Beam-Spin Asymmetries in SIDIS at HERMES

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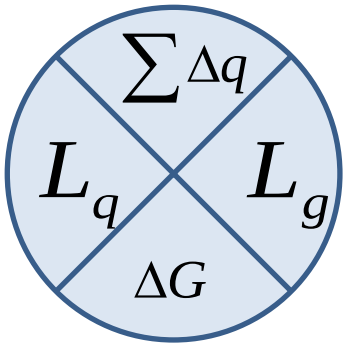
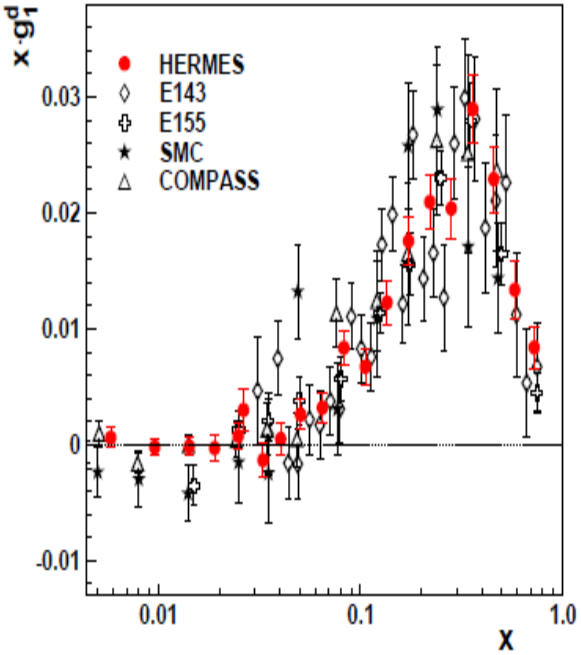
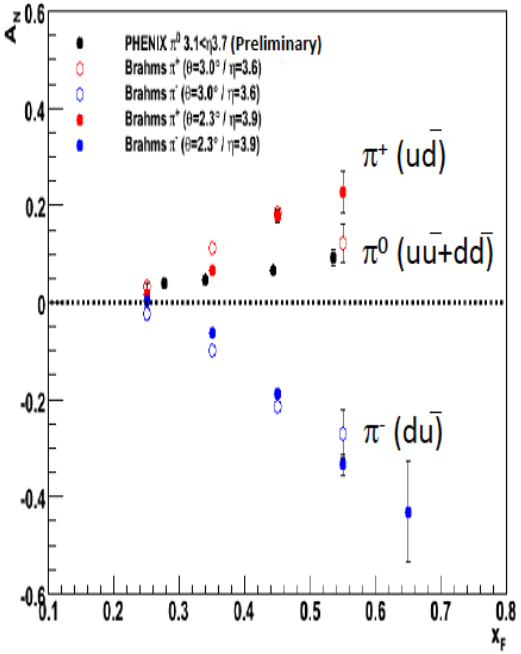
On behalf of the HERMES collaboration

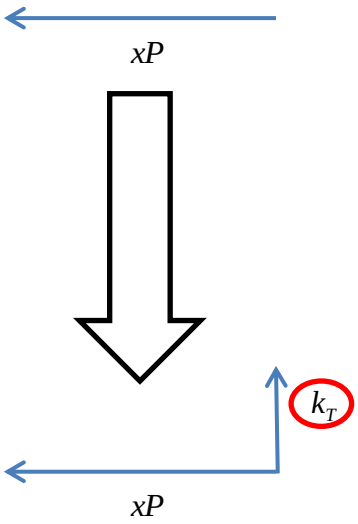
Investigating spin structure of nucleon



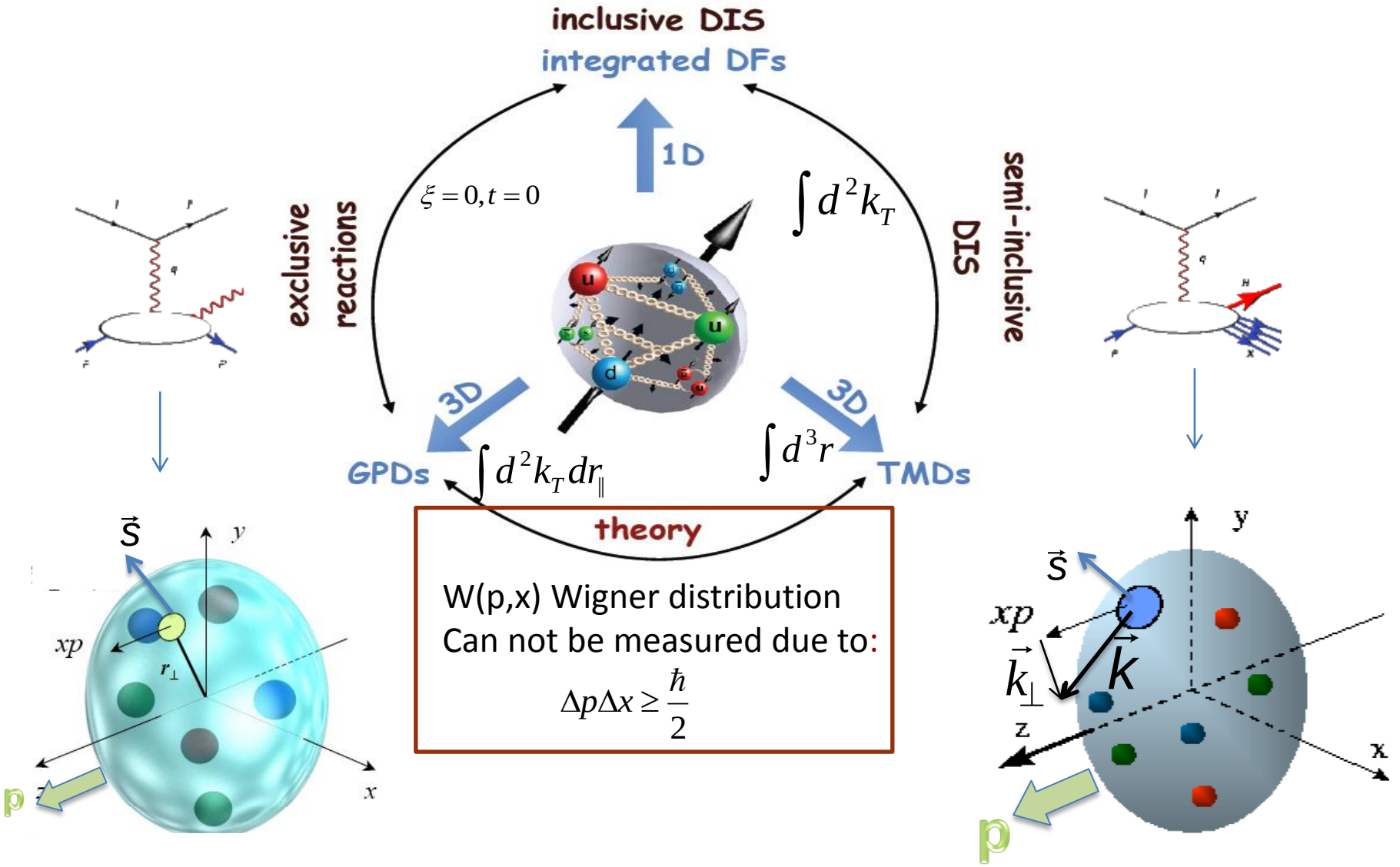
- **Spin crisis**
- **longitudinal and transverse momentum nucleon structure**
- **Large SSA in pion production**
- **quark transverse momentum role**



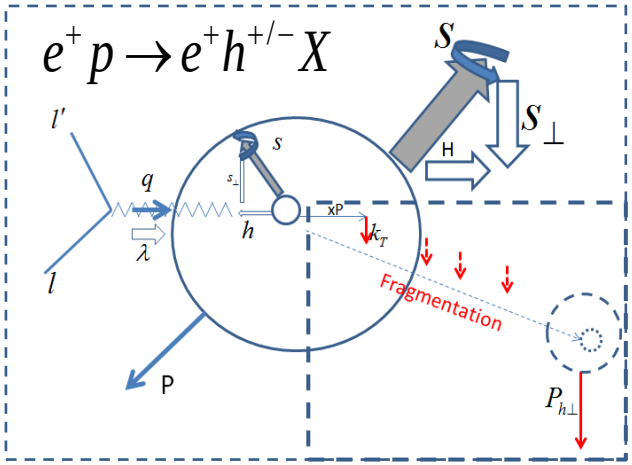




TMD approach

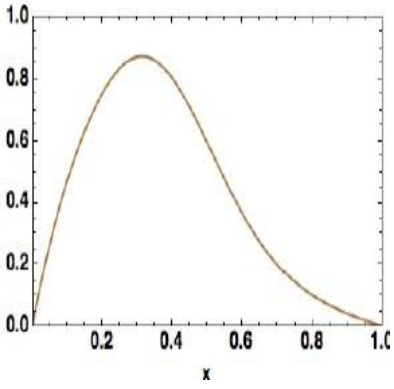


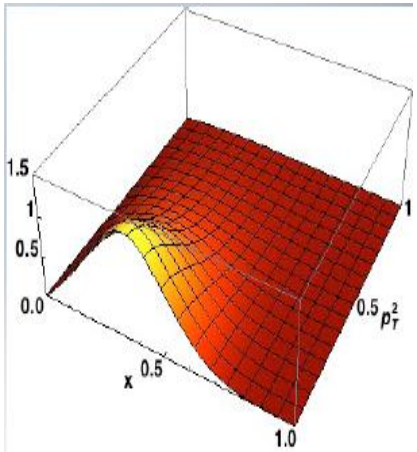
SIDIS cross section



inclusive semi-inclusive

$f_1(x)$ $f_1(x, p_T)$





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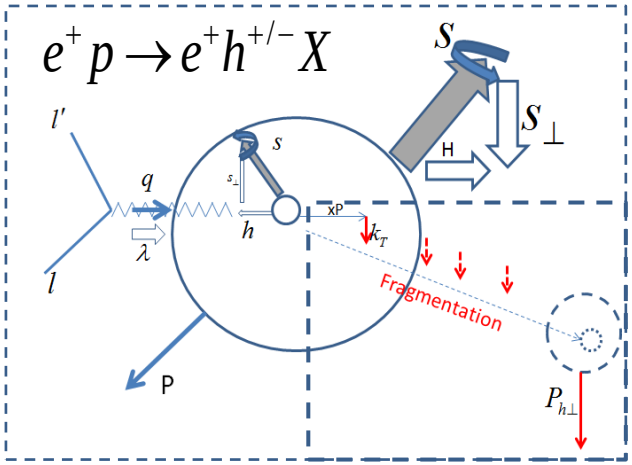

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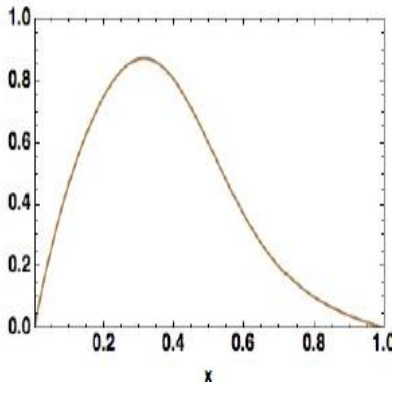

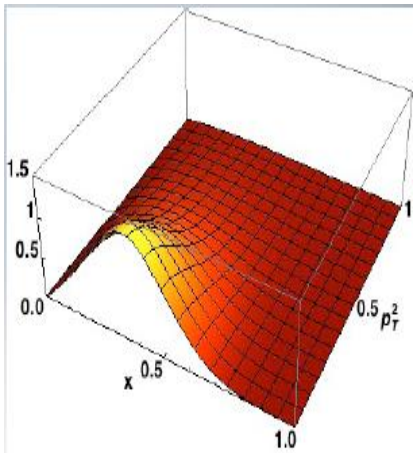

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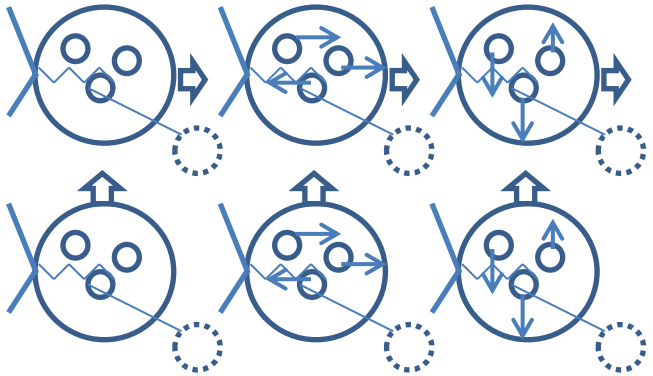
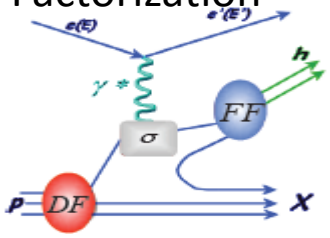


Superposition in basis of $s_\perp, s_\parallel, S_\parallel, S_\perp, \lambda_e$

DF TMD

		quark		
		U	L	T
nucleon	U	f_1		$h_1^\perp$
	L		g_1	$h_{1L}^\perp$
	T	$f_{1T}^\perp$	$g_{1T}^\perp$	$h_1\, h_{1T}^\perp$

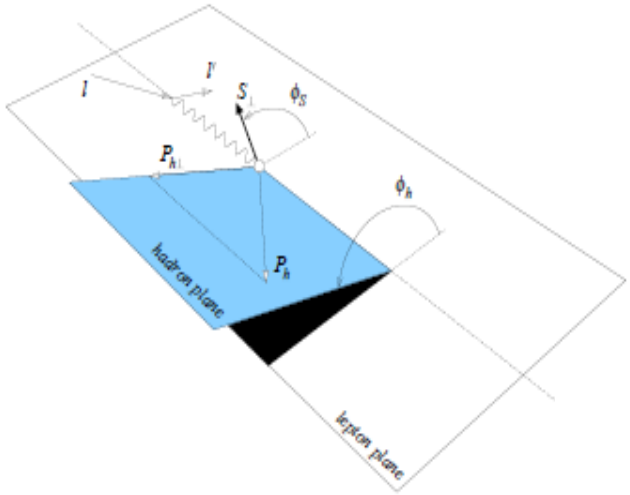
Factorization



$$\sigma^{eN->ehX} = \sum DF^{N\to q} \otimes \sigma^{eq\to eq} \otimes FF^{q\to h}$$

FF TMD

		quark		
		U	L	T
had	U	D_1		$H_1^\perp$



Subleading (twist-3) $A_{LU}^{\sin\phi_h}$

Total SIDIS cross section

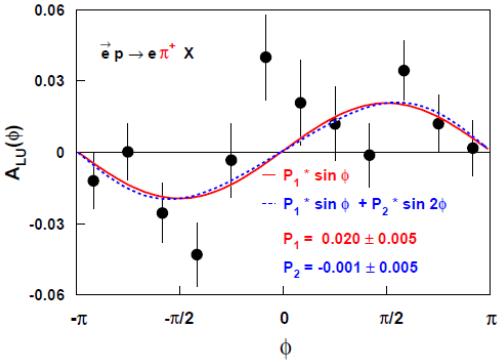
$$d\sigma = d\sigma_{UU} + \lambda_e \frac{1}{Q}\sin(\phi_h) d\sigma_{LU} + S_\parallel [...] d_{UL} + S_\parallel \lambda_e [...] d_{LL} +$$

$$+ S_\perp [...] d_{UT} + S_\perp \lambda_e [...] d_{LT} \overset{LU\ case}{=} d\sigma_{UU} \left\{ 1 + \lambda_e A_{LU}^{\sin\phi_h} \sin\phi_h \right\}$$

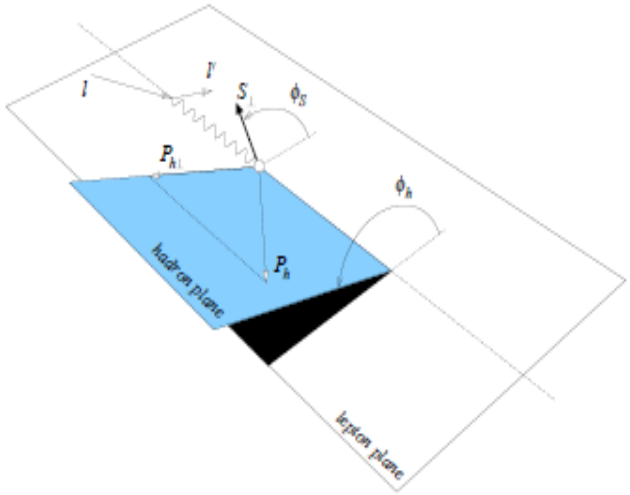
$$\frac{d\sigma_{LU}}{d\sigma_{UU}}$$

Beam spin asymmetry

$$A_{LU}(\phi_h) = \frac{d\sigma_{LU}}{d\sigma_{UU}} = \frac{d\sigma(\lambda_e) - d\sigma(-\lambda_e)}{d\sigma(\lambda_e) + d\sigma(-\lambda_e)} = A_{LU}^{\sin\phi_h} \sin(\phi_h)$$



$$d\sigma_{LU} \sim A_{LU}^{\sin\phi} \sim f(y) \cdot \frac{2M}{Q} C\left[-\frac{\hat{h}\cdot k_T}{M_h}\left(xeH_1^\perp + \frac{M_h}{M} f_1 \frac{\tilde{G}^\perp}{z} \right) + \frac{\hat{h}\cdot p_T}{M}\left(xg^\perp D_1 + \frac{M_h}{M} h_1^\perp \frac{\tilde{E}}{z} \right) \right]$$



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distribution functions

nucleon \ quark	U	L	T
U	f_1		$h_1^\perp$
L		g_1	$h_{1L}^\perp$
T	$f_{1T}^\perp$	$g_{1T}^\perp$	$h_1\, h_{1T}^\perp$

fragmentation functions

had \ quark	U	L	T
U	D_1		$H_1^\perp$

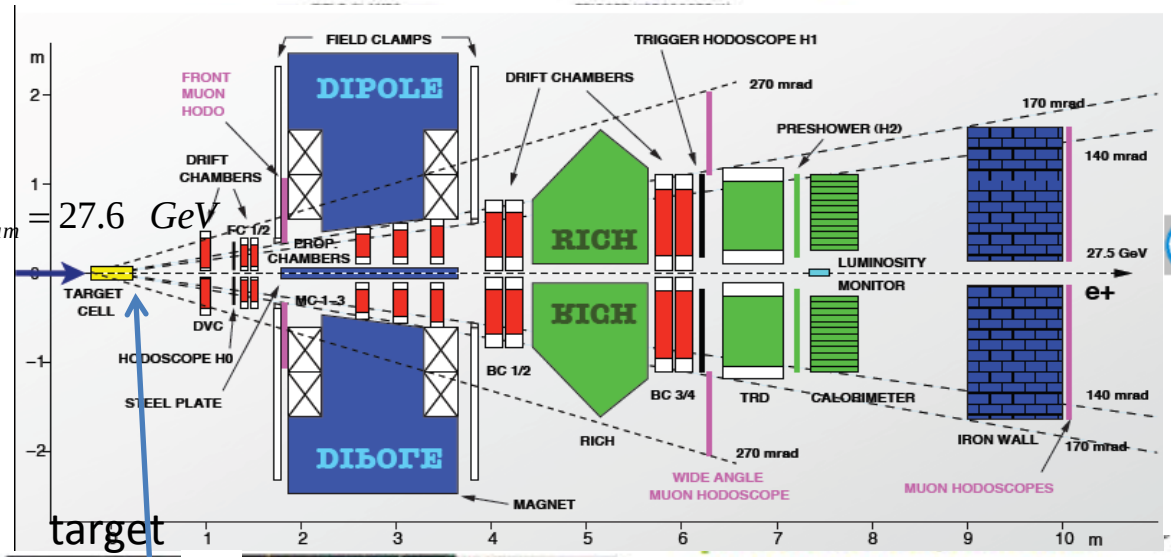
kinematic prefactor — twist-3 DF and FF

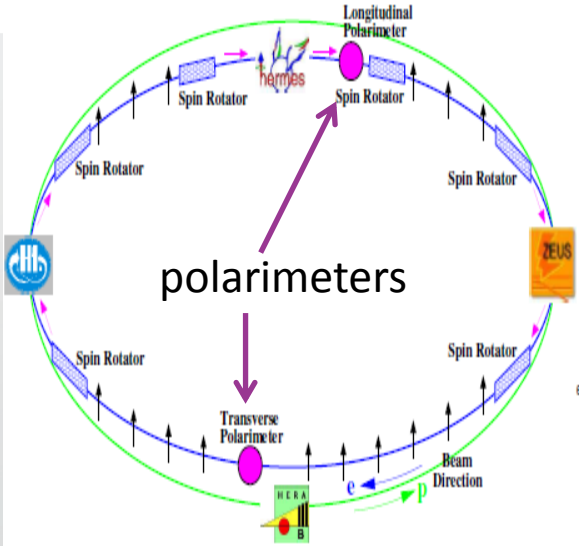
$$d\sigma_{LU} \sim f(y) \cdot \frac{2M}{Q} C \left[-\frac{\hat{h}\cdot k_T}{M_h} \left(x e H_1^\perp + \frac{M_h}{M} f_1 \frac{\tilde{G}^\perp}{z} \right) + \frac{\hat{h}\cdot p_T}{M} \left(x g^\perp D_1 + \frac{M_h}{M} h_1^\perp \frac{\tilde{E}}{z} \right) \right]$$

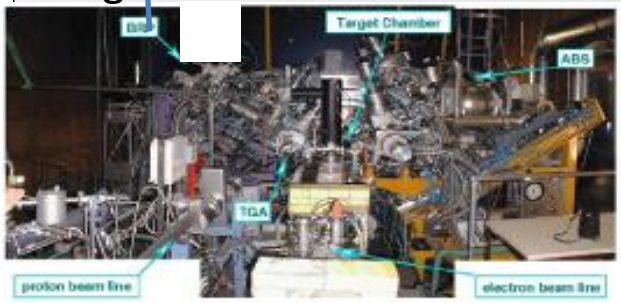
Collins — unpolarized — Boer - Mulders

The HERMES experiment at HERA

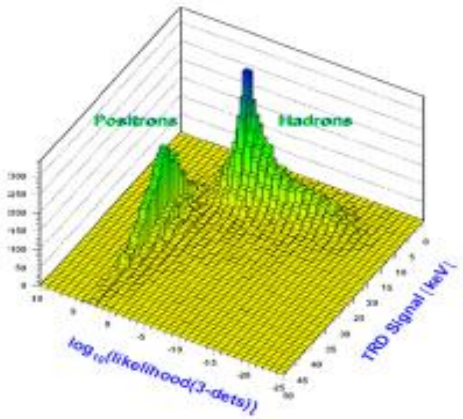
$E_{beam} = 27.6\ GeV$

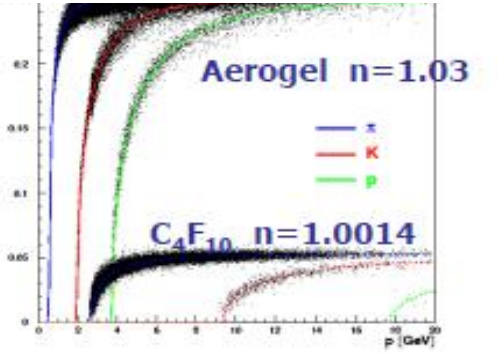






lepton-hadron > 98%





π ~ 98%, K ~ 88% , P ~ 85%

38

Hadron separation

Maximum likelihood function

- Data sample consist of N **independent** measured events with kinematic variables ξ
  ξ is $\phi_h, x_B, y, z, P_{h\perp}$
- events are distributed according to Probability Density Function, $p(\xi, \theta)$

Θ - is set of parameters(here 1 par): $A_{LU}^{\sin\phi_h} = \dfrac{d\sigma_{LU}}{d\sigma_{UU}}$

cuts

$Q^2 > 1 \ GeV^2$

$W^2 > 10 \ GeV^2$

$0.1 < y < 0.85$

$0.023 < x < 0.9$

$$p(\phi_h, A_{LU}^{\sin\phi_h}) \sim \left\{1 + \lambda_e A_{LU}^{\sin\phi_h} \sin\phi_h\right\}$$

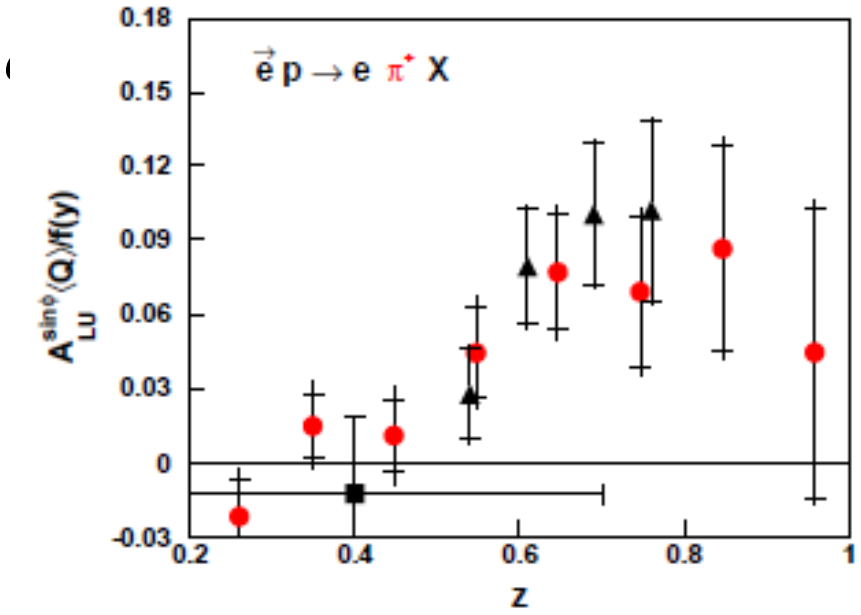
Likelihood function

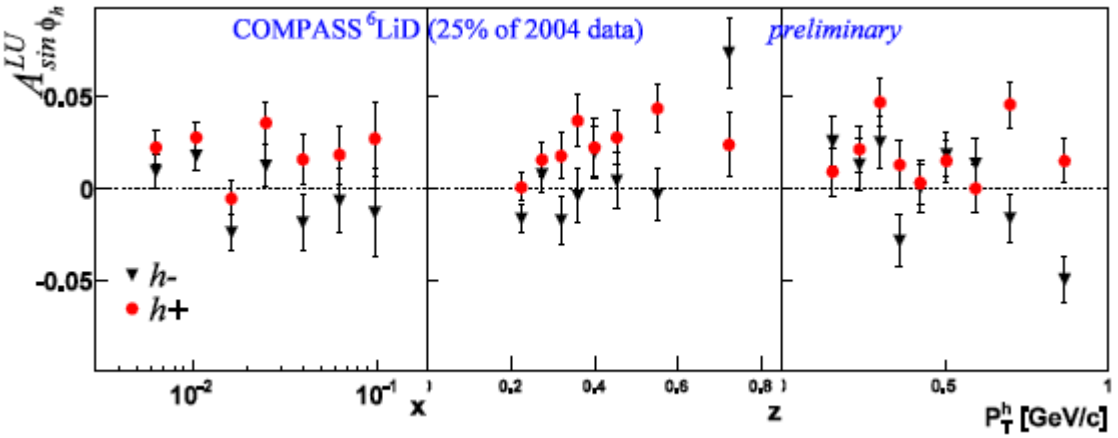
$$L(\phi_h, A_{LU}^{\sin\phi_h}) = \prod p(\phi_h, A_{LU}^{\sin\phi_h}) = \prod_{pol>0}^{N^+} p^{w^+}(\phi_h, A_{LU}^{\sin\phi_h}) \prod_{pol<0}^{N^-} p^{w^-}(\phi_h, A_{LU}^{\sin\phi_h})$$

Beam Balance

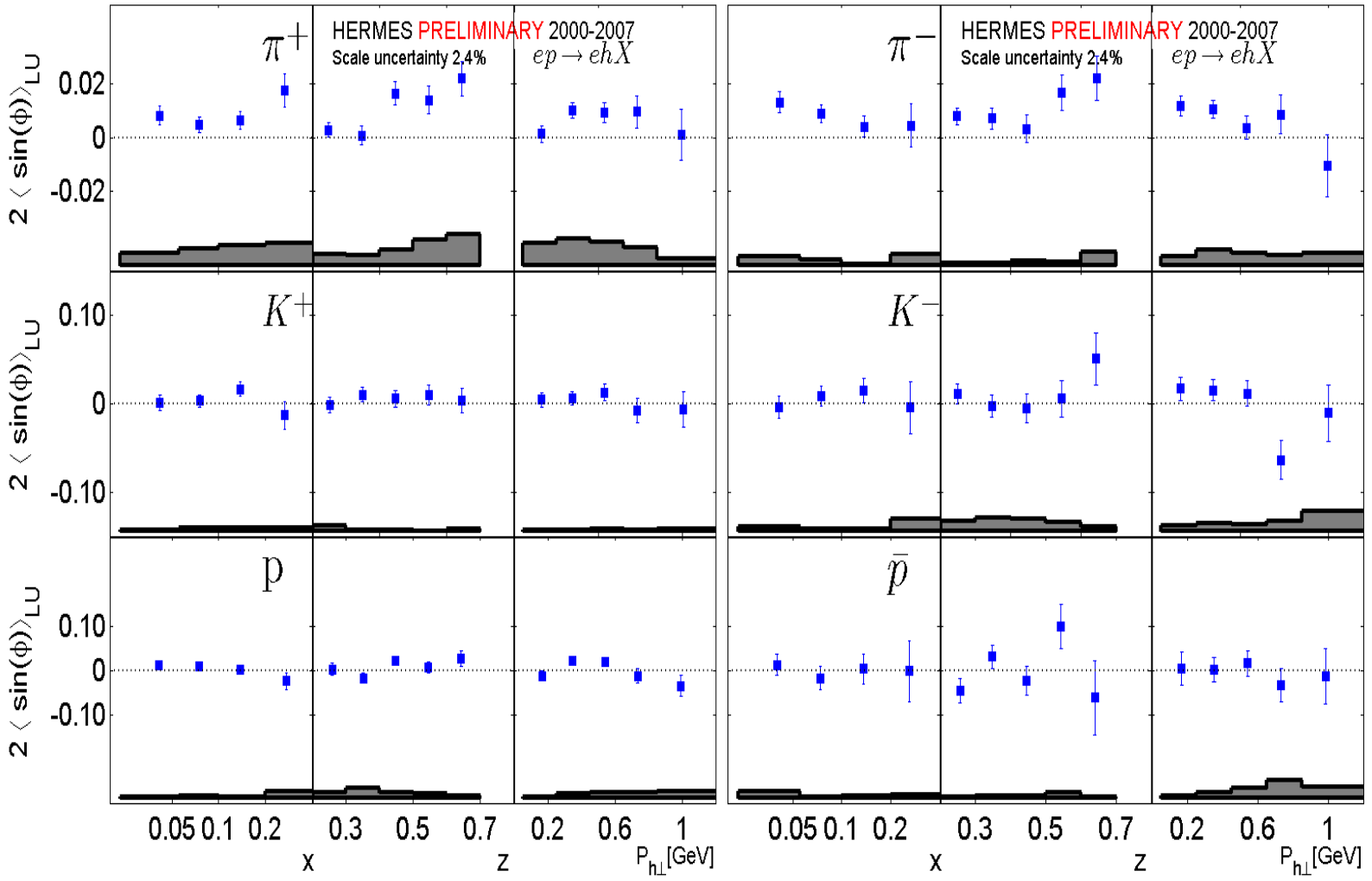
$$\sum_{i=1}^{DIS^+} P_i + w^- \sum_{i=1}^{DIS^-} P_i = 0 \quad \begin{cases} w^+ = 1 \\ w^- = \sum_{i=1}^{DIS^+} P_i \Big/ \sum_{i=1}^{DIS^-} P_i \end{cases}$$

Previous results at HERMES (E=27.6 GeV) (Phys. Lett. B648 (2007) 164)
Compared to CLAS(E=5.76 GeV) and COMPASS (E=160 GeV) experiments.

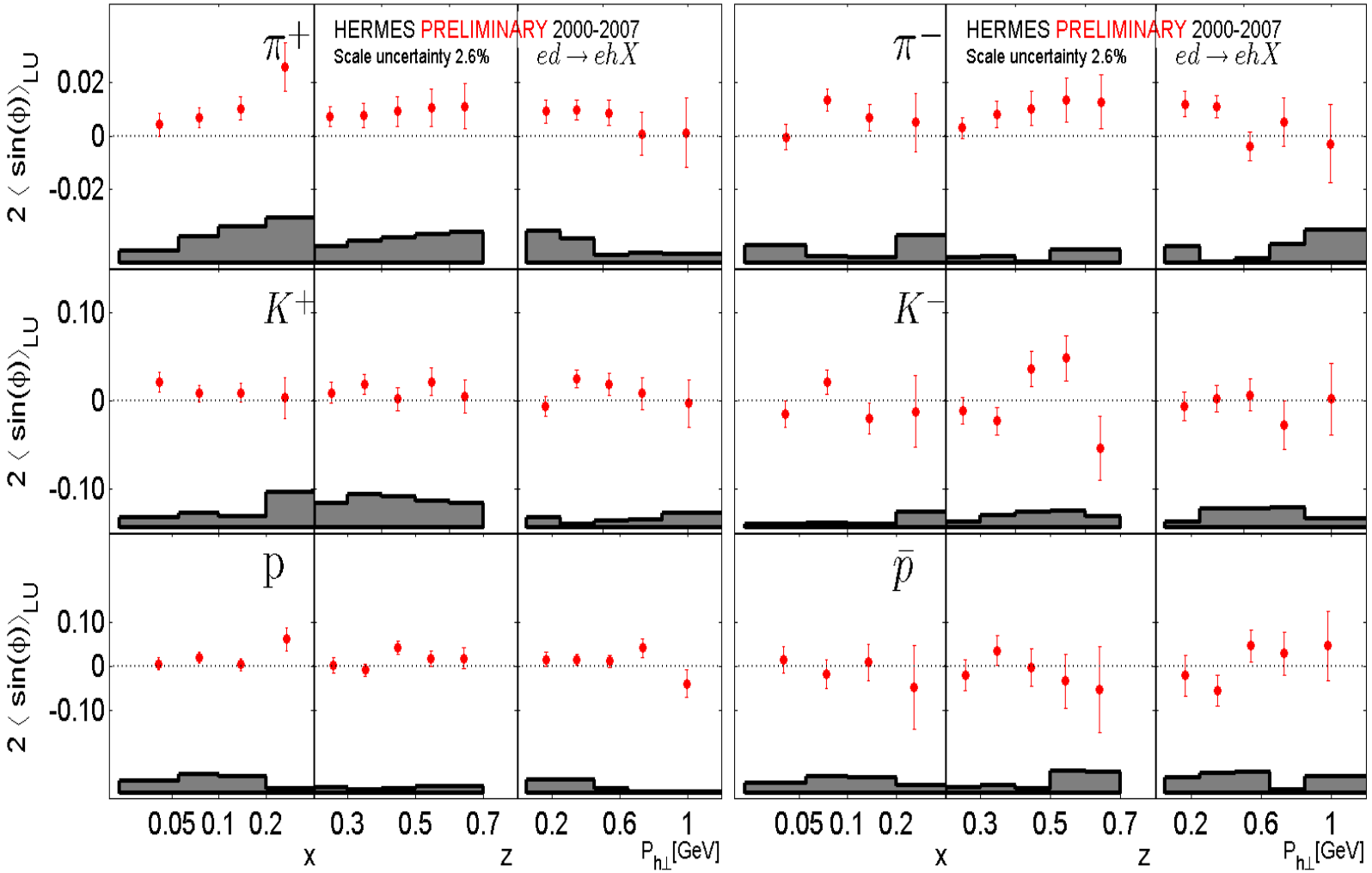




New results. Hydrogen target



New results. Deuterium target



Conclusions

- Recently obtained BSA of pions, kaons , proton and antiproton on hydrogen and deuterium target with increased statistics

- kaons BSA asymmetries are measured for the first time

- proton and antiproton BSA are presented for the first time in SIDIS analysis

- pions BSA are slightly positive

- kaon and proton/antiproton BSA are consistent with zero