SIDIS Studies for the ESR

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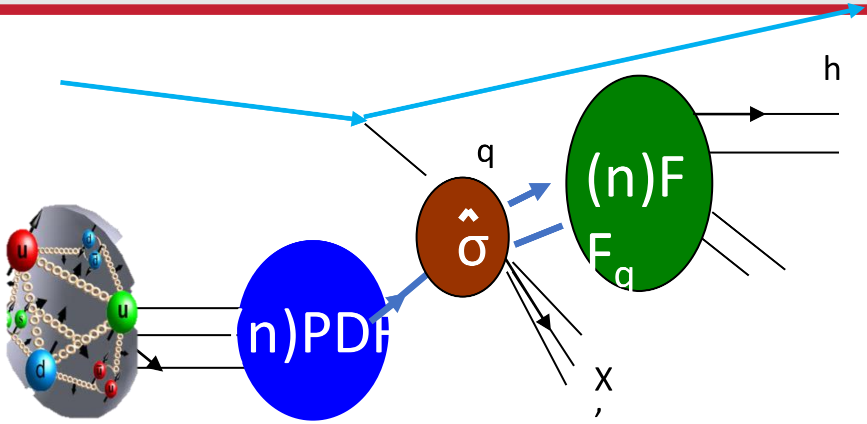
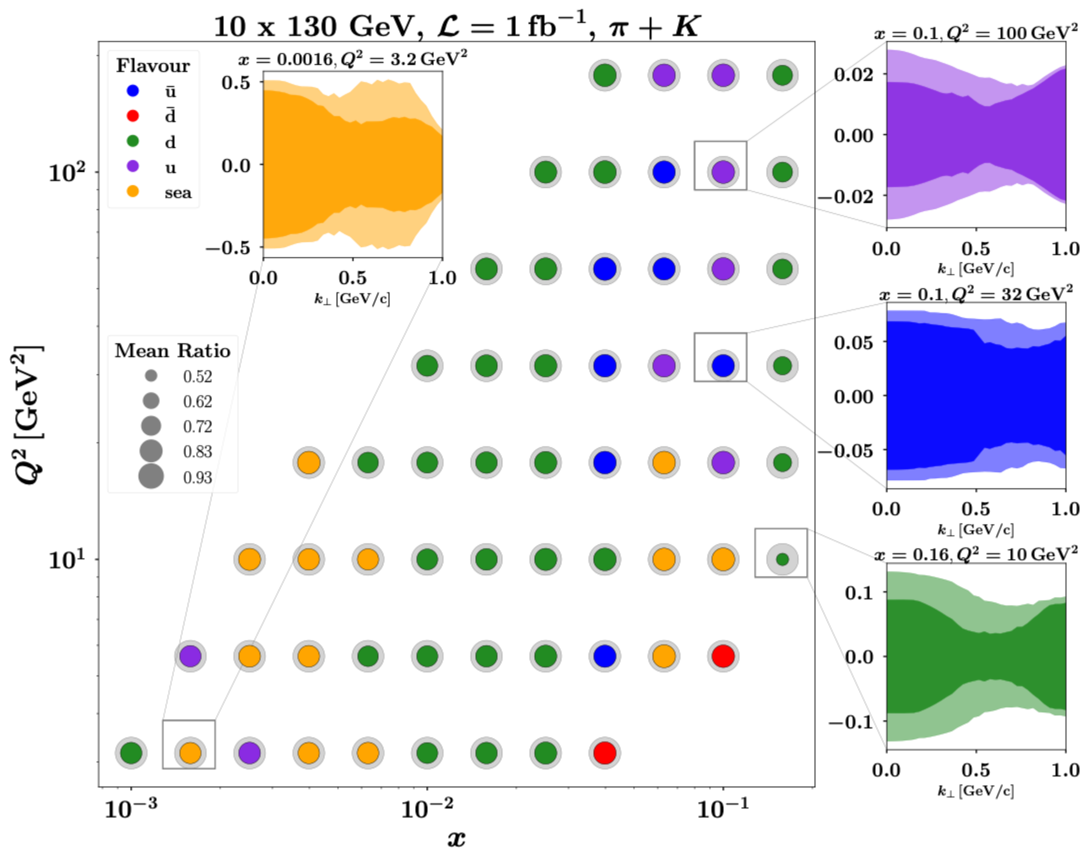
Overview



- The SIDIS program at the EIC will test our understanding of the factorized TMD framework of QCD in a wide kinematic phase space.
- PID of final state hadrons and $3He$ enables flavor separated studies.
- The Early Science Report highlights representative key parts of the SIDIS program
  - Flavor separated Extraction of unpolarized TMD PDFs in the nucleon
  - Transverse single spin asymmetries to access polarized TMD (FFs) e.g. Collins, Sivers effect
  - Helicity distributions of sea quarks

  - Low-x and saturation signatures
  - Nuclear and vacuum FFs, nuclear PDFs

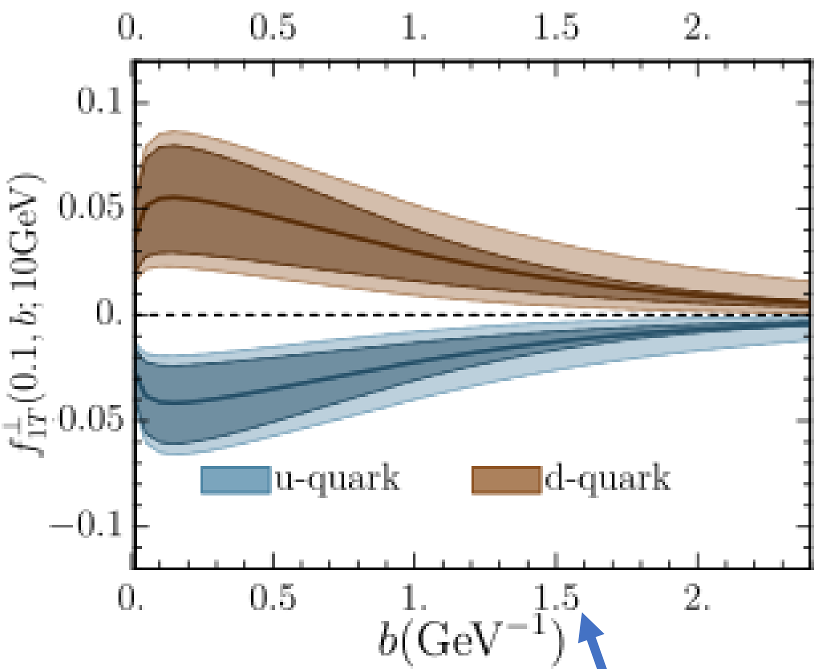
Unpolarized TMD PDFs

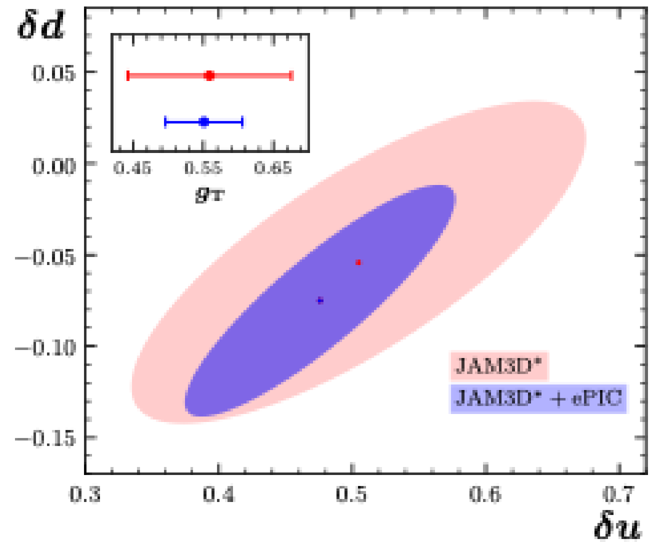


Color indicates Quark Flavor of distribution impacted most by the data

- Work by Marco Radici, INFN-Pavia and Lorenzo Rossi, University of Milano and INFN-Milano.
- Impact study within the MAP framework (Bacchetta et al. (MAP), JHEP 08 (2024) 232, arXiv:2405.13833)
- Each blob represents uncertainty averaged over k_T
- Systematics are taken as 1.5% scale, 3.5% point-to-point

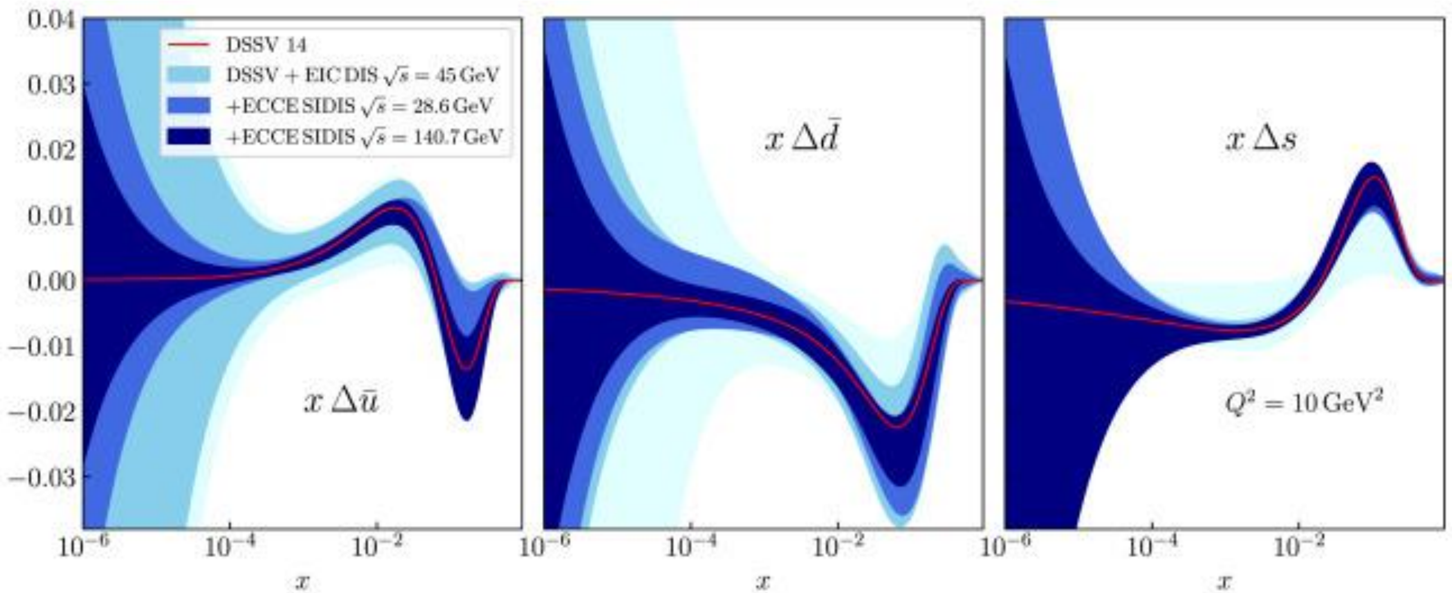
Transverse Single Spin Asymmetries





- Here: Extraction of Sivers $f_{1T}^{\perp}(x)$ and transversity/tensor charge
- Tensor charge: JAM3D-22/JAM3D* (*Phys.Rev.D* 109 (2024) 3, 034024) *Phys.Rev.D* 106 (2022) 3, 034014, provided by D. Pitonyak (LVC), A. Prokudin (PSU Berks), simulations produced by Ralf Seidl
- Extractions of Sivers impact: ART by A. Vladimirov (UCM)

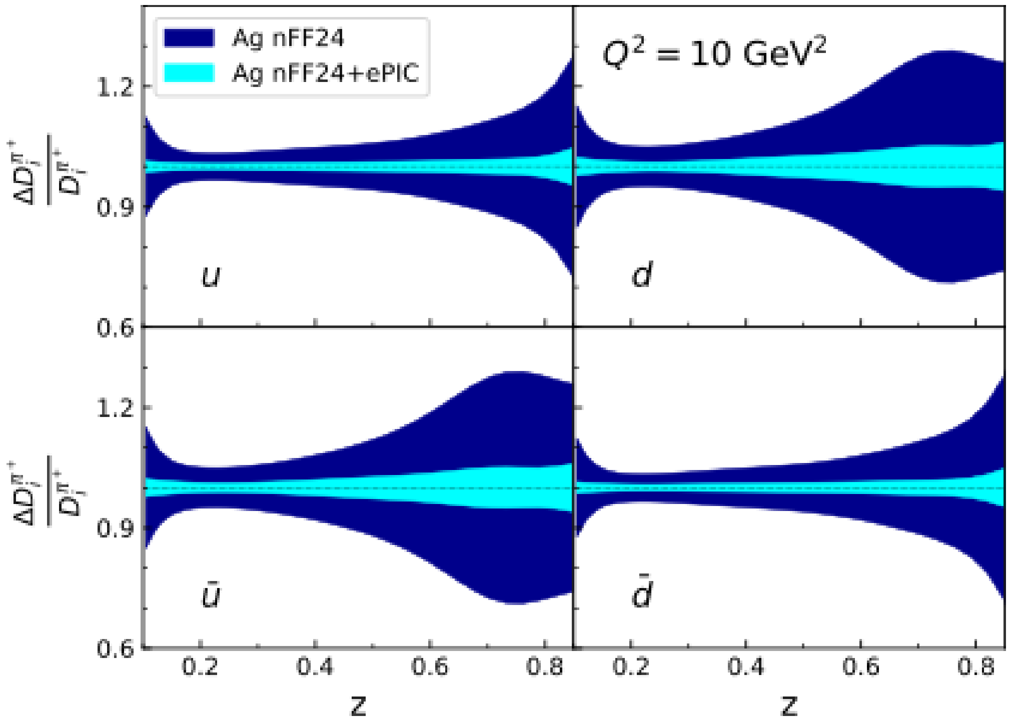
(sea) quark helicities



Example: To be replaced by final plot

- Impact based on DSSV framework (*Phys.Rev.Lett.* 133 (2024) 15, 15 e-Print: [2407.11635](https://arxiv.org/abs/2407.11635) [hep-ph])
- Based on $A_{LL}^{\pi^{\pm},\ K^{\pm}}$ projections produced by C. Van Hulse (VUB)

(n)FFs, PDFs



Example based on
1% statistics

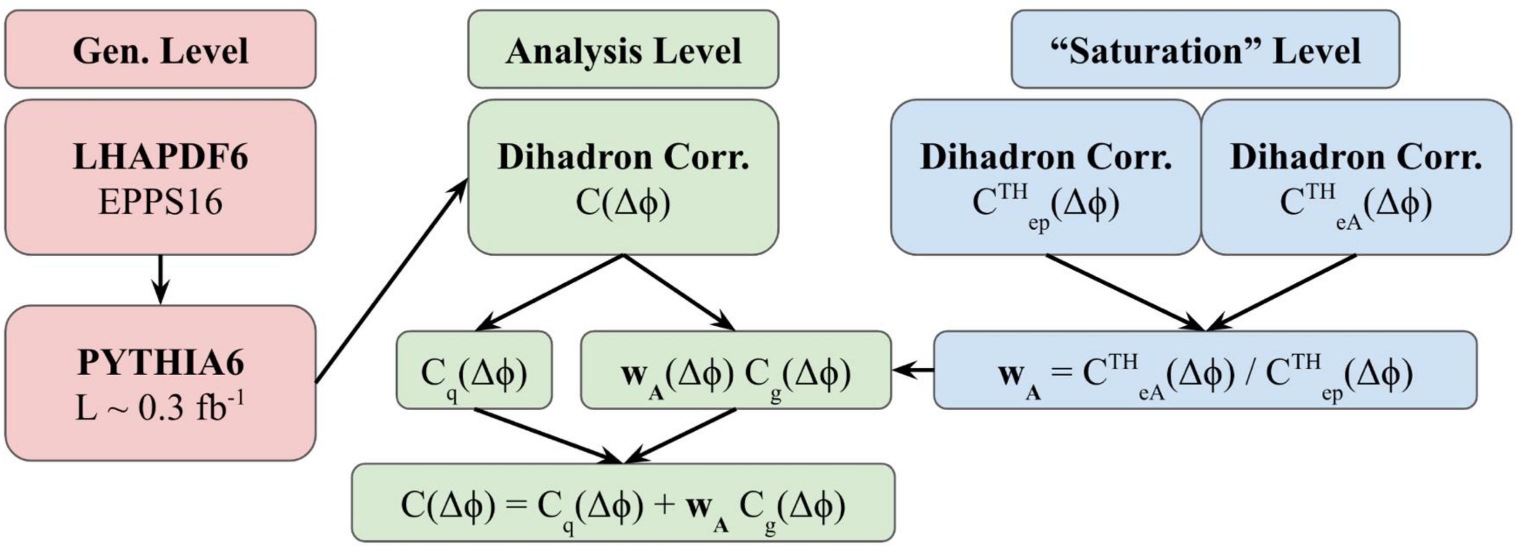
Updated plot expected for ESR (exploring best o options for weighting method)

- Impact on nFFs (Ag, Au) by Pia Zuriga (UCM) based on Phys. Rev. D 111, 034045 (2025), 2411.08222, simulations by C. Van Hulse
- Impact of full ESR dataset is so high that reweighting techniques fail

Di-hadron impact study: Method

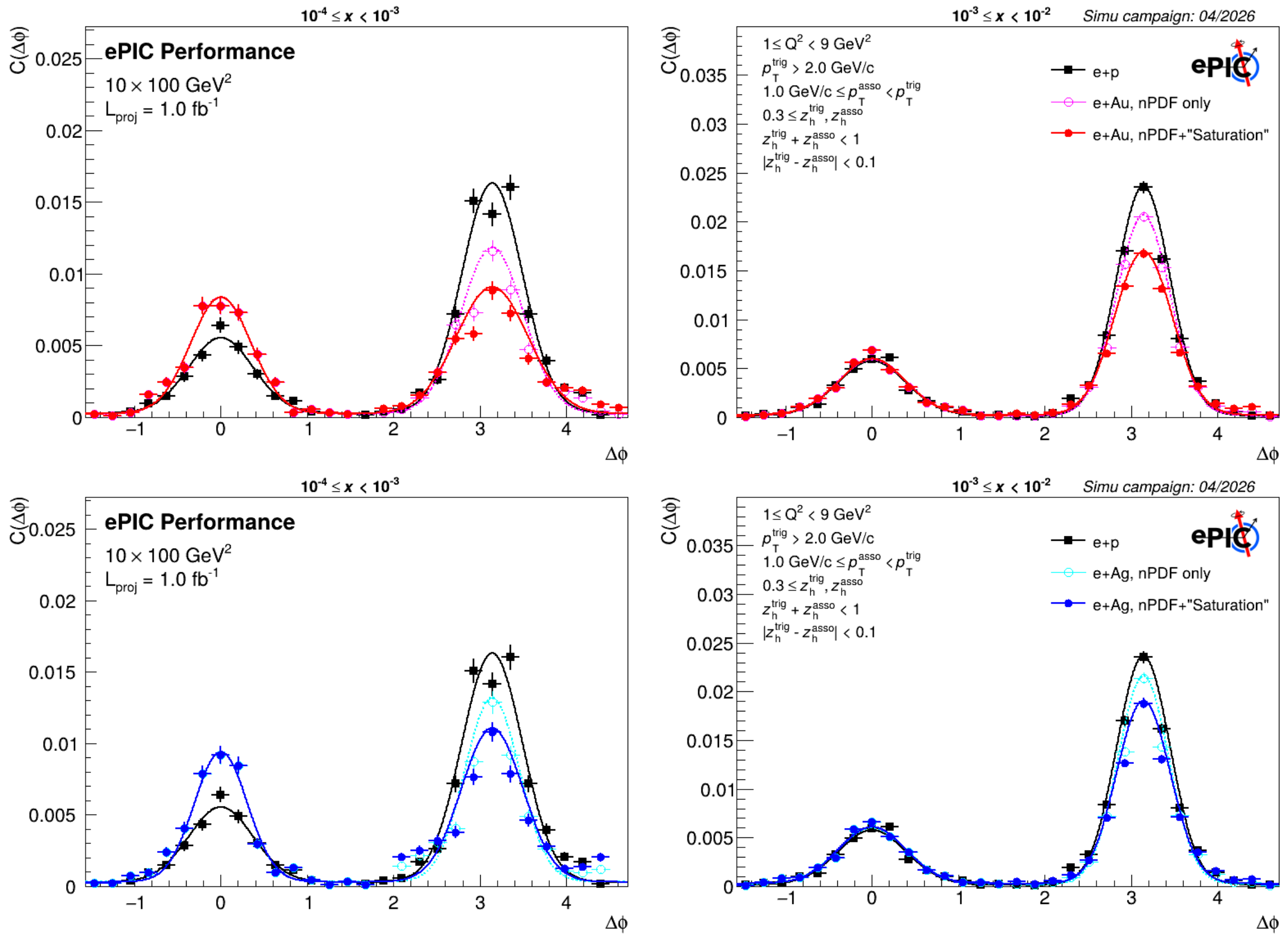
- **e+p (0.25 fb^{-1})**, **e+Ag (0.38 fb^{-1})**, **e+Au (0.40 fb^{-1})** at 10×100 GeV^2 → **Projected to 1.0 fb^{-1}**
- Di-hadron correlation analysis with event-level re-weighting method
- Coincidence probability across phase-space (Q^2, x, z_{h1}, z_{h2})

$$C(\Delta\phi) = \frac{1}{\frac{d\sigma_{\mathrm{SIDIS}}^{\gamma^*+A\to h_1+X}}{dz_{h1}}} \frac{d\sigma_{\mathrm{tot}}^{\gamma^*+A\to h_1+h_2+X}}{dz_{h1}dz_{h2}d\Delta\phi}$$



Di-hadron impact study: Results

- Suppression of away-side peak observed in e+A *vs* e+p
- Lower *x* more suppressed
- Difference between Ag and Au reflects nuclear size dependence
- Away-side area **suppression ~40%** in lowest *x* bin of e+Au relative to e+p



Conclusion

- Early science data already has significant impact on high priority SIDIS observables
- We expect additional impact that is harder to quantify due to exploring kinematic phase space not covered by previous experiments, examples: TMD evolution, model dependence of extractions.
- Additional channels and more sophisticated analyses can be pursued in a longer paper.
- Many thanks to ePIC and theory collaborators who worked hard till the deadline!