Azimuthal asymmetries in SIDIS di-hadron muoproduction off longitudinally polarized protons at COMPASS

Stefan Sirtl

Albert-Ludwigs Universität Freiburg

on behalf of the COMPASS Collaboration

SPIN16 Conference

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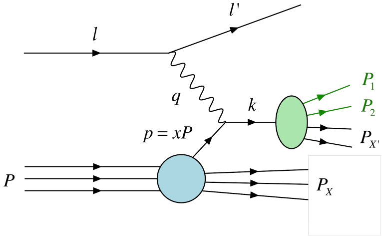
Bundesministerium
für Bildung
und Forschung

Theoretical Framework

Di-hadron SIDIS

Bacchetta & Radici: Phys. Rev. D69 094002
Bacchetta & Radici & Gliske: Phys. Rev. D90 114027

$$\mu(l) + p(P) \to \mu(l') + h_1^+(P_1) + h_2^-(P_2) + X$$



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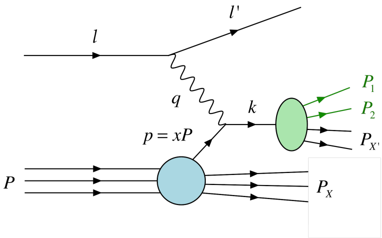

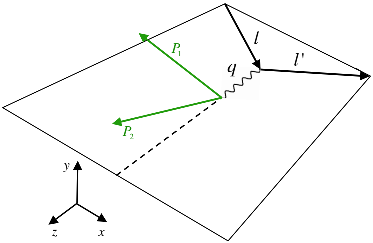

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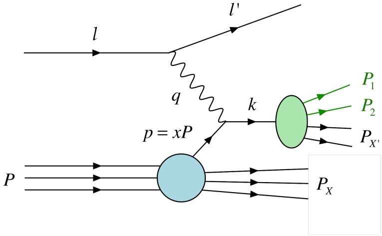

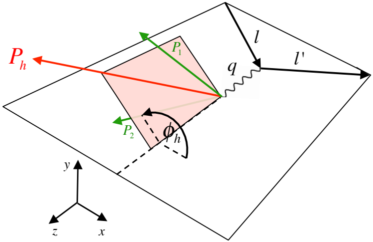

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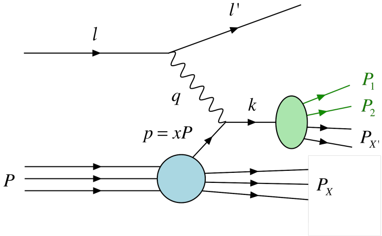

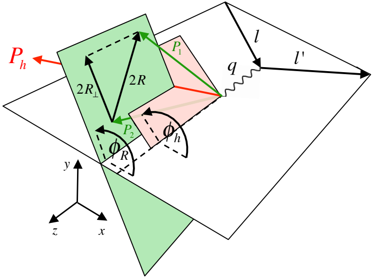

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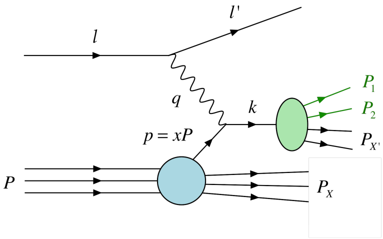

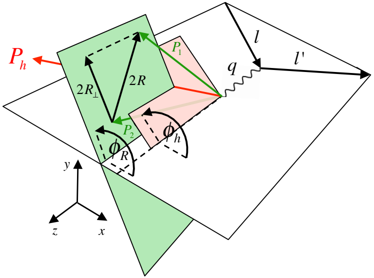

- X-section modulated in azimuthal angles ϕ_h and ϕ_R

$$\boldsymbol{R}_\perp \leftrightarrow \boldsymbol{R}_T = \frac{z_2 \boldsymbol{P}_{1\perp} - z_1 \boldsymbol{P}_{2\perp}}{z_1 + z_2} \qquad \text{with} \qquad z_i = \frac{E_i}{E - E'}$$

Theoretical Framework

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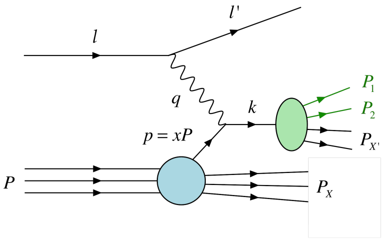

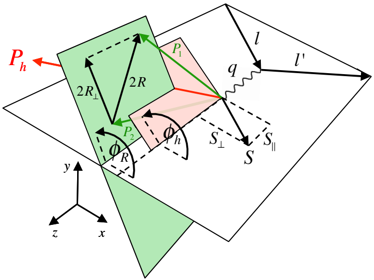

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- Negligible transverse polarization mixing $S_\perp \approx 0$

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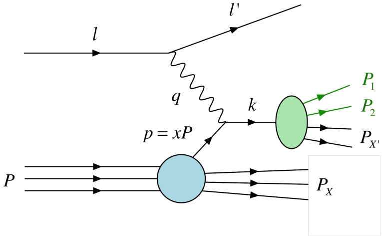

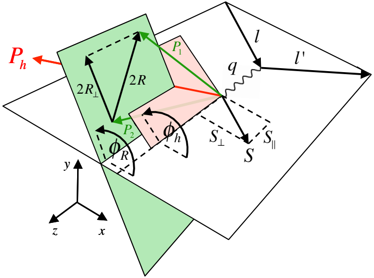

- X-section modulated in azimuthal angles ϕ_h and ϕ_R

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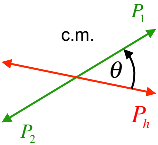

- Negligible transverse polarization mixing $S_\perp \approx 0$
- Partial wave expansion in θ, restricted to s- & p-waves

Theoretical Framework

X-Section: TMD & Twist-2

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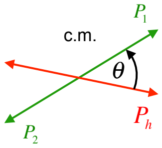
$$d\sigma = d\sigma_{UU} + \lambda_\mu d\sigma_{LU} + S_\parallel \left(d\sigma_{UL} + \lambda_\mu d\sigma_{LL} \right) + |S_\perp| \left(d\sigma_{UT} + \lambda_\mu d\sigma_{LT} \right)$$



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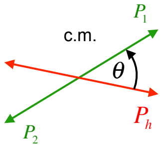
$$\varepsilon = \frac{1-y-\frac{1}{4}\gamma^2 y^2}{1-y+\frac{1}{2}y^2+\frac{1}{4}\gamma^2 y^2} \qquad \gamma = \frac{2Mx}{Q}$$

$$\begin{aligned} d^8\sigma_{UL} \propto\ & \sin(\phi_h - \phi_R)\left(A_{UL}^{\sin(\phi_h-\phi_R)\sin\theta} \sin\theta + A_{UL}^{\sin(\phi_h-\phi_R)\sin 2\theta} \sin 2\theta \right) \\ & + \sin(2\phi_h - 2\phi_R) \quad A_{UL}^{\sin(2\phi_h-2\phi_R)\sin^2\theta} \sin^2\theta \\ & + \varepsilon \Big\{ \sin(2\phi_h) \left(A_{UL}^{\sin(2\phi_h)} + A_{UL}^{\sin(2\phi_h)\cos\theta} \cos\theta + A_{UL}^{\sin(2\phi_h)\frac{1}{3}(3\cos^2\theta-1)} \frac{1}{3}\left(3\cos^2\theta - 1\right) \right) \\ & + \sin(\phi_h + \phi_R)\left(A_{UL}^{\sin(\phi_h+\phi_R)\sin\theta} \sin\theta + A_{UL}^{\sin(\phi_h+\phi_R)\sin 2\theta} \sin 2\theta \right) \\ & + \sin(2\phi_R) \quad A_{UL}^{\sin(2\phi_R)\sin^2\theta} \sin^2\theta \\ & + \sin(3\phi_h - \phi_R)\left(A_{UL}^{\sin(3\phi_h-\phi_R)\sin\theta} \sin\theta + A_{UL}^{\sin(3\phi_h-\phi_R)\sin 2\theta} \sin 2\theta \right) \\ & + \sin(4\phi_h - 2\phi_R) \quad A_{UL}^{\sin(4\phi_h-2\phi_R)\sin^2\theta} \sin^2\theta \Big\} \end{aligned}$$

$$\begin{aligned} d^8\sigma_{LL} \propto\ & \sqrt{1-\varepsilon^2} \Big\{ A_{LL}^{1} + A_{LL}^{\cos\theta} \cos\theta + A_{LL}^{\frac{1}{3}(3\cos^2\theta-1)} \frac{1}{3}\left(3\cos^2\theta - 1\right) \\ & + \cos(\phi_h - \phi_R)\left(A_{LL}^{\cos(\phi_h-\phi_R)\sin\theta} \sin\theta + A_{LL}^{\cos(\phi_h-\phi_R)\sin 2\theta} \sin 2\theta \right) \\ & + \cos(2\phi_h - 2\phi_R) \quad A_{LL}^{\cos(2\phi_h-2\phi_R)} \Big\} \end{aligned}$$



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$$d\sigma = d\sigma_{UU} + \lambda_\mu d\sigma_{LU} + S_\parallel \left(d\sigma_{UL} + \lambda_\mu d\sigma_{LL}\right) + |S_\perp| \left(d\sigma_{UT} + \lambda_\mu d\sigma_{LT}\right)$$

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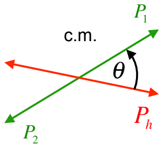

$$\langle\theta\rangle = \pi/2$$

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X-Section: TMD & Twist-2

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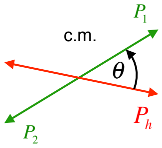
$$\begin{aligned} d^8\sigma_{LL} \propto\ & \sin(\phi_h - \phi_R)\ \ A_{UL}^{\sin(\phi_h - \phi_R)} \\ & + \sin(2\phi_h - 2\phi_R)\ \ A_{UL}^{\sin(2\phi_h - 2\phi_R)} \\ & + \varepsilon \Big\{ \sin(2\phi_h)\ \ A_{UL}^{\sin(2\phi_h)} \\ & + \sin(\phi_h + \phi_R)\ \ A_{UL}^{\sin(\phi_h + \phi_R)} \\ & + \sin(2\phi_R)\ \ A_{UL}^{\sin(2\phi_R)} \\ & + \sin(3\phi_h - \phi_R)\ \ A_{UL}^{\sin(3\phi_h - \phi_R)} \\ & + \sin(4\phi_h - 2\phi_R)\ \ A_{UL}^{\sin(4\phi_h - 2\phi_R)} \Big\} \end{aligned}$$

$$\begin{aligned} d^8\sigma_{LL} \propto\ & \sqrt{1-\varepsilon^2} \Big\{ A_{LL}^{1} \\ & + \cos(\phi_h - \phi_R)\ \ A_{LL}^{\cos(\phi_h - \phi_R)} \\ & + \cos(2\phi_h - 2\phi_R)\ \ A_{LL}^{\cos(2\phi_h - 2\phi_R)} \Big\} \end{aligned}$$



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$$d^8\sigma_{LL} \propto \sin(\phi_h - \phi_R) \quad A_{UL}^{\sin(\phi_h-\phi_R)} \qquad \sim g_{1L} \otimes G_{1,UT}^{\perp}$$

$$+ \sin(2\phi_h - 2\phi_R) \quad A_{UL}^{\sin(2\phi_h-2\phi_R)} \qquad \sim g_{1L} \otimes G_{1,TT}^{\perp}$$

$$+ \varepsilon \Big\{ \sin(2\phi_h) \quad A_{UL}^{\sin(2\phi_h)} \qquad \sim h_{1L}^{\perp} \otimes H_{1,UU}^{\perp}$$

$$+ \sin(\phi_h + \phi_R) \quad A_{UL}^{\sin(\phi_h+\phi_R)} \qquad \sim h_{1L}^{\perp} \otimes H_{1,UT}^{\angle}$$

$$+ \sin(2\phi_R) \quad A_{UL}^{\sin(2\phi_R)} \qquad \sim h_{1L}^{\perp} \otimes H_{1,TT}^{\angle}$$

$$+ \sin(3\phi_h - \phi_R) \quad A_{UL}^{\sin(3\phi_h-\phi_R)} \qquad \sim h_{1L}^{\perp} \otimes H_{1,UT}^{\perp}$$

$$+ \sin(4\phi_h - 2\phi_R) \quad A_{UL}^{\sin(4\phi_h-2\phi_R)} \Big\} \qquad \sim h_{1L}^{\perp} \otimes H_{1,TT}^{\perp}$$

$$d^8\sigma_{LL} \propto \sqrt{1-\varepsilon^2} \Big\{ A_{LL}^{1} \qquad \sim g_{1L} \otimes D_{1,UT}$$

$$+ \cos(\phi_h - \phi_R) \quad A_{LL}^{\cos(\phi_h-\phi_R)} \qquad \sim g_{1L} \otimes D_{1,TT}$$

$$+ \cos(2\phi_h - 2\phi_R) \quad A_{LL}^{\cos(2\phi_h-2\phi_R)} \Big\} \qquad \sim g_{1L} \otimes D_{1,UU}$$

TMD / Twist-2		Quark U	Quark L	Quark T
Nucleon	U	f_1		$h_1^{\perp}$
Nucleon	L		g_{1L}	$h_{1L}^{\perp}$
Nucleon	T	$f_{1T}^{\perp}$	$g_{1T}^{\perp}$	h_{1T} $h_{1T}^{\perp}$

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$$d^8\sigma_{LL} \propto \sin(\phi_h - \phi_R) \quad A_{UL}^{\sin(\phi_h-\phi_R)} \qquad \sim g_{1L} \otimes G_{1,UT}^{\perp}$$

$$+ \sin(2\phi_h - 2\phi_R) \quad A_{UL}^{\sin(2\phi_h-2\phi_R)} \qquad \sim g_{1L} \otimes G_{1,TT}^{\perp}$$

$$+ \varepsilon\Big\{ \sin(2\phi_h) \quad A_{UL}^{\sin(2\phi_h)} \qquad \sim h_{1L}^{\perp} \otimes H_{1,UU}^{\perp}$$

$$+ \sin(\phi_h + \phi_R) \quad A_{UL}^{\sin(\phi_h+\phi_R)} \qquad \sim h_{1L}^{\perp} \otimes H_{1,UT}^{\angle}$$

$$+ \sin(2\phi_R) \quad A_{UL}^{\sin(2\phi_R)} \qquad \sim h_{1L}^{\perp} \otimes H_{1,TT}^{\angle}$$

$$+ \sin(3\phi_h - \phi_R) \quad A_{UL}^{\sin(3\phi_h-\phi_R)} \qquad \sim h_{1L}^{\perp} \otimes H_{1,UT}^{\perp}$$

$$+ \sin(4\phi_h - 2\phi_R) \quad A_{UL}^{\sin(4\phi_h-2\phi_R)} \Big\} \qquad \sim h_{1L}^{\perp} \otimes H_{1,TT}^{\perp}$$

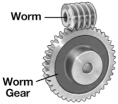
$$d^8\sigma_{LL} \propto \sqrt{1-\varepsilon^2}\Big\{ A_{LL}^{1} \qquad \sim g_{1L} \otimes D_{1,UT}$$

$$+ \cos(\phi_h - \phi_R) \quad A_{LL}^{\cos(\phi_h-\phi_R)} \qquad \sim g_{1L} \otimes D_{1,TT}$$

$$+ \cos(2\phi_h - 2\phi_R) \quad A_{LL}^{\cos(2\phi_h-2\phi_R)} \Big\} \qquad \sim g_{1L} \otimes D_{1,UU}$$

TMD / Twist-2		Quark U	Quark L	Quark T
Nucleon	U	f_1		$h_1^{\perp}$
Nucleon	L		g_{1L}	$h_{1L}^{\perp}$
Nucleon	T	$f_{1T}^{\perp}$	$g_{1T}^{\perp}$	h_{1T} $h_{1T}^{\perp}$

Helicity (g_{1L}) Worm-Gear-L ($h_{1L}^{\perp}$)



Theoretical Framework

X-Section: Collinear & Twist-3

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$$d\sigma = d\sigma_{UU} + \lambda_\mu d\sigma_{LU} + S_{\parallel}\left(d\sigma_{UL} + \lambda_\mu d\sigma_{LL}\right) + |S_\perp|\left(d\sigma_{UT} + \lambda_\mu d\sigma_{LT}\right)$$

$$d^7\sigma_{UU} \propto 1 + \sqrt{2\varepsilon(1+\varepsilon)}\cos(\phi_R) \quad A_{UU}^{\cos(\phi_R)}$$
$$+ \varepsilon\cos(2\phi_R) \quad A_{UU}^{\cos(2\phi_R)}$$

$$d^7\sigma_{LU} \propto \sqrt{2\varepsilon(1-\varepsilon)}\sin(\phi_R) \quad A_{LU}^{\sin(\phi_R)}$$

$$d^7\sigma_{UL} \propto \sqrt{2\varepsilon(1+\varepsilon)}\sin(\phi_R) \quad A_{UL}^{\sin(\phi_R)}$$
$$+ \varepsilon\sin(2\phi_R) \quad A_{UL}^{\sin(2\phi_R)}$$

$$d^7\sigma_{LL} \propto \sqrt{1-\varepsilon^2} \quad A_{LL}^{1}$$
$$+ \sqrt{2\varepsilon(1-\varepsilon)}\cos(\phi_R) \quad A_{LL}^{\cos(\phi_R)}$$

Theoretical Framework

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$$d\sigma = d\sigma_{UU} + \lambda_\mu d\sigma_{LU} + S_{\parallel} \left(d\sigma_{UL} + \lambda_\mu d\sigma_{LL} \right) + |S_\perp| \left(d\sigma_{UT} + \lambda_\mu d\sigma_{LT} \right)$$

$$d^7\sigma_{UU} \propto 1 + \sqrt{2\varepsilon(1+\varepsilon)} \cos(\phi_R) \quad A_{UU}^{\cos(\phi_R)}$$

$$+ \varepsilon \cos(2\phi_R) \quad A_{UU}^{\cos(2\phi_R)}$$

$$d^7\sigma_{LU} \propto \sqrt{2\varepsilon(1-\varepsilon)} \sin(\phi_R) \quad A_{LU}^{\sin(\phi_R)}$$

Collinear Twist-3		Quark U	Quark L	Quark T
Nucleon	U	$f^\perp$	$g^\perp$	$h \;\; e$
Nucleon	L	$f_L^\perp$	$g_L^\perp$	$h_L \;\; e_L$
Nucleon	T	$f_T \;\; f_T^\perp$	$g_T \;\; g_T^\perp$	$h_T \;\; e_T \;\; h_T^\perp \;\; e_T^\perp$

$$d^7\sigma_{UL} \propto \sqrt{2\varepsilon(1+\varepsilon)} \sin(\phi_R) \quad A_{UL}^{\sin(\phi_R)} \qquad \sim Q^{-1} \left[h_L \cdot H_{1,UT}^{\angle} + g_1 \cdot \tilde{G}_{UT}^{\angle} \right]$$

$$+ \varepsilon \sin(2\phi_R) \quad A_{UL}^{\sin(2\phi_R)}$$

T-odd

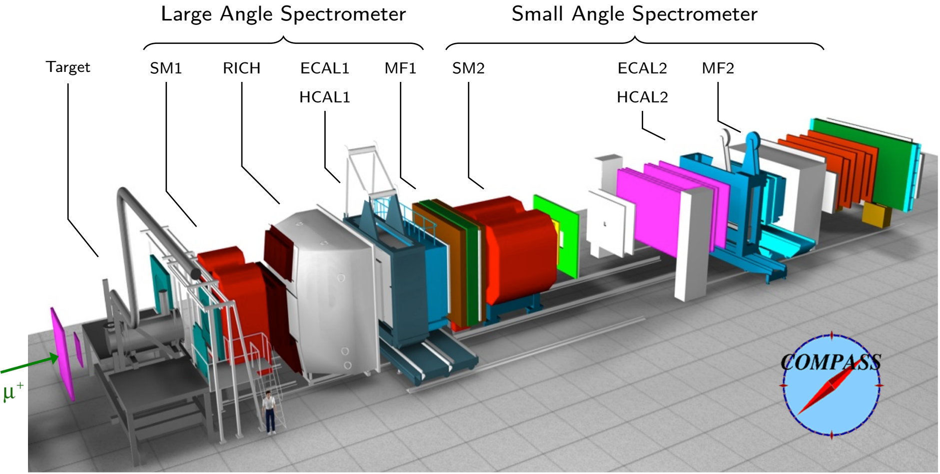
Wandzura-Wilczek approximation

$$d^7\sigma_{LL} \propto \sqrt{1-\varepsilon^2} \quad A_{LL}^{1}$$

$$+ \sqrt{2\varepsilon(1-\varepsilon)} \cos(\phi_R) \quad A_{LL}^{\cos(\phi_R)} \quad \sim Q^{-1} \left[e_L \cdot H_{1,UT}^{\angle} + g_1 \cdot \tilde{D}_{UT}^{\angle} \right]$$

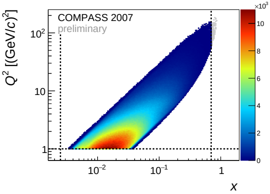
The COMPASS Experiment

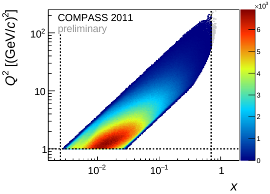
- Polarized μ^+-Beam (100-200 GeV)
- Polarizable Target (NH_3, ^{6}LiD)
- High Luminosity L $\approx 5 \cdot 10^{32}$ cm^{-2} s^{-1}
- Beam Polarization $\langle P_B \rangle \approx 81\%$
- Target Polarization $\langle P_T \rangle \approx 87\%$
- Target Dilution Factor $\langle f \rangle \approx 15\%$



Data

Kinematics & Angles





- Two years of longitudinal data:

  2007: 160 GeV μ^+-beam
  2011: 200 GeV μ^+-beam

- Q^2-dependence smaller than experimental accuracy
  - merge two data sets

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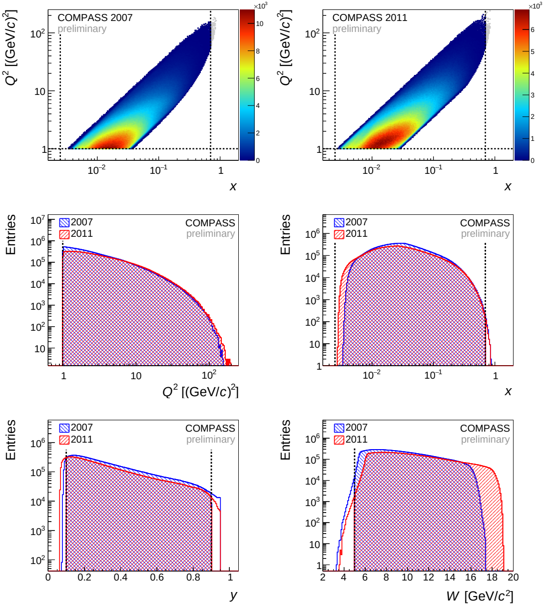
Kinematics & Angles



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- Basic kinematic cuts:

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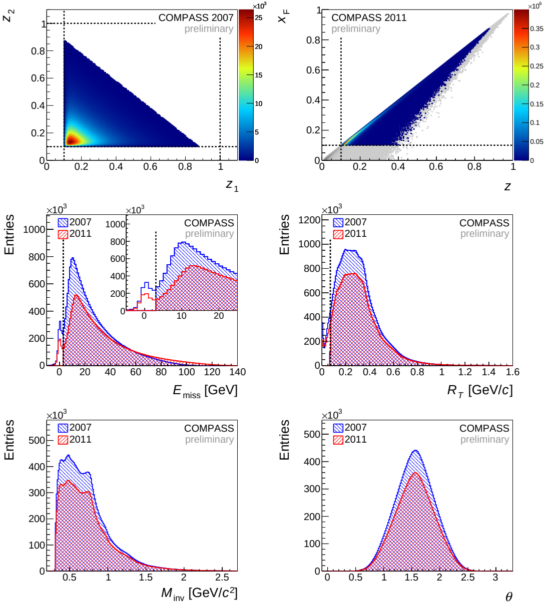

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$$E_{\text{miss}} > 3\,\text{GeV}$$
$$R_T > 0.07$$

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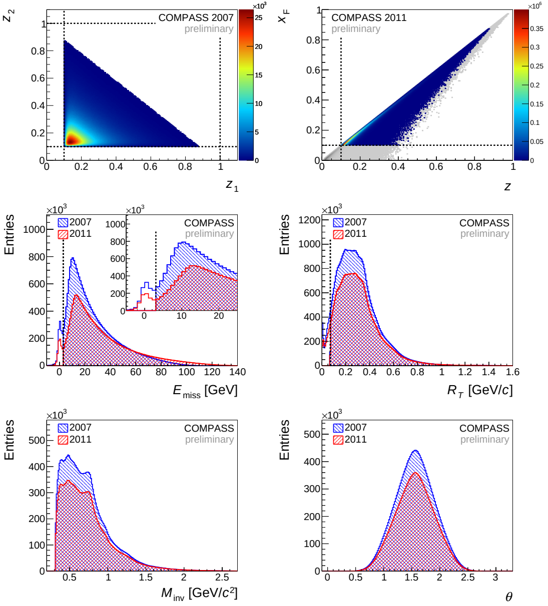

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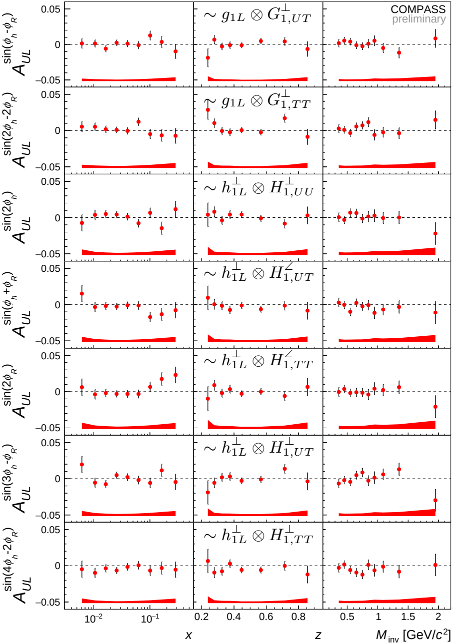
- Asymmetries extracted in bins of x, z and M_{inv}

Single Spin Asymmetries at twist-2



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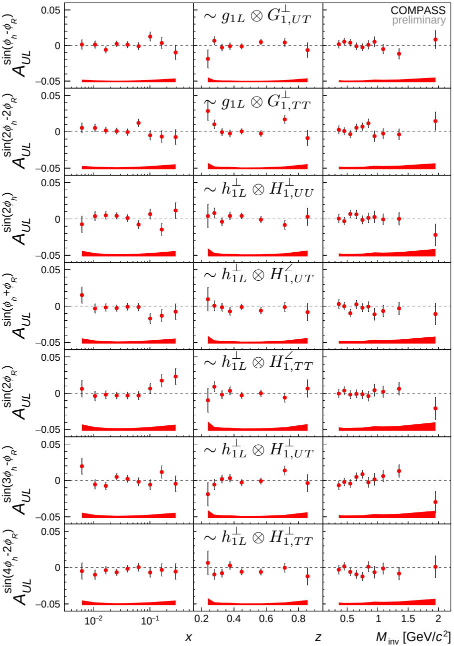
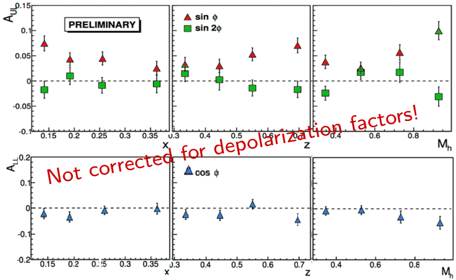


CLAS 6 GeV

Pereira: PoS (DIS 2014) 231



Not corrected for depolarization factors!

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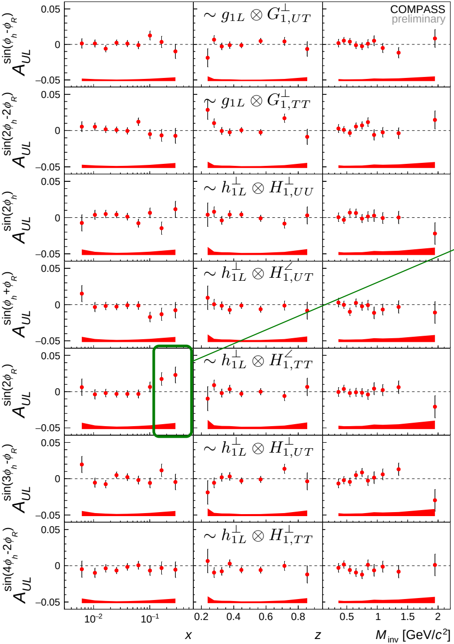

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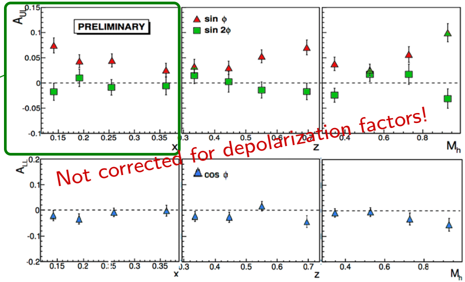
Pereira: PoS (DIS 2014) 231



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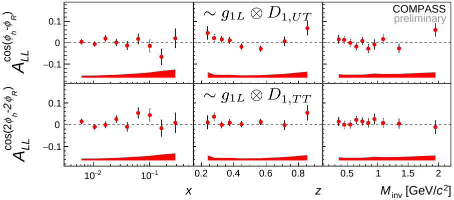

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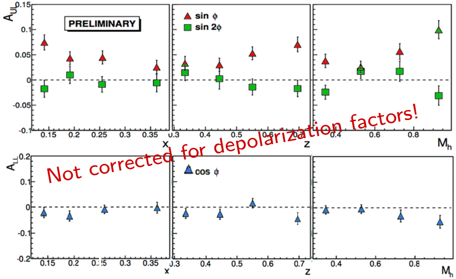

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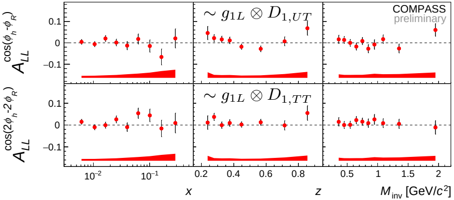
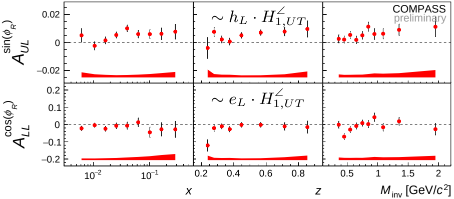
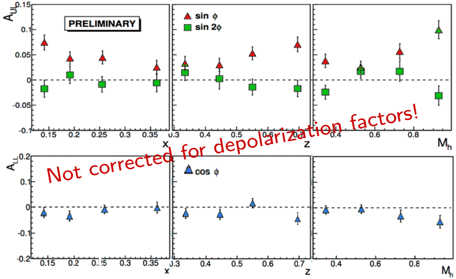


Asymmetries at twist-3



CLAS 6 GeV

Pereira: PoS (DIS 2014) 231



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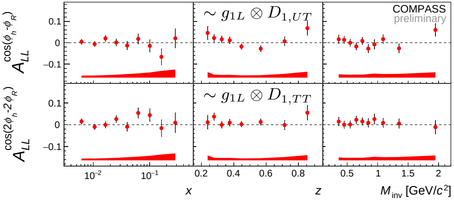

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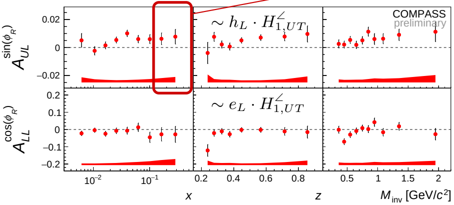

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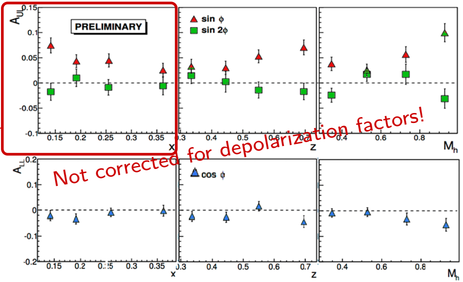

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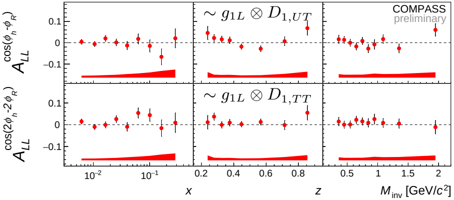

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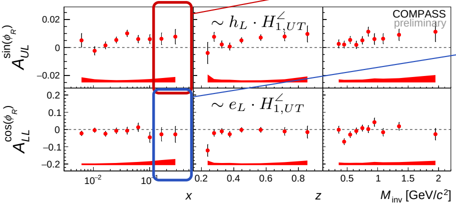

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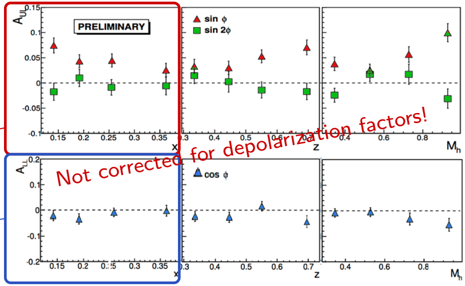
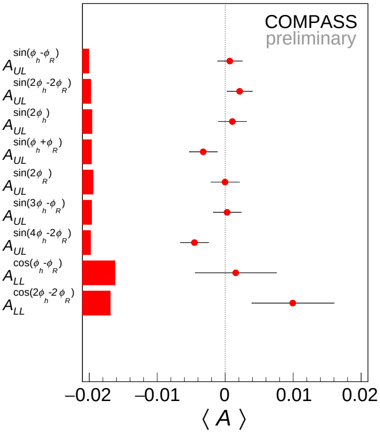
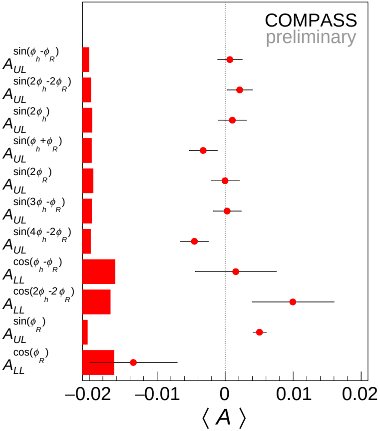


Conclusions



- 1st comprehensive analysis of azimuthal asymmetries of hadron pairs in SIDIS off longitudinally polarized protons at COMPASS
- No evidence for sizable asymmetries at leading twist

Conclusions

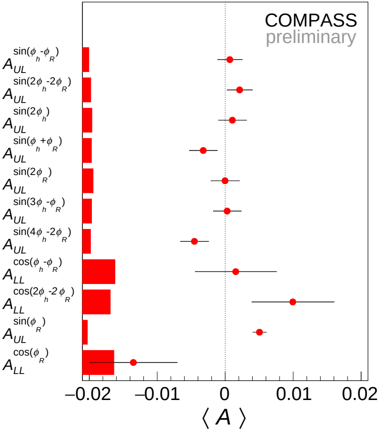


- 1st comprehensive analysis of azimuthal asymmetries of hadron pairs in SIDIS off longitudinally polarized protons at COMPASS
- No evidence for sizable asymmetries at leading twist
- Non-zero asymmetry at subleading twist:

$$A_{UL}^{\sin(\phi_R)} = 0.0050 \pm 0.0010(\text{stat}) \pm 0.0007(\text{sys})$$

  - ▶ Access to unknown collinear h_L
- $A_{LL}^{\cos(\phi_R)}$ allows for validation of Wandzura-Wilzcek approximation

Conclusions



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Thank you for your attention!

Appendix

Theoretical Framework

X-Section: TMD & Twist-2

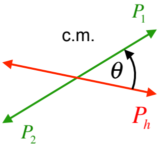
Bacchetta & Radici: Phys. Rev. D69 094002
Bacchetta & Radici & Gliske: Phys. Rev. D90 114027

$$d\sigma = d\sigma_{UU} + \lambda_\mu d\sigma_{LU} + S_\parallel \left(d\sigma_{UL} + \lambda_\mu d\sigma_{LL}\right) + |S_\perp| \left(d\sigma_{UT} + \lambda_\mu d\sigma_{LT}\right)$$

$$\varepsilon = \frac{1-y-\frac{1}{4}\gamma^2 y^2}{1-y+\frac{1}{2}y^2+\frac{1}{4}\gamma^2 y^2} \qquad \gamma = \frac{2Mx}{Q}$$

$$\begin{aligned}
d^8\sigma_{UU} \propto\; & A_{UU,T} + A_{UU}^{\cos\theta}\cos\theta + A_{UU}^{\frac{1}{3}(3\cos^2\theta-1)}\frac{1}{3}\left(3\cos^2\theta-1\right) \\
& + \cos(\phi_h-\phi_R)\left(A_{UU}^{\cos(\phi_h-\phi_R)\sin\theta}\sin\theta + A_{UU}^{\cos(\phi_h-\phi_R)\sin 2\theta}\sin 2\theta\right) \\
& + \cos(2\phi_h-2\phi_R)\quad A_{UU}^{\cos(2\phi_h-2\phi_R)\sin^2\theta}\sin^2\theta \\
& + \varepsilon\Big\{A_{UU,L} + \cos(2\phi_h)\left(A_{UU}^{\cos(2\phi_h)} + A_{UU}^{\cos(2\phi_h)\cos\theta}\cos\theta + A_{UU}^{\cos(2\phi_h)\frac{1}{3}(3\cos^2\theta-1)}\frac{1}{3}\left(3\cos^2\theta-1\right)\right) \\
& + \cos(\phi_h+\phi_R)\left(A_{UU}^{\cos(\phi_h+\phi_R)\sin\theta}\sin\theta + A_{UU}^{\cos(\phi_h+\phi_R)\sin 2\theta}\sin 2\theta\right) \\
& + \cos(2\phi_R)\quad A_{UU}^{\cos(2\phi_R)\sin^2\theta}\sin^2\theta \\
& + \cos(3\phi_h-\phi_R)\left(A_{UU}^{\cos(3\phi_h-\phi_R)\sin\theta}\sin\theta + A_{UU}^{\cos(3\phi_h-\phi_R)\sin 2\theta}\sin 2\theta\right) \\
& + \cos(4\phi_h-2\phi_R)\quad A_{UU}^{\cos(4\phi_h-2\phi_R)\sin^2\theta}\sin^2\theta\Big\}
\end{aligned}$$

$$\begin{aligned}
d^8\sigma_{LU} \propto \sqrt{1-\varepsilon^2}\Big\{ & \sin(\phi_h-\phi_R)\left(A_{LU}^{\sin(\phi_h-\phi_R)\sin\theta}\sin\theta + A_{LU}^{\sin(\phi_h-\phi_R)\sin 2\theta}\sin 2\theta\right) \\
& + \sin(2\phi_h-2\phi_R)\quad A_{LU}^{\sin(2\phi_h-2\phi_R)\sin^2\theta}\sin^2\theta\Big\}
\end{aligned}$$



Hadron Pair Selection

Topology

- Best primary vertex
- 1 incident muon μ
- $N_{\text{out}} \geq 3$

Incident μ

- $\chi^2_{\text{red}}(\mu) < 10$
- μ is beam
- Beam crosses all target cells
- 2007: $140 < p(\mu)/(\text{GeV/c}) < 180$
  2011: $185 < p(\mu)/(\text{GeV/c}) < 215$
- 2011: $0.01 < LH_{\text{back}} < 1.0$
- 2011: $N_{\text{BMS}} > 2$

Scattered μ'

- Is scattered μ'
- $X/X_0(\mu') > 30$
- $\chi^2_{\text{red}}(\mu') < 10$
- $Z_{\text{first}}(\mu') < 350$ cm
- 350 cm $< Z_{\text{last}}(\mu') <$ 3300 cm

Vertex

- Vertex inside target

Kinematics

- $Q^2 > 1\,(\text{GeV/c})^2$
- $W > 5\,\text{GeV/c}^2$
- $0.0025 < x < 0.7$
- $0.1 < y < 0.9$

Hadrons

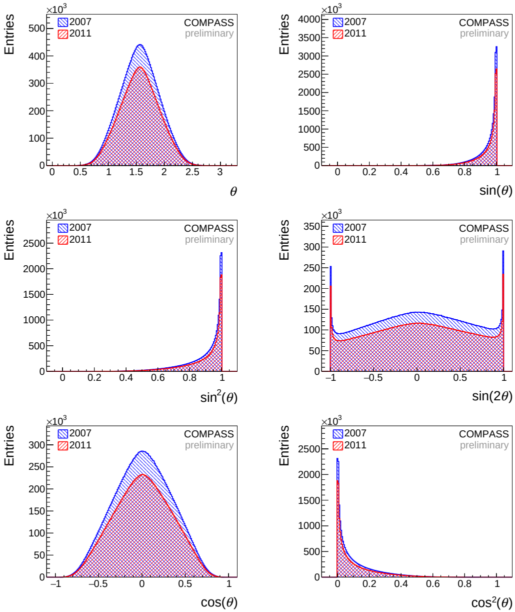
- $X/X_0(h) < 10$
- $\chi^2_{\text{red}}(h) < 10$
- $Z_{\text{first}}(h) < 350$ cm
- 350 cm $< Z_{\text{last}}(h) <$ 3300 cm

Hadron Pairs

- $q(h_1) = +1$, $q(h_2) = -1$
- $0.1 < z(h_{1/2}) < 1.0$
- $0.1 < x_F(h_{1/2}) < 1.0$
- $E_{\text{miss}} > 3$ GeV
- $R_T > 0.07$

Data

Angles



- Clear dominance of $\sin\theta$- and $\sin^2\theta$-weighed partial amplitudes

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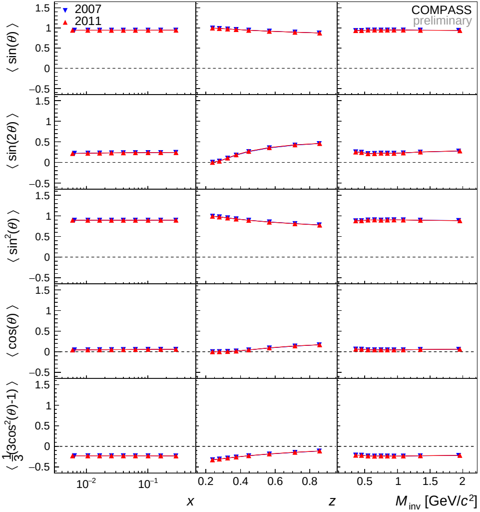

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Extraction of Asymmetries

Extraction Methods

1D Product Ratio (1D PR)

$$N_i^{\pm}(\phi_h, \phi_R) = \Phi_i^{\pm} a_i^{\pm}(\phi_h, \phi_R) n_i \sigma_{UU} \Big(1 + A_{XU}(\phi_h, \phi_R) \pm A_{XL}(\phi_h, \phi_R)\Big)$$

$$r1234(\phi_h, \phi_R) = \prod_{i=1}^{4} \frac{N_i^{+}(\phi_h, \phi_R)}{N_i^{-}(\phi_h, \phi_R)} \approx 1 + 8A_{XL}(\phi_h, \phi_R)$$

Φ	Muon Flux
$a(\phi_h, \phi_R)$	Acceptance
n	# protons
σ_{UU}	(ϕ_h, ϕ_R)-independent part of unpol. x-section

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Unbinned Maximum Likelihood (UB LH)

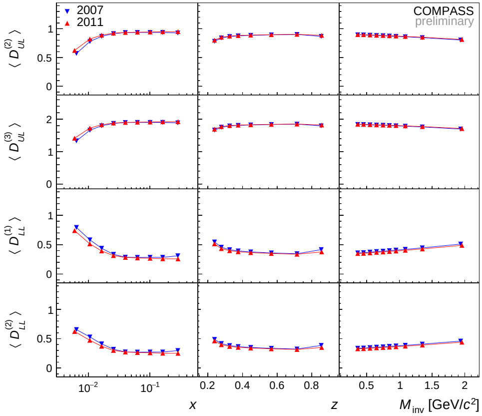
$$p_i^{\pm}(\phi_h, \phi_R) = a_i^{\pm}(\phi_h, \phi_R) \cdot (1 + A_{XU}(\phi_h, \phi_R) \pm A_{XL}(\phi_h, \phi_R))$$

$$P_i^{\pm}(\phi_h, \phi_R) = \mu_i^{\pm} \cdot p_i^{\pm}(\phi_h, \phi_R) \qquad \int_0^{2\pi}\int_0^{2\pi} P_i^{\pm}(\phi_h, \phi_R)\, d\phi_h d\phi_R = \mu_i^{\pm}$$

$$\mathcal{L} = \prod_{i=1}^{4} \left[\left(e^{\mu_i^{+}} \prod_{m=1}^{N_i^{+}} P_i^{+}(\phi_{h_m}, \phi_{R_m}) \right)^{\frac{\bar{N}}{N_i^{+}}} \cdot \left(e^{\mu_i^{-}} \prod_{n=1}^{N_i^{-}} P_i^{-}(\phi_{h_n}, \phi_{R_n}) \right)^{\frac{\bar{N}}{N_i^{-}}} \right]$$

Extraction of Asymmetries

Raw Asymmetry Correction



$$A_{UL}^{m(\phi_h,\phi_R)} = \frac{A_{UL,\text{Raw}}^{m(\phi_h,\phi_R)}}{\langle f|P_T|D_{UL}^{m(\phi_h,\phi_R)}\rangle}$$

$$A_{LL}^{m(\phi_h,\phi_R)} = \frac{A_{LL,\text{Raw}}^{m(\phi_h,\phi_R)}}{\langle f P_B|P_T|D_{LL}^{m(\phi_h,\phi_R)}\rangle}$$

Depolarization Factors

$$D_{UL}^{(1)} = 1$$

$$D_{UL}^{(2)} = \varepsilon$$

$$D_{UL}^{(3)} = \sqrt{2\varepsilon(1+\varepsilon)}$$

$$D_{LL}^{(1)} = \sqrt{1-\varepsilon^2}$$

$$D_{LL}^{(2)} = \sqrt{2\varepsilon(1-\varepsilon)}$$

Extraction of Asymmetries

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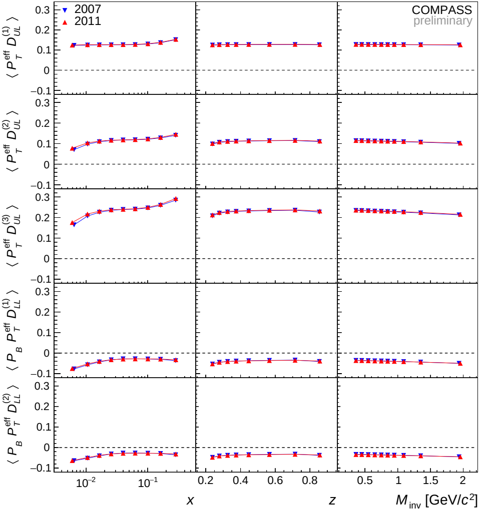

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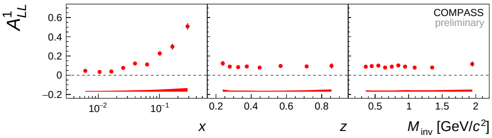
A_{LL}^1



- Alternative access to helicity g_{1L}

Inclusive DIS & 1h-SIDIS

COMPASS Collaboration: Phys. Lett. B (2010) 693