Single-spin azimuthal asymmetries in π^0 electroproduction

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for the hermes collaboration

- Introduction
- Cross section asymmetry
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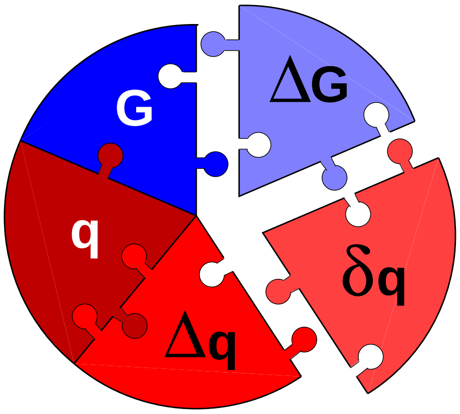
- Summary & Outlook



motivation

at leading twist:

	q	(x, Q^2)	quark number density distribution	(f_1)
	Δq	(x, Q^2)	quark helicity distribution	(g_1)
***	δq	(x, Q^2)	quark transversity distribution	(h_1)
	G	(x, Q^2)	gluon number density distribution	
**	ΔG	(x, Q^2)	gluon spin distribution	

first glimps: $\Delta G/G$ is positive

transversity δq UNmeasured

$\Rightarrow$ chiral-odd object:
NOT accessible in inclusive DIS BUT in processes involving another chiral-odd structure

$\Rightarrow$ semi-inclusive DIS:
appearance of a chiral-odd FF

semi-inclusive DIS

$$\sigma^{\mathrm{eH}\rightarrow\mathrm{ehX}} = \sum_{\mathrm{q}} f^{\mathrm{H}\rightarrow\mathrm{q}} \otimes \sigma^{\mathrm{eq}\rightarrow\mathrm{eq}} \otimes D^{\mathrm{q}\rightarrow\mathrm{h}}$$

$\Downarrow$ chiral-odd DF

$\Downarrow$ chiral-odd (time-odd) FF

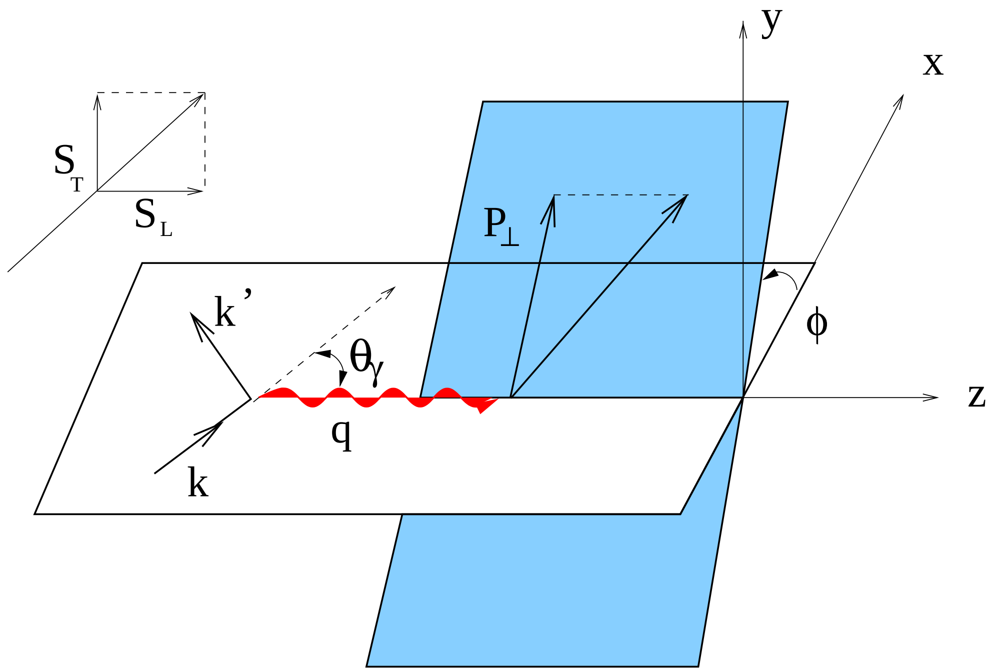
[J. Collins, 1993]

$\Rightarrow$ single-spin asymmetries (SSA)
where either the **beam** *or* **target** is **polarised**

SSA $= 0$ in naive parton models: non interacting collinear parton and parity, angular momentum, helicity conservation

SSA originates from multi-parton correlation and intrinsic quark transverse momentum $\mathrm{k_T}$

kinematics: ep $\to$ e$'\pi$X



$$\sin\theta_\gamma \approx \frac{2Mx}{Q}\sqrt{1-y}\,,$$

$$\begin{aligned} Q^2 &= (k-k')^2 \\ \nu &= E-E' \\ x &= Q^2/(2M\nu) \\ y &= \nu/E \\ z &= E_\pi/\nu \end{aligned}$$

$P_\perp$ pion transverse momentum

ϕ azimuthal angle of π around the virtual-photon direction

data selection

target hydrogen

polarisation:

$$\langle P_t \rangle = (0.86 \pm 0.05)\,\%$$

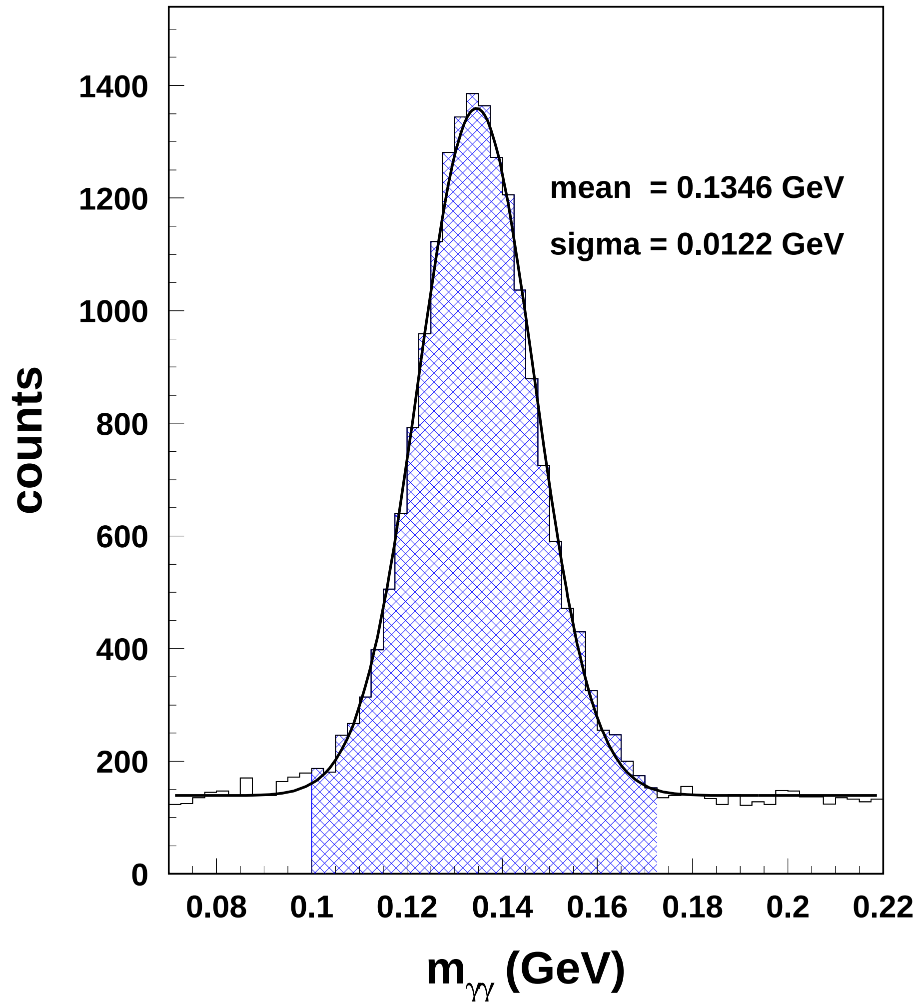
positron

		Q^2	$>$	1.0	GeV^2
		W^2	$>$	4.0	GeV^2
		y	$<$	0.85	
0.02	$<$	x	$<$	0.4	

data selection

$\boxed{\pi^0}$ $\Leftarrow$ two photon cluster in the calorimeter without corresponding track:

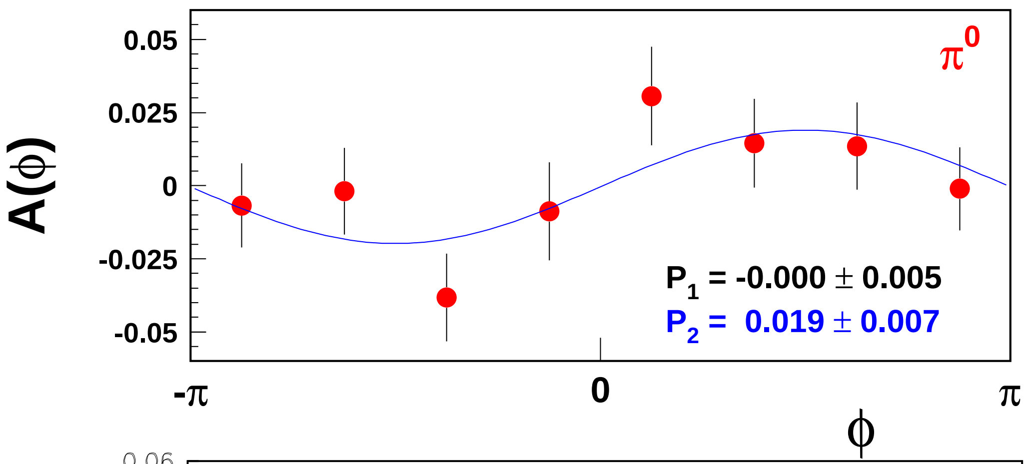
$$
\begin{array}{ccccc}
 & & E_\gamma & > & 1.0 \quad \text{GeV} \\
0.1 & < & m_{\gamma\gamma} & < & 0.17 \quad \text{GeV} \\
 & & & & \\
 & & z & < & 0.7 \\
 & & P_\perp & > & 0.05 \quad \text{GeV}
\end{array}
$$

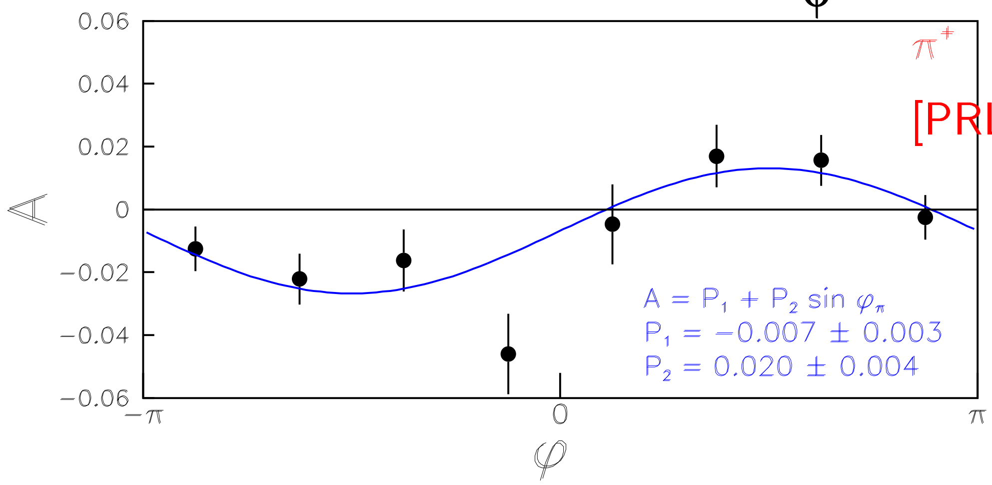


single target-spin azimuthal asymmetry

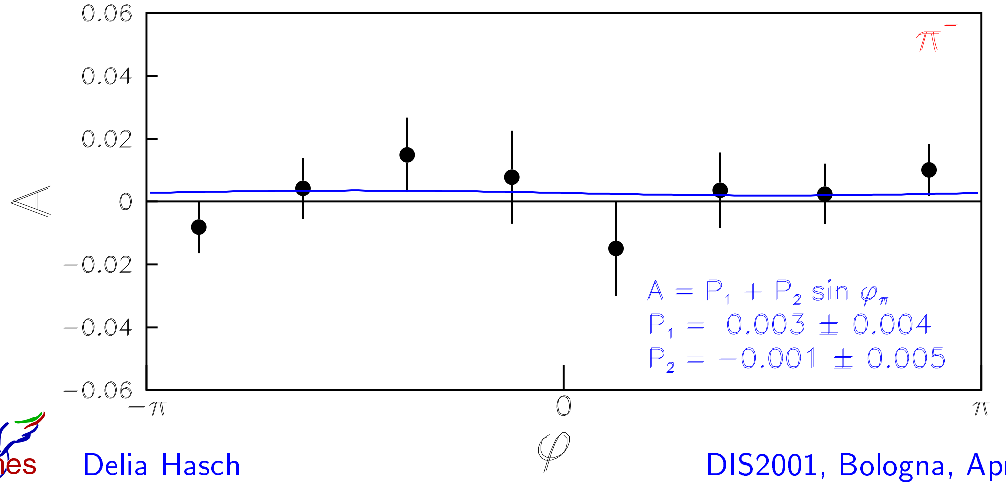
$$A(\phi) = \frac{1}{\langle P_{\rm t} \rangle} \cdot \frac{N^+(\phi) - N^-(\phi)}{N^+(\phi) + N^-(\phi)}$$

$\mathrm{P}_1 + \mathrm{P}_2 \sin\phi$





[PRL 84, 2000]



azimuthally weighted asymmetries

analysing powers for target longitudinal polarisation:

$$A_{\mathrm{UL}}^{W} = \frac{\frac{L^{\rightarrow}}{L_{\mathrm{P}}^{\rightarrow}} \sum_{i=1}^{N^{\rightarrow}} W(\phi_i^{\rightarrow}) - \frac{L^{\leftarrow}}{L_{\mathrm{P}}^{\leftarrow}} \sum_{i=1}^{N^{\leftarrow}} W(\phi_i^{\leftarrow})}{\frac{1}{2}[N^{\rightarrow} + N^{\leftarrow}]}$$

$\rightarrow$ and $\leftarrow$ denote opposite beam (target) helicity states
$L^{\rightarrow(\leftarrow)}$ and $L_{\mathrm{P}}^{\rightarrow(\leftarrow)}$ luminosities and lumi weighted polarisations

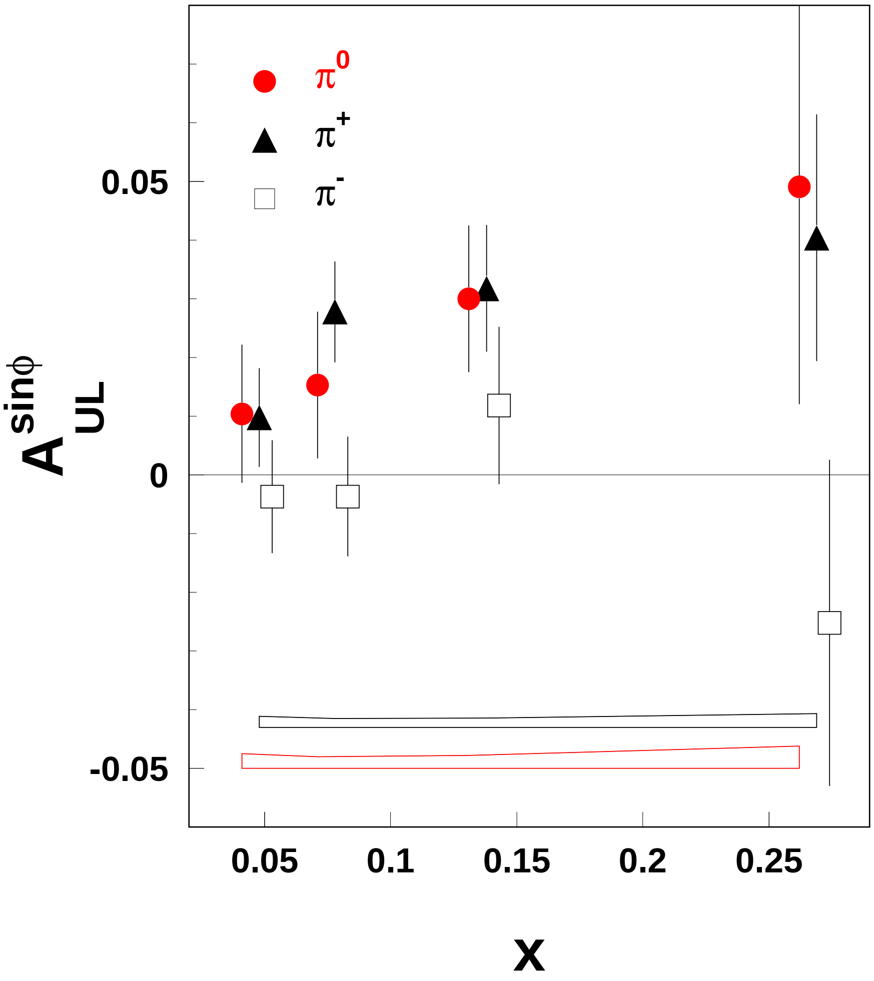
$$W(\phi) = \sin\phi, \sin 2\phi, \ldots, \cos\phi, \cos 2\phi, \ldots$$

$$\begin{aligned} \langle \frac{P_{\mathrm{T}}}{zM_{\mathrm{h}}} \sin\phi \rangle_{\mathrm{UL}} \quad \propto \quad & S_{\mathrm{L}} \frac{2(2-y)}{Q\sqrt{1-y}} \sum_{a,\bar{a}} e_a^2 x\, h_{\mathrm{L}}^{a}(x)\; H_1^{\perp a}(z) \\ + \quad & S_{\mathrm{T}} \quad (1-y) \sum_{a,\bar{a}} e_a^2 x\, h_1^{a}(x)\; H_1^{\perp a}(z) \end{aligned}$$

HERMES: longitudinal polarised target: $S_{\mathrm{T}} \propto \sin\theta_{\gamma}$
second term contributes with 20% to 30%

$h_{\mathrm{L}}(x)$ includes interaction dependent twist-3 part
$h_{\mathrm{L}}(x) = h_1(x) - \frac{\mathrm{d}}{\mathrm{d}x} h_{1\mathrm{L}}^{\perp(1)}(x)$

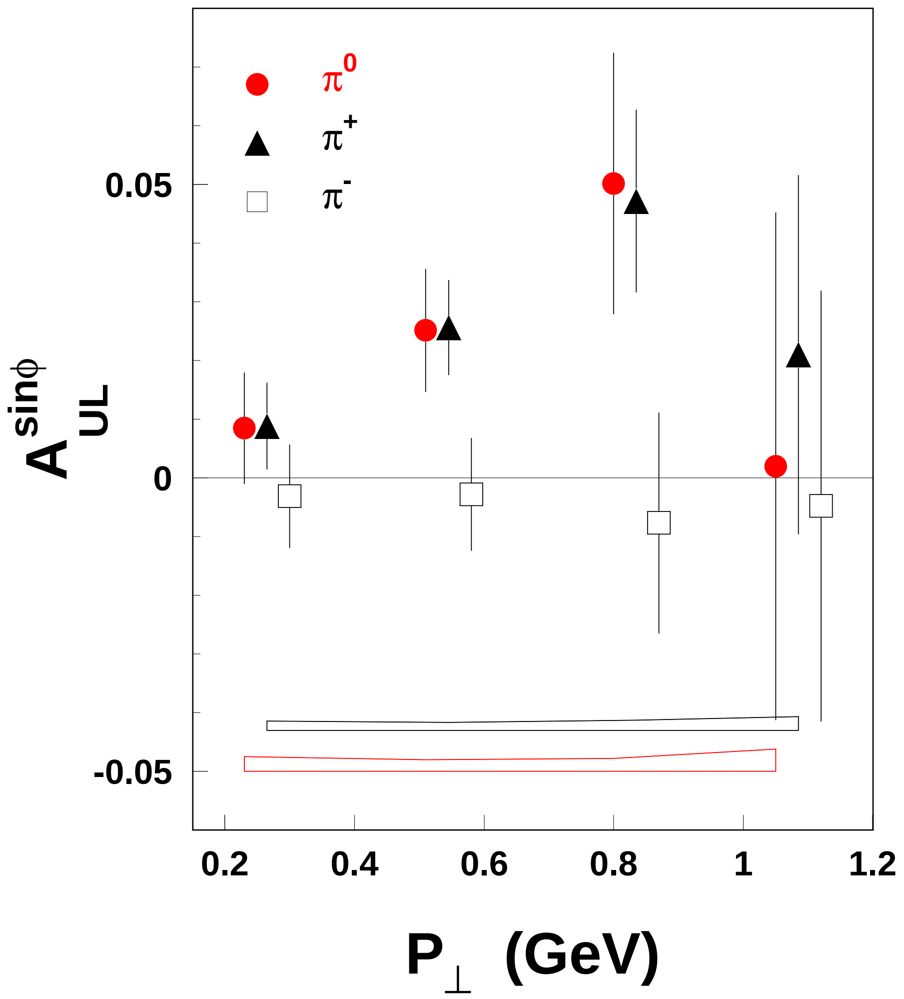
SSA $A_{\rm UL}^{\sin\phi}$: x dependence



similar behaviour of π^0 and π^+

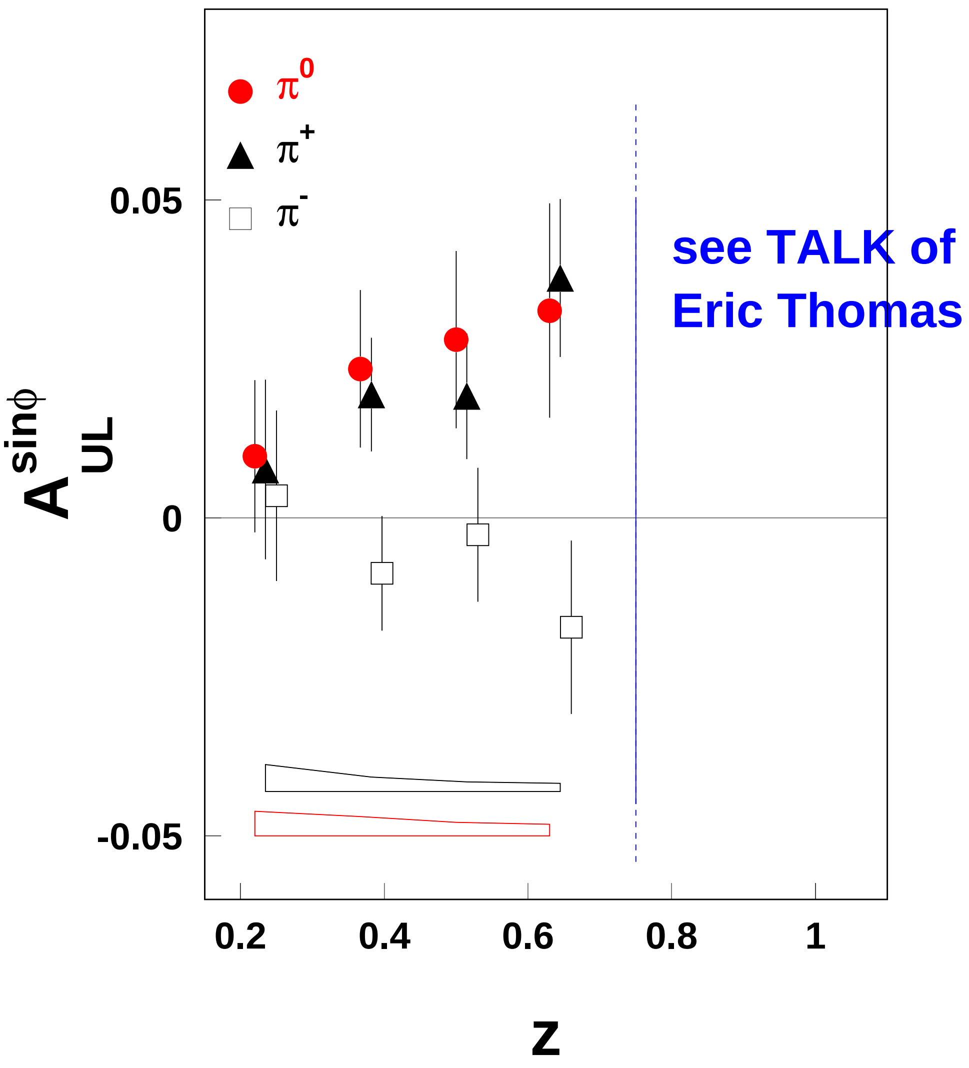
behaviour consistent with increase suggests that single-spin asymmetries are associated with valence quark contributions

SSA $A_{UL}^{\sin\phi}$: P$_\perp$ dependence



related to the dominant kinematic role of the intrinsic transverse momentum of the quark, if $P_\perp$ remains below the typical hadronic mass of $\sim$ 1 GeV

SSA $A_{\mathrm{UL}}^{\sin\phi}$: z dependence



different behaviour of SSA in semi-inclusive and (semi-)exclusive region for π^0 and π^+

summary & outlook

observation of single-spin azimuthal asymmetries for pions produced in semi-inclusive DIS of a positron beam on a **longitudinally** polarised hydrogen target

[hep-ex/0104005], [PRL 84, 2000]

- significant x, $P_\perp$ and z dependence of $A_{\mathrm{UL}}^{\sin\phi}$ for π^+ and π^0
- π^0 asymmetry is similar to π^+ asymmetry
- π^- asymmetry consistent with zero

$\Rightarrow$ observed $A_{\mathrm{UL}}^{\sin\phi}$ for neutral and charged pions are **consistent with u-quark dominance in both DF and FF**

$\Rightarrow$ existence of a non-zero chiral-odd structure that describes the transverse polarisation of quarks

$\Rightarrow$ good promise for **HERMES Run 2001+** transverse target program
$\Rightarrow$ **focus on transversity**