27th International Workshop on Deep-Inelastic Scattering and Related Subjects

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Beam-helicity asymmetries in semi-inclusive deep-inelastic single-hadron production from unpolarized hydrogen and deuterium targets

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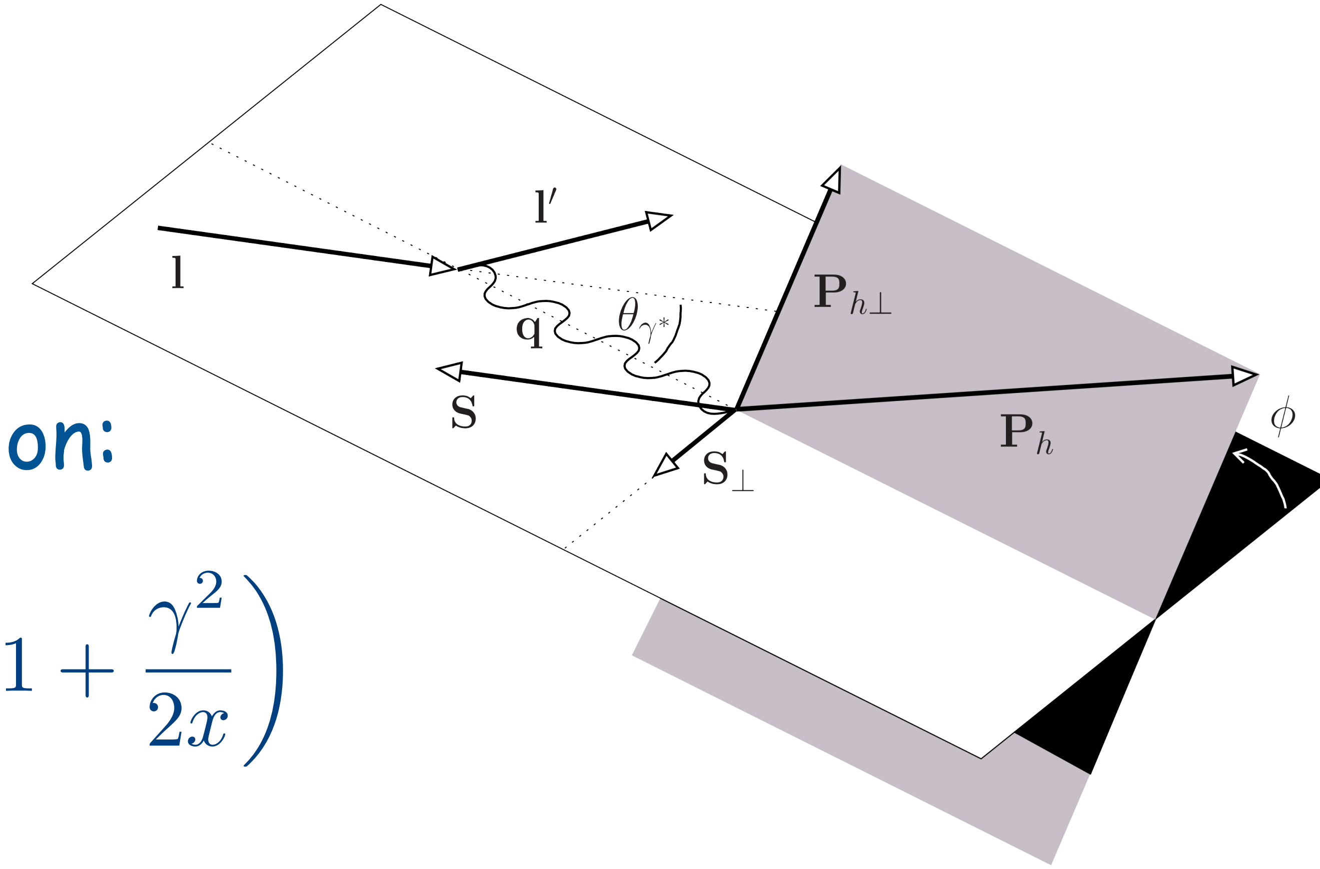
semi-inclusive DIS



- excluding transverse polarization:

$$\frac{\mathrm{d}\sigma^h}{\mathrm{d}x\,\mathrm{d}y\,\mathrm{d}z\,\mathrm{d}P_{h\perp}^2\,\mathrm{d}\phi} = \frac{2\pi\alpha^2}{xyQ^2}\frac{y^2}{2(1-\epsilon)}\left(1+\frac{\gamma^2}{2x}\right)$$

$$\Big\{ F_{UU,T}^h + \epsilon F_{UU,L}^h + \lambda\Lambda\sqrt{1-\epsilon^2}F_{LL}^h$$

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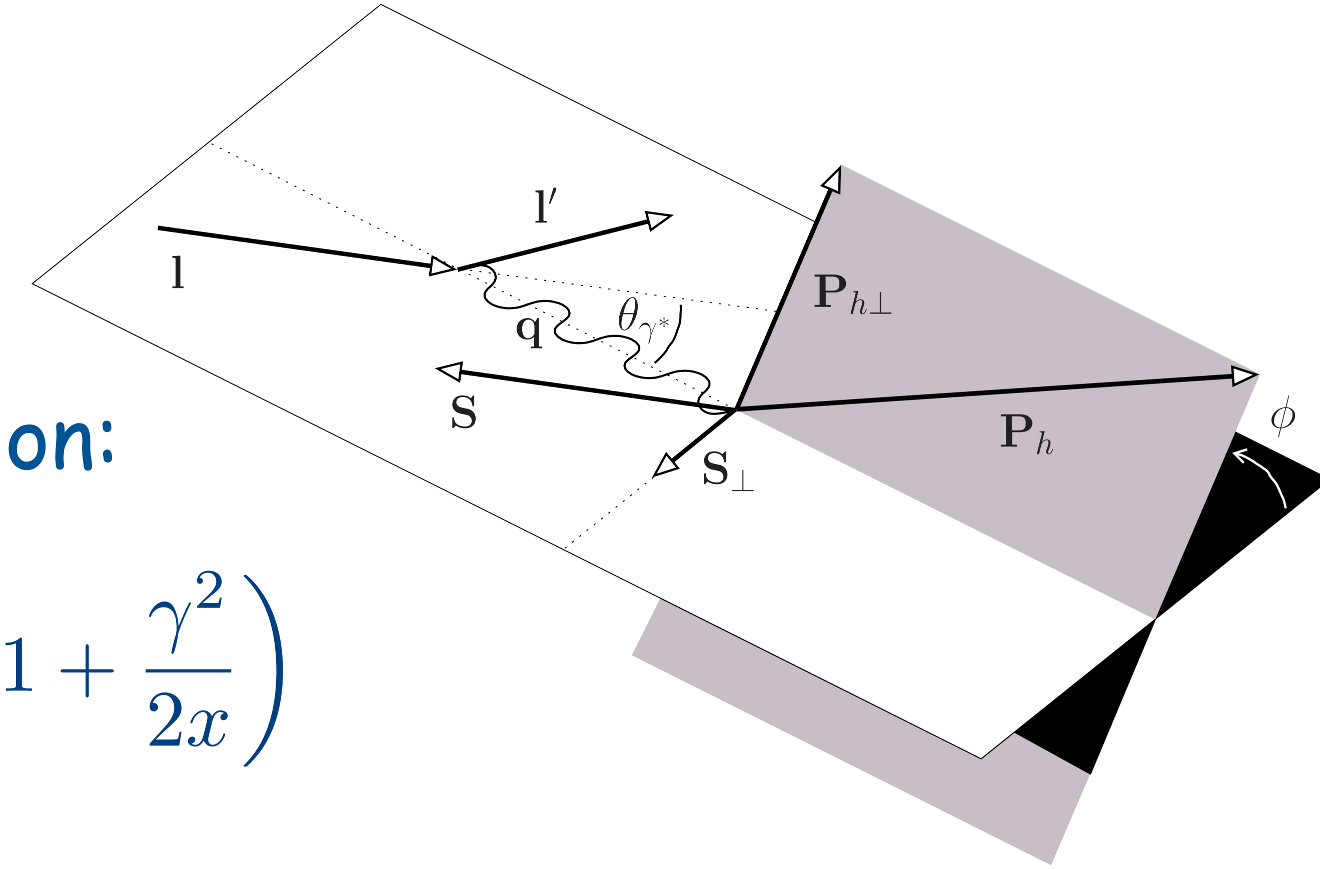
$$F_{XY}^{h,\mathrm{mod}} = F_{XY}^{h,\mathrm{mod}}(x, Q^2, z, P_{h\perp})$$

Beam (λ) / Target (Λ) helicities

semi-inclusive DIS



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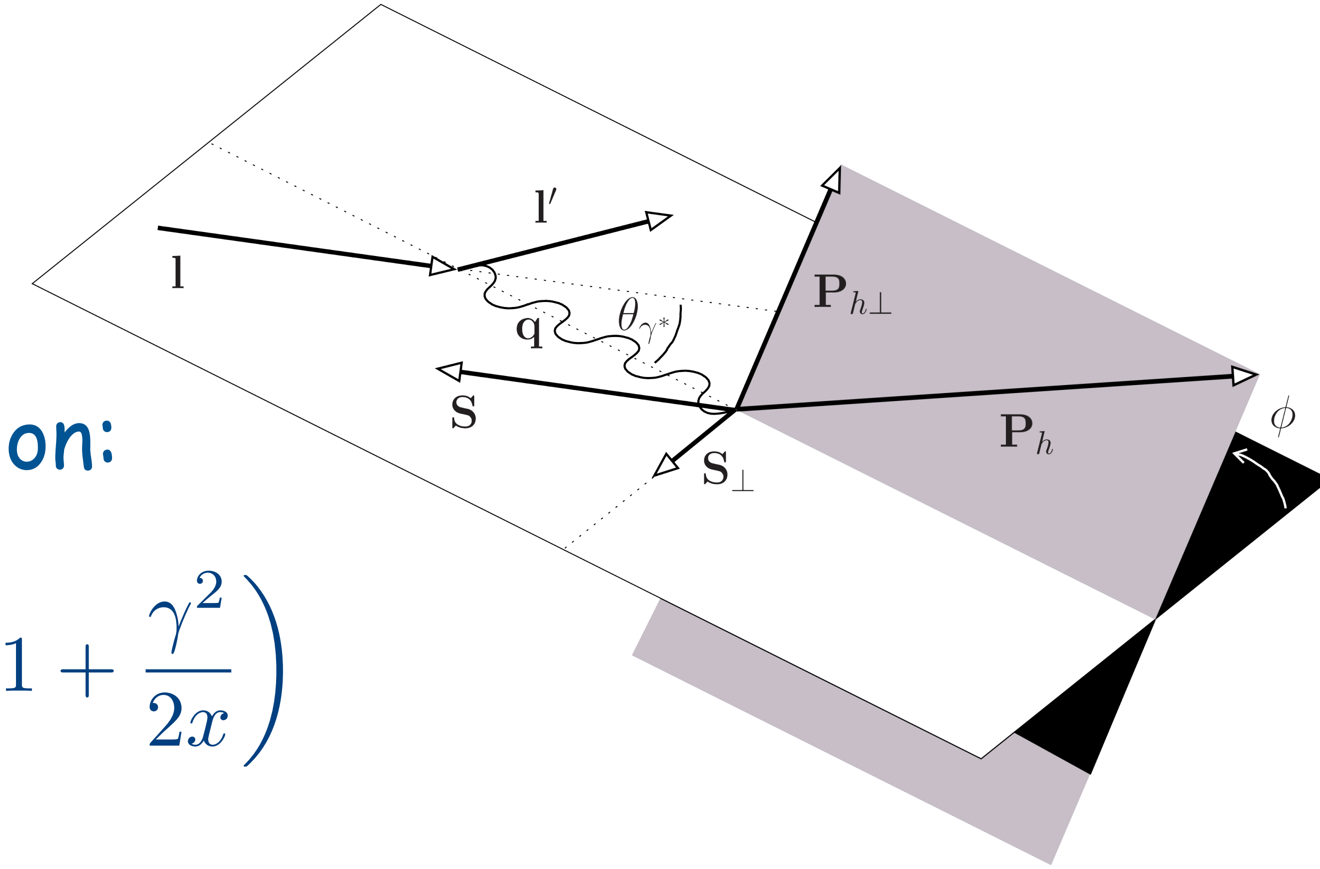

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beam-helicity asymmetry

$$\frac{M_h}{Mz} h_1^{\perp} \tilde{E} \oplus x g^{\perp} D_1 \oplus \frac{M_h}{Mz} f_1 \tilde{G}^{\perp} \oplus x e H_1^{\perp}$$

- naive-T-odd Boer-Mulders (BM) function coupled to a twist-3 FF
  - signs of BM from unpolarized SIDIS
  - little known about interaction-dependent FF

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- **all terms vanish in WW-type approximation**

☛ K. Tezgin (We, WG-6)

choice of fitting function

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  - what about twist suppression and other kinematically suppressed contributions?
- asymmetry amplitudes extracted by minimizing

$$-\ln \mathbb{L} = -\sum_i w_i \ln\left[1 + P_{B,i}\sqrt{2\epsilon_i(1-\epsilon_i)}\, A_{LU}^{h,\sin(\phi)} \sin(\phi_i)\right]$$

where w_i is event weight from hadron-ID, charge-symmetric BG etc.

interlude: dealing with multi-d dependences

multi-d dependences

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    - some easily parametrized (e.g., azimuthal dependences)
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  - even different kinematic bins can't disentangle underlying physics dependences
  - e.g., binning in x involves [incomplete] integration(s) over $P_{h\perp}$
- further complication: physics (cross sections) folded with acceptance
  - NO experiment has flat acceptance in full multi-d kinematic space

multi-d dependences

$$\frac{N^{+}(x) - N^{-}(x)}{N^{+}(x) - N^{-}(x)} = \frac{\int \mathrm{d}\omega\, \epsilon(x,\omega)\, \Delta\sigma(x,\omega)}{\int \mathrm{d}\omega\, \epsilon(x,\omega)\, \sigma(x,\omega)}$$

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- measured cross sections / asymmetries often contain "remnants" of experimental acceptance ϵ
- difficult to evaluate precisely in absence of good physics model
  - general challenge to statistically precise data sets
  - avoid 1d binning/presentation of data
  - theorist: watch out for precise definition (if given!) of experimental results reported ... and try not to treat data points of different projections as independent

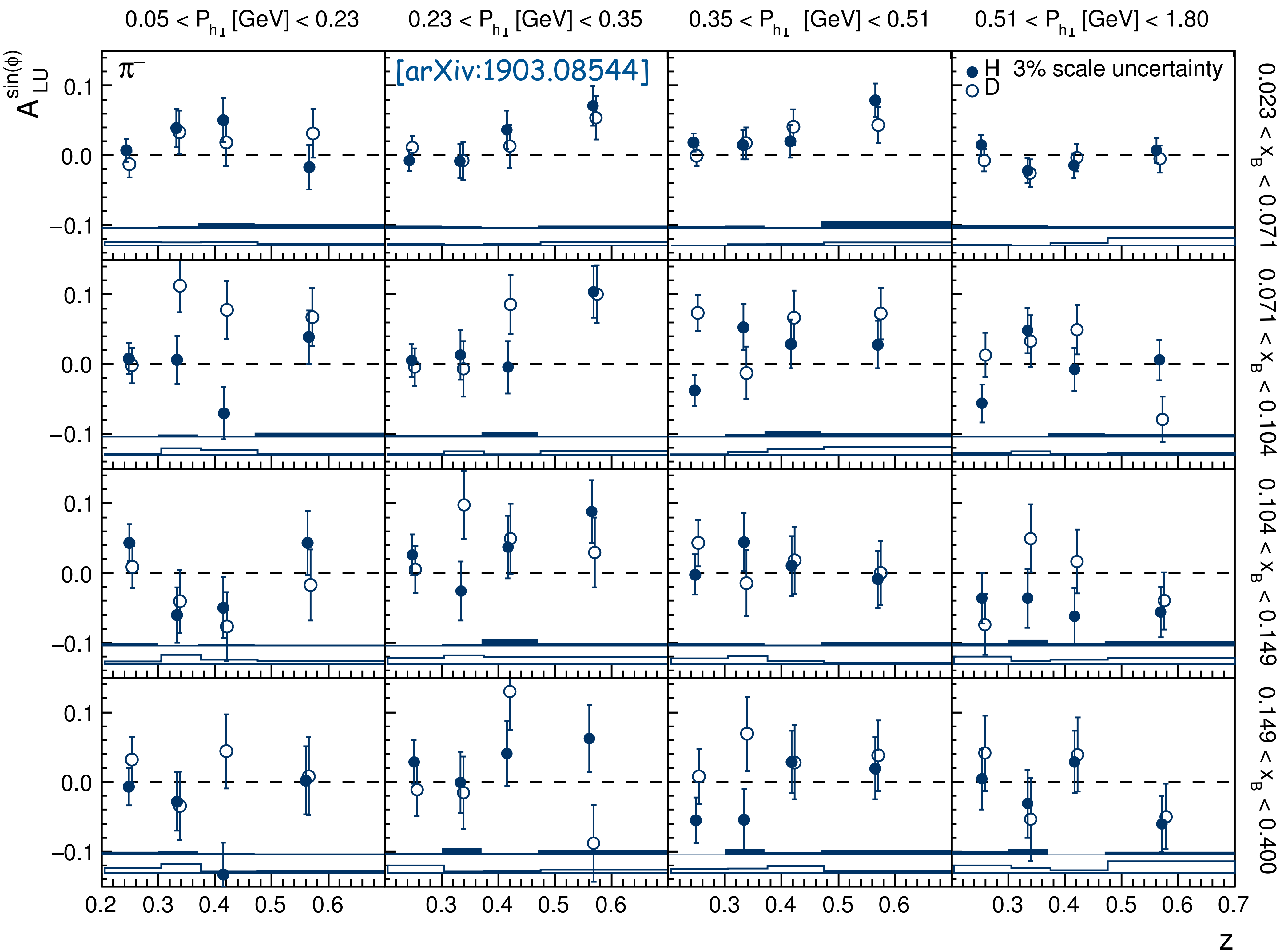
multi-d dependences

- in analysis, implement data-driven model*) into Monte Carlo
- analyzed like real data
- difference between input model evaluated at average kinematics and extracted MC asymmetry in each bin assigned as systematic uncertainty

*) first terms in Taylor expansion in kinematic variables fit to data in unbinned max. likelihood fit

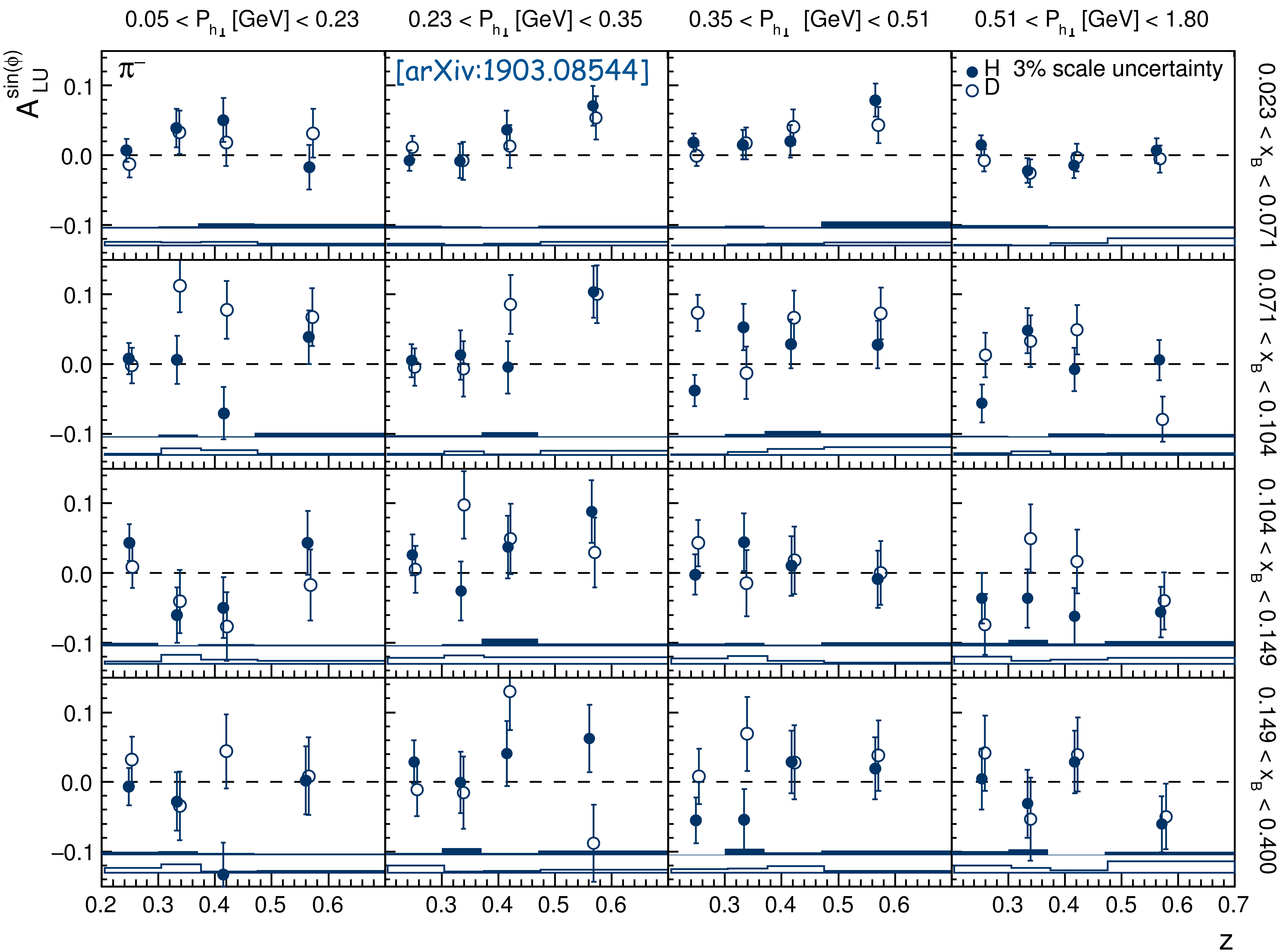
results

3d beam-helicity asymmetry for π^-



- full 1996-2007 data set; precision driven by statistical uncertainty

3d beam-helicity asymmetry for π^-



- most comprehensive presentation, for discussion use 1d binning

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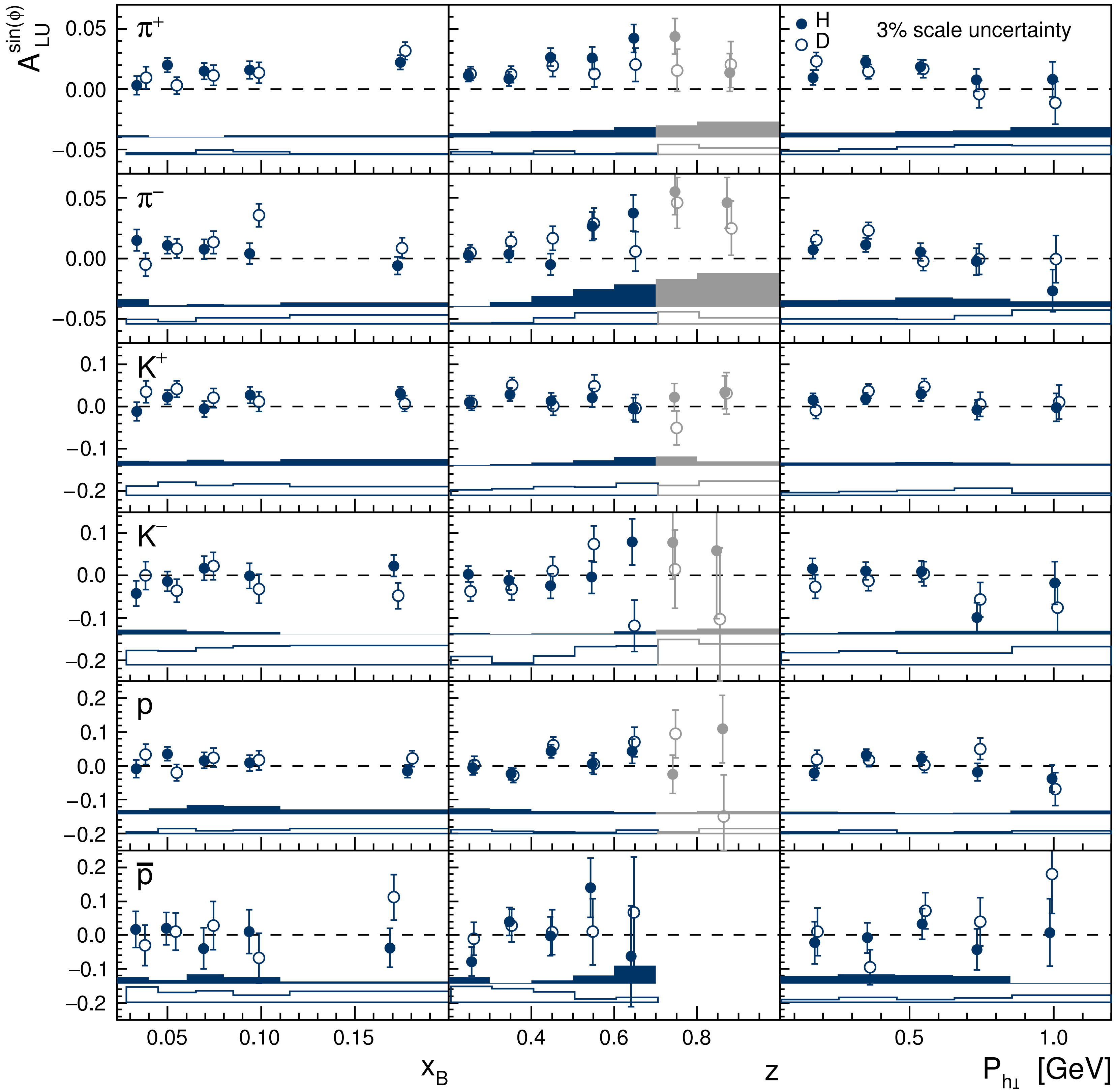
[arXiv:1903.08544]



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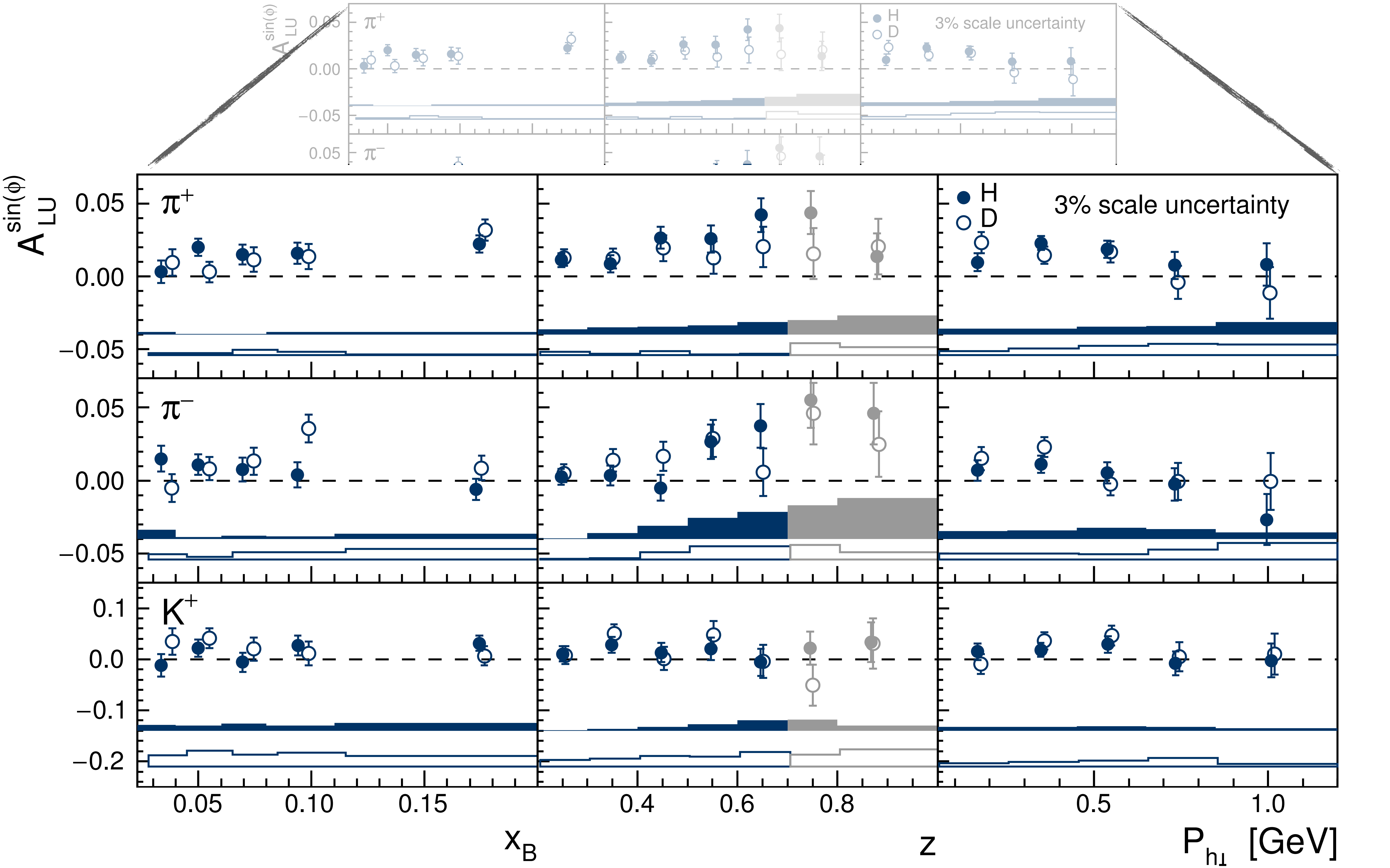

HERMES - CLAS comparison

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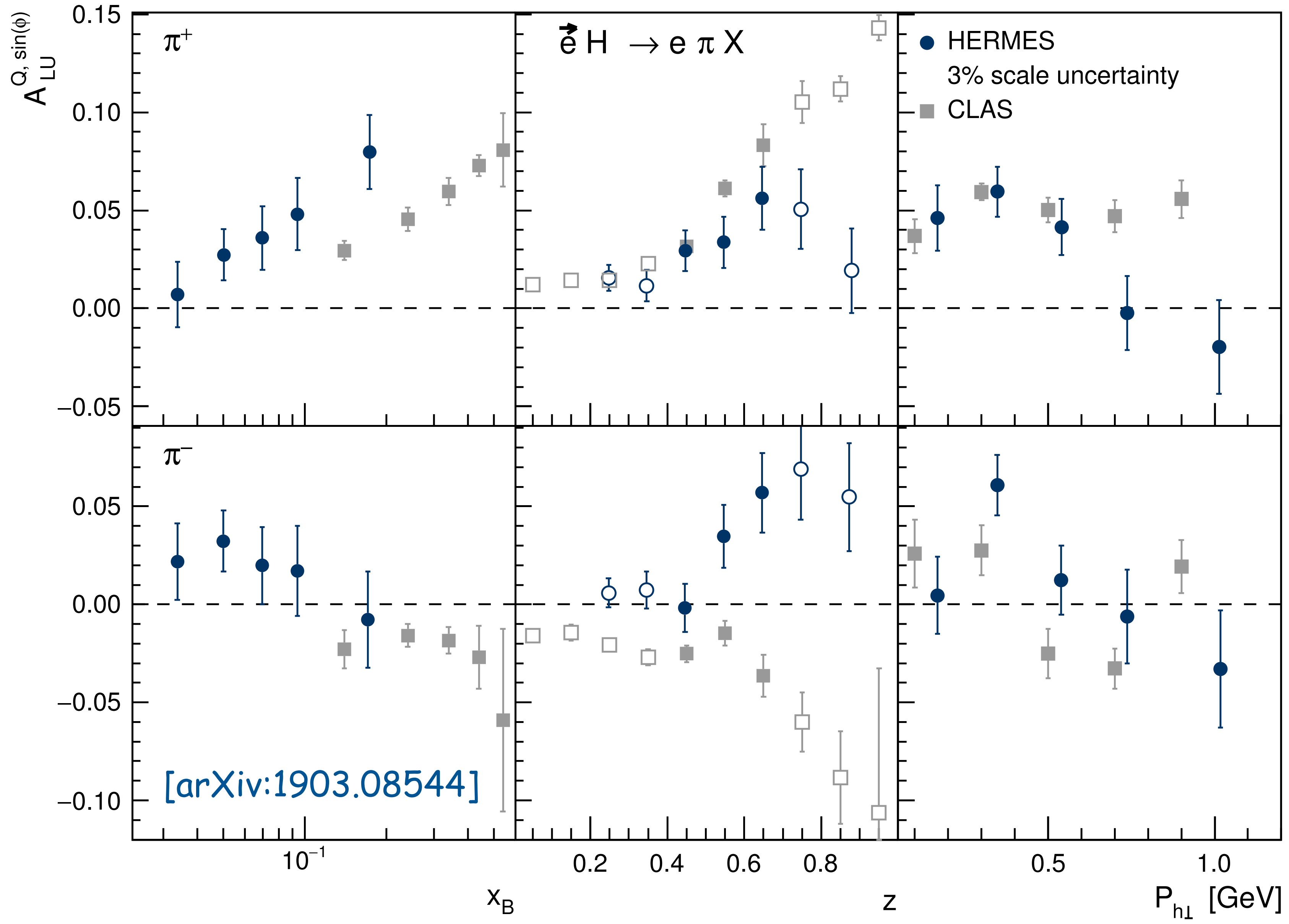

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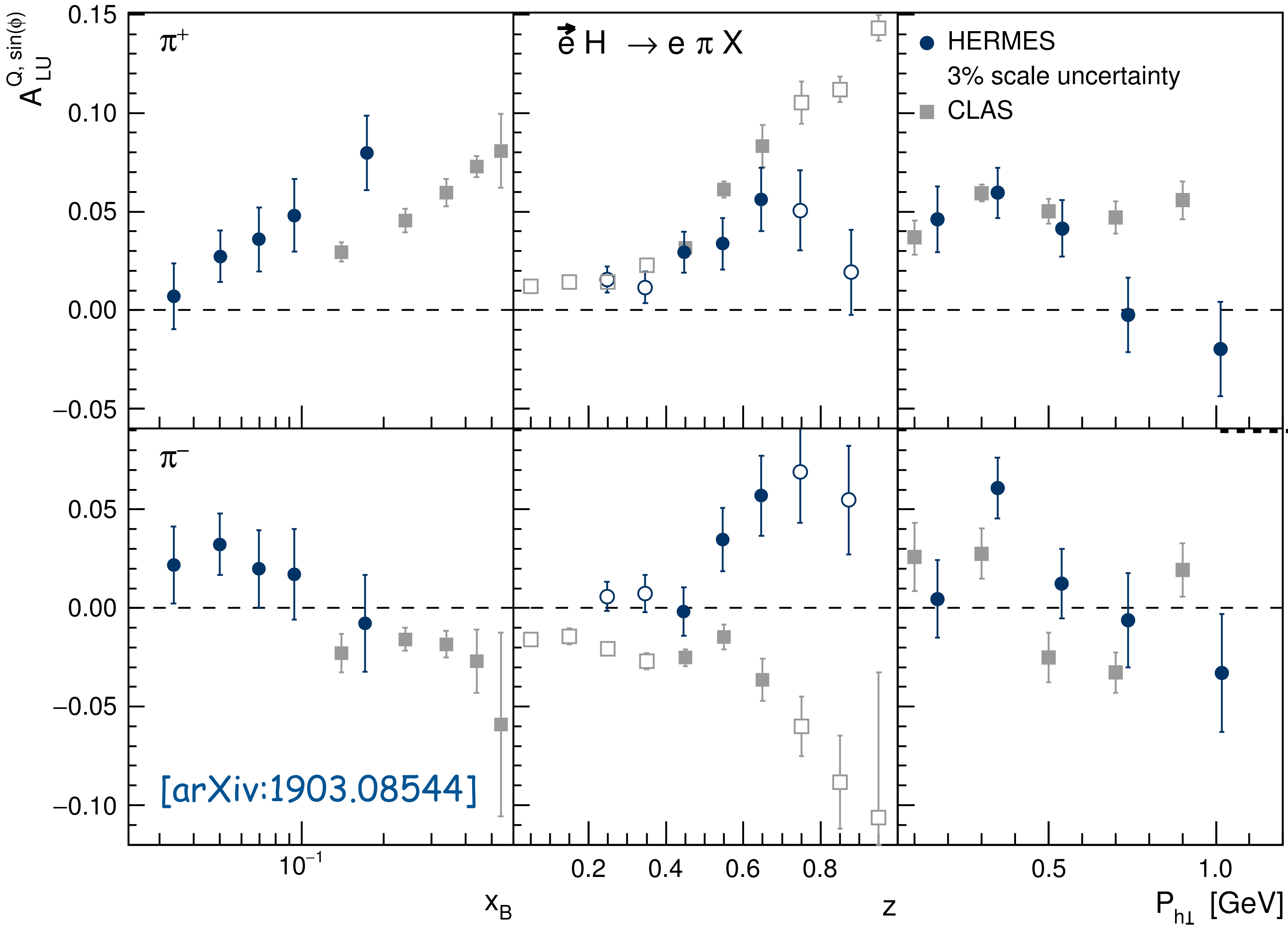
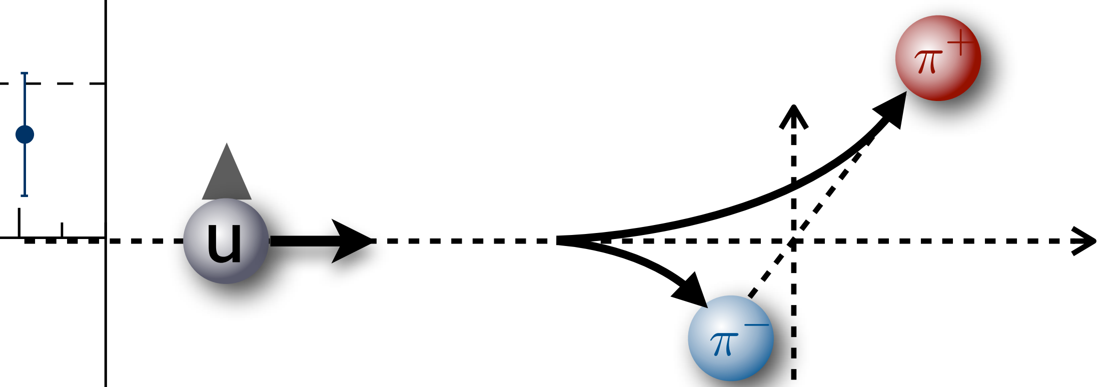
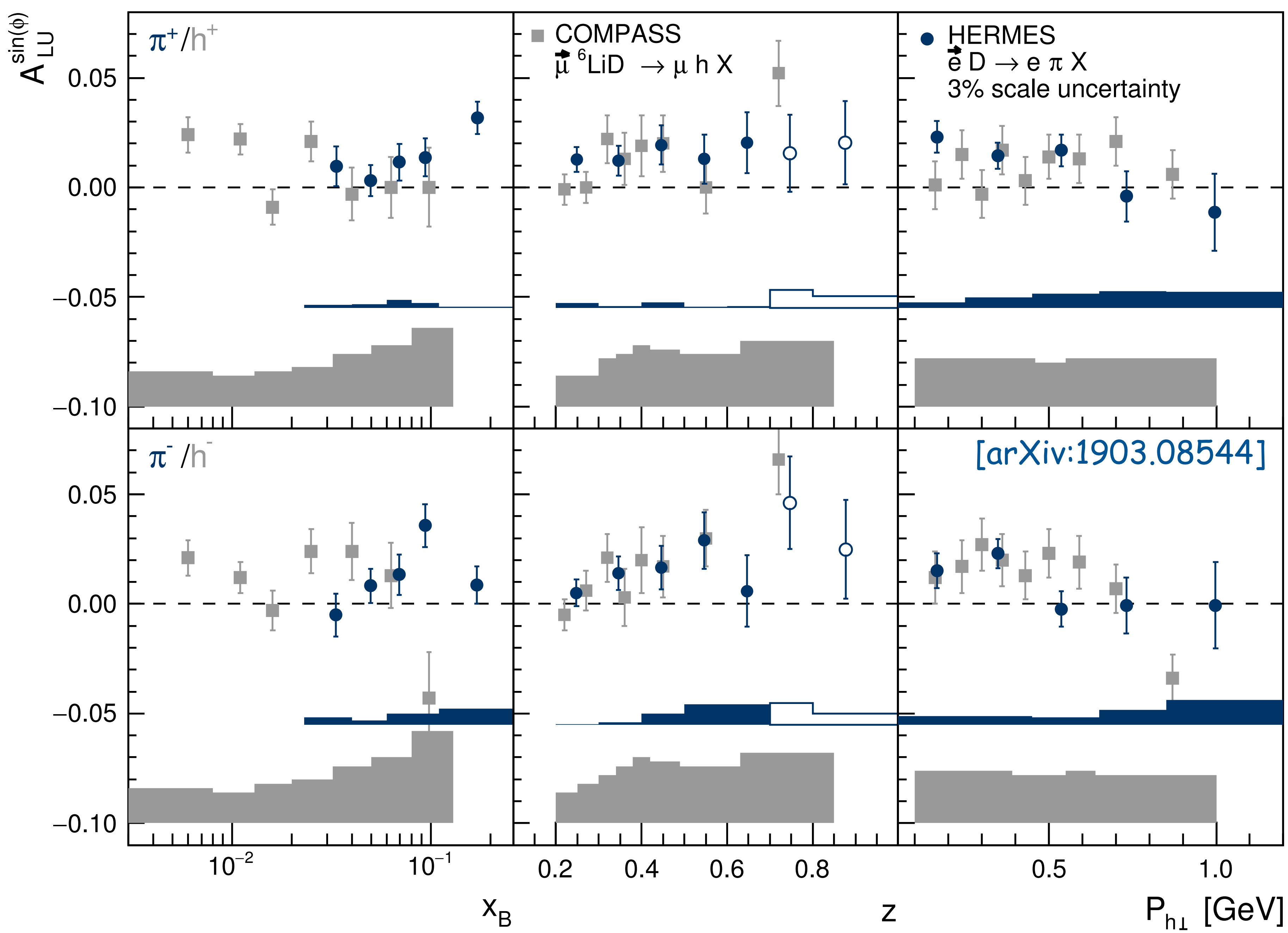




- opposite behavior at HERMES/CLAS of negative pions in z projection due to different x-range probed
- CLAS more sensitive to e(x)Collins term due to higher x probed?

HERMES - COMPASS comparison

$$\frac{M_h}{Mz} h_1^\perp \tilde{E} \oplus xg^\perp D_1 \oplus \frac{M_h}{Mz} f_1 \tilde{G}^\perp \oplus xeH_1^\perp$$



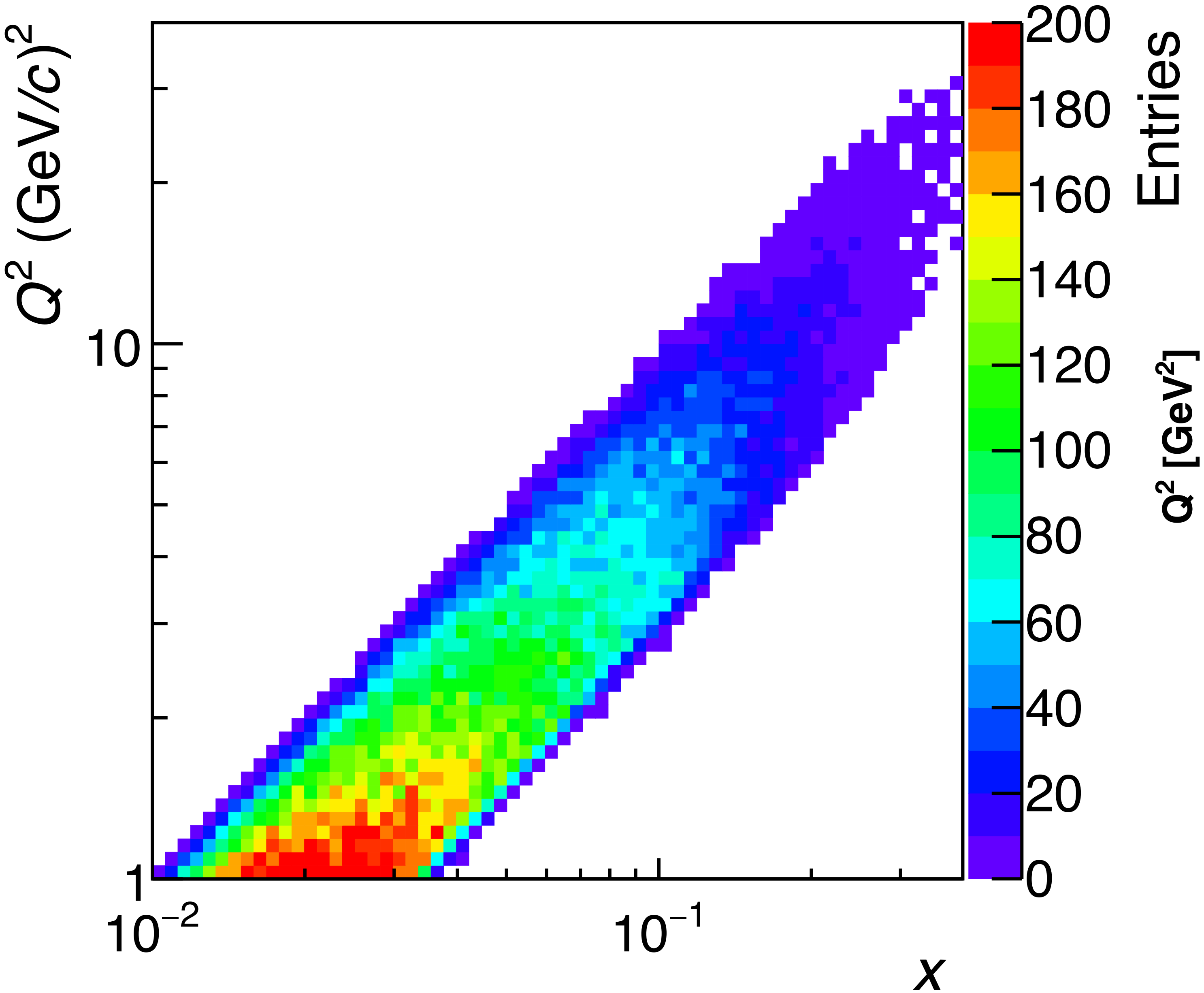
- consistent behavior for charged pions / hadrons at HERMES / COMPASS for isoscalar targets

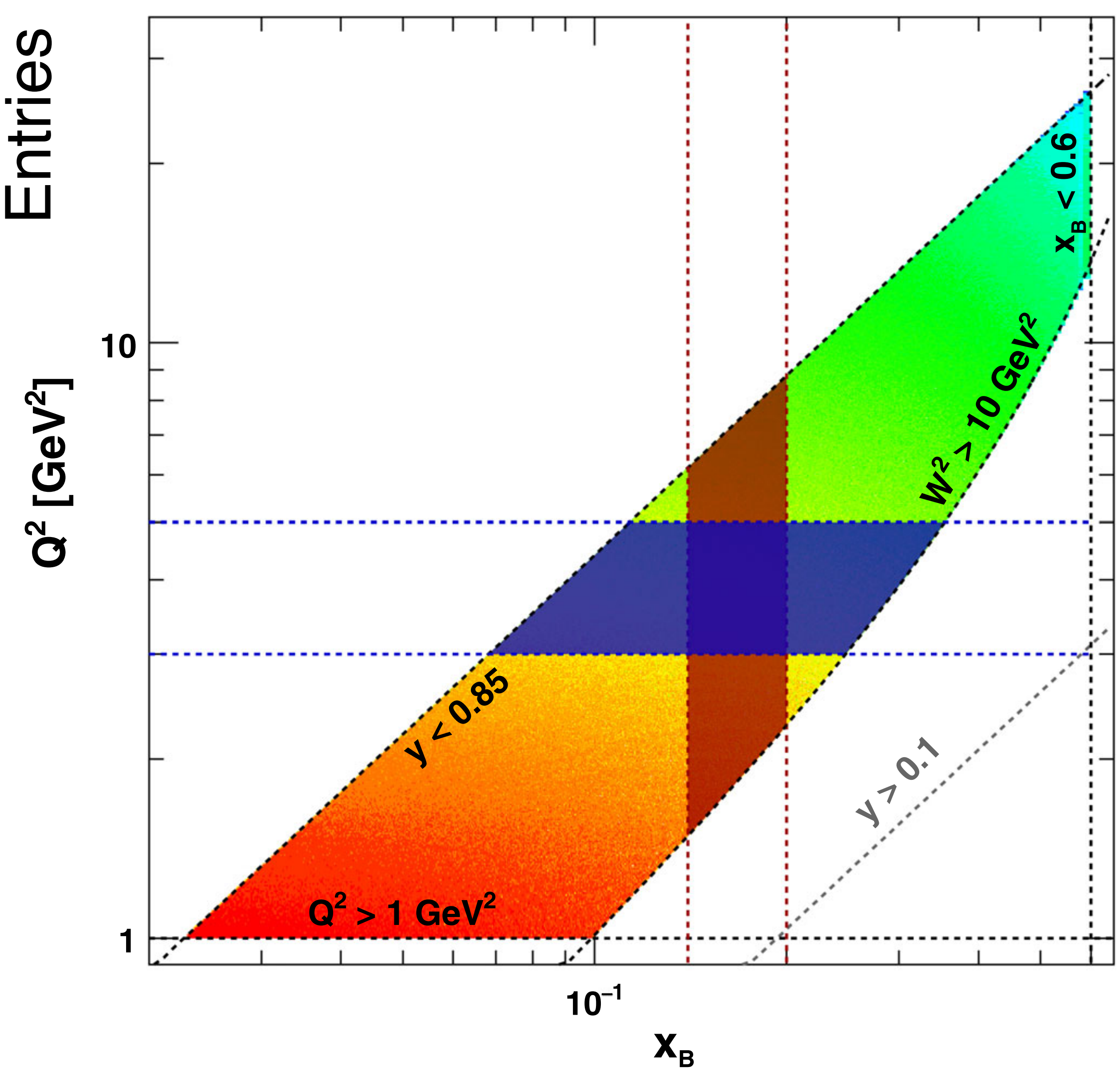
conclusions

- clearly non-zero beam-helicity asymmetries observed for charged pions and K^+
  - sizable twist-3 effects, in contrast to WW-type approx.
- intriguing kinematic dependences might shed light at different roles of the various terms contributing
  - high-x behavior might be driven by TMD e & Collins FF
- COMPASS and HERMES in agreement despite different Q^2 ranges probed
- (not shown:) sin2ϕ asymmetry, which could arise from 2-photon exchange, found to be consistent with zero

backup

kinematic coverage





- COMPASS
- HERMES