Sivers/Collins pseudo-data and figures

5/20/2026

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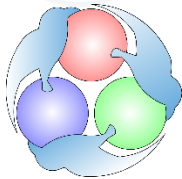
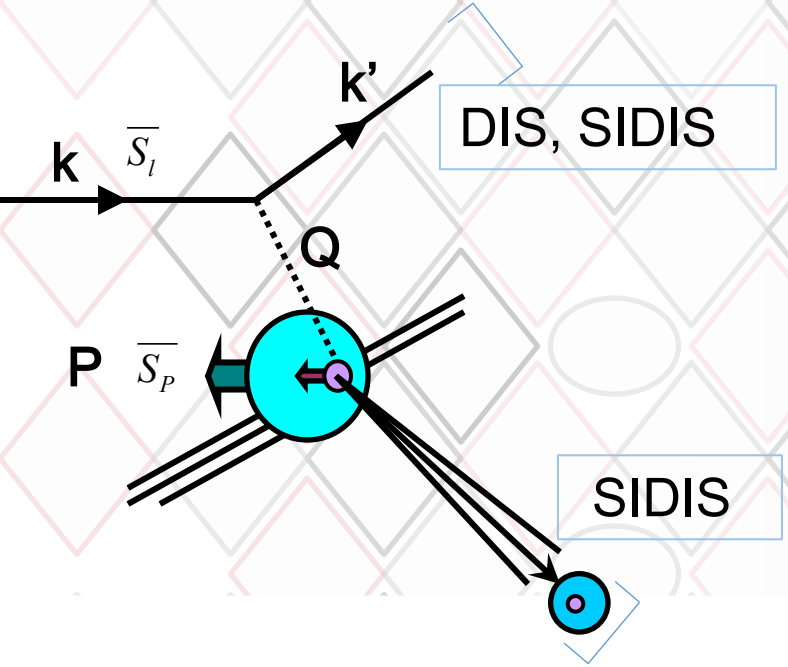
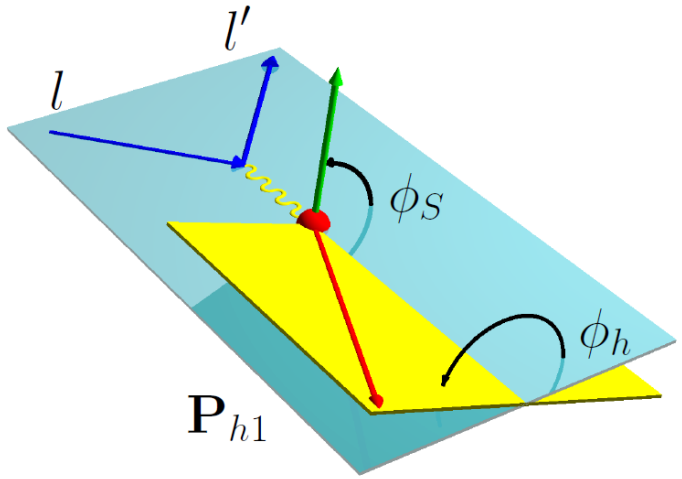


SIDIS Kinematics





Detect also final-state hadron(s): Additional benefit of flavor, spin and transverse momentum sensitivity via Fragmentation functions

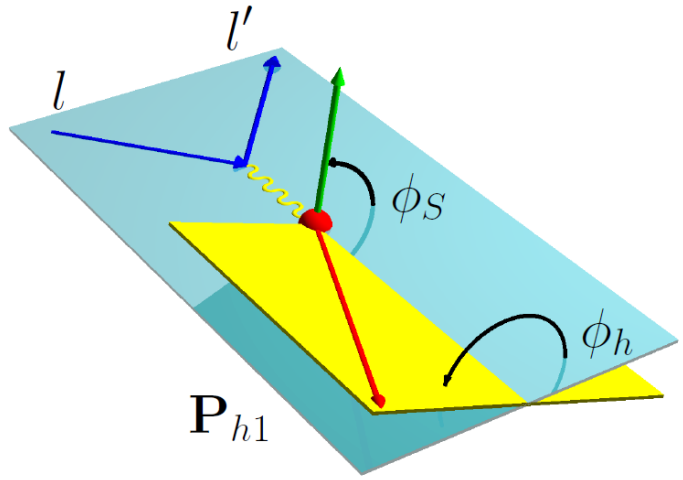
$$\frac{d^6\sigma}{dxdQ^2dzdP_{hT}d\phi_S d\phi_h} \overset{LO}{\propto} \sum_{q,\overline{q}} e_q^2 q(x,Q^2,k_t) \otimes D_{1,q}^h(z,Q^2,p_t)$$

z:	Fractional hadron momentum wrt to parton momentum (0<z<1)
P_{hT}:	transverse hadron momentum wrt to virtual photon (convolution over intrinsic transverse momenta of PDFs and FFs)
ϕ_S:	Azimuthal angle of nucleon (transverse) spin wrt to scattering plane, along virtual photon axis
ϕ_h:	Azimuthal angle of hadron wrt to scattering plane, along virtual photon axis

- Current fragmentation: related to struck quark (favored fragmentation $u \rightarrow \pi^+$, $d \rightarrow \pi^-$, $s \rightarrow K^-$, etc)
- Transverse momentum and angles rely also on correct boost to hadron rest system

Experimental access to Transversity/tensor charge and Sivers function

- Both functions are accessible as different azimuthal modulations in transversely polarized SIDIS of single hadrons
- Reweight events according to true parton flavor q, hadron h, x, z, Q^2, P_{hT}, azimuthal angles and random spin orientiation
- Input structure functions (Collins, Sivers and unpolarized) from Torino global fits (arXiv:0812.4366, arXiv:0805.2677) as in https://github.com/prokudin/tmd-parametrizations/
- Currently no partonic event record for e+3He →all weights are unity (zero asymmetries)→will be fixed for with next simulations
- For e+^{3}He currently only tagging on the truth level → need to implement reconstructed tagging (but effi+purity high accd to W.Lin's study)

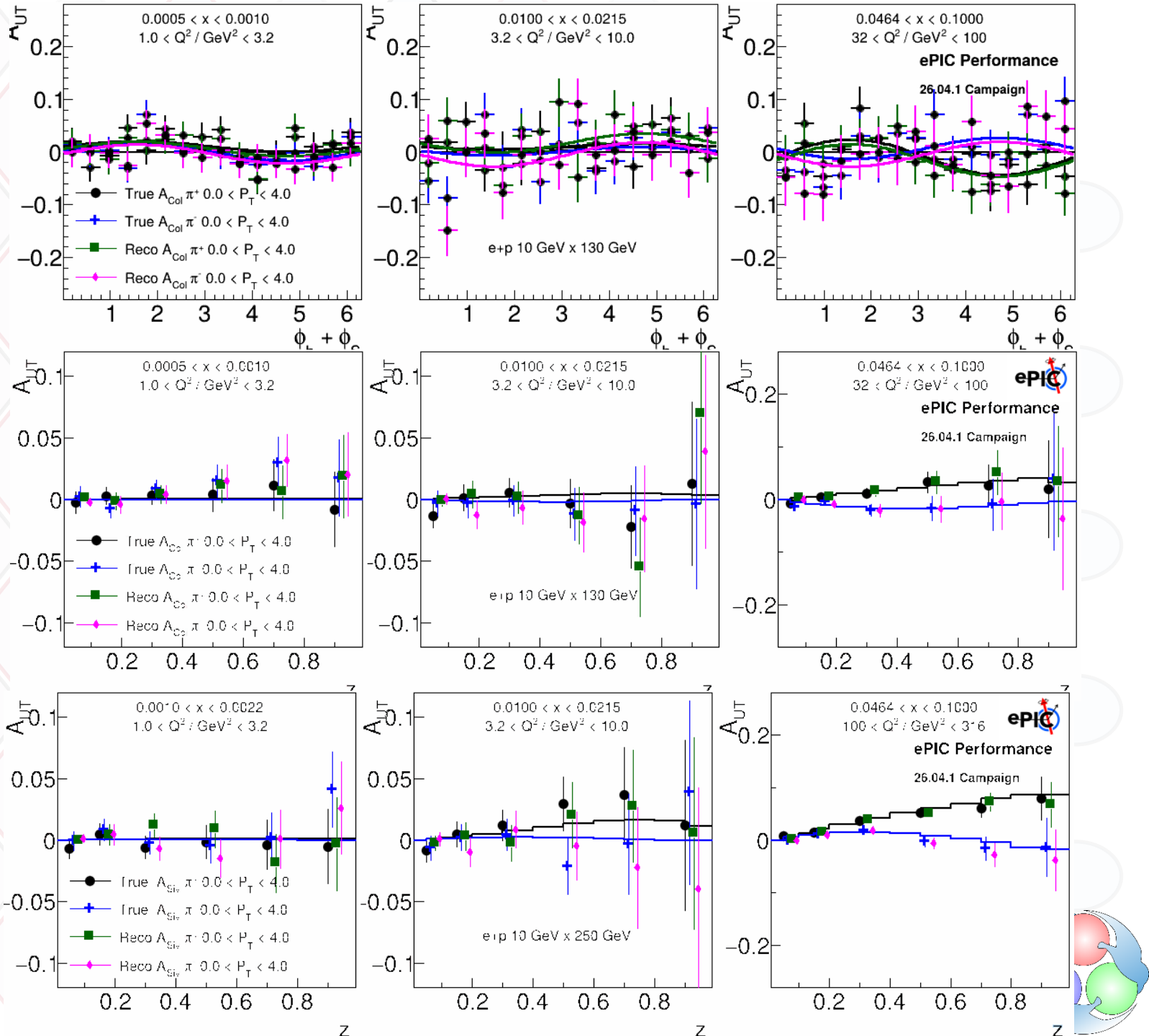


$$A_{UT}^{\sin(\phi_h+\phi_S)}(x,z,P_T) \propto \mathbf{S}_T \frac{\sum_{q,\overline{q}} e_q^2 \delta q(x,k_t) \otimes H_1^{\perp}(z,p_t)}{\sum_{q,\overline{q}} e_q^2 q(x,k_t) \otimes D_1(z,p_t)}$$

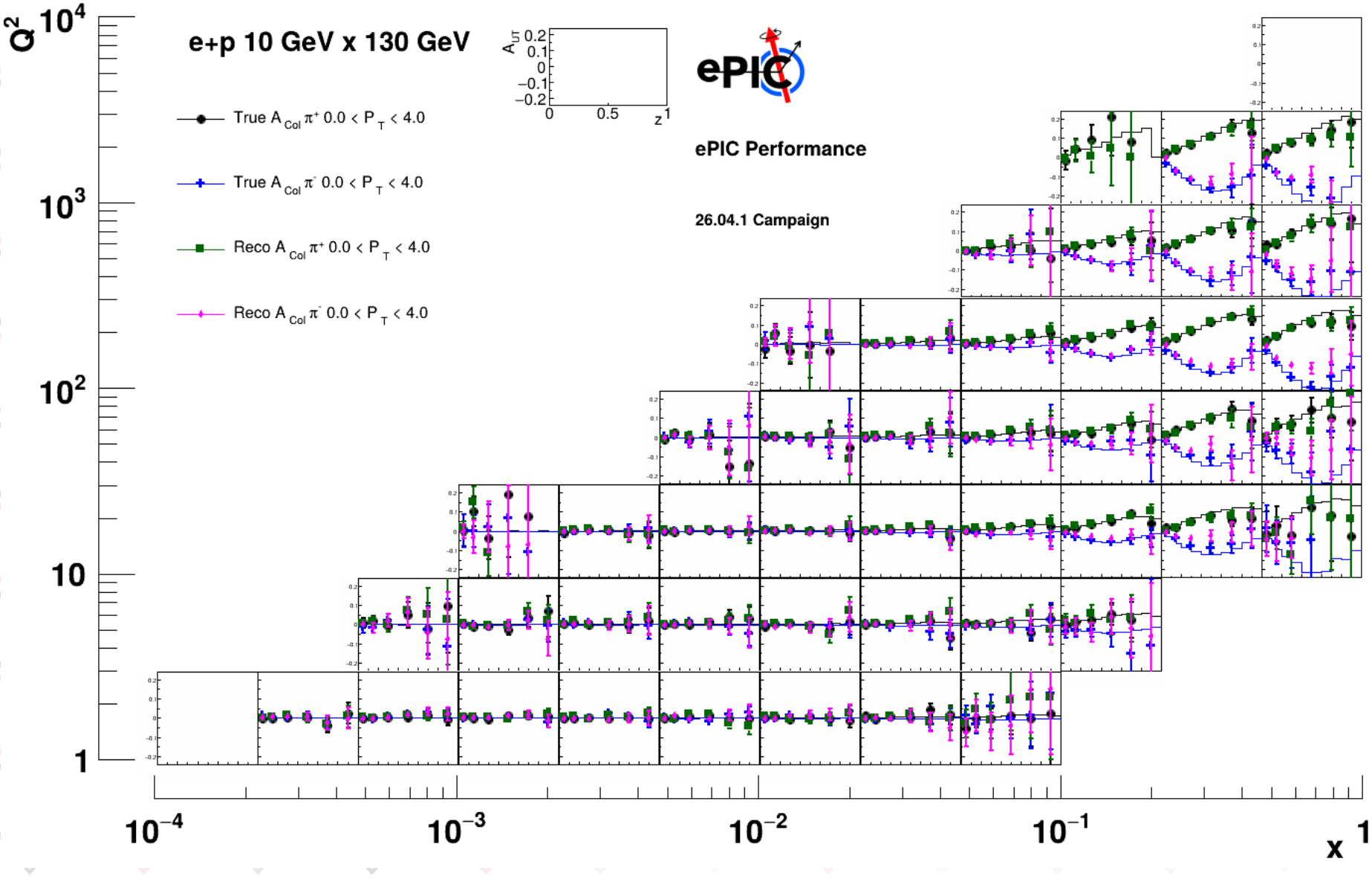
$$A_{UT}^{\sin(\phi_h-\phi_S)}(x,z,P_T) \propto \mathbf{S}_T \frac{\sum_{q,\overline{q}} e_q^2 f_{1T}^{\perp,q}(x,k_t) \otimes D_1(z,p_t)}{\sum_{q,\overline{q}} e_q^2 q(x,k_t) \otimes D_1(z,p_t)}$$

Example Asymmetries

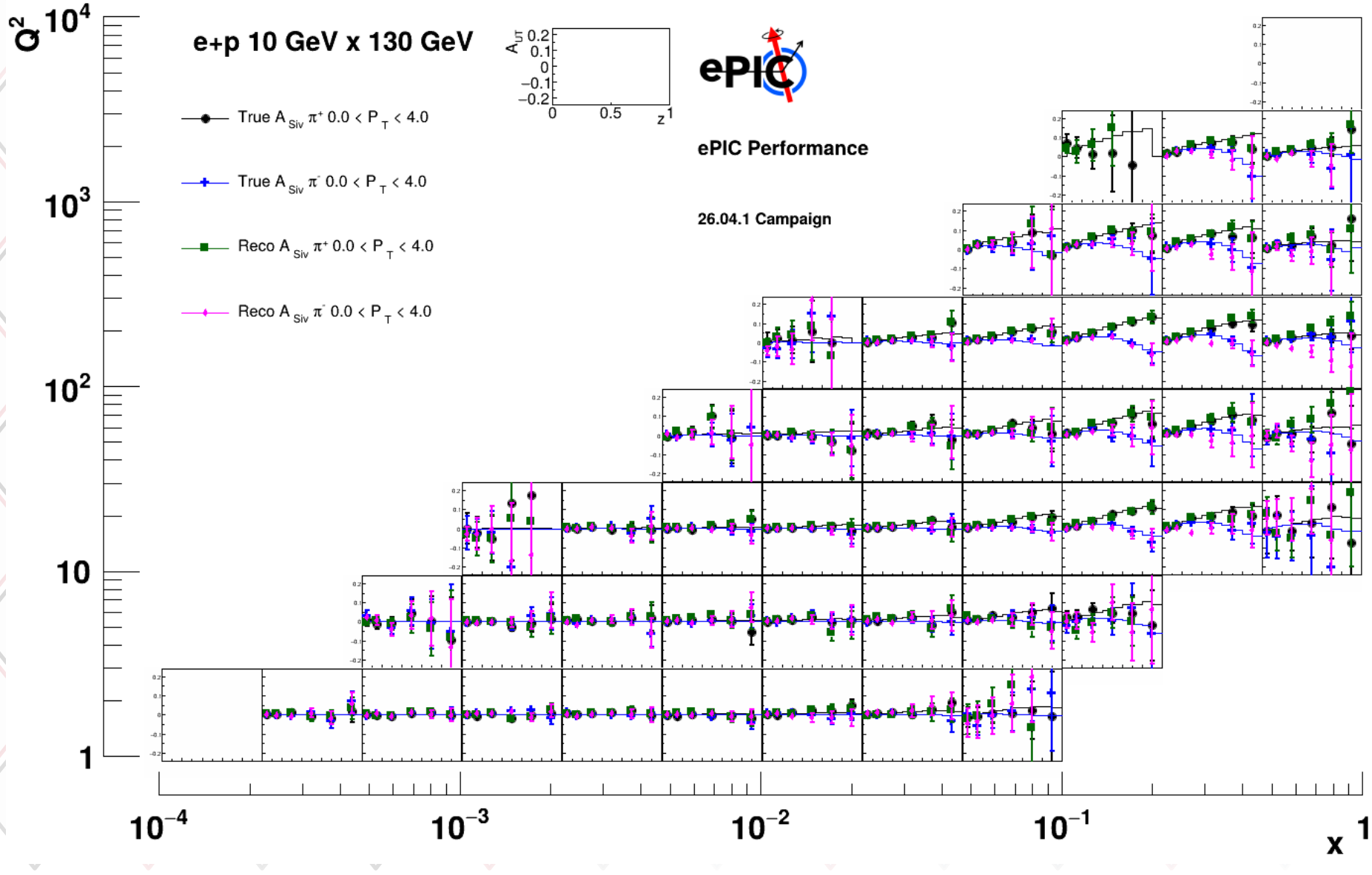
- Examples in 3 x and Q^2 bins: on top for the Collins angular combination for charged pions true and reconstructed in an intermediate z bin
- Lower figures: Collins, Sivers projected vs z (integrated over P_{hT} bins)



Collins Asymmetries vs z (integrated over P_{hT})

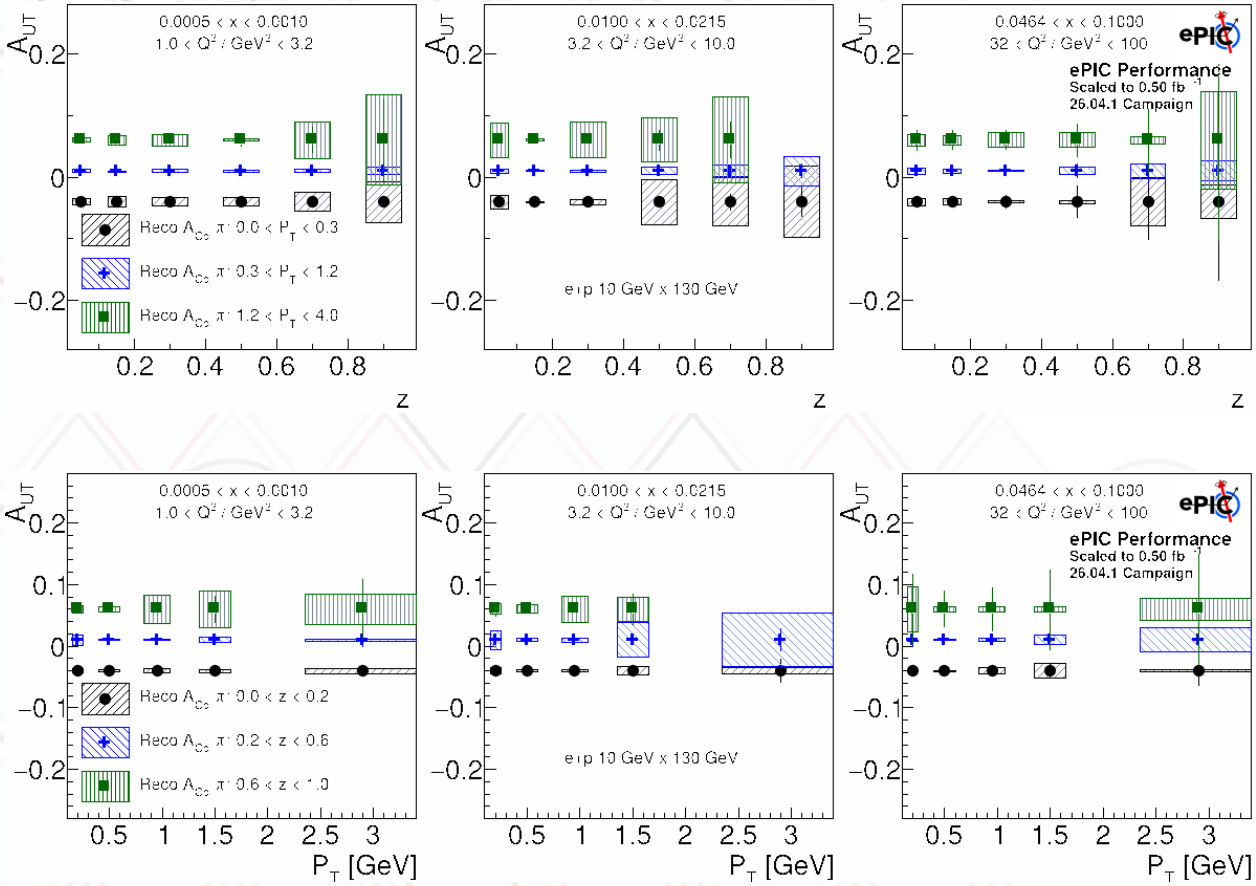


Sivers asymmetries



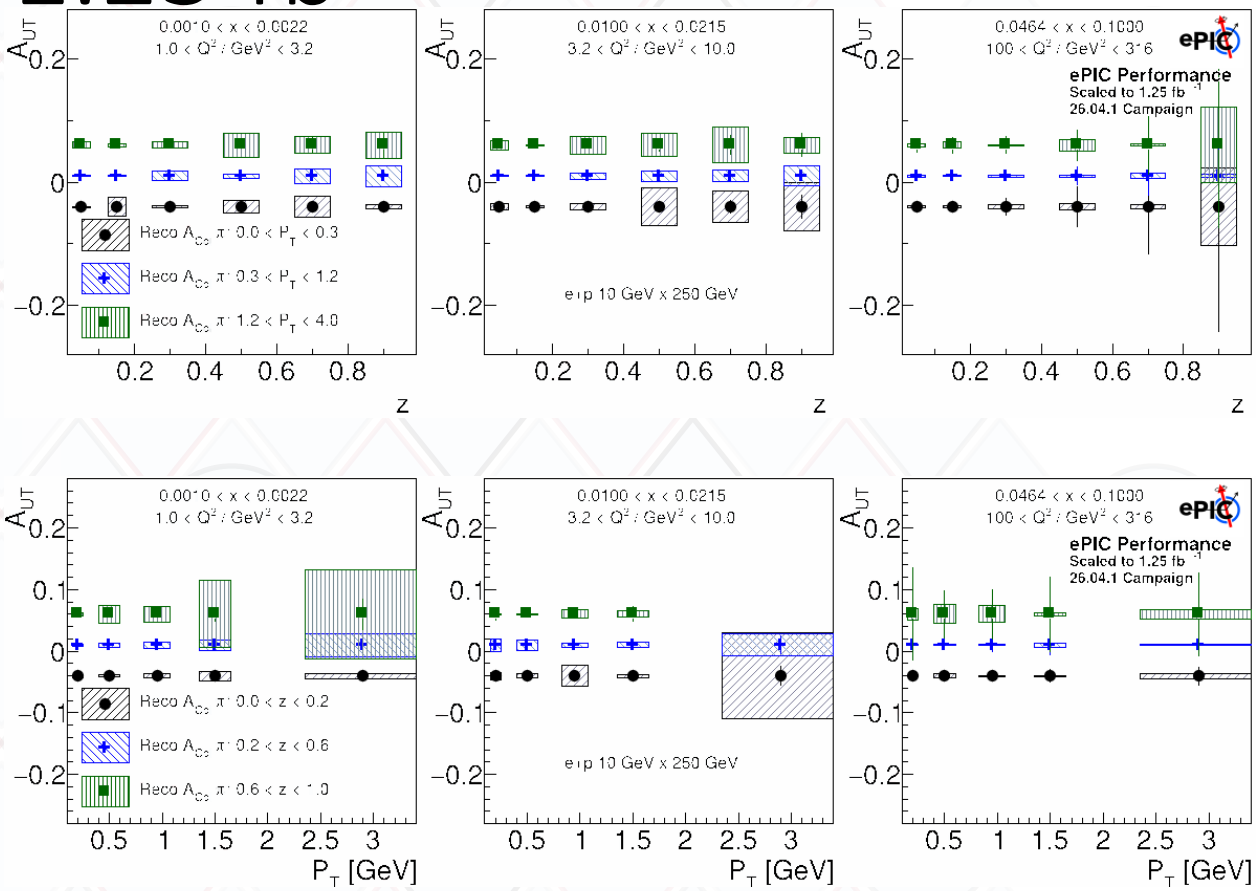
Projections (10x130) to 0.5 fb^{-1}

- Systematic uncertainties estimated from differences between true and reconstructed asymmetries → they are likely largely overestimated since most of the kinematic smearing would be unfolded, but give a sense of where uncertainties still might be larger due to that unfolding



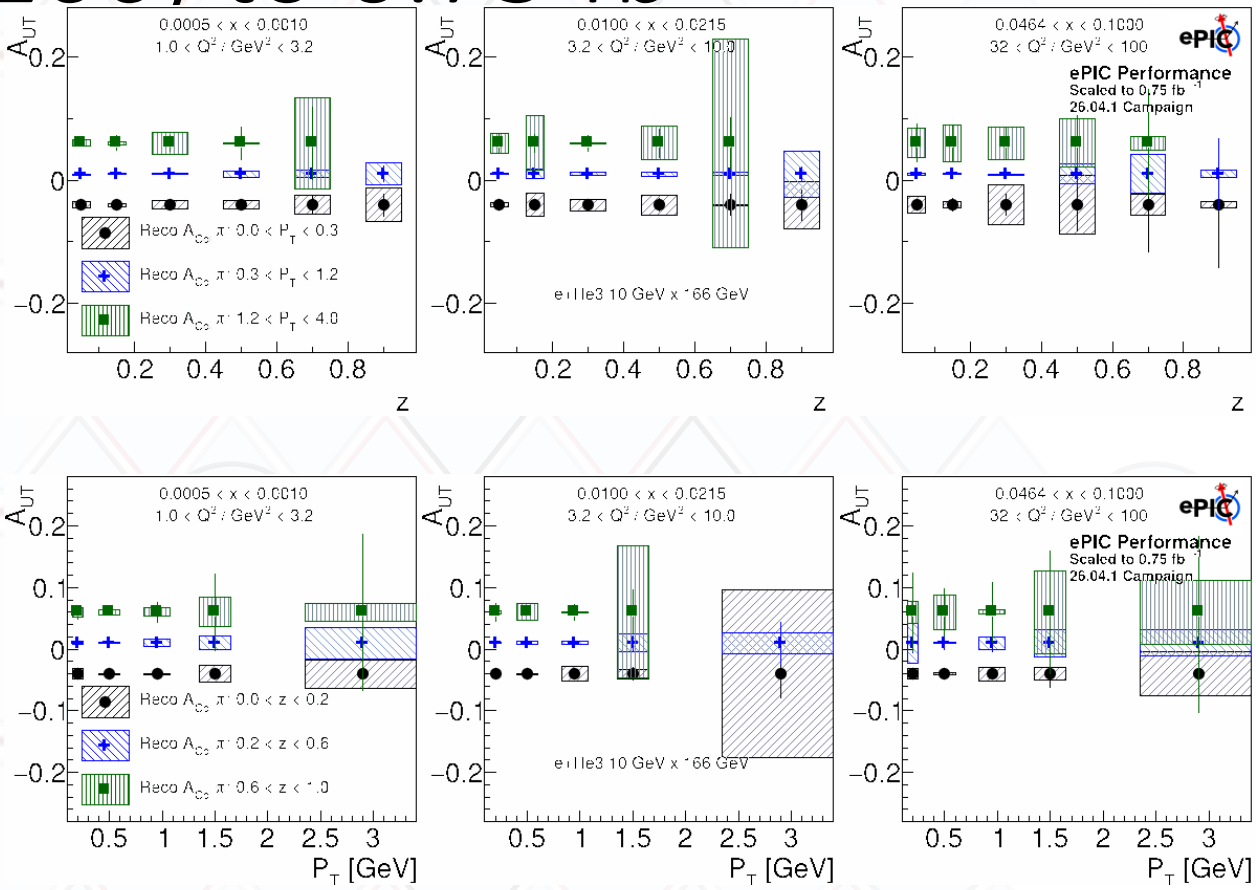
Projections (10x250) to 1.25 fb^{-1}

- Systematic uncertainties estimated from differences between true and reconstructed asymmetries → they are likely largely overestimated since most of the kinematic smearing would be unfolded, but give a sense of where uncertainties still might be larger due to that unfolding



Projections (e+3He 10x166) to 0.75 fb^{-1}

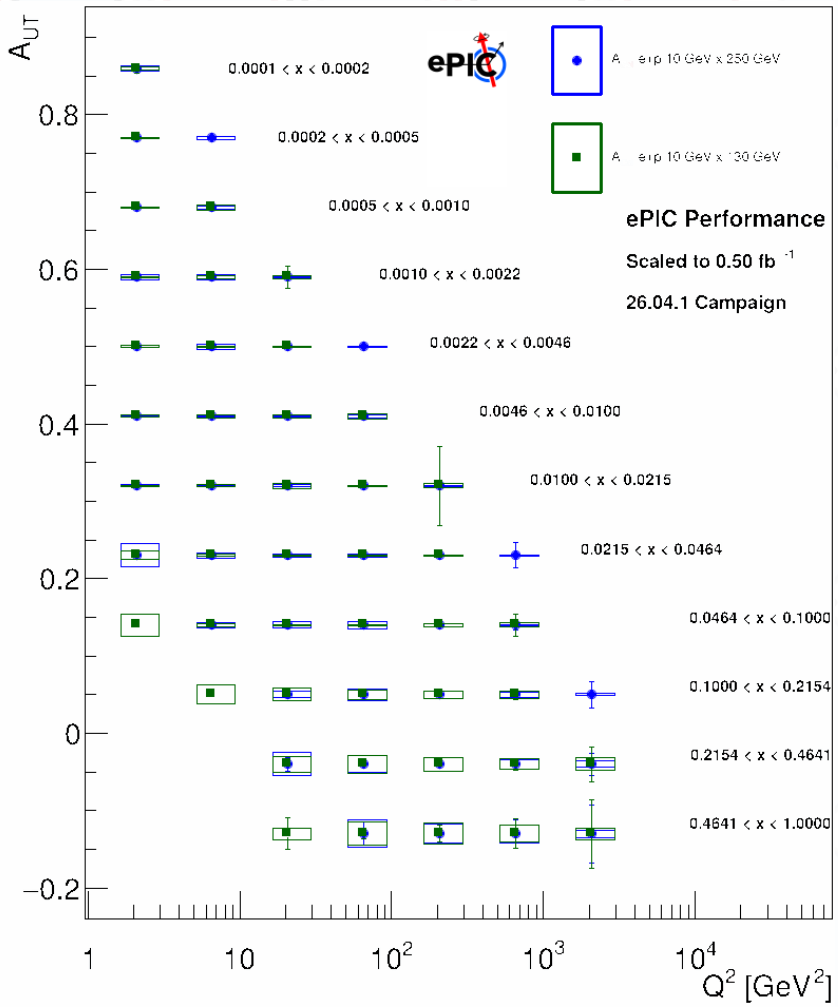
- Systematic uncertainties estimated from differences between true and reconstructed asymmetries → they are likely largely overestimated since most of the kinematic smearing would be unfolded, but give a sense of where uncertainties still might be larger due to that unfolding



Due to tagging, essentially e+n

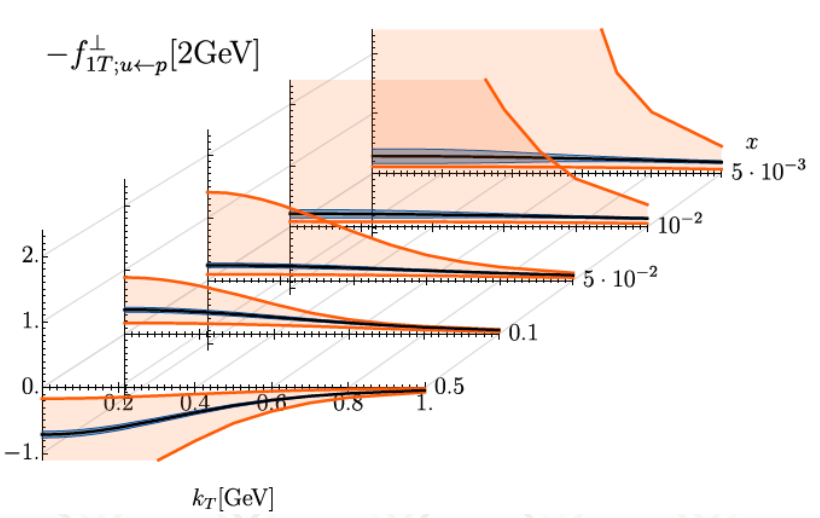
Scale dependence (and interplay of collision energies ESR)

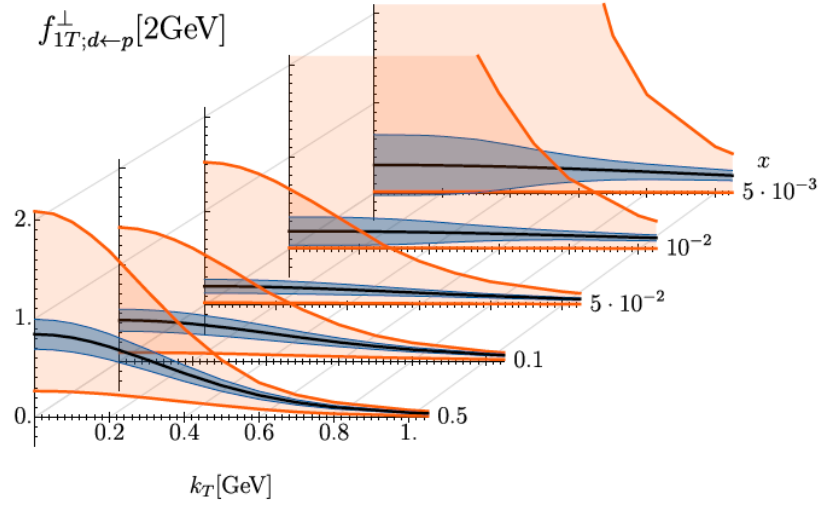
- An example of the expected uncertainties in x and Q^2 to study the scale dependence of the Sivers/Collins asymmetries (as TMD evolution is not very well known/contains other nonperturbative pieces)
- Even ESR energies show overlap and lever arm
- Note: in future evolution analysis likely more Q^2 bins and maybe not as fine x binning



Need new Impact for Sivers functions

- Similar to YR impact studies following the latest BPV global fit (arXiv:2103.03270) for the Sivers function based on the existing SIDIS +DY data
- Uncertainties are shown for current level of knowledge on up/down Sivers functions at various x vs kt and expected impact from ECCE





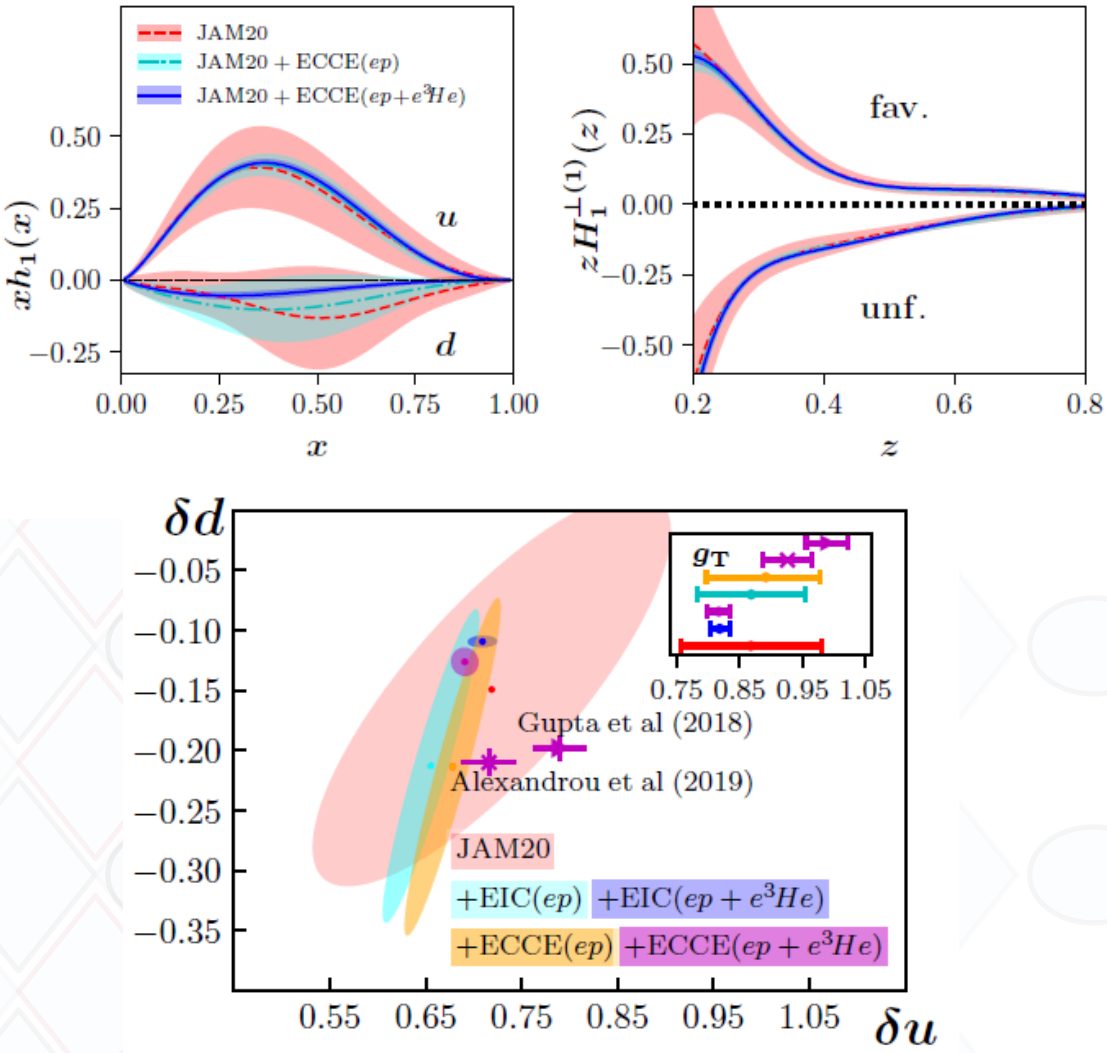
hep-ex:2207.10890

Need new impact for Tensor charges

- Similar to Gamberg et al *Phys.Lett.B* 816 (2021) 136255

  (for YR) use fitting code from latest global fit Cammarota et al arXiv:2002.08384 to extract impact on Transversity, Collins functions and tensor charges

- Together with projected JLAB12 data precision to compare with Lattice results (and check for possible discrepancies)



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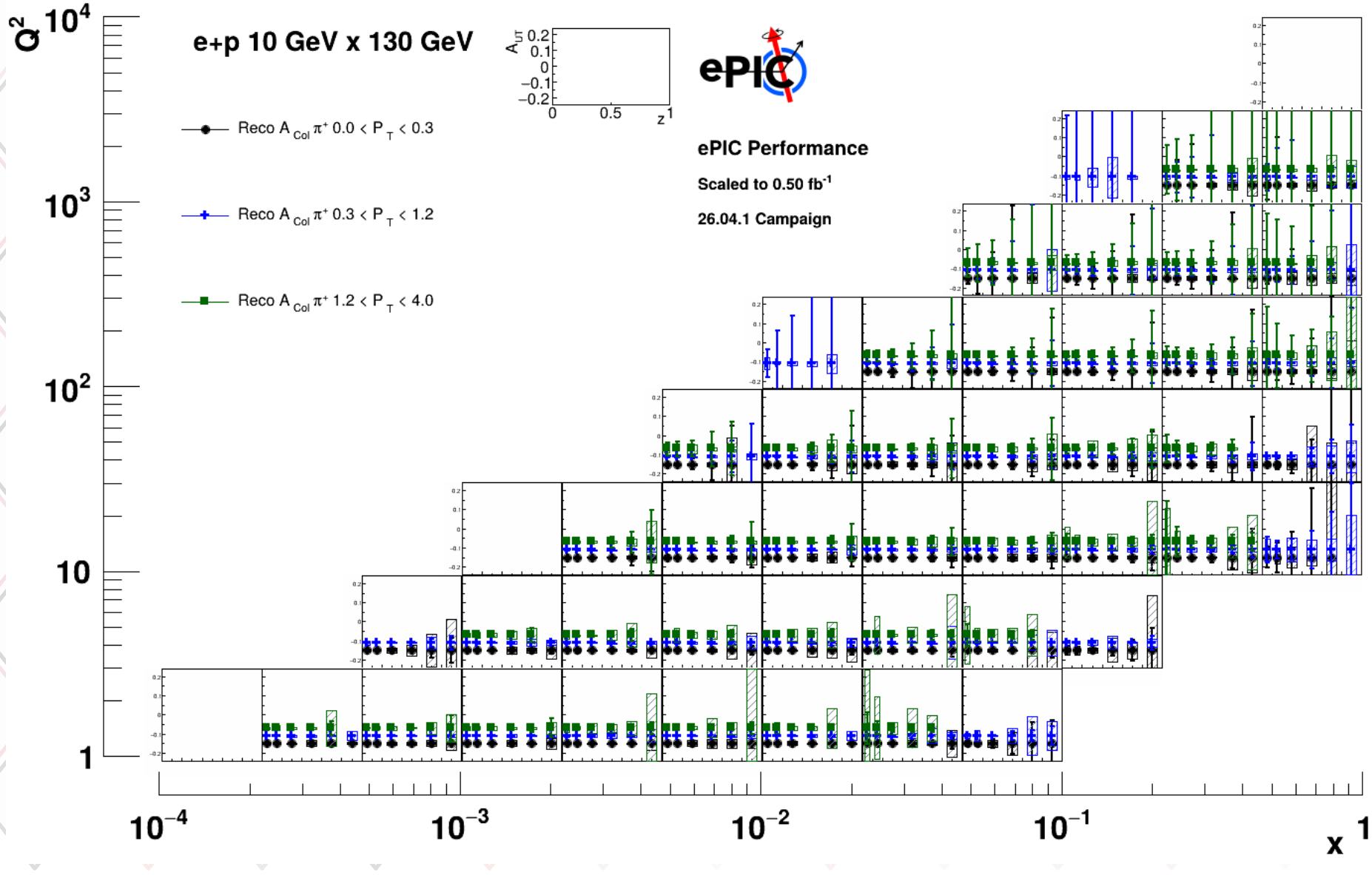
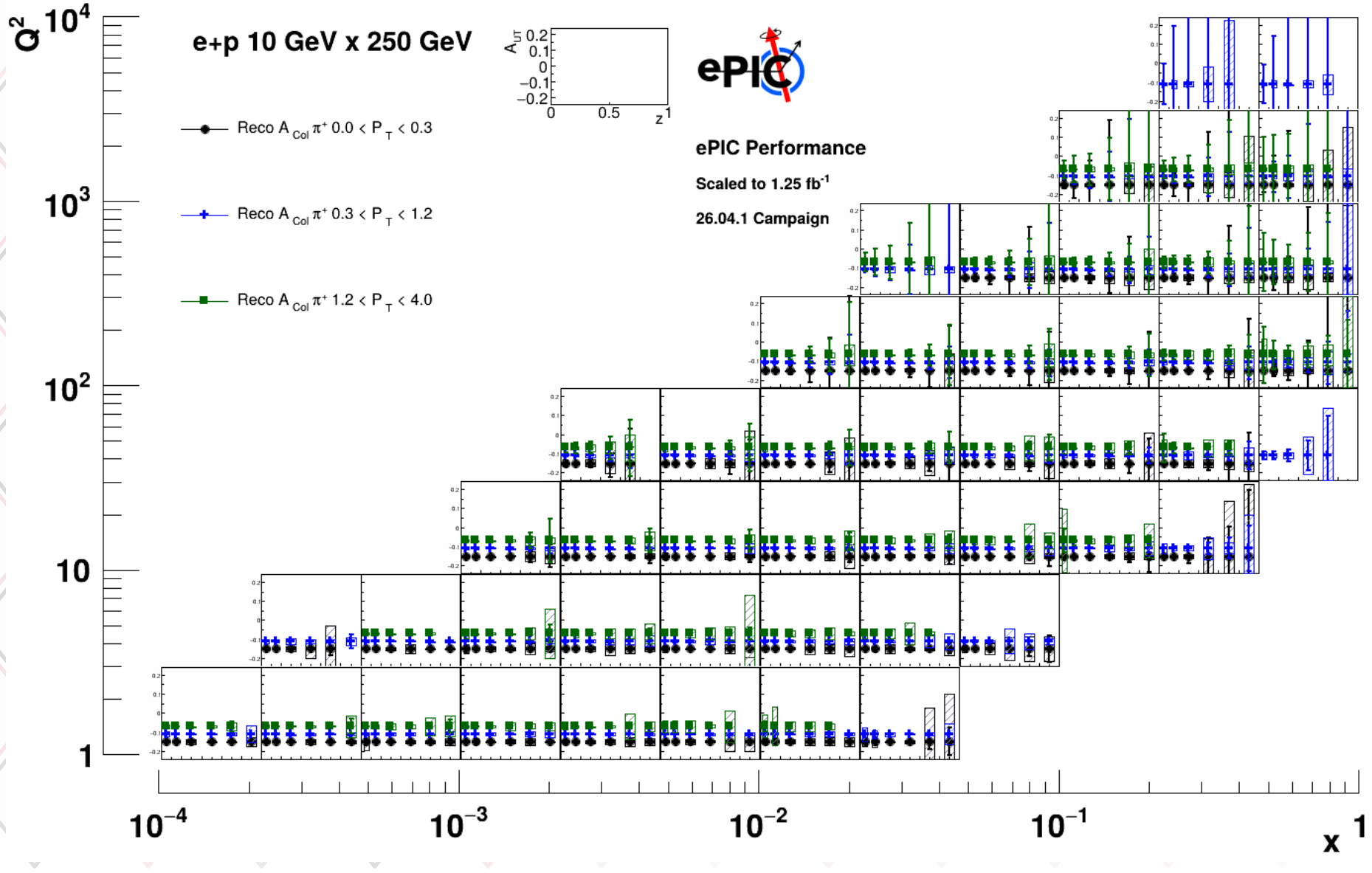
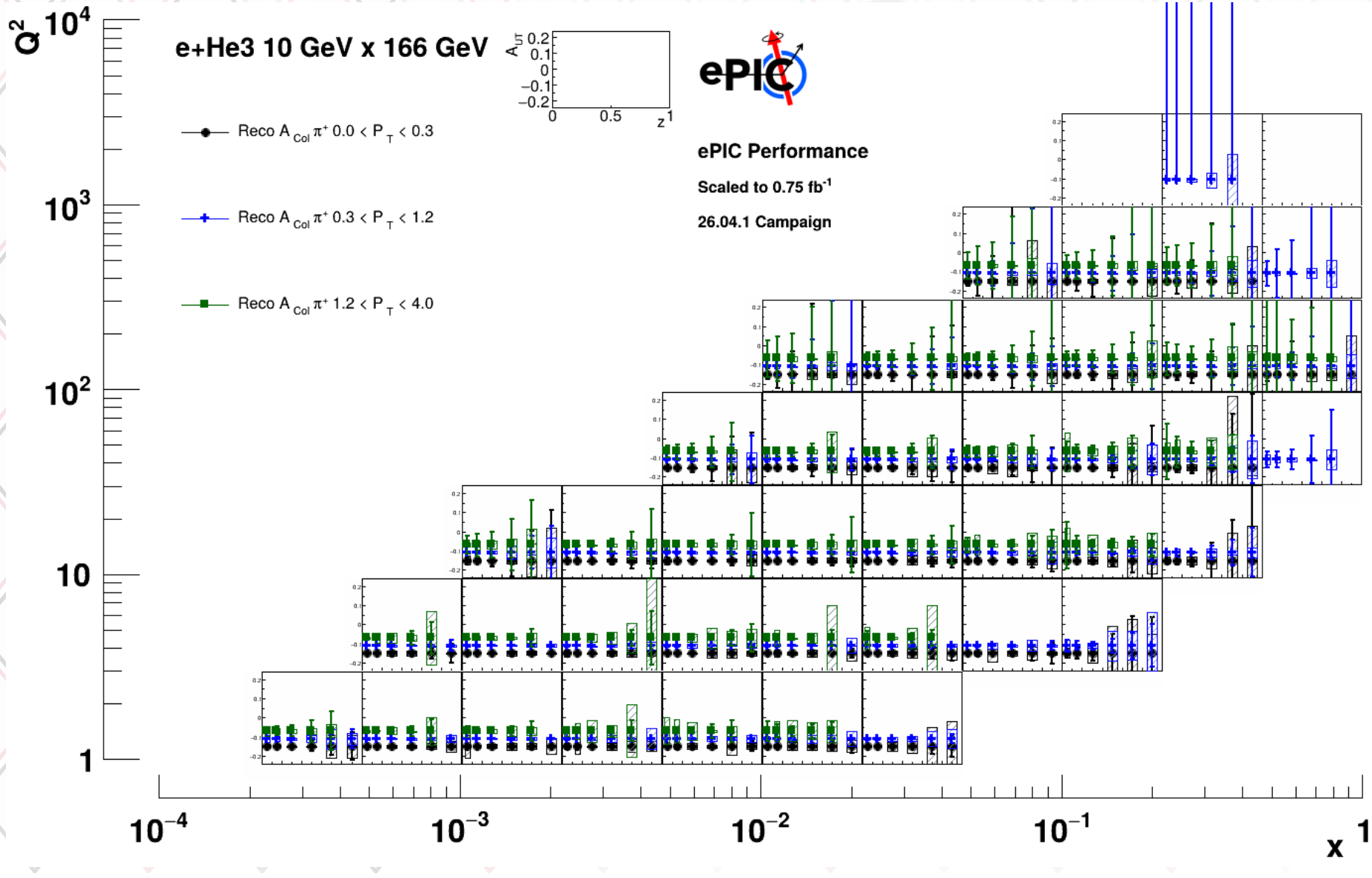

e+p 10 GeV x 130 GeV
ePIC
ePIC Performance
Scaled to 0.50 fb-1
26.04.1 Campaign
Reco A Col π+ 0.0 < P T < 0.3
Reco A Col π+ 0.3 < P T < 1.2
Reco A Col π+ 1.2 < P T < 4.0
A UT
z
Q2
x


e+p 10 GeV x 250 GeV
ePIC
ePIC Performance
Scaled to 1.25 fb-1
26.04.1 Campaign
Reco A Col π+ 0.0 < P T < 0.3
Reco A Col π+ 0.3 < P T < 1.2
Reco A Col π+ 1.2 < P T < 4.0
A UT
z
Q2
x


e+He3 10 GeV x 166 GeV
ePIC
ePIC Performance
Scaled to 0.75 fb-1
26.04.1 Campaign
Reco A Col π+ 0.0 < P T < 0.3
Reco A Col π+ 0.3 < P T < 1.2
Reco A Col π+ 1.2 < P T < 4.0
A UT
z
Q2
x

Outlook

- Provide the pseudo-data to JAM group (Pitonyak and Prokudin) and Alexey Vladimirov for impact studies
- Hope that A.Prokudin adds more parameterizations + uncertainties to code such that one can see impact already on asymmetry level

- Fix beam energies when available
- Fix 3He asymmetry weighting when available
- Include reco tagging of 3He, provide tagged/non-tagged comparison of weighted asymmetries