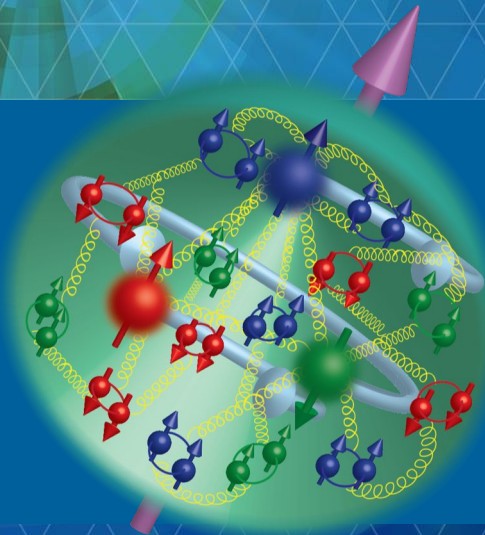


Multiplicities and spin asymmetries in SIDIS



Maria ŽUREK
Argonne National Laboratory, zurek@anl.gov

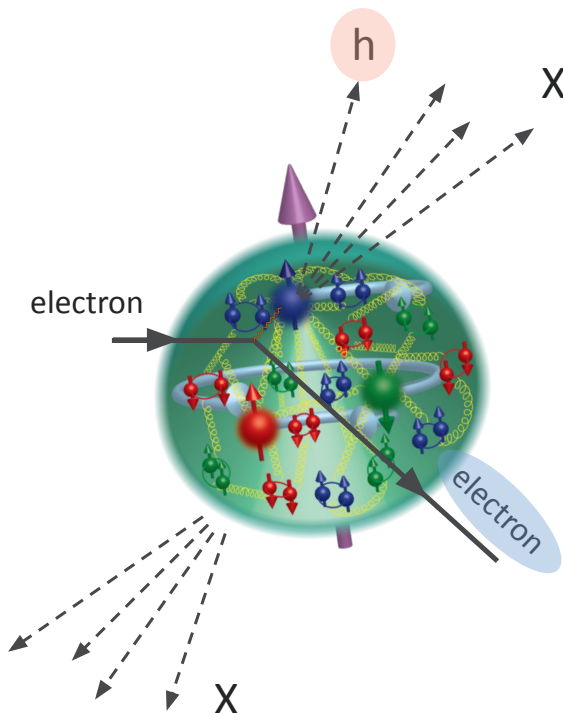
From 1D PDFs to multidimensional nucleon structure

Inclusive DIS

$$e + N \rightarrow e' + X$$

PDF

Access to longitudinal
parton momentum and
helicity structure



Semi-Inclusive DIS

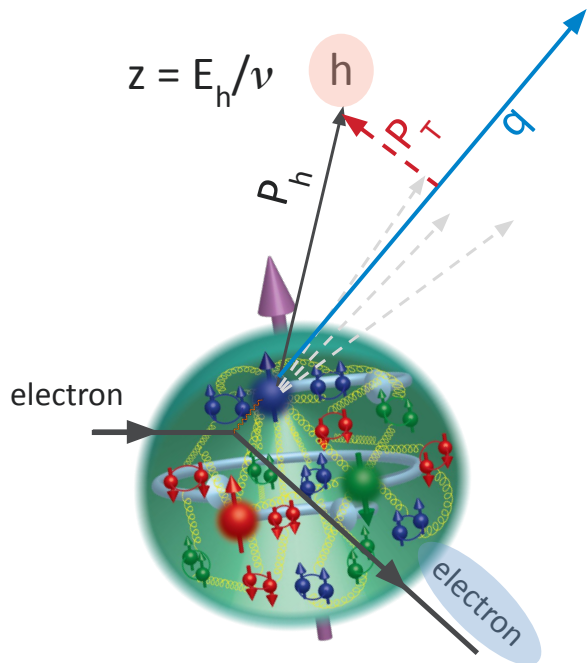
$$e + N \rightarrow e' + h + X$$

TMD PDF ⊗ FF

Access to flavor, transverse
momentum, spin–momentum
correlations and hadronization

SIDIS connects parton flavor, transverse motion, spin, and hadronization

SIDIS provides multiple handles on nucleon structure



x, Q^2 - hard-scattering DIS variables

z - fraction of the virtual-photon γ^* energy carried by the h

$\vec{P}_T$ - h transverse momentum relative to the γ^* direction

ϕ_h - hadron azimuthal angle

Semi-Inclusive DIS

$$e + N \rightarrow e' + h + X$$

Nucleon side: TMD PDFs $f(x, k_T)$

parton longitudinal momentum x + intrinsic transverse momentum k_T

Fragmentation side: fragmentation functions $D(z, p_\perp)$

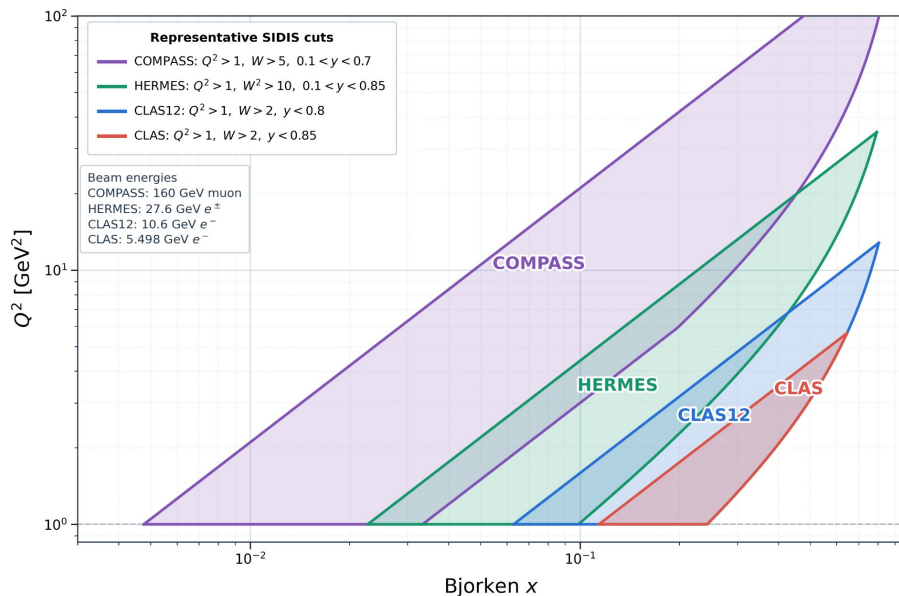
hadronization of the struck parton into the observed hadron

At Leading Order:

$$\vec{P}_T \simeq z \vec{k}_T + \vec{p}_\perp$$

SIDIS measurements across very different kinematics

Focus of this talk only on recent fixed-target results



Regions based on published SIDIS analysis selections. Acceptance, hadron cuts, and analysis specific x binning not included.

Jefferson Lab: Deep into the valence region with H/D and nuclear targets

CLAS: Large acceptance + multidimensionality

- Broad multidimensional coverage
- π , K and multi-hadron final states
- Unpolarized, beam-spin and polarized-target observables

Hall C: Focused precision measurements

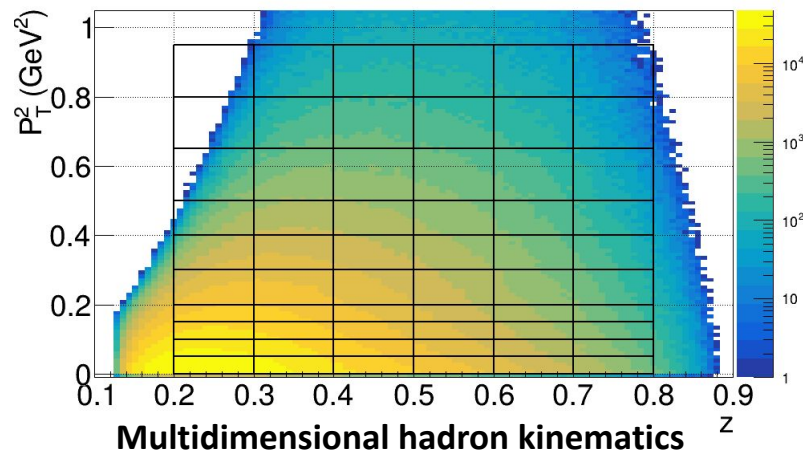
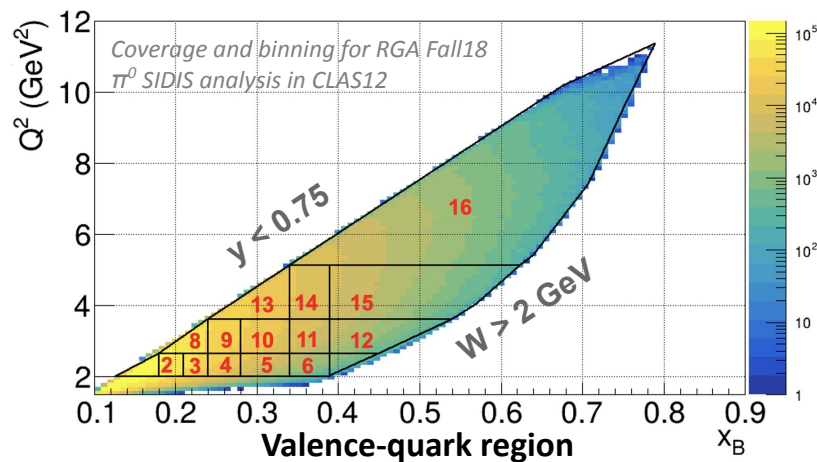
- Absolute SIDIS cross sections
- Targeted scans in z and PT
- Direct L/T separations

COMPASS: High-energy muon SIDIS

- Extends to much lower x
- Broad Q^2 and hadron kinematics
- π , K and unidentified charged hadrons
- Longitudinal and transverse target polarization

Together, these experiments test SIDIS over complementary x , Q^2 , PT , flavor and polarization regimes.

SIDIS deep in the valence region - CLAS12 Example



10.6 GeV polarized e^- | high luminosity + large acceptance identified π , K, ... | polarized + unpolarized H/D targets

Large acceptance and high statistics enable multidimensional SIDIS measurements across the valence region

Mapping the SIDIS Cross Section

U = unpolarized, L = longitudinal; kinematic prefactors suppressed, transverse-target terms omitted from the equation for clarity.
Dihadron SIDIS: analogous structure with additional ϕ_R modulations

$$d\sigma \sim F_{UU} + \cos \phi_h F_{UU}^{\cos \phi_h} + \cos 2\phi_h F_{UU}^{\cos 2\phi_h} + \lambda_e \sin \phi_h F_{LU}^{\sin \phi_h} + S_L \left[\sin \phi_h F_{UL}^{\sin \phi_h} + \lambda_e \left(F_{LL} + \cos \phi_h F_{LL}^{\cos \phi_h} \right) \right] + \dots$$



Unpolarized Yield Multiplicities

transverse momentum +
fragmentation



Unpolarized Azimuthal Modulations

transverse-momentum
correlations



Beam Spin Asymmetries

twist-3 + spin-dependent
fragmentation



Polarized-target observables

Longitudinal target: h_L , helicity
TMD g_{1L} , twist-3 fragmentation

Transverse target: transversity,
Sivers and other TMD
spin-momentum correlations

Different beam/target polarizations and hadron final states isolate complementary pieces of nucleon structure and fragmentation.

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π^0 multiplicities probe transverse dynamics

$$M^{\pi^0}(x, Q^2, z, P_T^2) = \frac{d^4 \sigma^{ep \rightarrow e' \pi^0 X} / dx dQ^2 dz dP_T^2}{d^2 \sigma^{ep \rightarrow e' X} / dx dQ^2}$$

differential hadron yield per DIS event
→ probability to produce a hadron (π^0) per DIS event

ϕ_h integrated after acceptance correction

$$F_{UU,T} \sim \mathcal{C}[f_1(x, k_T) D_1(z, p_\perp)]$$

Leading-power TMD picture
at low P_T

z-dependence: Fragmentation + k_T lever arm

Strong sensitivity to fragmentation
→ constraints fragmentation functions

Controls how intrinsic k_T maps into the observed P_T

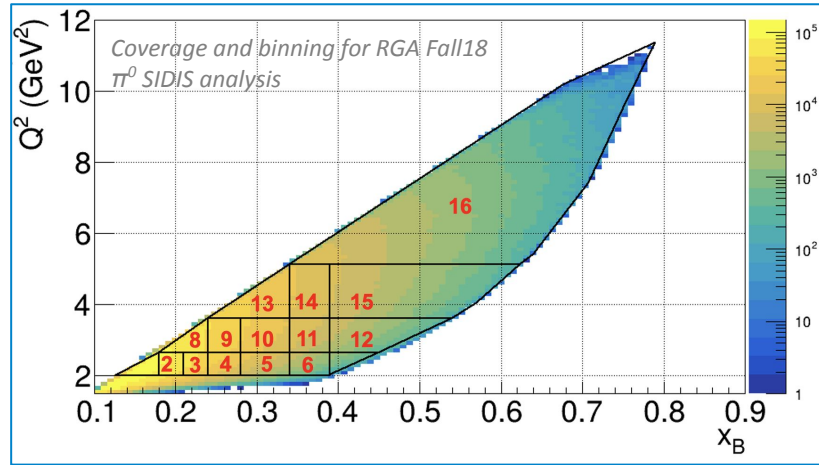
P_T -dependence: Transverse-Momentum Dynamics

P_T receives contributions from both
intrinsic parton k_T and fragmentation $p_\perp$

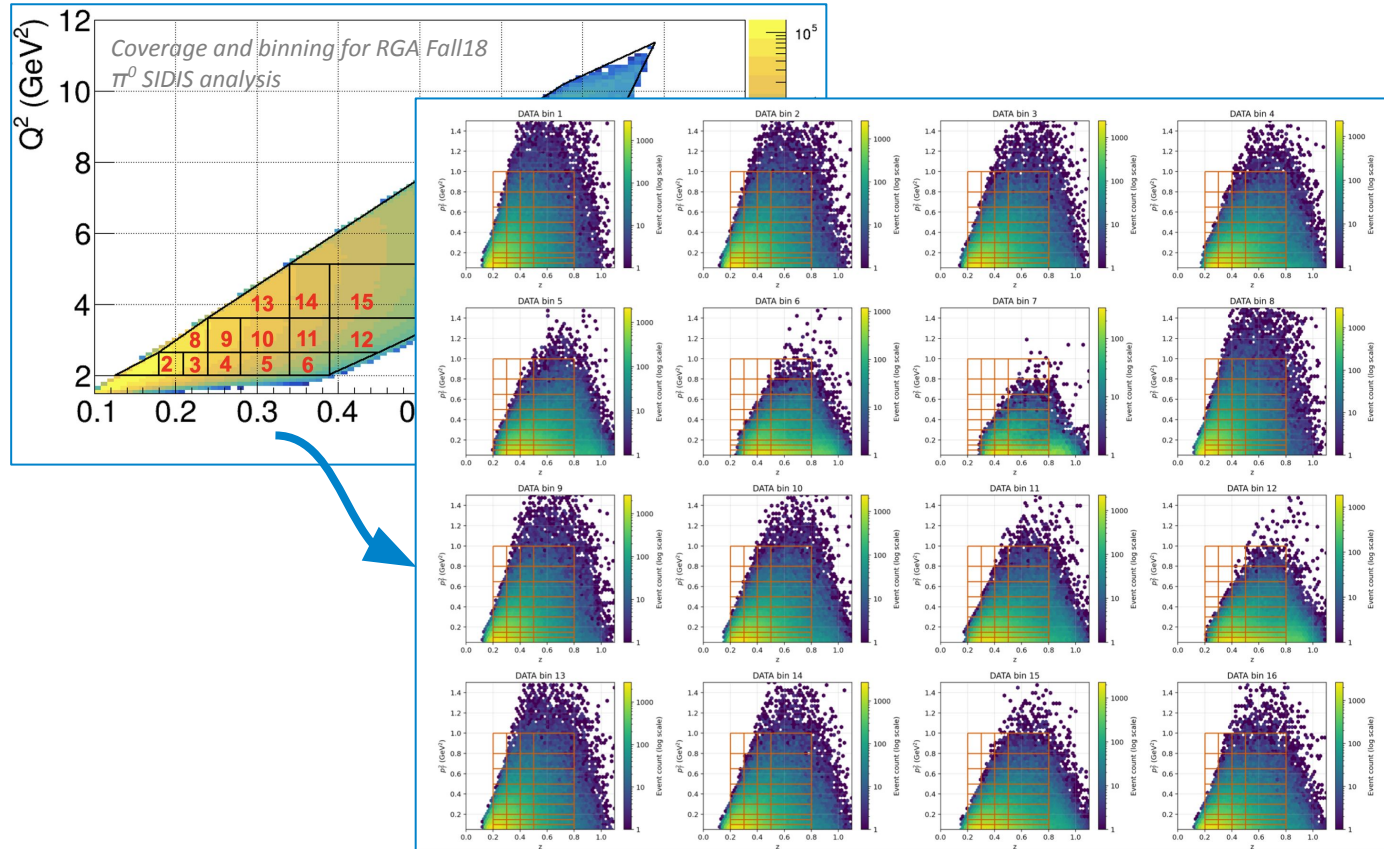
$$\vec{P}_T \simeq z \vec{k}_T + \vec{p}_\perp$$

The combined z- P_T dependence helps constrain transverse momentum in the nucleon and in fragmentation

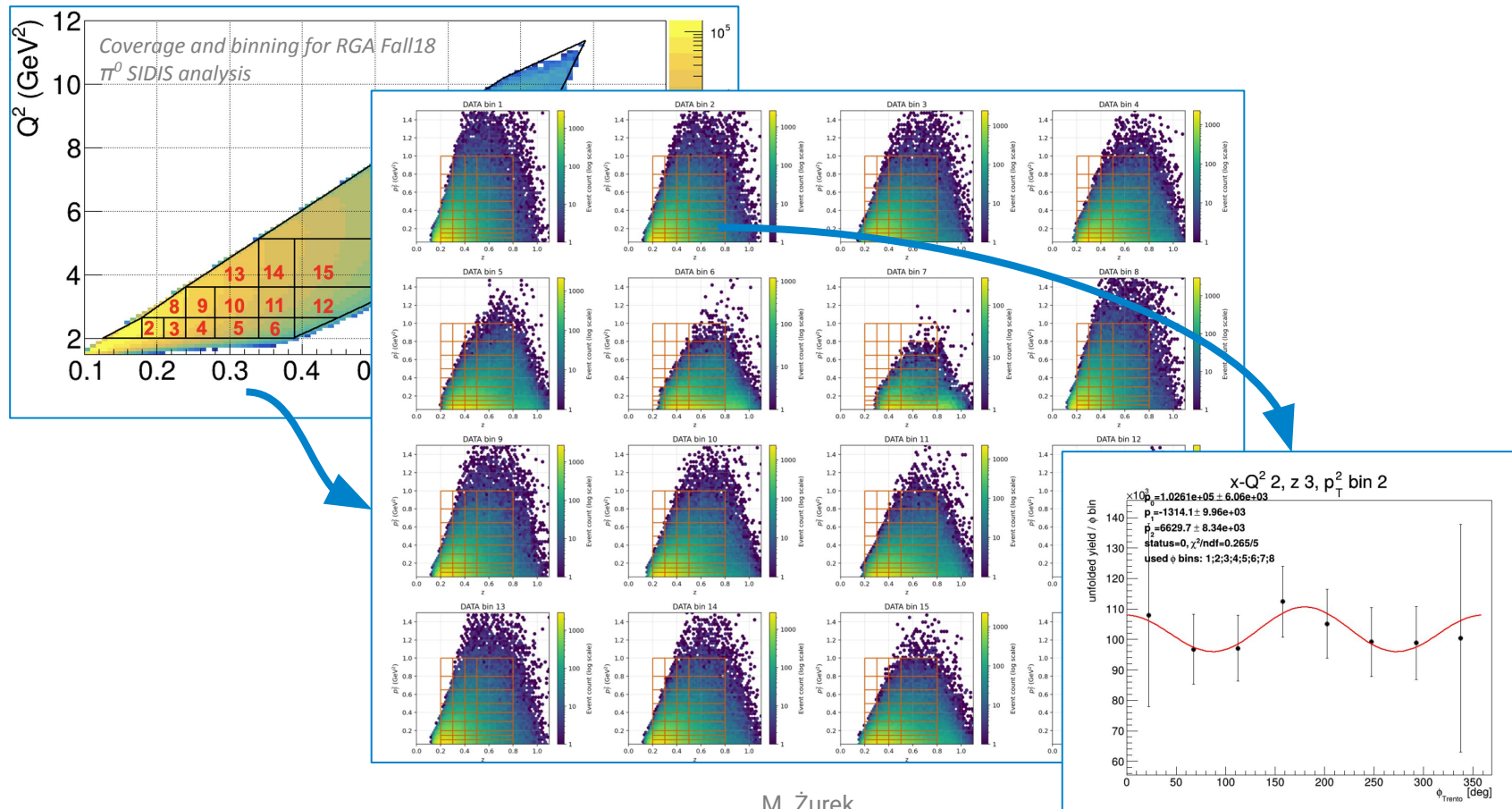
5D corrections preserve the SIDIS structure



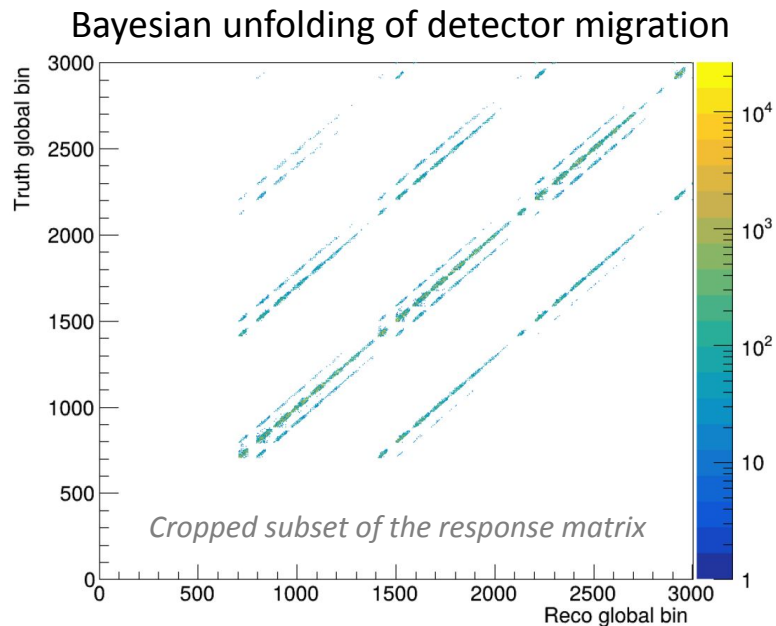
5D corrections preserve the SIDIS structure



5D corrections preserve the SIDIS structure



5D corrections preserve the SIDIS structure



Corrections in $(x, Q^2, z, P_T^2, \phi_h)$

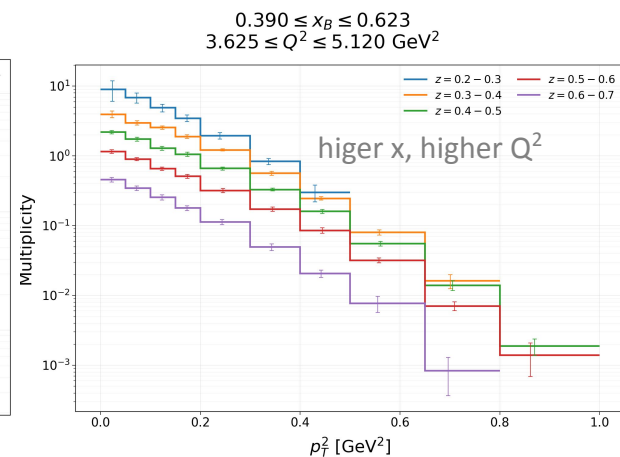
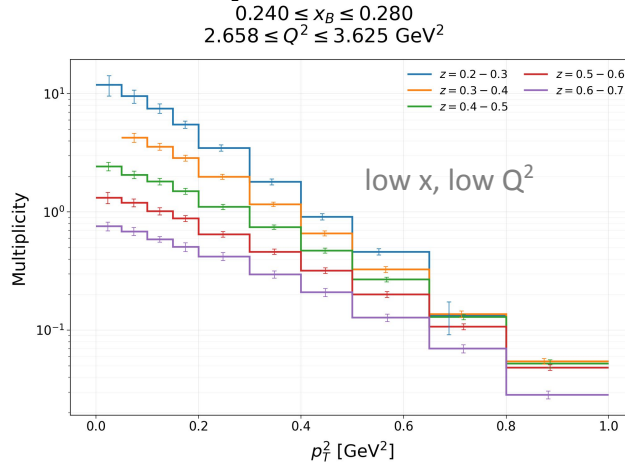
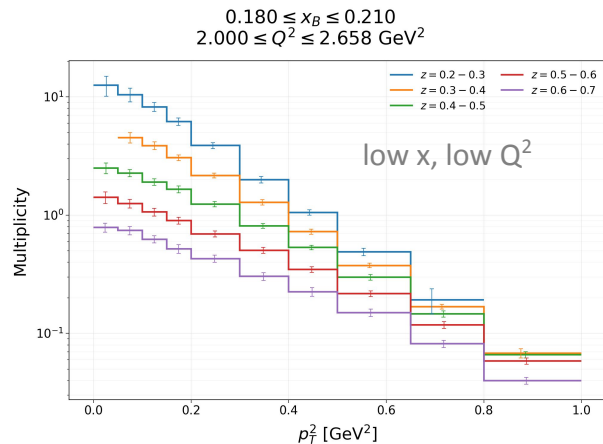
- acceptance + efficiency correction
- bin migration/unfolding
- radiative corrections
- ϕ_h corrected before integration

$W > 2 \text{ GeV}, Q^2 > 2 \text{ GeV}^2, y < 0.75, M_X > 1.5 \text{ GeV}$

Multidimensional corrections account for acceptance and migration across the full SIDIS phase space.

Multiplicities reveal the P_T structure

V. Klimenko, JLab HiLumi26



$$M^{\pi^0}(P_T^2) \sim \exp \left[-\frac{P_T^2}{\langle P_T^2 \rangle} \right]$$

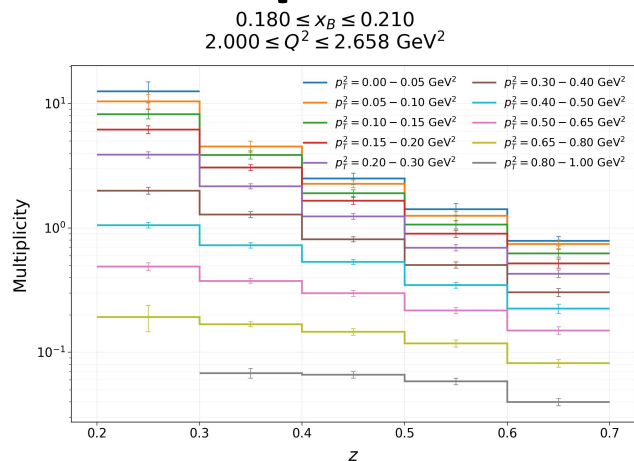
*Gaussian approximation,
low-to-moderate P_T*

- Approximately exponential P_T^2 dependence over much of the measured phase space
- Shape evolves with z and (x, Q^2)
- High- z , high- P_T^2 bins increasingly approach $M_x > 1.5 \text{ GeV}$ fiducial boundary

The P_T^2 dependence probes transverse dynamics, across a broad range of valence kinematics.

The z dependence tests fragmentation

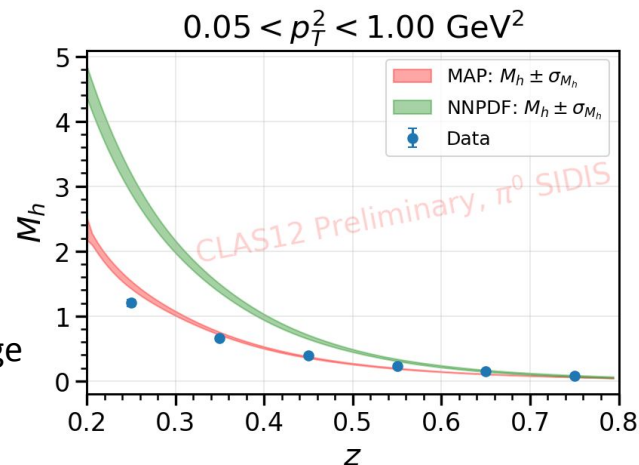
V. Klimenko, JLab HiLumi26



$$\int dP_T^2$$

integrate over a common
 P_T^2 range with full z coverage

Several P_T^2 slices shown as a function of z



P_T^2 -integrated multiplicity vs z

$$\frac{dM^{\pi^0}}{dz} \sim \frac{\sum_q e_q^2 f_1^q(x, Q^2) D_1^{q \rightarrow \pi^0}(z, Q^2)}{\sum_q e_q^2 f_1^q(x, Q^2)}$$

LO for illustration

- After P_T^2 integration, the z dependence is primarily sensitive to flavor-weighted fragmentation functions
- Data trend is closer to MAPFF, which includes SIDIS multiplicity data

Hall C adds precision charged-pion multiplicities

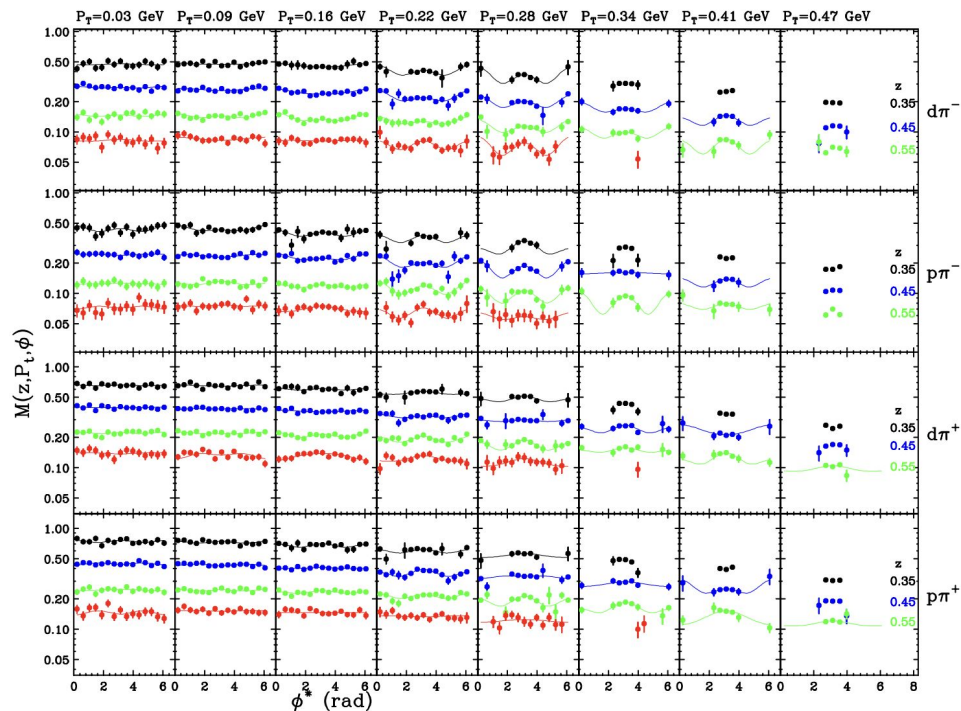
- π^+ and π^- multiplicities on H and D
- Targeted scans in z , P_T and ϕ
- Precision charge and target comparisons
- Sensitive to flavor-dependent fragmentation

Complementary to CLAS12:

focused settings + tight control of systematics

- Similar P_T dependence across all four channels
- Gaussian width grows strongly with z
- $\cos\phi_h$: $\pi^+ < 0$ while π^- often significantly > 0
- $\cos 2\phi_h$: consistent with zero

Phys.Rev.C 113 (2026) 3, 035205



I) $x=0.31$, $Q^2=3 \text{ GeV}^2$ II) $x=0.30$, $Q^2=4.1 \text{ GeV}^2$ III) $x=0.45$, $Q^2=4.5 \text{ GeV}^2$

COMPASS multiplicities at lower x and higher energy

- $h^\pm$, $\pi^\pm$ and $K^\pm$ final states with 160 GeV muon beam
- Much lower x than JLab
- Multidimensional in x, Q^2 , z and P_T

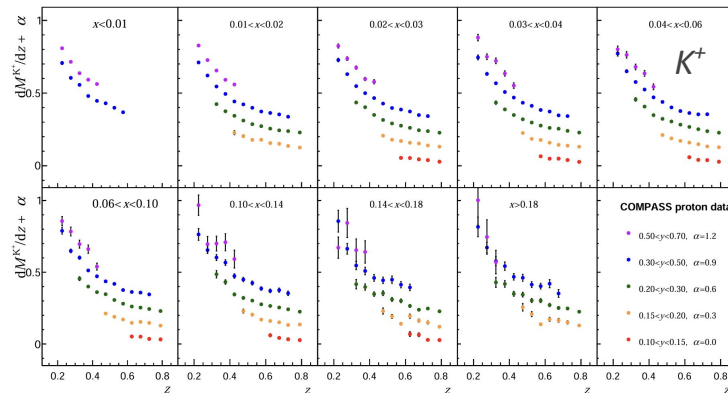
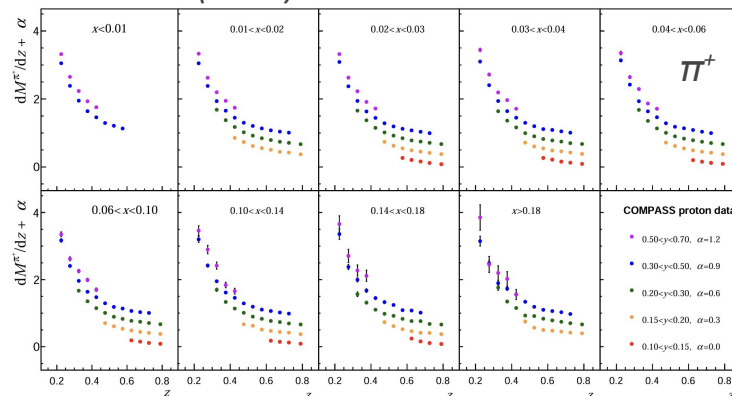
Precision requires major corrections

- radiative effects + PID / acceptance
- diffractive ρ^0 and ϕ production can be sizable

Recent developments

- Published ^6LiD multiplicities; 2016 proton results with updated DJANGO radiative corrections
- Up to 12% shifts relative to the earlier radiative treatment
- P_T -dependent proton results from the 2016 data are preliminary

PRD 112 (2025) 012002



Hall C separation of longitudinal and transverse SIDIS

$$F_{UU} = F_{UU,T} + \epsilon F_{UU,L}, \text{ with } R_{\text{SIDIS}} = F_{UU,L} / F_{UU,T}$$

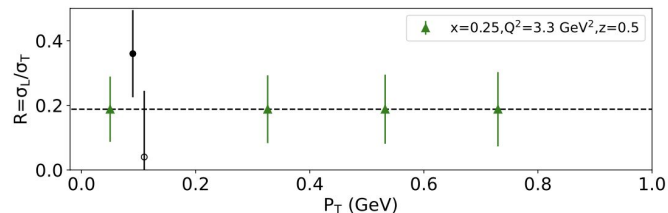
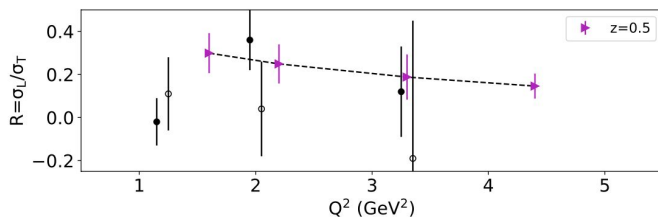
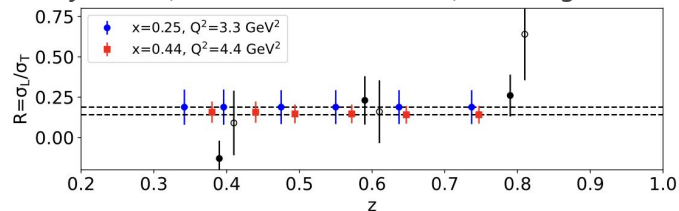
Why it matters?

- R_{SIDIS} is often assumed to follow R_{DIS}
- Experimentally, this has been essentially untested
- SIDIS dynamics can introduce dependence on z , P_T , hadron charge and target

New Hall C program: E12-06-104 - data taken 2025–2026

- Rosenbluth L/T separation for charged pions
- $Q^2=1.6\text{--}4.4 \text{ GeV}^2$
- dedicated x scans at $x=0.25$ and 0.44
- P_T dependence up to $\sim 0.8 \text{ GeV}$
- H and D comparisons

Projections, Source: Dave Gaskell, JLab HighLumi 26



A direct L/T separation tests an assumption that enters many SIDIS interpretations

Azimuthal modulations probe transverse dynamics

Unpolarized Yield Azimuthal Moments

$$\frac{d\sigma_{UU}}{d\phi_h} = A_0 \left[1 + A_{UU}^{\cos \phi_h} \cos \phi_h + A_{UU}^{\cos 2\phi_h} \cos 2\phi_h \right]$$

$$F_{UU}^{\cos \phi_h} \sim \underbrace{\frac{k_T}{Q} f_1 \otimes D_1}_{\text{Cahn / kinematic}} + \underbrace{\text{other twist-3 contributions}}_{\text{dynamical}}$$

$\cos \phi_h$ modulation

Twist-3 suppressed by $1/Q$

$$F_{UU}^{\cos 2\phi_h} \sim \underbrace{h_1^\perp \otimes H_1^\perp}_{\text{Boer--Mulders} \otimes \text{Collins}} + \dots$$

$\cos 2\phi_h$ modulation

Leading twist (twist-2)

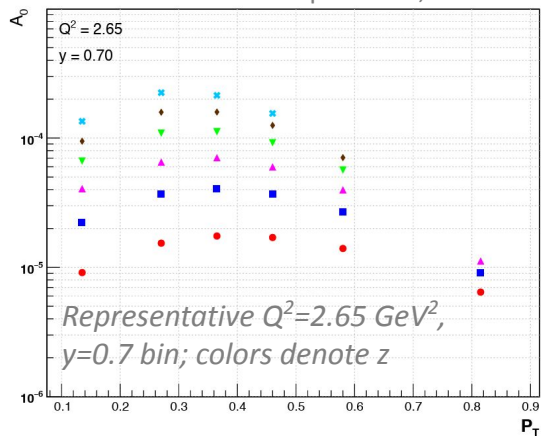
- Sensitive to intrinsic transverse momentum and twist-3 dynamics
- Probes transverse quark spin–momentum correlations

Complementary probes of transverse momentum and spin–momentum correlations

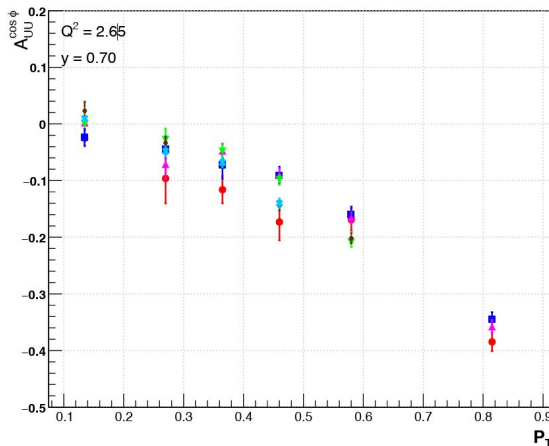
First multidimensional azimuthal moments from CLAS12

CLAS12 Preliminary — A_0

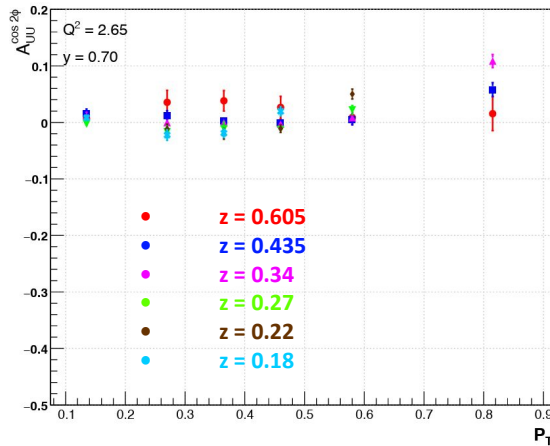
R. Capobianco, DNP26



CLAS12 Preliminary — $A_{UU}^{\cos \phi}$



CLAS12 Preliminary — $A_{UU}^{\cos 2\phi}$



5D extraction: 455 (Q^2 , y , z , P_T) bins x 24 ϕ_h bins with unfolding, Radiative Correction, and VM subtraction

$\cos \phi_h$: Strong P_T dependence; magnitude grows toward larger P_T

$\cos 2\phi_h$: Generally small; structure becomes visible primarily at larger P_T

Mapping the SIDIS Cross Section

U = unpolarized, L = longitudinal; kinematic prefactors suppressed, transverse-target terms omitted from the equation for clarity.
 Dihadron SIDIS: analogous structure with additional ϕ_R modulations

$$d\sigma \sim F_{UU} + \cos \phi_h F_{UU}^{\cos \phi_h} + \cos 2\phi_h F_{UU}^{\cos 2\phi_h} + \lambda_e \sin \phi_h F_{LU}^{\sin \phi_h} + S_L \left[\sin \phi_h F_{UL}^{\sin \phi_h} + \lambda_e \left(F_{LL} + \cos \phi_h F_{LL}^{\cos \phi_h} \right) \right] + \dots$$



Unpolarized Yield Multiplicities

transverse momentum +
fragmentation

Unpolarized Azimuthal Modulations

transverse-momentum
correlations

Beam Spin Asymmetries

twist-3 + spin-dependent
fragmentation

Polarized-target observables

Longitudinal target: h_L , helicity
TMD g_{1L} , twist-3 fragmentation

Transverse target: transversity,
Sivers and other TMD
spin-momentum correlations

Different beam/target polarizations and hadron final states isolate complementary pieces of nucleon structure and fragmentation.

Beam-spin asymmetries probe twist-3 dynamics

Longitudinally polarized beam, unpolarized target

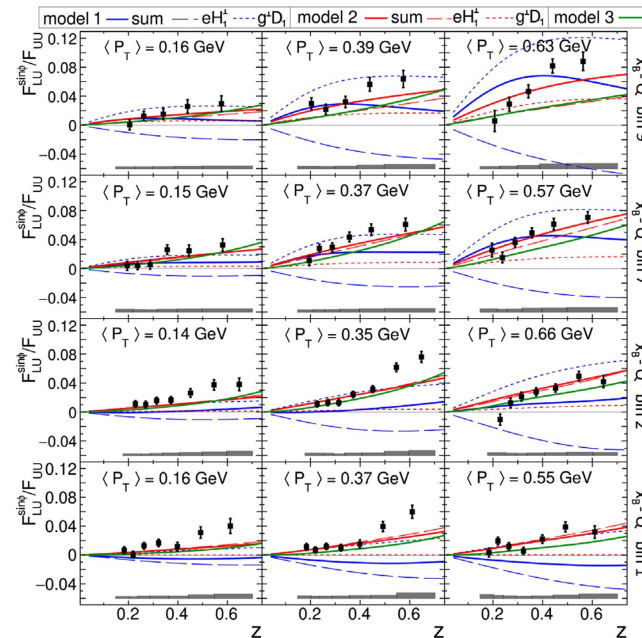
$$A_{LU}(\phi_h) \propto \sin \phi_h \frac{F_{LU}^{\sin \phi_h}}{F_{UU}}$$

twist-3 observable: sensitive to quark–gluon correlations and nonperturbative QCD dynamics

$$F_{LU}^{\sin \phi_h} \sim e \otimes H_1^\perp + g^\perp \otimes D_1 + f_1 \otimes \tilde{G}^\perp + h_1^\perp \otimes \tilde{E}$$

- Strong z and P_T dependence evolves across x and Q^2
→ multidimensional information is essential
- Hadronic feed-down, including vector-meson contributions, is an important part of the interpretation

CLAS12, S. Diehl et al., PRL 128, 062005 (2022)



π^+ BSA, one of the first CLAS12
multidimensional SIDIS measurements

344 multidimensional bins in (Q^2, x, z, P_T)

Kaons probe different fragmentation dynamics

Same observable, different hadronization channel

Changing the hadron probes different fragmentation dynamics

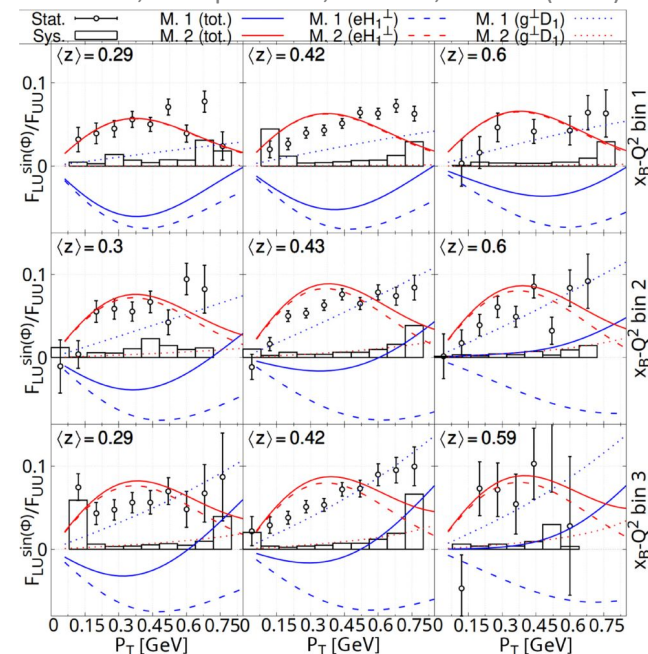
Models 1–2: spectator-diquark calculations with $eH_1^\perp + g^\perp D_1$; different axial-vector diquark treatment

- **Model 2 reproduces the sign and main trends at low–moderate P_T , but is challenged at larger P_T**

- K^+ asymmetries show clear multidimensional kinematic dependence
- Comparison with π^+ probes hadron-dependent fragmentation and reaction mechanisms

Hadronic feed-down is final-state dependent and enters the quantitative interpretation.

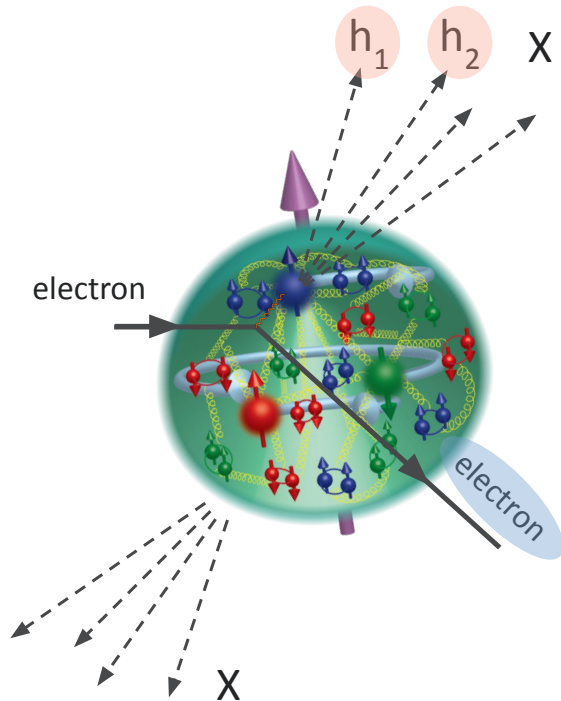
CLAS12, A. Kripko et al., PRC 112, 055202 (2025)



First multidimensional K^+ BSA in the valence region

3 Q^2 - x regions with multidimensional (P_T, z) binnig

Dihadrons open different access to quark correlations



$$P_h = P_1 + P_2, \quad R \sim P_1 - P_2$$

$$M_{hh}, \quad \varphi_R$$

Detecting two hadrons provides an additional internal degree of freedom: the relative momentum R and its azimuthal angle φ_R

$$F_{LU}^{\sin \phi_R} \propto \frac{M}{M_{hh}} x e(x) H_1^{\lessdot}(z, M_{hh}) + \frac{1}{z} f_1(x) \tilde{G}^{\lessdot}(z, M_{hh})$$

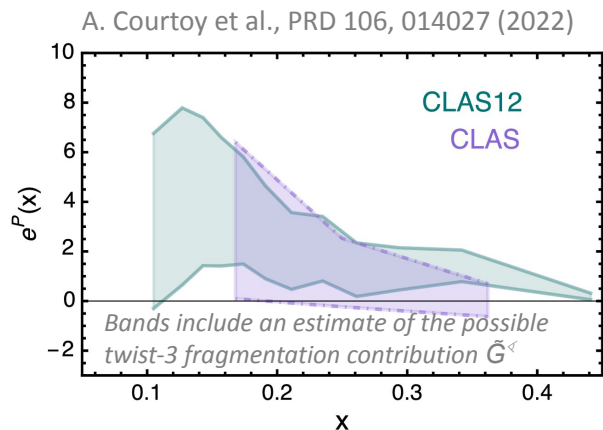
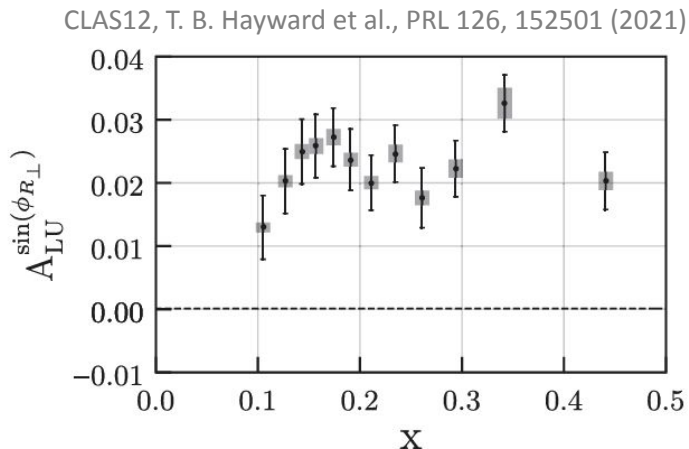
$H_1^{\lessdot}$: chiral-odd interference fragmentation function, known from Belle
→ provides a chiral-odd partner for the twist-3 distribution $e(x)$

$$F_{LU}^{\sin(\phi_h - \phi_{R\perp})} \propto f_1(x) \otimes G_1^{\perp}(z, M_{hh})$$

$G_1^{\perp}$: helicity-dependent dihadron fragmentation function
→ spin correlations generated during fragmentation

Dihadrons probe the internal dynamics of fragmentation while different angular modulations provide distinct access to nucleon structure

First point-by-point extraction of the twist-3 PDF $e(x)$



CLAS12 provided the high-precision BSA input $\rightarrow$ First point-by-point extraction of $e(x)$

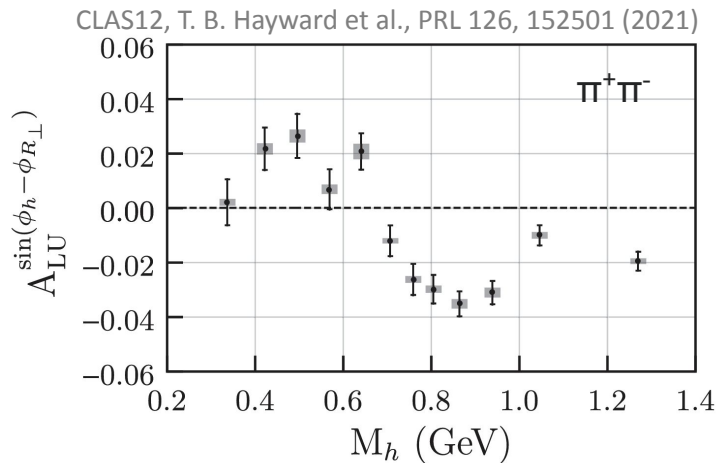
- CLAS12 result favors $e^P(x) > 0$ with $\sim 93\%$ probability

$e(x)$: chiral-odd twist-3 PDF probing quark–gluon correlations and the scalar quark structure of the nucleon

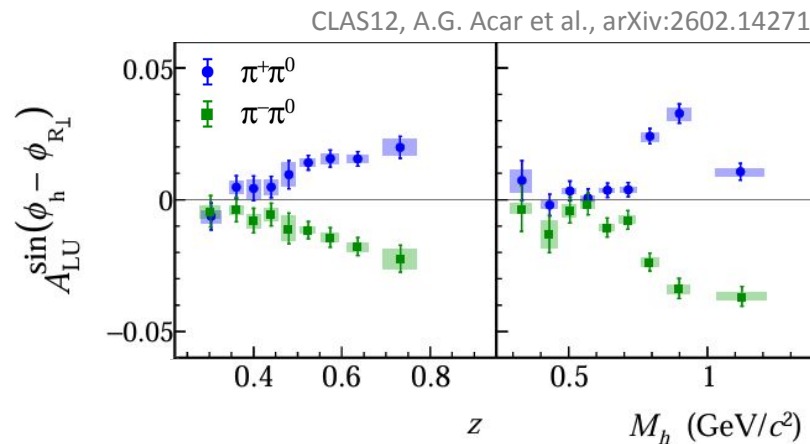
Dihadron SIDIS provides comparatively clean collinear access to $e(x)$, with substantially fewer competing structures than single-hadron SIDIS

Spin-dependent dihadron fragmentation

$G_1^\perp$ correlates quark helicity with the orientation of the hadron pair



- First measurement sensitive to $G_1^\perp$
- M_{hh} dependence, with sign change near the ρ , predicted by spectator models



- Opposite signs for $\pi^+\pi^0$ and $\pi^-\pi^0$
- First experimental evidence for isospin dependence of $G_1^\perp$

Changing the hadron pair reveals the isospin structure of spin-dependent fragmentation

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Longitudinal target spin asymmetries open access to $h_L(x)$

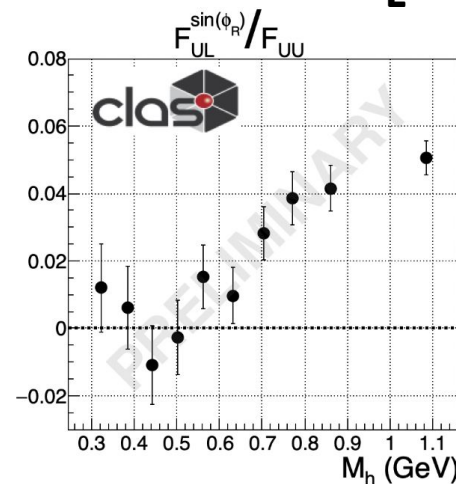
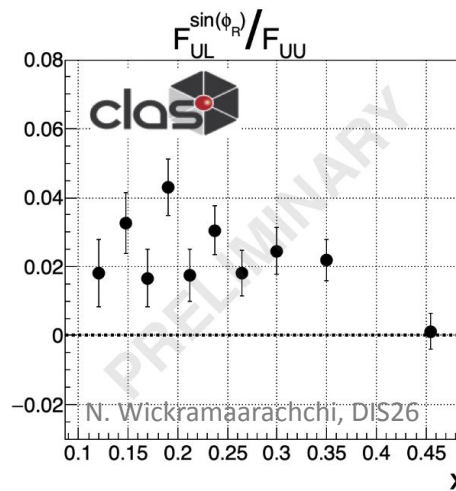
Same dihadron analyzer - different twist-3 PDF

beam spin: $F_{LU}^{\sin\phi_R} \rightarrow$ sensitive to $e(x)H_1^\perp + \dots$

target spin: $F_{UL}^{\sin\phi_R} \rightarrow$ sensitive to $h_L(x)H_1^\perp + \dots$

$h_L(x)$ - chiral-odd twist-3 PDF

- x^3 moment related to the longitudinal gradient of the transverse color force on a transversely polarized quark
- no published experimental extraction yet



CLAS12 Preliminary dipion F_{UL}/F_{UU}
Nonzero positive $\sin\phi_R$ target-spin amplitude

The same dihadron analyzer used to access $e(x)$ now provides sensitivity to the twist-3 $h_L(x)$

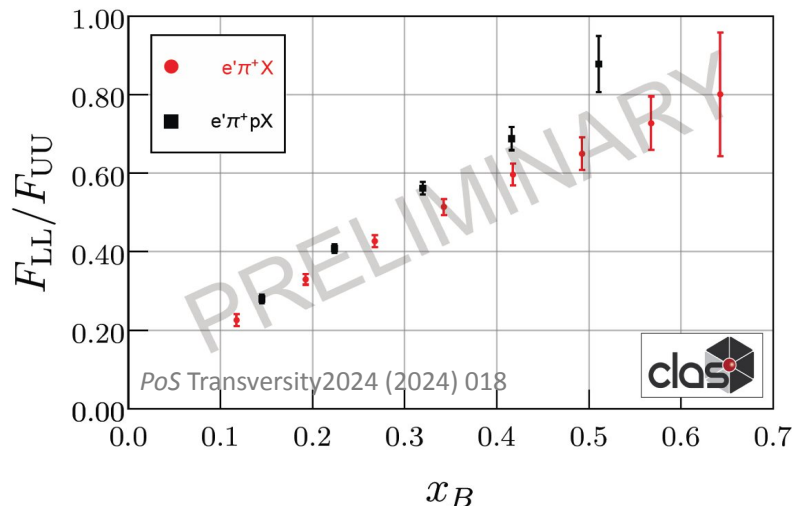
A_{LL} maps helicity in transverse momentum

Longitudinal double-spin asymmetry

$$F_{LL} \sim g_{1L}(x, k_T) \otimes D_1(z, p_\perp)$$

Sensitivity to **helicity TMD**

- difference between quarks with helicity aligned and anti-aligned with the proton spin
- P_T dependence tests whether **polarized quarks have different transverse motion**



CLAS12 Preliminary $\pi^+ F_{LL}/F_{UU}$
Strong rise with x in the valence region

Important experimental control: removing ρ contributions increases A_{LL} by up to ~15% in some kinematics

$A_{LL}(P_T)$ connects the proton's helicity structure to the transverse motion of its quarks

Double-spin dihadrons constrain twist-3 fragmentation

$$A_{LL}(\phi_R) = A_{LL}^{\text{const}} + A_{LL}^{\cos \phi_R} \cos \phi_R + \dots$$

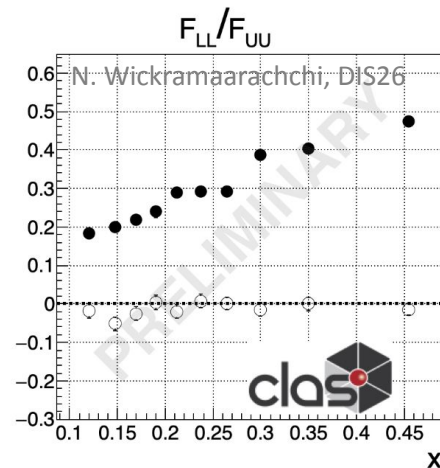
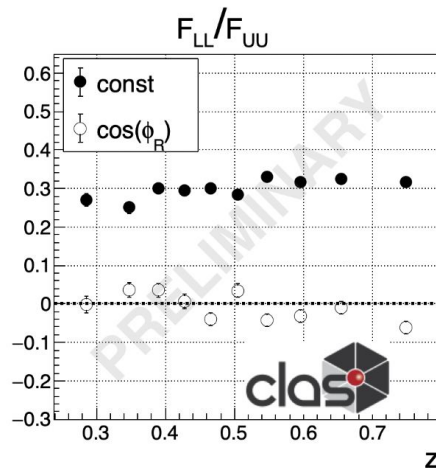
Angle-independent term - leading twist

$$F_{LL}^{\text{const}} \sim g_{1L} D_1$$

Cos modulation - Twist-3 FF

$$F_{LL}^{\cos \phi_R} \sim g_{1L} \tilde{D}$$

Comparing the two amplitudes
constrains the relative size of D_1 to $\tilde{D}$



CLAS12 Preliminary di pion F_{LL}/F_{UU}

$\cos \phi_R$ term is much smaller than the constant contribution

Preliminary indication $\tilde{D} \ll D_1$

Double-spin dihadrons constrain the poorly known twist-3 fragmentation sector.

Transverse-target SIDIS gives access to transversity

Collins

$$A_{UT}^{\sin(\phi_h+\phi_S)} \rightarrow h_1 \otimes H_{1\perp}^\perp$$

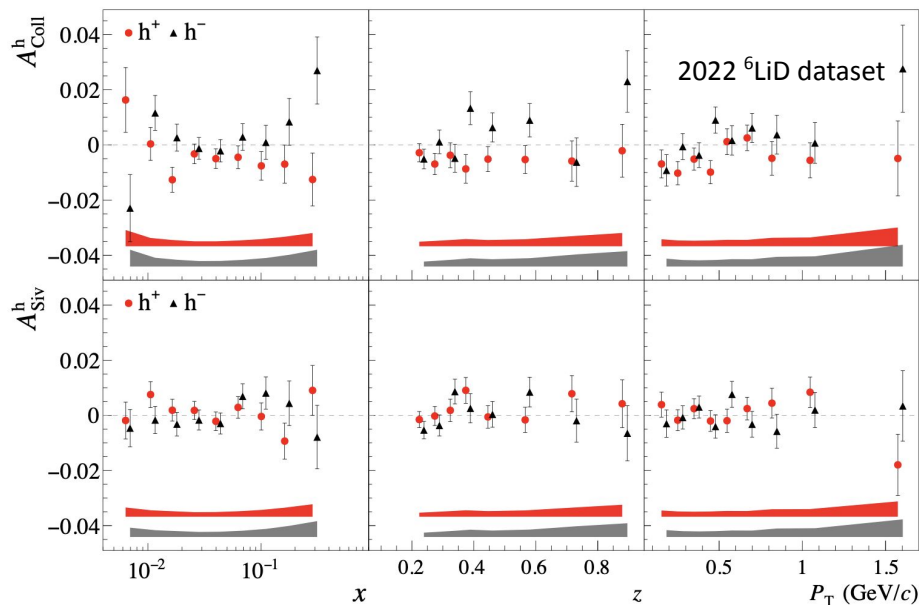
- h_1 : transversity
- $H_{1\perp}$: Collins fragmentation
- leading-twist access to transverse quark polarization

Sivers

$$A_{UT}^{\sin(\phi_h-\phi_S)} \rightarrow f_{1T}^\perp \otimes D_1$$

- $f_{1T}^\perp$: Sivers TMD
- correlation between nucleon transverse spin and quark transverse momentum

COMPASS, Phys. Rev. Lett. 133, 101903 (2024)



The 2022 deuteron run provides the flavor leverage needed to turn transverse-spin asymmetries into much tighter u- and d-quark TMD constraints

Transverse-target SIDIS gives access to transversity

Collins

$$A_{UT}^{\sin(\phi_h+\phi_S)} \rightarrow h_1 \otimes H_{1\perp}^\perp$$

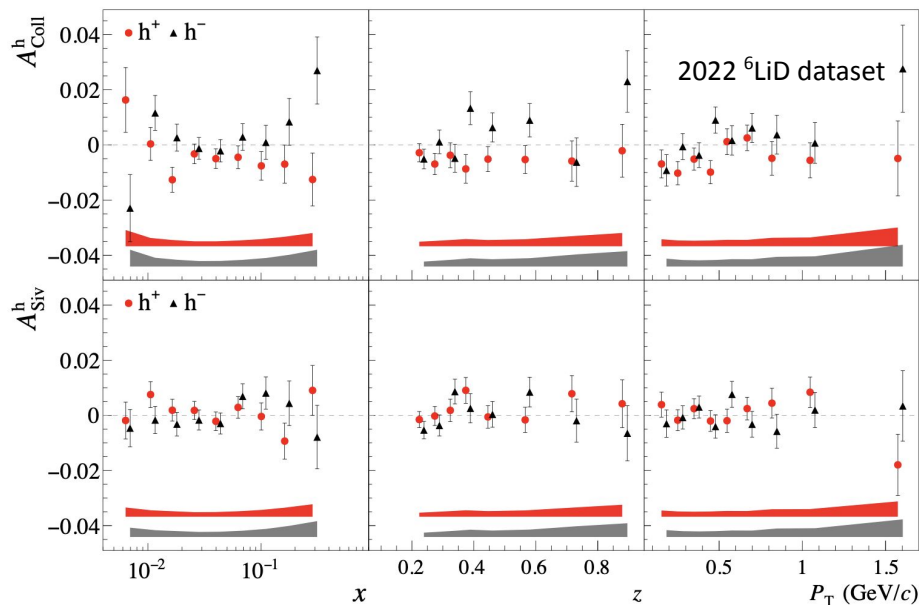
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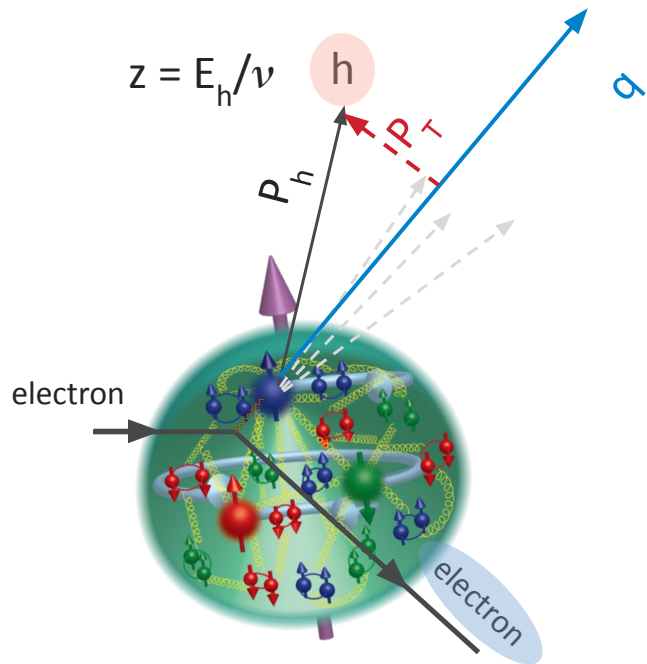
COMPASS, Phys. Rev. Lett. 133, 101903 (2024)



The 2022 COMPASS transverse-target program is producing new results

- dihadron transverse-spin asymmetries — [arXiv:2512.22311](#), accepted by PRL
- new g_{1T} , K^0 , and other transverse-spin measurements in progress/preliminary

SIDIS a precision multidimensional probe of nucleon structure



- This talk focused on **recent fixed-target SIDIS measurements** from JLab and COMPASS
- **Multiplicity measurements** constrain fragmentation and transverse-momentum dynamics
- **Azimuthal and spin asymmetries** access complementary leading- and subleading-twist structure
- **CLAS12, Hall C and COMPASS are highly complementary** in kinematic reach, precision and polarization observables
- The **EIC will extend this program dramatically** in x , Q^2 flavor and multidimensional precision

Fixed-target measurements establish the detailed valence-region baseline; the EIC will carry multidimensional SIDIS into a much broader kinematic regime.

Backup

$$\begin{aligned}
\frac{d^6\sigma}{dx dy d\psi dz d\phi_h dP_T^2} &= \frac{\alpha^2}{xyQ^2} \frac{y^2}{2(1-\varepsilon)} \left(1 + \frac{\gamma^2}{2x} \right) \cdot \\
&\left\{ F_{UU,T} + \varepsilon F_{UU,L} + \sqrt{2\varepsilon(1+\varepsilon)} F_{UU}^{\cos\phi_h} \cos\phi_h + \varepsilon F_{UU}^{\cos 2\phi_h} \cos 2\phi_h \right. \\
&+ \lambda \left(\sqrt{2\varepsilon(1-\varepsilon)} F_{LU}^{\sin\phi_h} \sin\phi_h \right) \\
&+ S_L \left(\sqrt{2\varepsilon(1+\varepsilon)} F_{UL}^{\sin\phi_h} \sin\phi_h + \varepsilon F_{UL}^{\sin 2\phi_h} \sin 2\phi_h \right) \\
&+ S_L \lambda \left(\sqrt{1-\varepsilon^2} F_{LL} + \sqrt{2\varepsilon(1-\varepsilon)} F_{LL}^{\cos\phi_h} \cos\phi_h \right) \\
&+ S_T \left(\left(F_{UT,T}^{\sin(\phi_h-\phi_S)} + \varepsilon F_{UT,L}^{\sin(\phi_h-\phi_S)} \right) \sin(\phi_h - \phi_S) \right. \\
&\quad + \varepsilon F_{UT}^{\sin(\phi_h+\phi_S)} \sin(\phi_h + \phi_S) + \varepsilon F_{UT}^{\sin(3\phi_h-\phi_S)} \sin(3\phi_h - \phi_S) \\
&\quad + \sqrt{2\varepsilon(1+\varepsilon)} F_{UT}^{\sin\phi_S} \sin\phi_S + \sqrt{2\varepsilon(1+\varepsilon)} F_{UT}^{\sin(2\phi_h-\phi_S)} \sin(2\phi_h - \phi_S) \Big) \\
&+ S_T \lambda \left(\sqrt{1-\varepsilon^2} F_{LT}^{\cos(\phi_h-\phi_S)} \cos(\phi_h - \phi_S) \right. \\
&\quad \left. \left. + \sqrt{2\varepsilon(1-\varepsilon)} F_{LT}^{\cos\phi_S} \cos\phi_S + \sqrt{2\varepsilon(1-\varepsilon)} F_{LT}^{\cos(2\phi_h-\phi_S)} \cos(2\phi_h - \phi_S) \right) \right\}.
\end{aligned}$$



"This is the perfect time to panic!" —
Woody

HALL C Azimuthal Modulations

Complementary to CLAS12:

focused settings + tight control of systematics

- Similar P_T dependence across all four channels
- Gaussian width grows strongly with z
- $\cos\phi_h$: $\pi^+ < 0$ while π^- often significantly > 0
- $\cos 2\phi_h$: consistent with zero

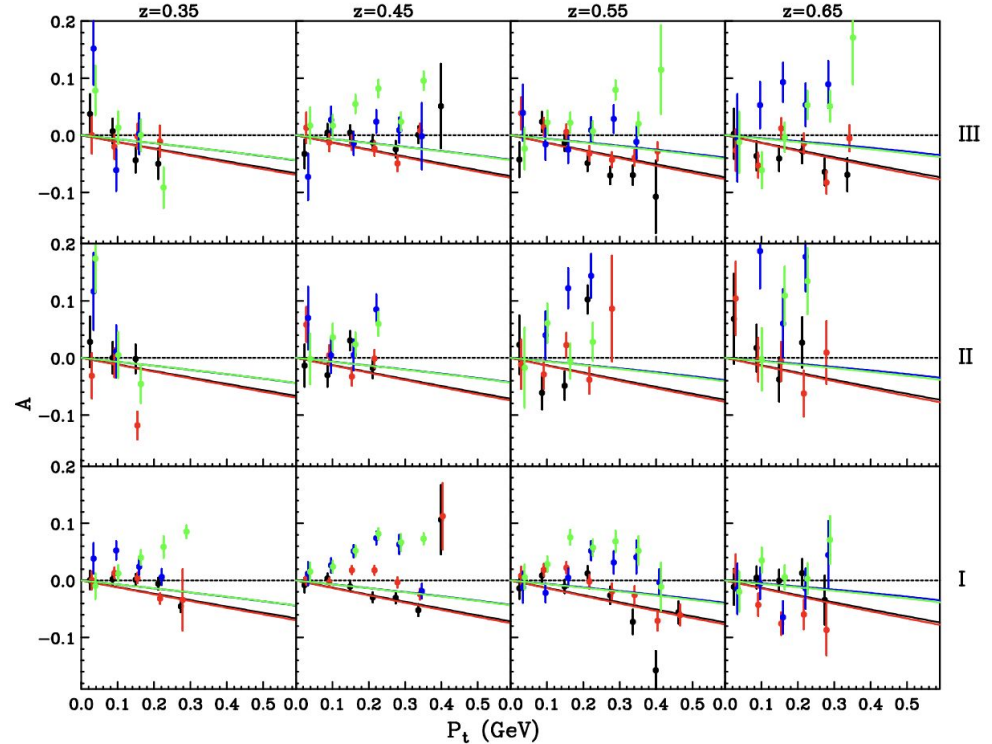


FIG. 17. Results from this experiment (solid circles) for the coefficients A that scale the $\cos(\phi^*)$ distributions for (p, π^+) (black), (d, π^+) (red), (p, π^-) (green), and (d, π^-) (blue). Relative systematic errors (not shown) are estimated to be 0.01 (0.02) point-to-point for setting III (settings I and II). The scale uncertainty is negligibly small. The open circles are from HERMES at $Q^2 = 6.6 \text{ GeV}^2$, $x = 0.36$ and $\langle z \rangle = 0.45$ [16], and curves are from a fit to HERMES and COMPASS data [16,23]. The curves follow the same color scheme as the data points.

Transversely polarized target

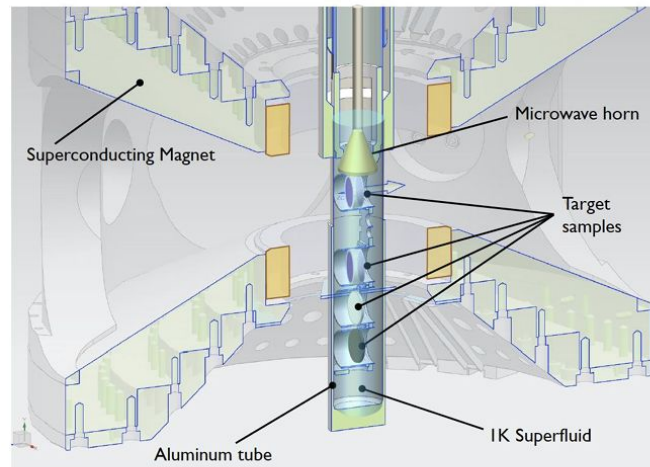
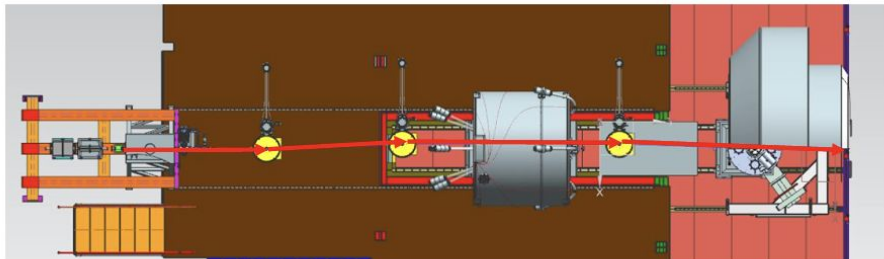
Physics case — Run Group H (RGH)

- DVCS target-spin asymmetry → GPD E (quark orbital angular momentum, J_L sum rule)
- SIDIS → Sivers and transversity (tensor charge)
- PAC53 (2025): 4 experiments approved, rated A, with NH₃ target (100+25 days)

Status

- Magnet geometry & performance defined; cryostat design complete; procurement package in preparation
- Beamline chicane magnets + new μ RWell/TOF recoil detector: R&D expected complete 2027

Chicane system w/ commercial 7.5 T magnets

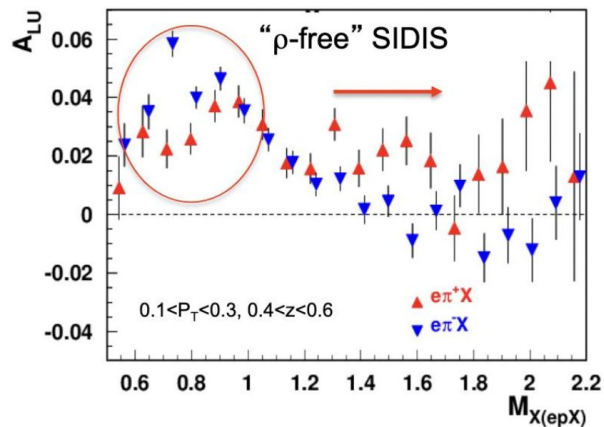


How the target is polarized

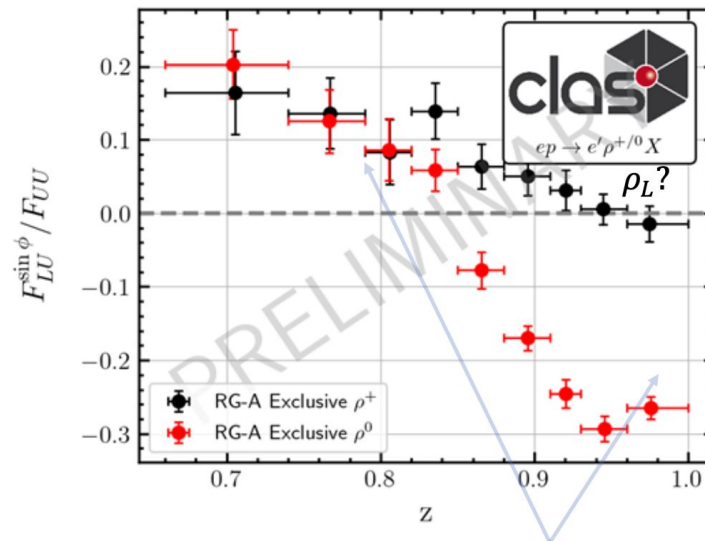
- NH₃ (ammonia) samples cooled to ~1 K in superfluid He
- Polarized via microwave-driven Dynamic Nuclear Polarization (DNP)
- Housed in a 5 T superconducting magnet (transverse field)

Design based on the Hall-A G2p/GEp target and Hall-C E12-15-005 magnet

Background from Exclusive Vector Meson Production



- ρ contribution depends on SDMEs
- Highly dependent on experimental acceptance



Different production mechanisms for ρ^0 and $\rho^\pm$