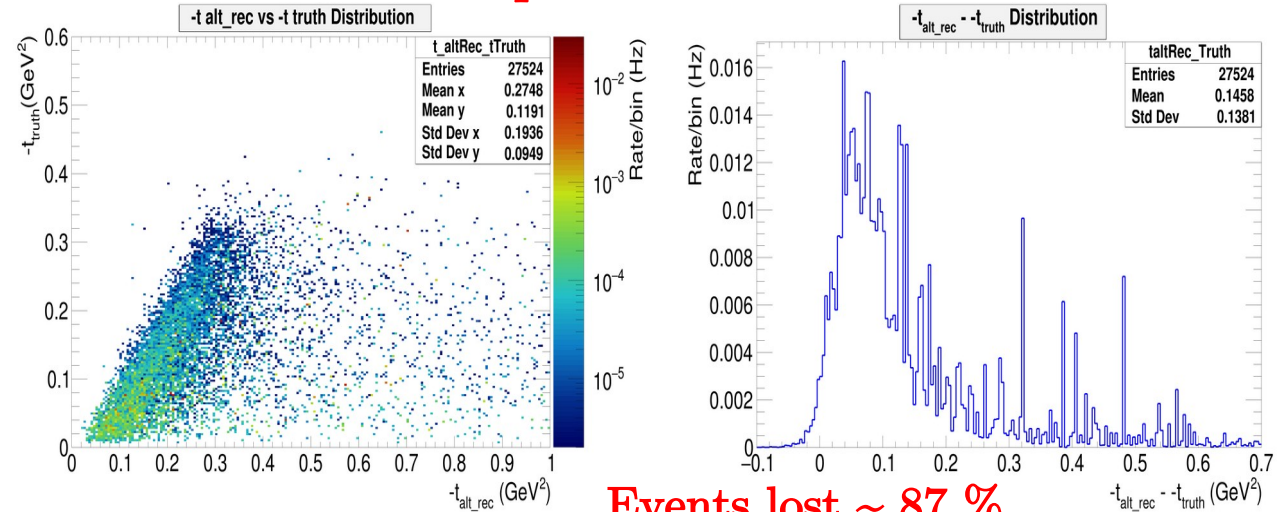
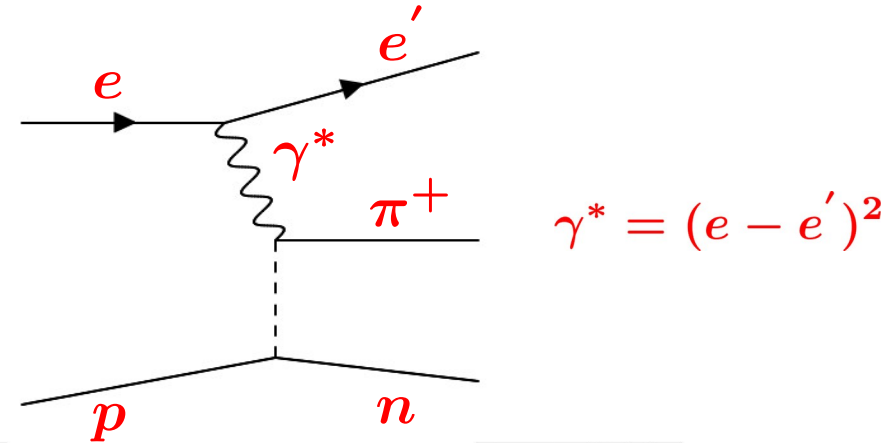
# -t reconstruction using proton-baryon vertex (Method - 2)

- $e'\pi^+n$  triple coincidence events.
- $-t_{\text{truth}}$  corresponds to truth information.

$$-t_{\text{truth}} = -(\gamma^* - \pi^+)^2$$

- $-t_{\text{alt\_rec}}$  corresponds to reconstructed information.

$$-t_{\text{alt\_rec}} = -(p - n)^2$$



Events lost ~ 87 %

# -t reconstruction using pT of e' and $\pi^+$ (Method - 3)

- $e'\pi^+n$  triple coincidence events.
- $-t_{\text{truth}}$  corresponds to truth information.

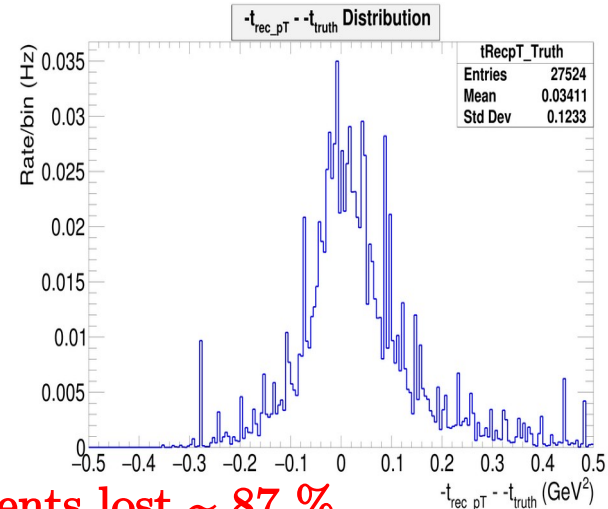
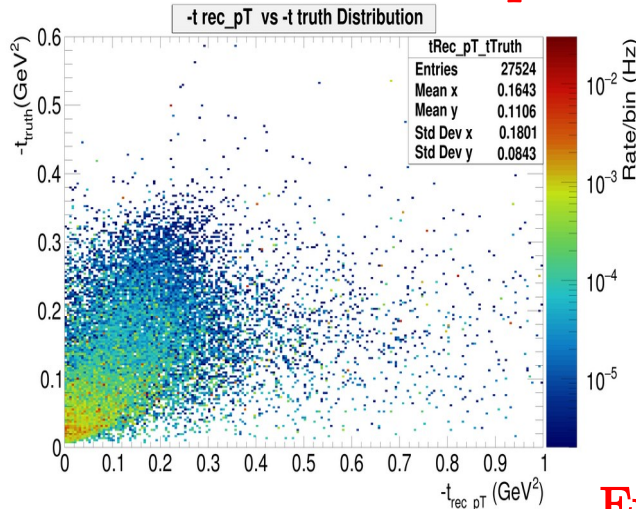
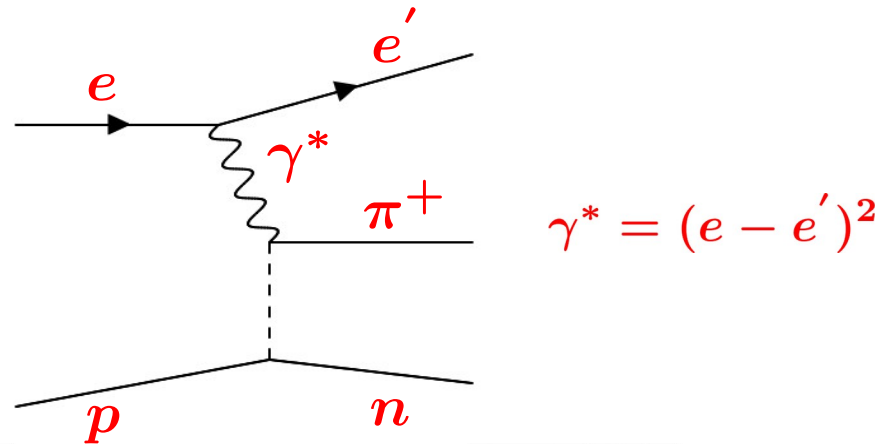
$$-t_{\text{truth}} = -(\gamma^* - \pi^+)^2$$

- $-t_{\text{rec\_pT}}$  corresponds to reconstructed information.

$$-t_{\text{rec\_pT}} \approx -(p_{T,\pi^+} + p_{T,e'})^2$$

Valid for small -t and small  $Q^2$ .

How high can go in  $Q^2$  ?



Events lost ~ 87 %



# -t reconstruction using corrected n track (Method - 4)

- $-t_{\text{truth}}$  corresponds to truth information.

$$-t_{\text{truth}} = -(\gamma^* - \pi^+)^2$$

- $-t_{\text{rec\_corr}}$  corresponds to reconstructed information.

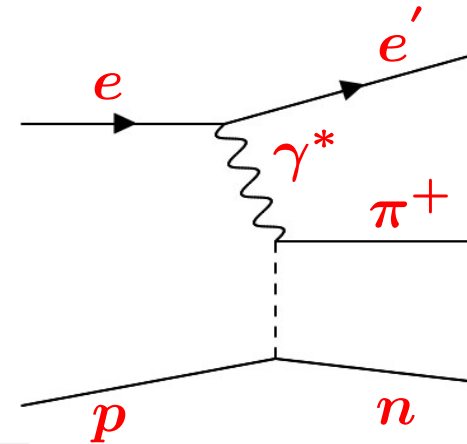
- Reconstructed new **neutron track** using missing momentum information.

$$\mathbf{p}_{\text{miss}} = |\vec{p}_e + \vec{p}_p - \vec{p}_{e'} - \vec{p}_{\pi^+}|$$

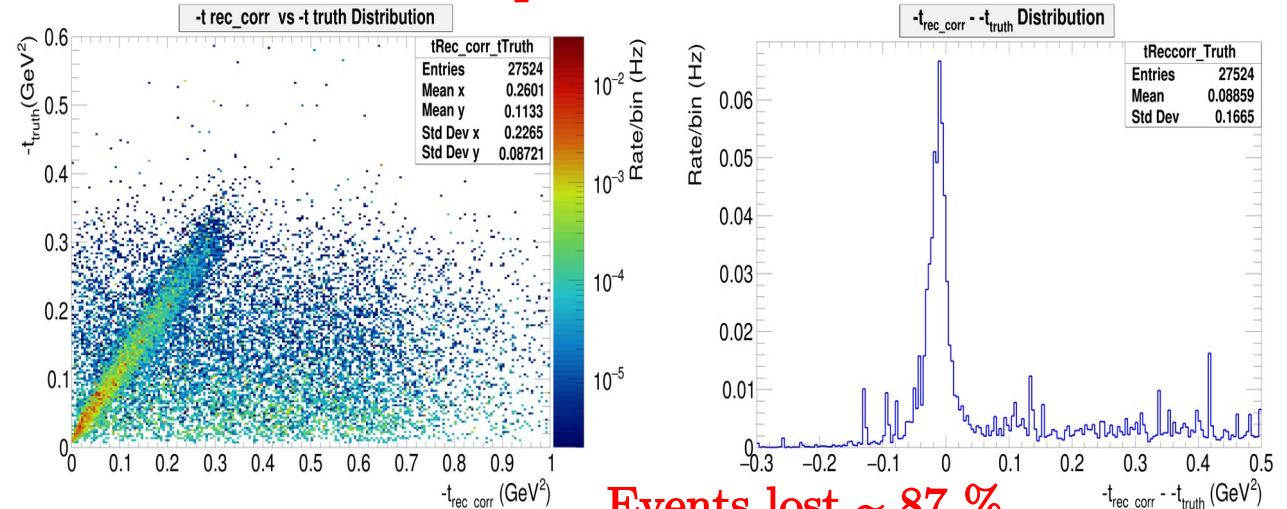
- Replaced angles,  $\theta_{\text{Miss}}$  and  $\phi_{\text{Miss}}$  in missing momentum by ZDC hit position,  $\theta_{\text{ZDC}}$  and  $\phi_{\text{ZDC}}$ .

- Mass fixed to be of the neutron mass.

$$-t_{\text{rec\_corr}} = -(\mathbf{p} - \mathbf{n}_{\text{corr}})^2$$

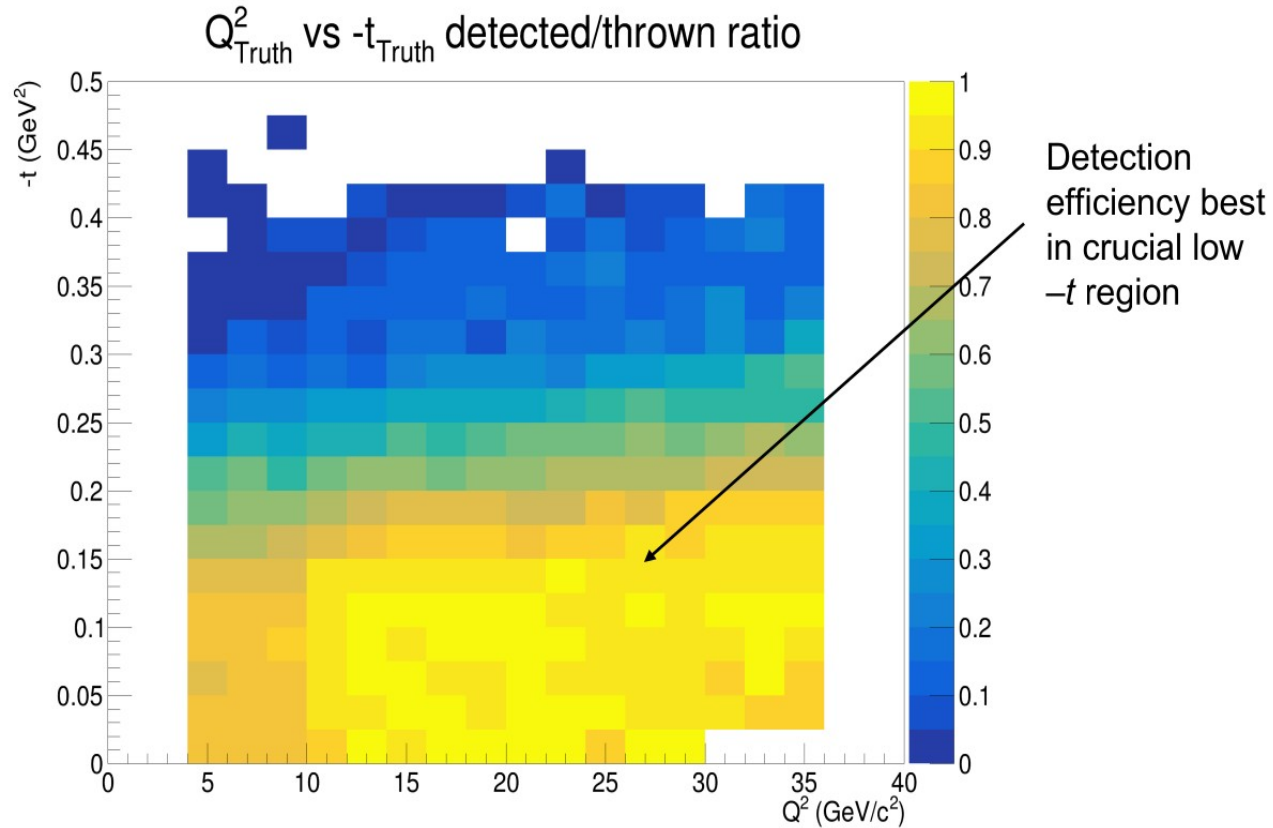


$$\gamma^* = (e - e')^2$$



Events lost ~ 87 %

# Detection efficiency per $(Q^2, t)$ bin from ECCE simulations



[G. M. Huber, S. J. D. Kay]

# Summary

- Generating **plots for TDR** for both exclusive reactions.
- Efficiency of **neutrons** observed to be significantly low compared to ECCE simulations.
- No information available on neutrons in **Emcal** (EcalFarForwardZDCClusters).
- For  $\pi^+$  electroproduction, will **compare results** with the previously generated **ECCE simulation plots at 5on100 energy combination**.
  - Everything is optimistic EXCEPT for the very **low neutron efficiency (~ 13%)**.
  - Will present results of the comparison studies after applying various kinematics cuts.
  - Form factor projections will be measured.
- Next step is to **simulate  $K^+$**  events through ePIC simulations.

# Thank you !



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**EIC-Canada**

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