HERMES Status Report

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47th DESY PRC
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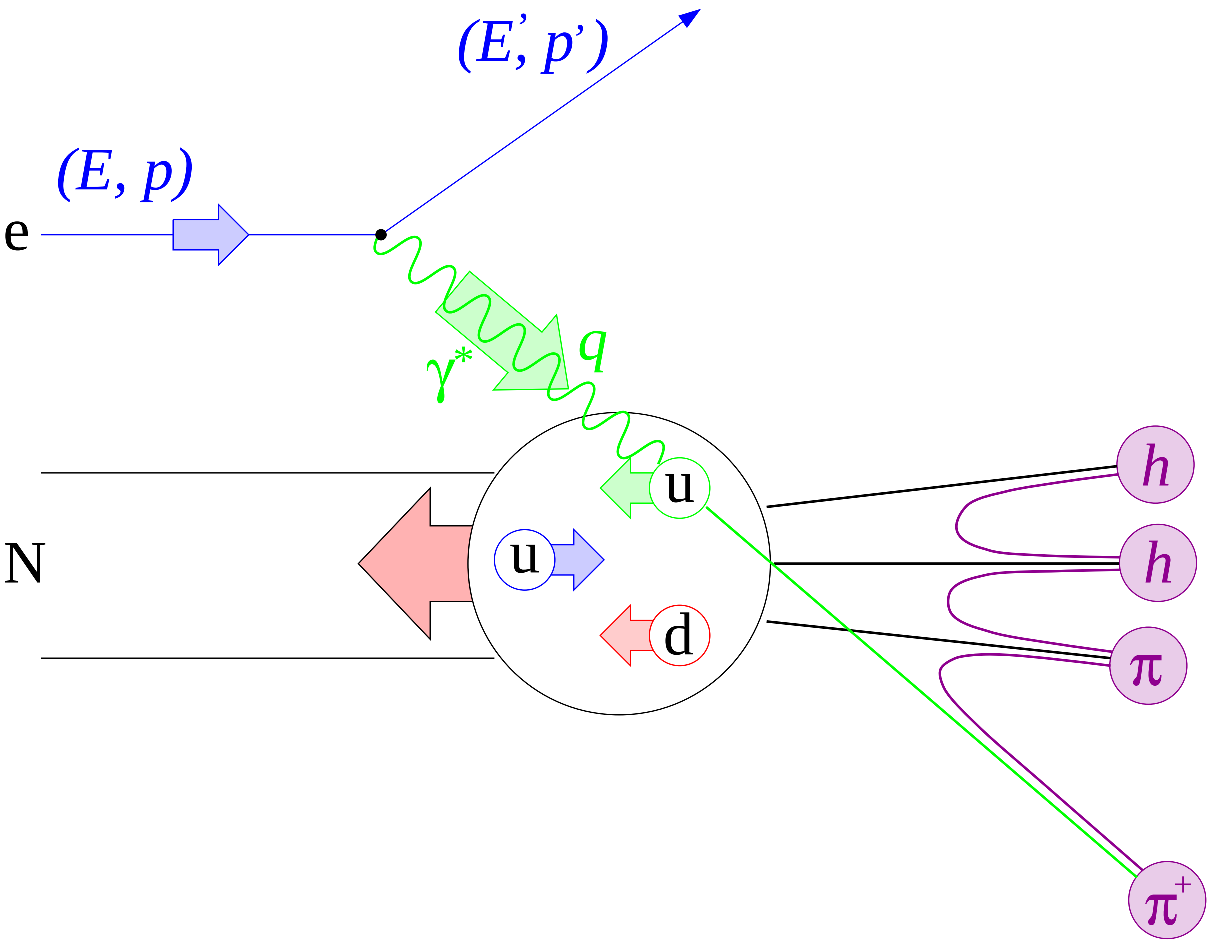
- 1998/99 Data Taking
- New HERMES Results:
  - Quark Polarizations from 1995-1997 data
  - Asymmetry of Pairs of Hadrons at High p_T
  - Spin-Azimuthal Asymmetries
  - Asymmetry of Diffractive Vector Meson Production
  - Cross Section Ratios for ^{3}He/D and ^{14}N/D

Semi-Inclusive DIS

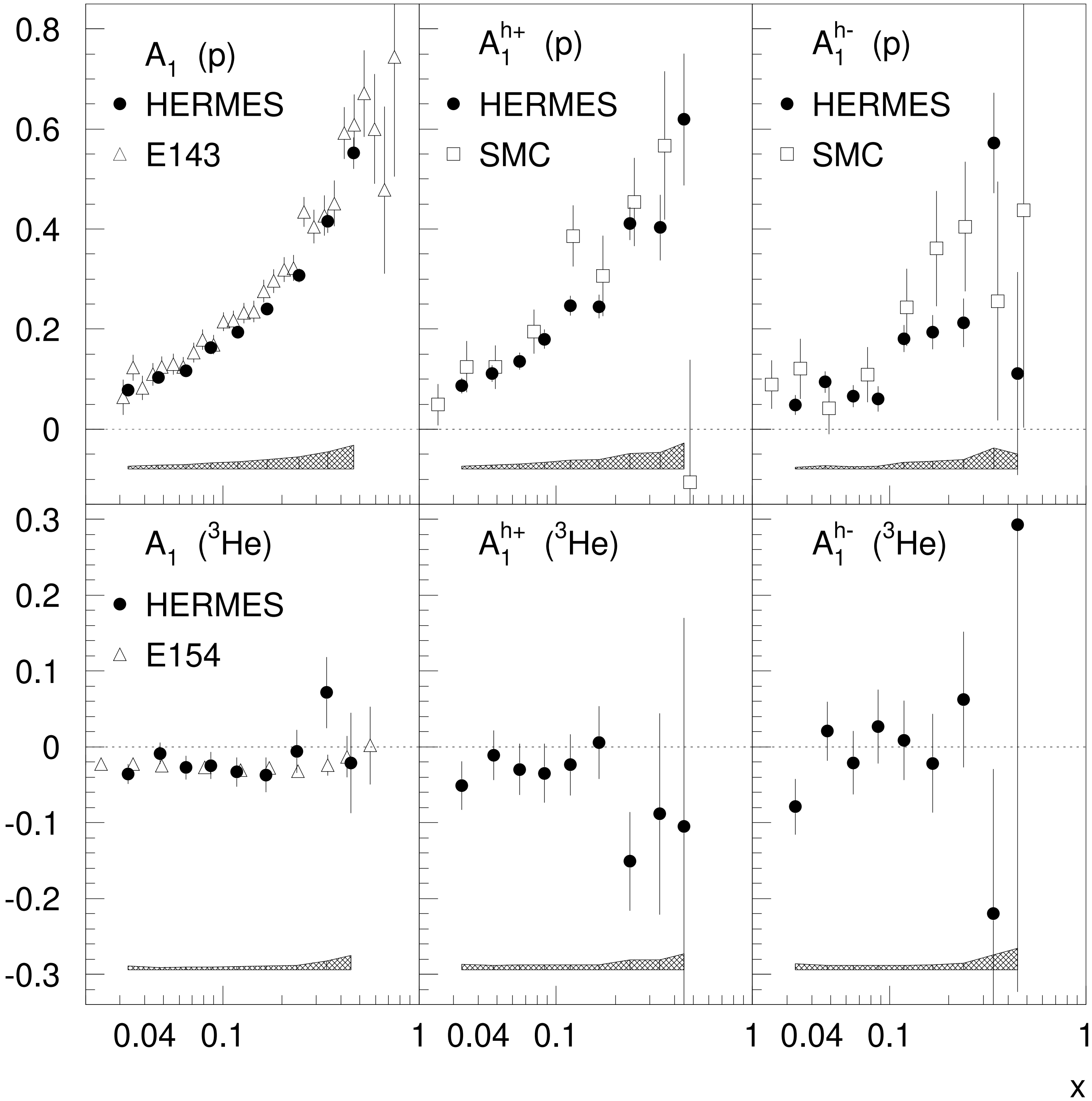
In semi-inclusive DIS a hadron h is detected in coincidence with the scattered lepton



Flavour Tagging:

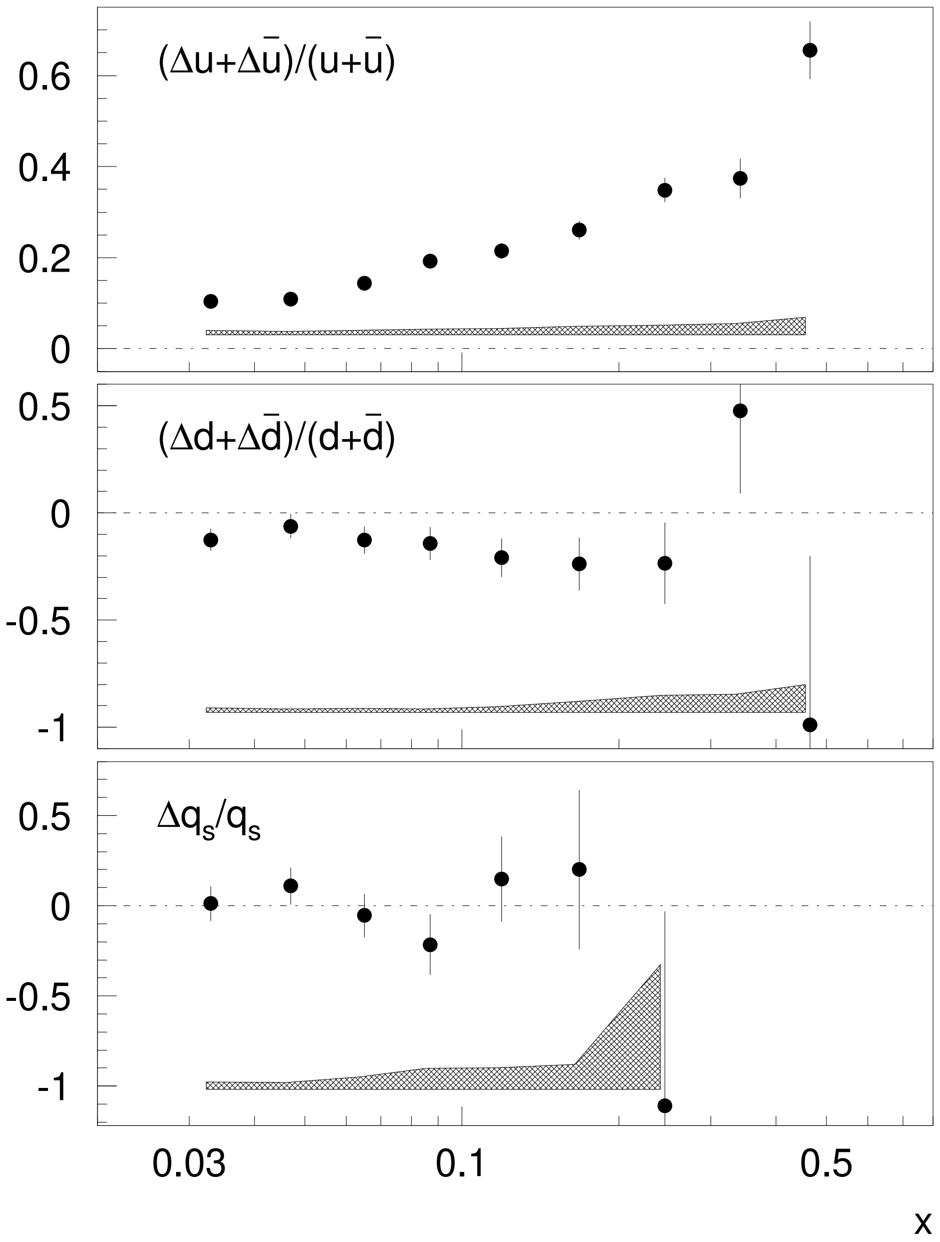
$\Rightarrow$ Determine polarizations of individual quark flavours

Semi-inclusive Asymmetries



Data given at mean Q^2 of each x. Error bars of HERMES (SLAC and SMC) are statistical (total) uncertainties. Bands are HERMES systematic error. Inclusive results compared to SLAC g_1/F_1.

Flavour Decomposition



Result insensitive to choice of sea assumption:

$$\frac{\Delta q_s}{q_s} \equiv \frac{\Delta u_s}{u_s} = \frac{\Delta d_s}{d_s} = \frac{\Delta s}{s} = \frac{\Delta \overline{u}}{\overline{u}} = \frac{\Delta \overline{d}}{\overline{d}} = \frac{\Delta \overline{s}}{\overline{s}}$$

$$\Delta q_s \equiv \Delta u_s = \Delta d_s = \Delta s = \Delta \overline{u} = \Delta \overline{d} = \Delta \overline{s}$$

First and Second Moments

HERMES **flavour decomposition** ($Q^2 = 2.5$)

	total integral	prediction		Q^2
$\Delta u + \Delta\bar{u}$	0.56 ± 0.04	0.66 ± 0.03	SU(3)[1]	2.5
$\Delta d + \Delta\bar{d}$	-0.25 ± 0.08	-0.35 ± 0.03	SU(3)[1]	2.5
$\Delta s + \Delta\bar{s}$	-0.02 ± 0.05	-0.08 ± 0.02	SU(3)[1]	2.5

Low-x extrapolation via Regge parametrization.

HERMES **Singlet** (Δq_0), **Triplet** (Δq_3), **and Octet** (Δq_8) ($Q^2 = 2.5$)

	total integral	prediction		Q^2
Δq_0	0.28 ± 0.10	0.23 ± 0.04	SU(3)[1]	2.5
Δq_3	0.83 ± 0.09	1.01 ± 0.05	$\lvert g_A/g_V \rvert$	2.5
Δq_8	0.32 ± 0.13	0.46 ± 0.03	$(3F - D)$	2.5

HERMES **valence distributions** ($Q^2 = 2.5$) **vs lattice QCD**

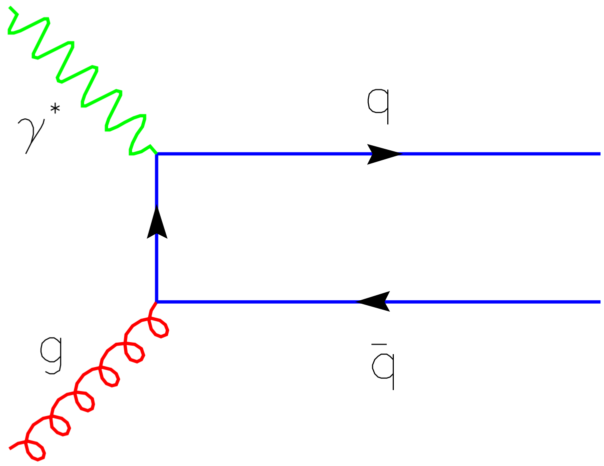
	total integral	prediction	Q^2
Δu_v	0.57 ± 0.09	0.84 ± 0.05[2]	5
Δd_v	-0.21 ± 0.16	-0.25 ± 0.02[2]	5
$x\Delta u_v$	0.124 ± 0.016	0.198 ± 0.008[2]	4
$x\Delta d_v$	-0.022 ± 0.034	-0.048 ± 0.003[2]	4

[1] J. Ellis and M. Karliner, Phys. Lett. B **341** (1995) 397; hep-ph/9601280
[2] M. Göckeler *et al.*, Phys. Lett. B **414** (1997) 81

High p_T Hadron Pairs

$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_z$$

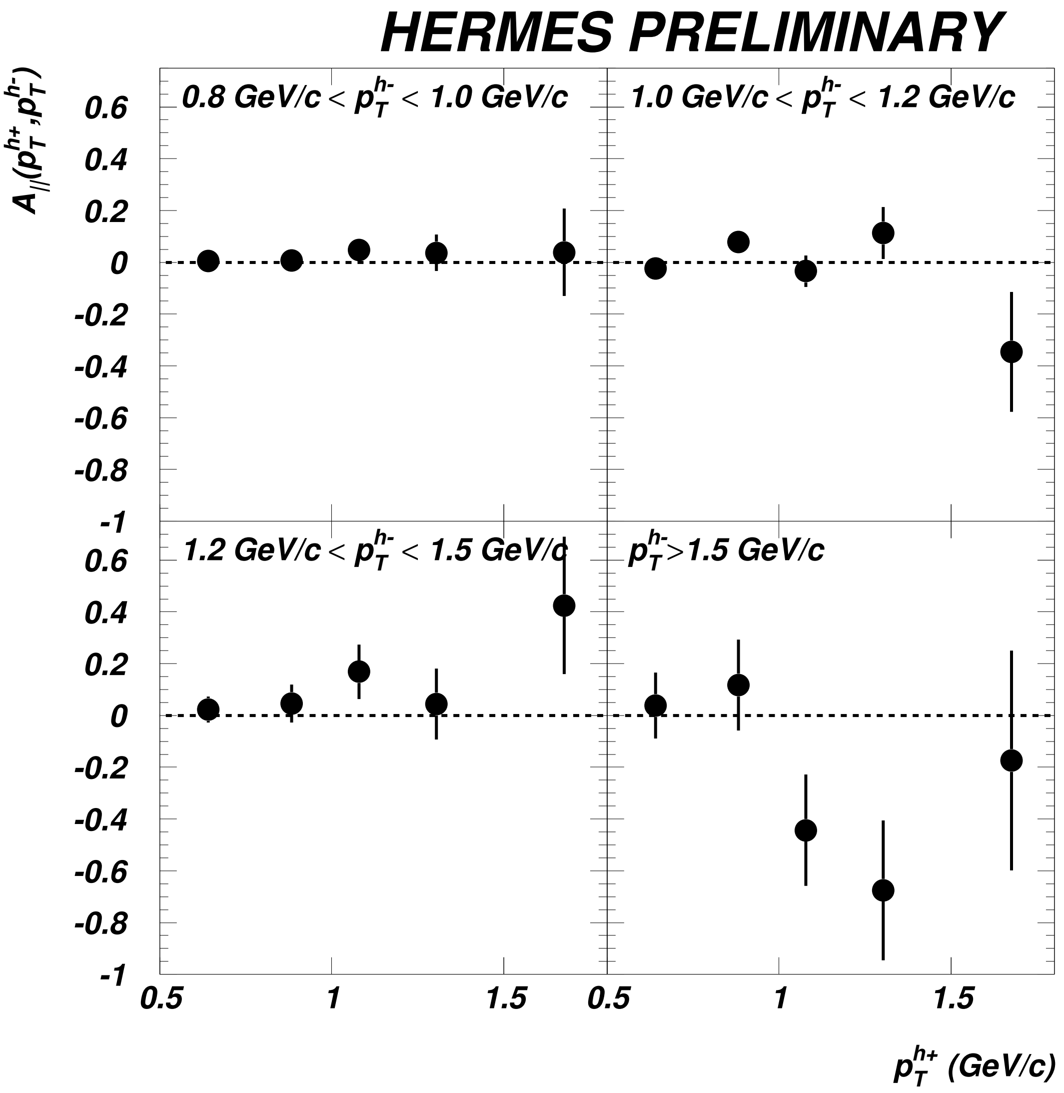
- Isolation of photon gluon fusion process
  $\rightarrow$ sensitivity to **gluon distribution**
- Spin asymmetry in photon gluon fusion
  $\rightarrow$ sensitivity to **gluon polarization** $\Delta G/G$



HERMES: measure asym of pairs of hadrons at high p_T

- require at least **two hadrons of opposite charge**
- require $M(2\pi) > 1.0$ GeV/c^2 to remove ρ and ϕ resonances
- do not require scattered e^+ in spectrometer
  $\Rightarrow$ **photoproduction** ($Q^2 \simeq 0$)

Measured Asymmetry $A_{||}(p_T^{h^+}, p_T^{h^-})$

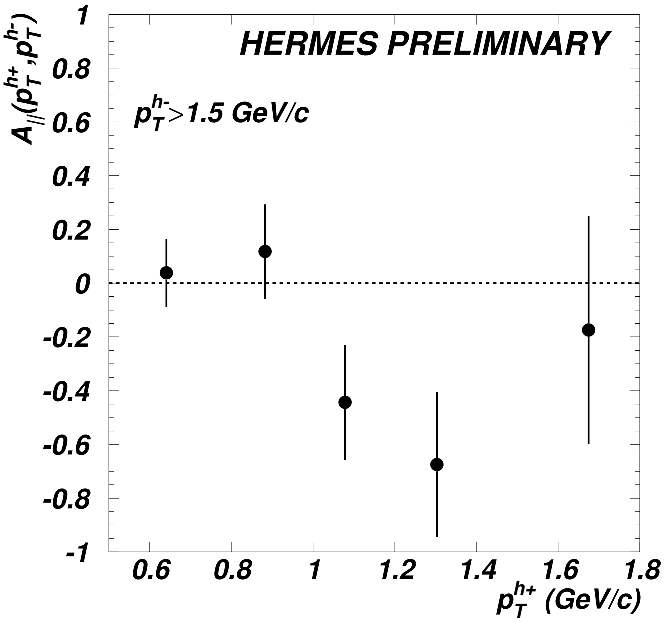


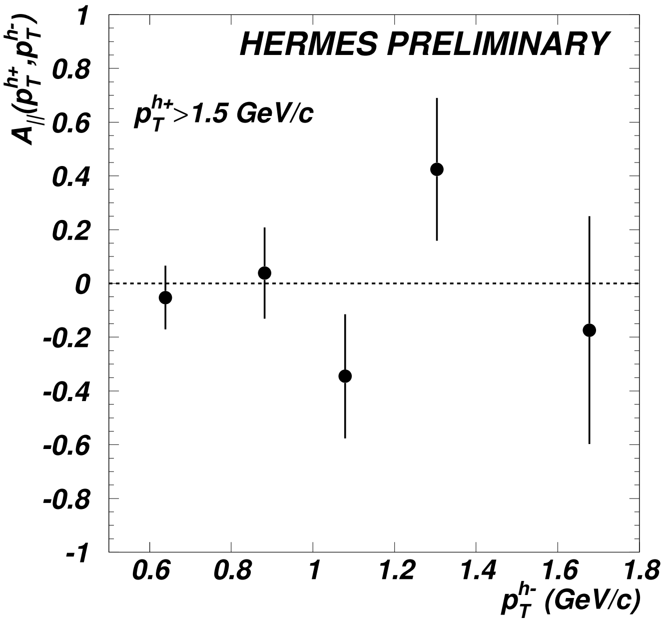
systematic error $\approx$ 8 % of measurement

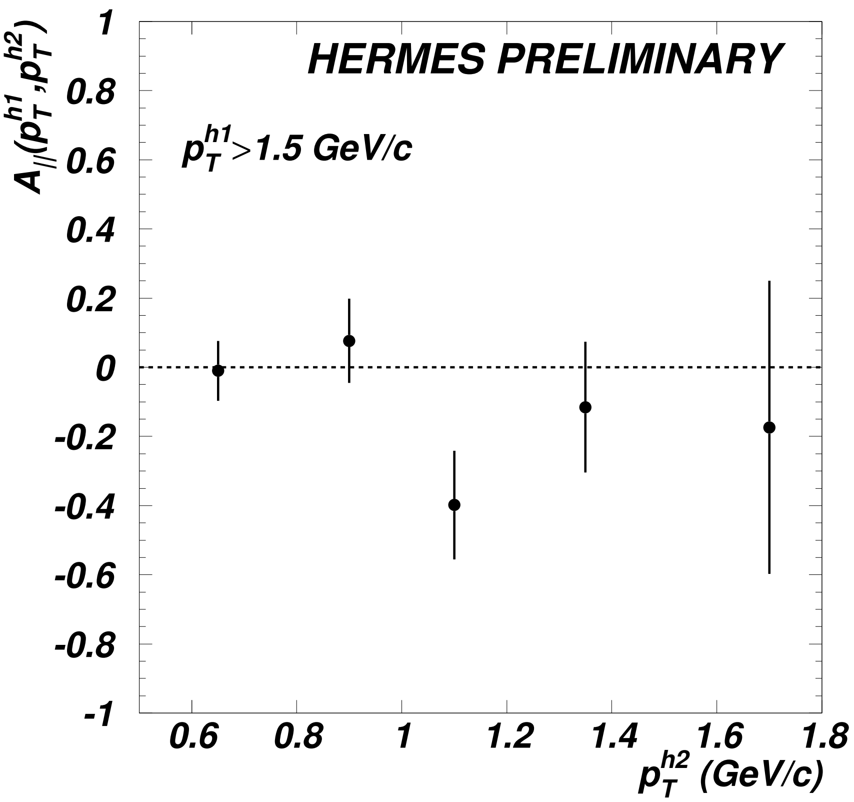
checks that have been performed on the data:

- $e^+ - h^+$ misidentification.
- particle identification cut variation.
- momentum ($\sim z$) cut variation.
- consistent result obtained using identified pions only.

Region of interest



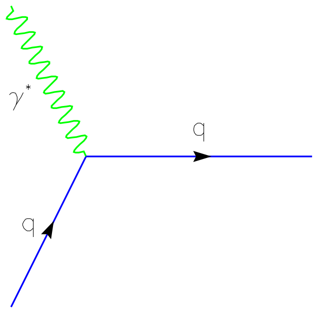




systematic error $\approx$ 8 % of measurement

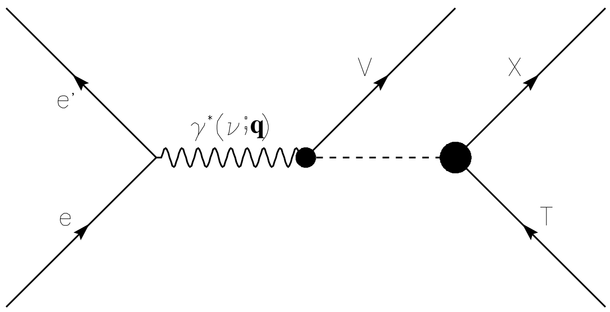
Interpretation

Assume four different processes may contribute:



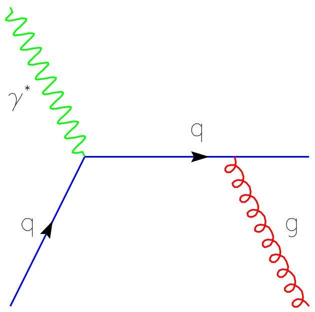
DIS

negligible contribution



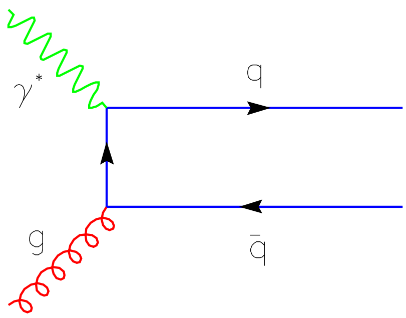
VMD

assume $A_{\mathrm{VMD}} = 0$



QCDC

$A_{\mathrm{QCDC}} \sim \frac{\Delta q}{q}$



PGF

$A_{\mathrm{PGF}} \sim \frac{\Delta G}{G}$

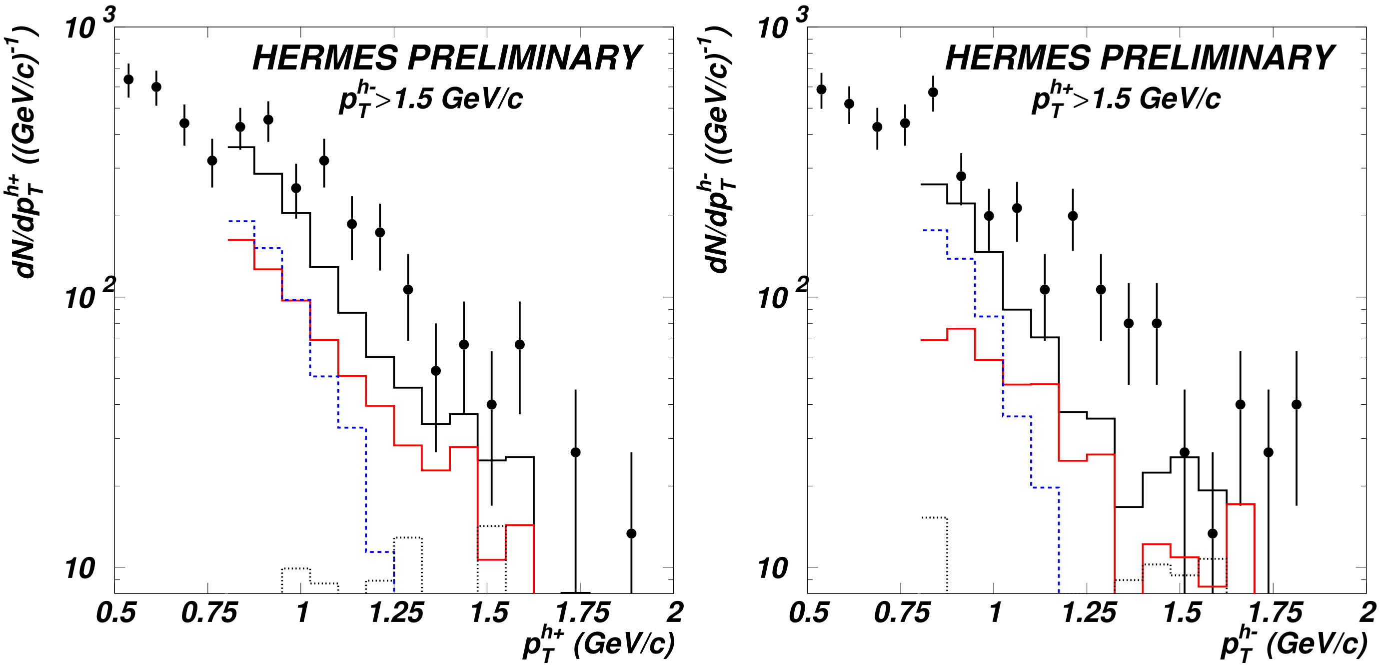
... estimate their relative contributions using PYTHIA

$\rightarrow$ extract $\Delta G/G$

NOTE: Possible contribution from anomalous photon neglected, expected to be small at these energies.

MC-Data Comparisons

Comparisons of measured yields with predictions of model implemented in PYTHIA.



solid black = total yield

solid red = PGF

dashed blue = QCDC

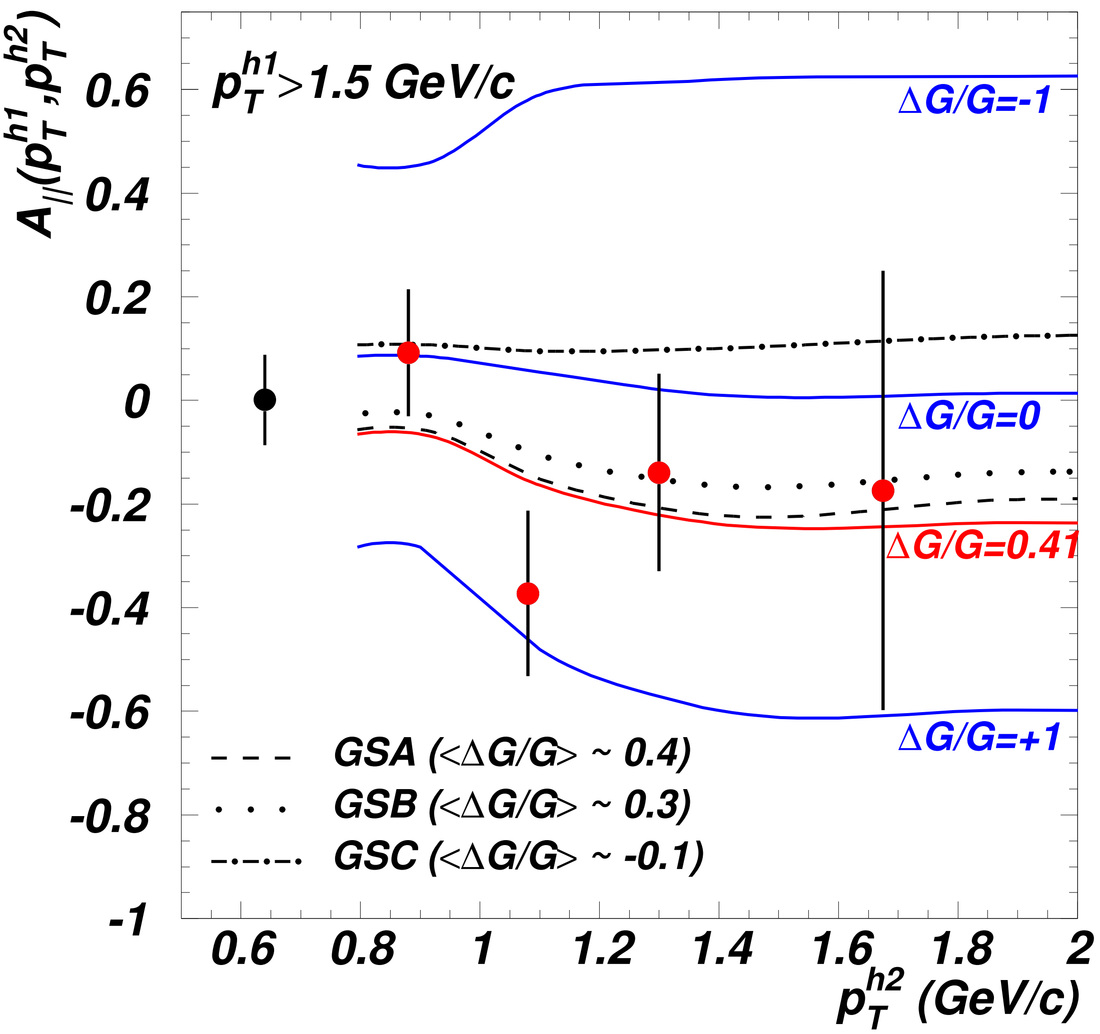
dotted black = VMD

Data are interpreted in terms of $\Delta G/G$ only in region where PYTHIA model is independent of $\hat{p}_T^{\min}$ cutoff parameter.

Result Using PYTHIA Model

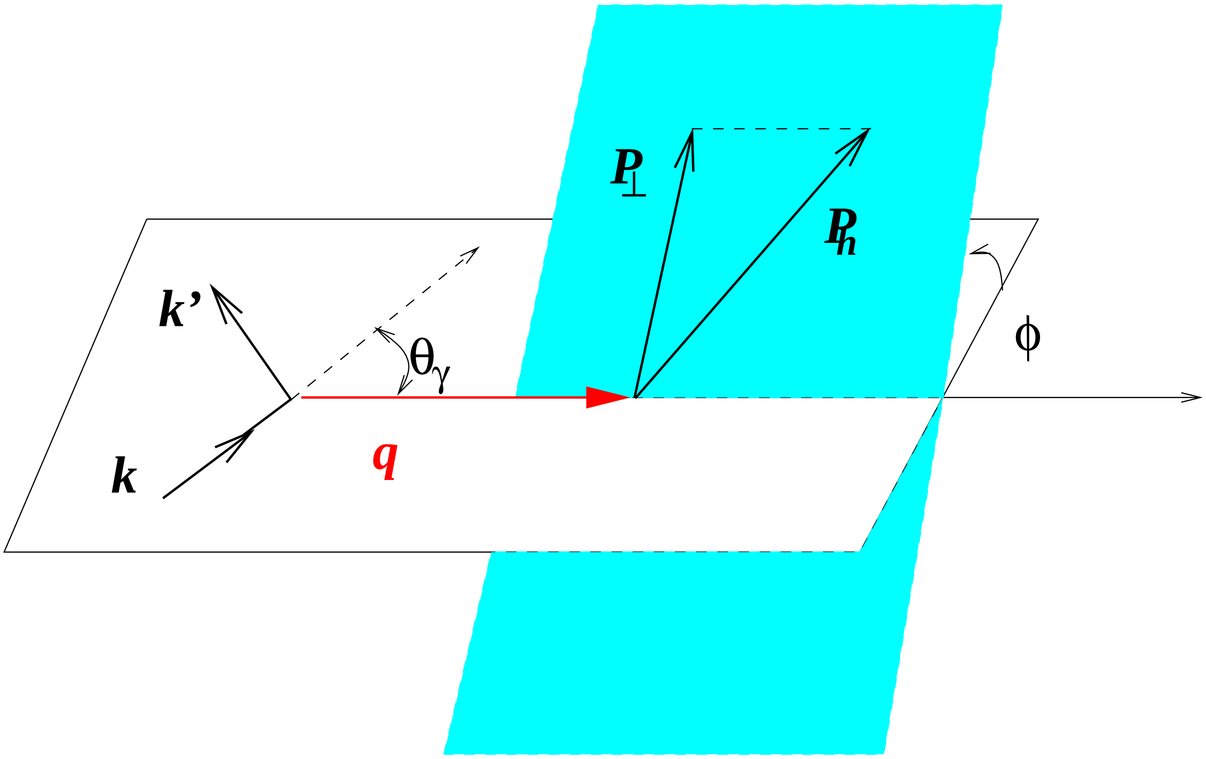
$$\Delta G/G = 0.41 \pm 0.18\text{(stat)} \pm 0.03 \text{ (exp. syst)}$$

at $\langle x_G \rangle = 0.17$ and $\langle \hat{p}_T^2 \rangle = 2.1$ GeV/c^2



Unknown theoretical uncertainty from contribution and spin asymmetry of anomalous photon and NLO QCD corrections. If only a dilution, value of $\Delta G/G$ will increase but significance of deviation from zero will not change.

Spin-Azimuthal Asymmetries



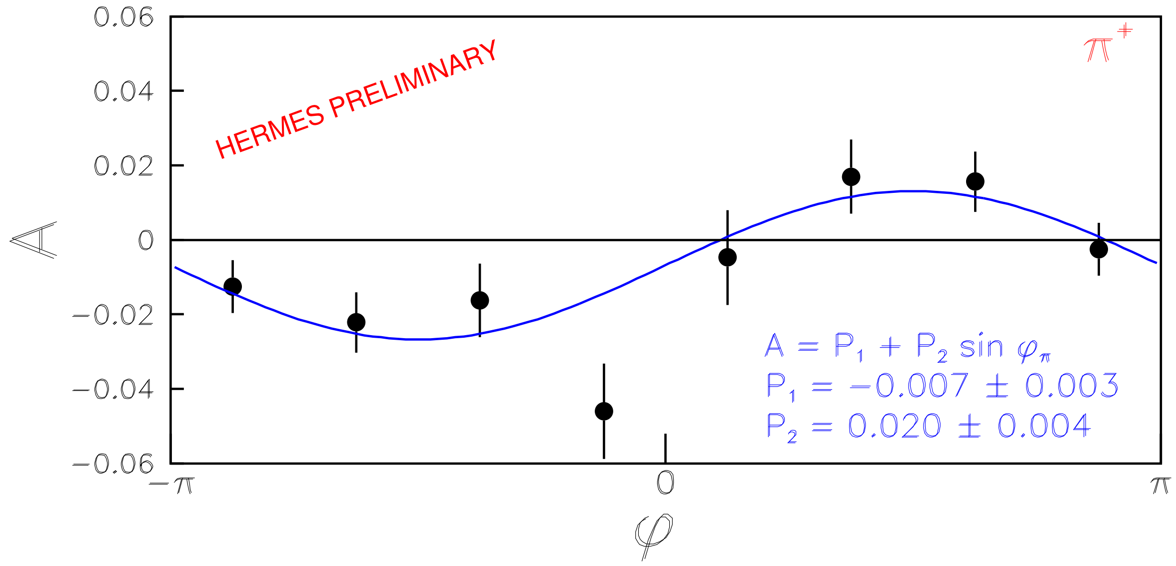
Goal: measure **azimuthal moments** ($\sin\phi, \cos\phi, ...$) of **asymmetries** with respect to:

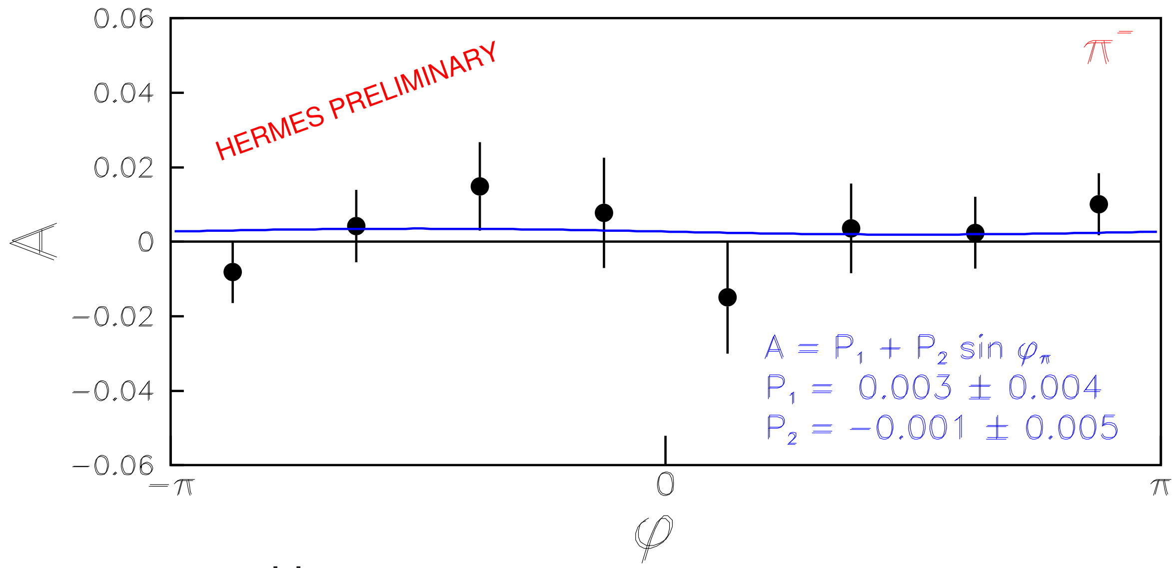
spin of **• beam • target • final-state hadron** which can be **• un- • longitudinally • transversely** polarized

Here, we present the **single-spin asymmetry** with respect to **longitudinal target polarization**

Spin-Azimuthal Asymmetries

Longitudinal target spin asymmetry: $$A(\phi) = \frac{1}{P}\frac{N^+(\phi) - N^-(\phi)}{N^+(\phi) + N^-(\phi)}$$

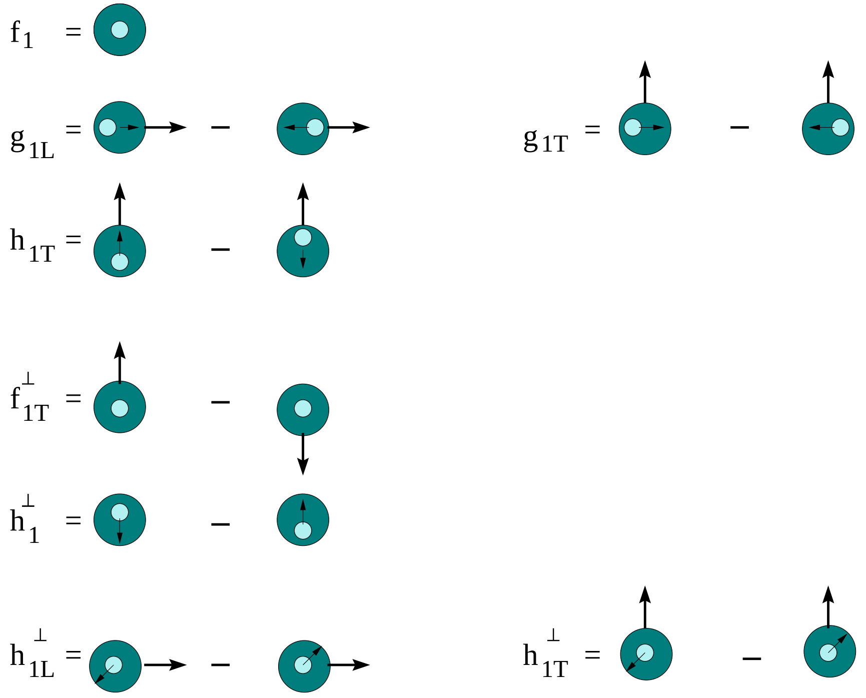




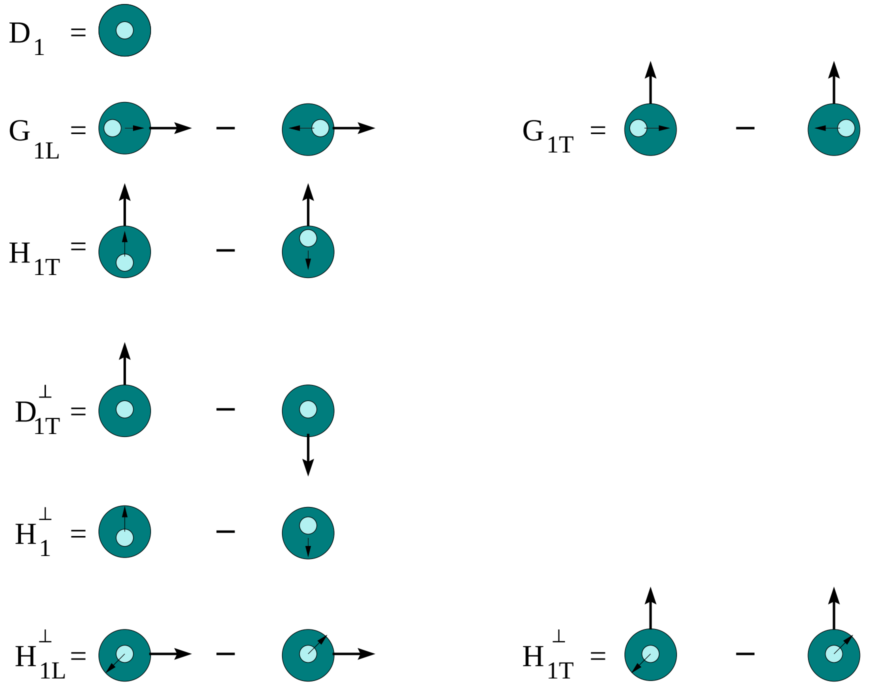
Sin ϕ moment sensitive to:

- $h_L(x)$ = twist 3, chiral odd distribution function, related to h_1, $h_{1L}^\perp$
- $H_1^\perp(z)$ = T-odd, chiral odd "Collins" fragmentation function

Distribution Functions



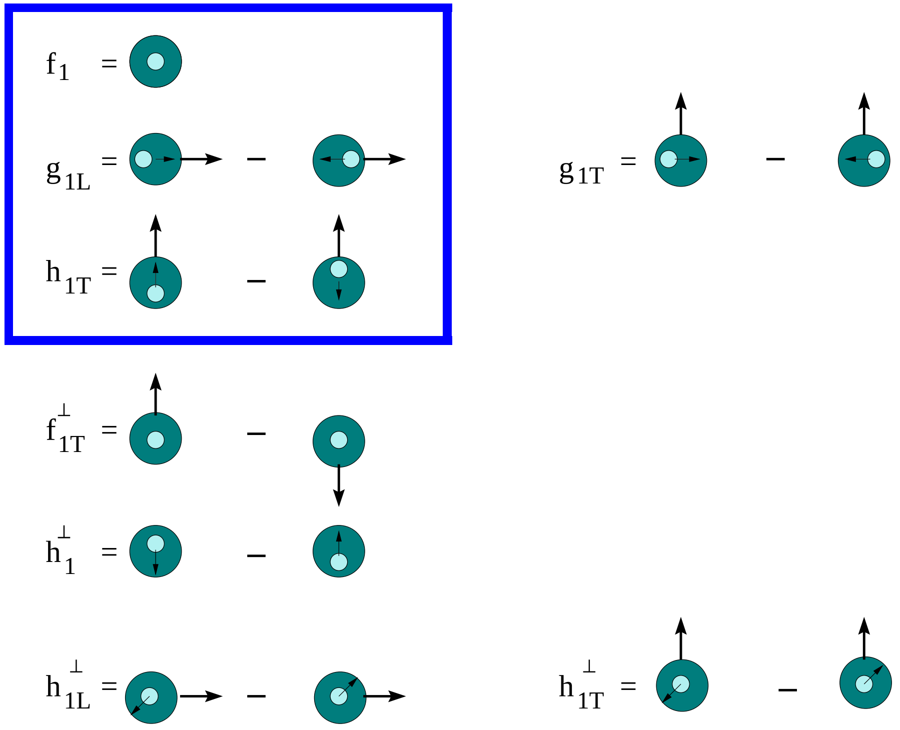
Fragmentation Functions



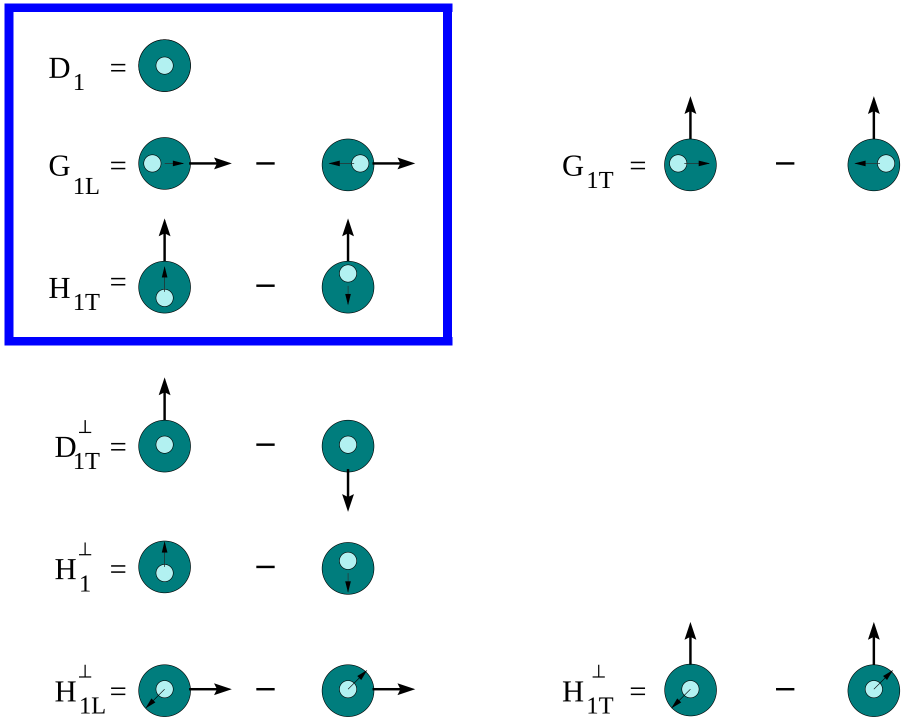
Functions Surviving on Integration over Transverse Momenta

- The others are sensitive to intrisic $< k_t >$ in the nucleon & in the fragmentation process

Distribution Functions



Fragmentation Functions



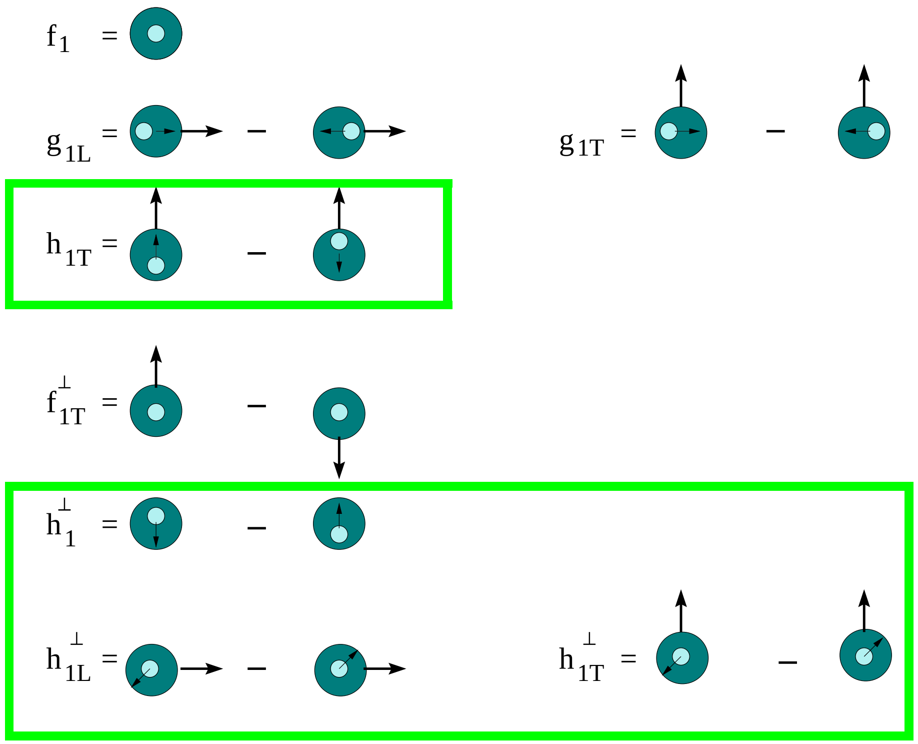
Higher Twist Functions
(no pictures)

- Sensitive to parton-parton correlations
- Have a twist-2 part ... e.g. $h_L(x) = 2x \int_x^1 dy \frac{h_1(y)}{y^2}$

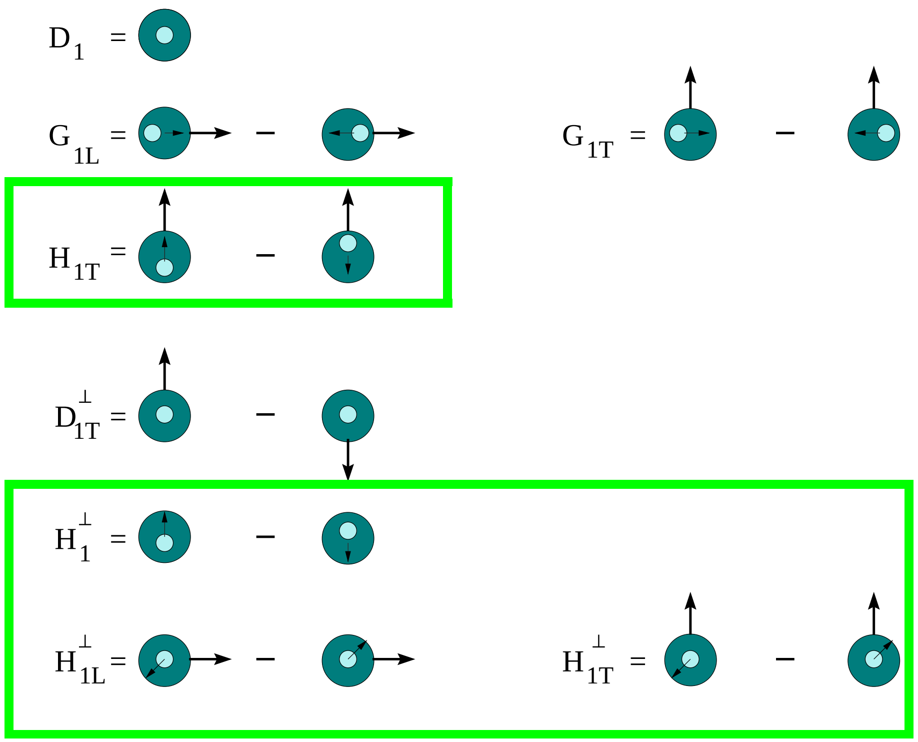
Chiral-Odd Functions

- Involve helicity flip of transverse quark
- Appear in pairs in cross-sections

Distribution Functions



Fragmentation Functions



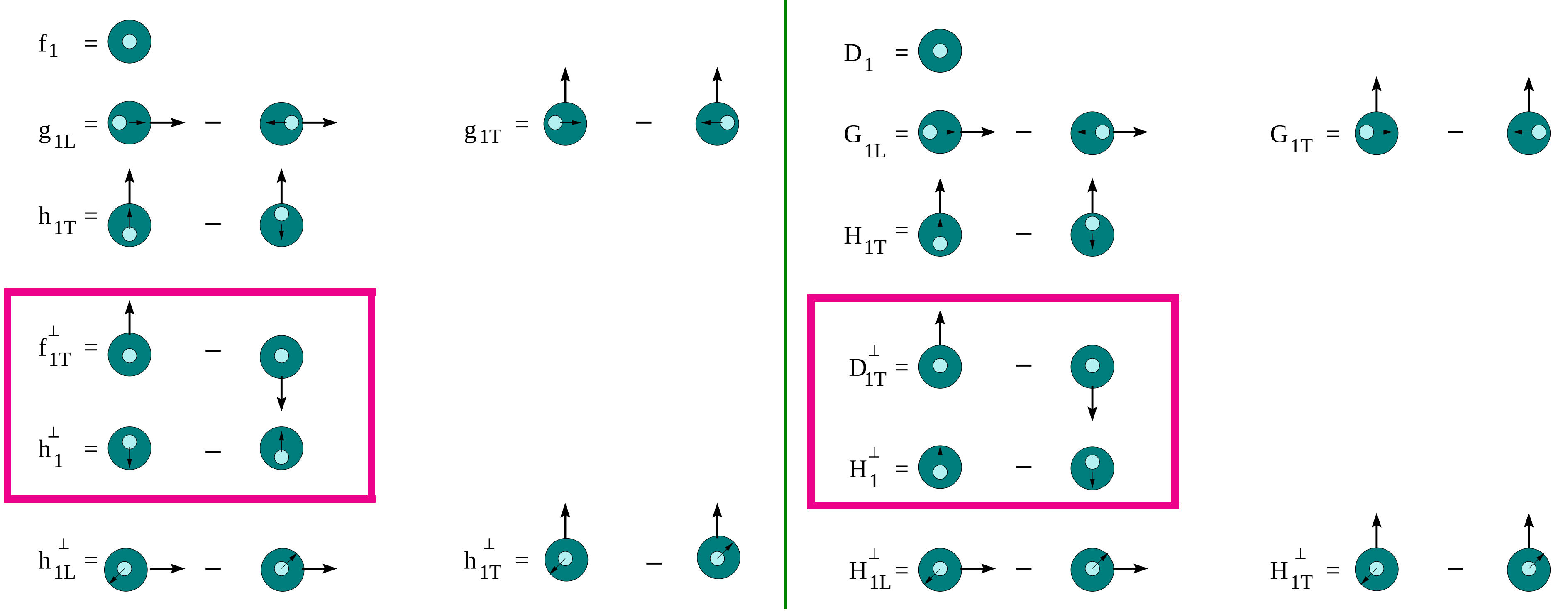
e.g. Transversity $h_1(x)$

- $h_1(x) \sim \delta q(x)$ ... cf. $f_1(x) \sim q(x), g_1(x) \sim \Delta q(x)$
- $\delta q(x) \neq \Delta q(x) \rightarrow$ relativistic / spin-orbit effects

T-Odd Functions

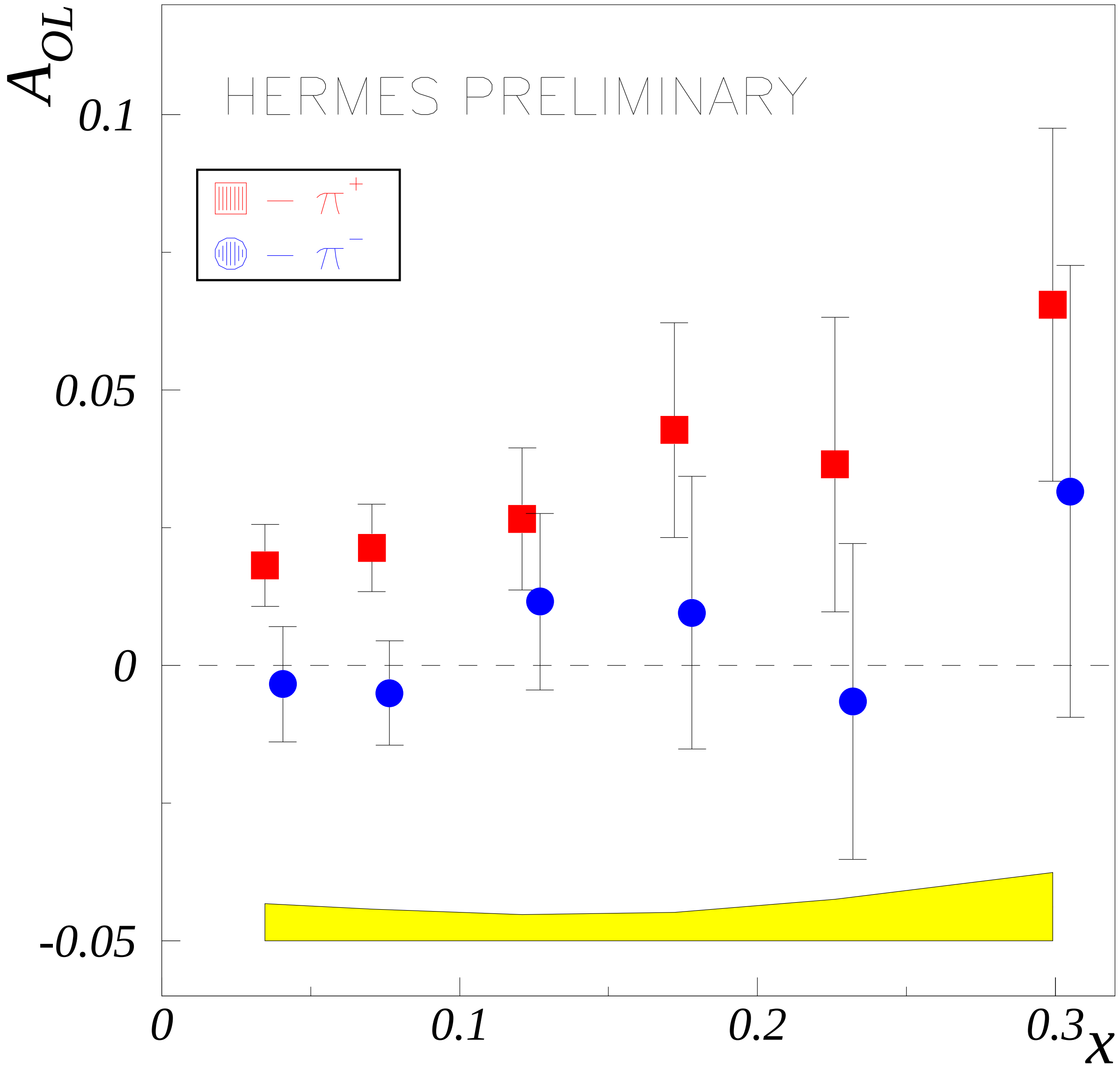
- one T-odd functon required to produce single spin asymmetries in SIDIS
- sensitive to transversely polarized quarks/hadrons given unpolarized hadrons/quarks

Distribution Functions | Fragmentation Functions



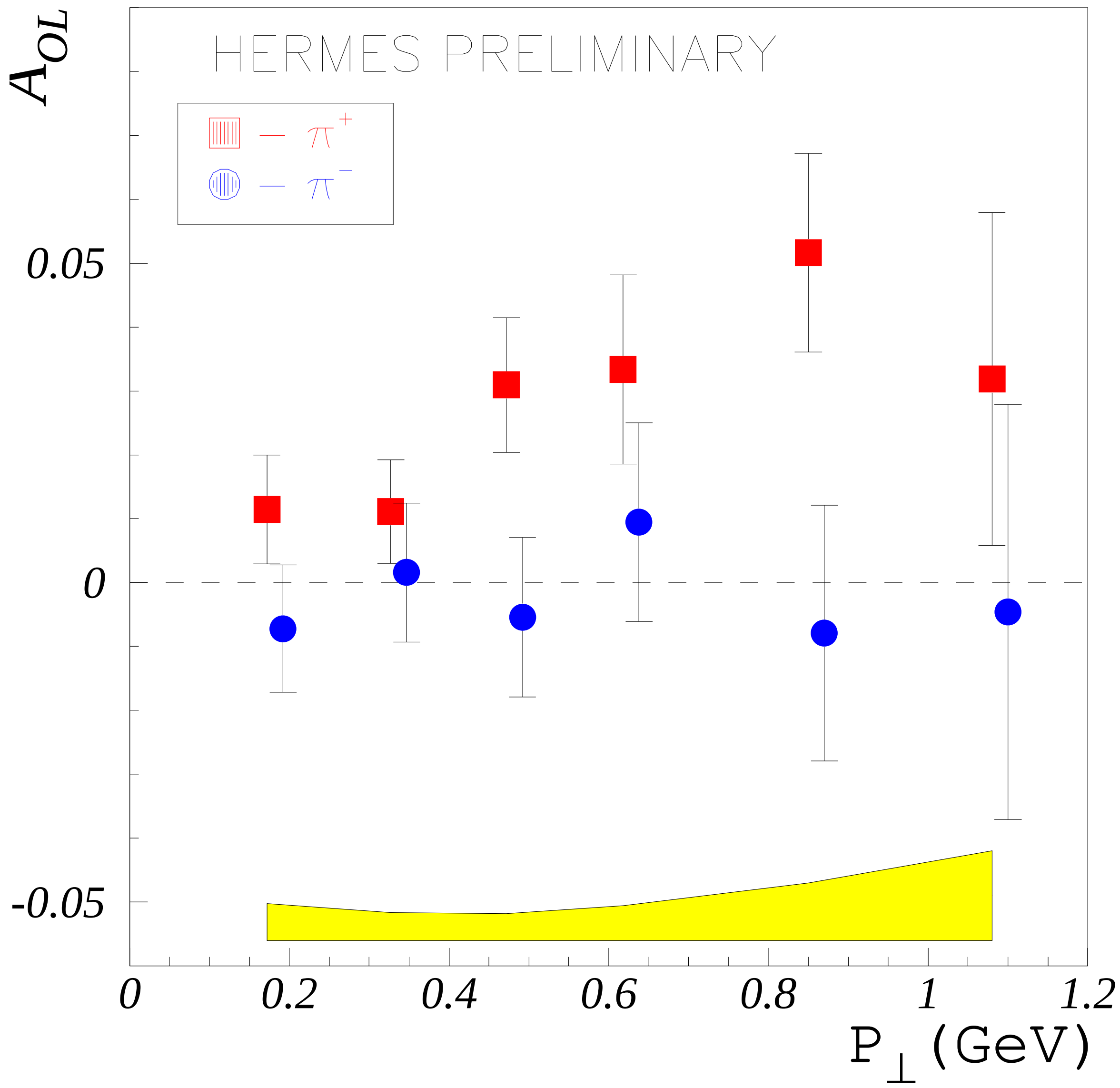
A_{OL}: x dependence

$A_{OL} = \langle \sin\phi \rangle$ moment of longitudinal target asymmetry



Band on bottom of plot represents systematic uncertainty.

A_{OL}: $P_\perp$ dependence



Band on bottom of plot represents systematic uncertainty.

Transverse Target Test

June 22-25, 1999

Transverse target magnet and compensating coils ramped ... **no effect** on:

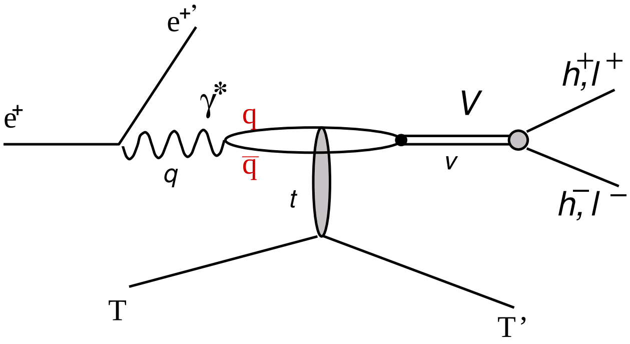
- beam lifetime
- detector rates
- beam polarization

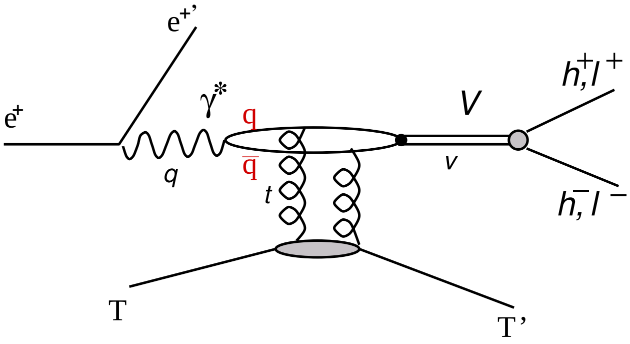
Target performance:

- H, D target gases tested
- holding field scanned: expected depolarizing resonances observed
- preliminary: transverse target polarization $\simeq$ 90%

Much offline analysis still to be done!

Spin Asymmetry in Diffractive Vector Meson Production





Naive expectation: **no spin dependence**

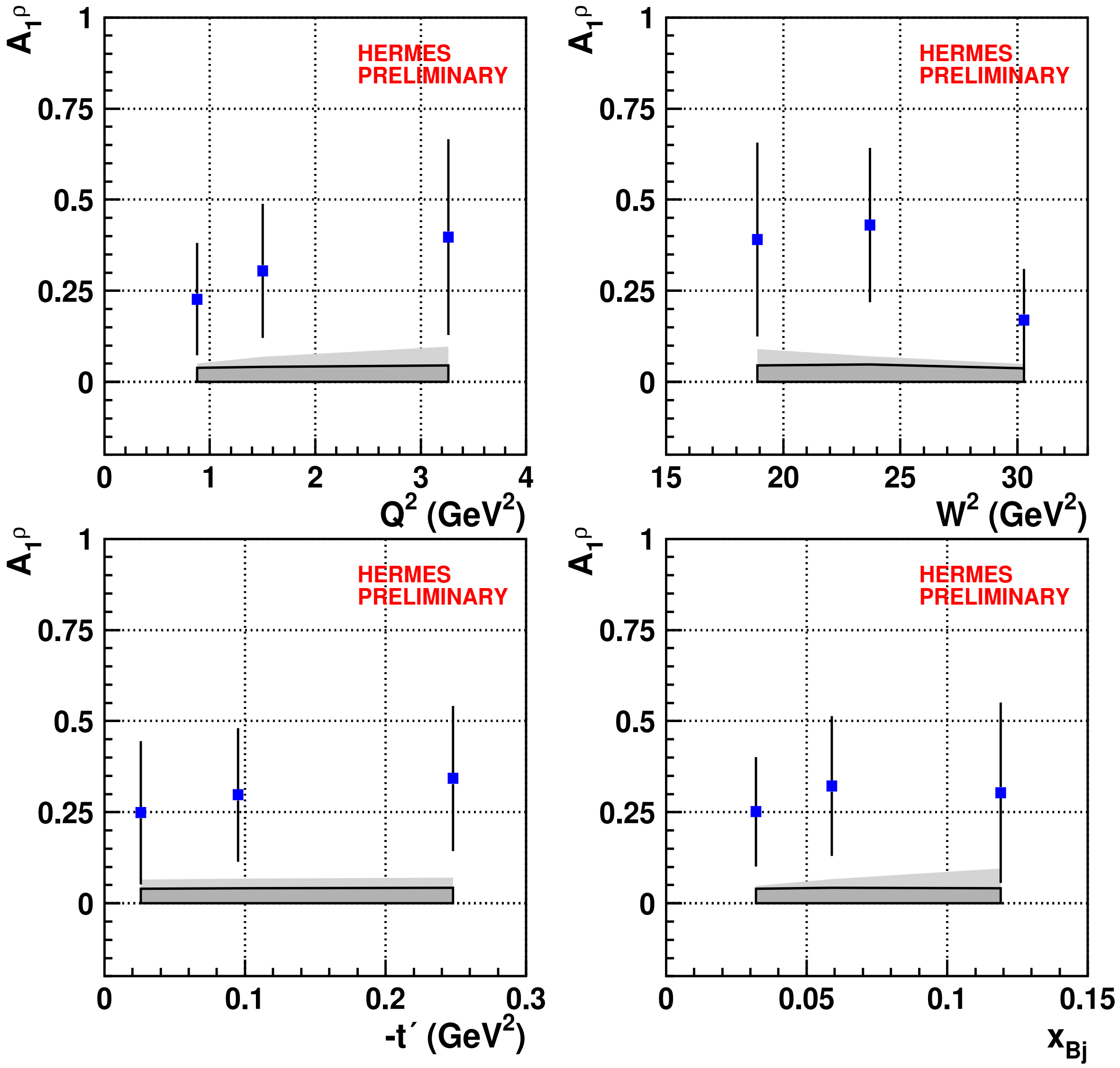
(e.g. exchange of 0^{++} Pomeron)

Channels reconstructed at HERMES

$\rho^0 \to \pi^+\pi^-$ $\qquad\qquad$ $\phi \to K^+K^-$

$J/\psi \to e^+e^-$ $\qquad\qquad$ $J/\psi \to \mu^+\mu^-$

Photon Absorption Asymmetry



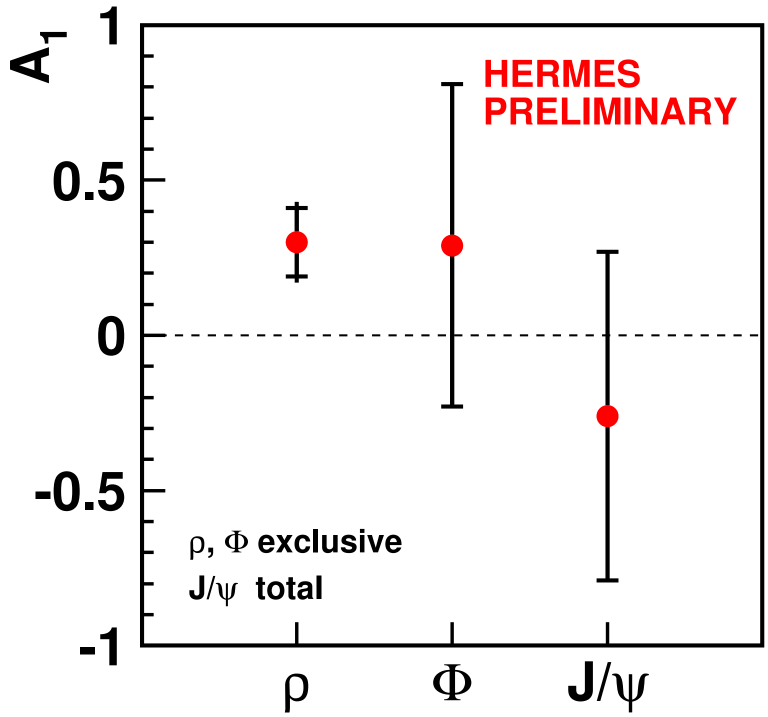
Maximum possible contribution of unknown A_2^ρ added in quadrature to experimental systematic uncertainty $\Rightarrow$ light gray error band

Assume $A_2^\rho = \pm \min(\sqrt{R}, 1) \Rightarrow \delta_{\rm syst}(A_1^\rho) \leq \eta A_2^\rho$

(Theorists claim that this is probably an overestimate).

Summary

Comparison of Vector Meson Asymmetries



- Clear positive asymmetry for diffractive ρ's

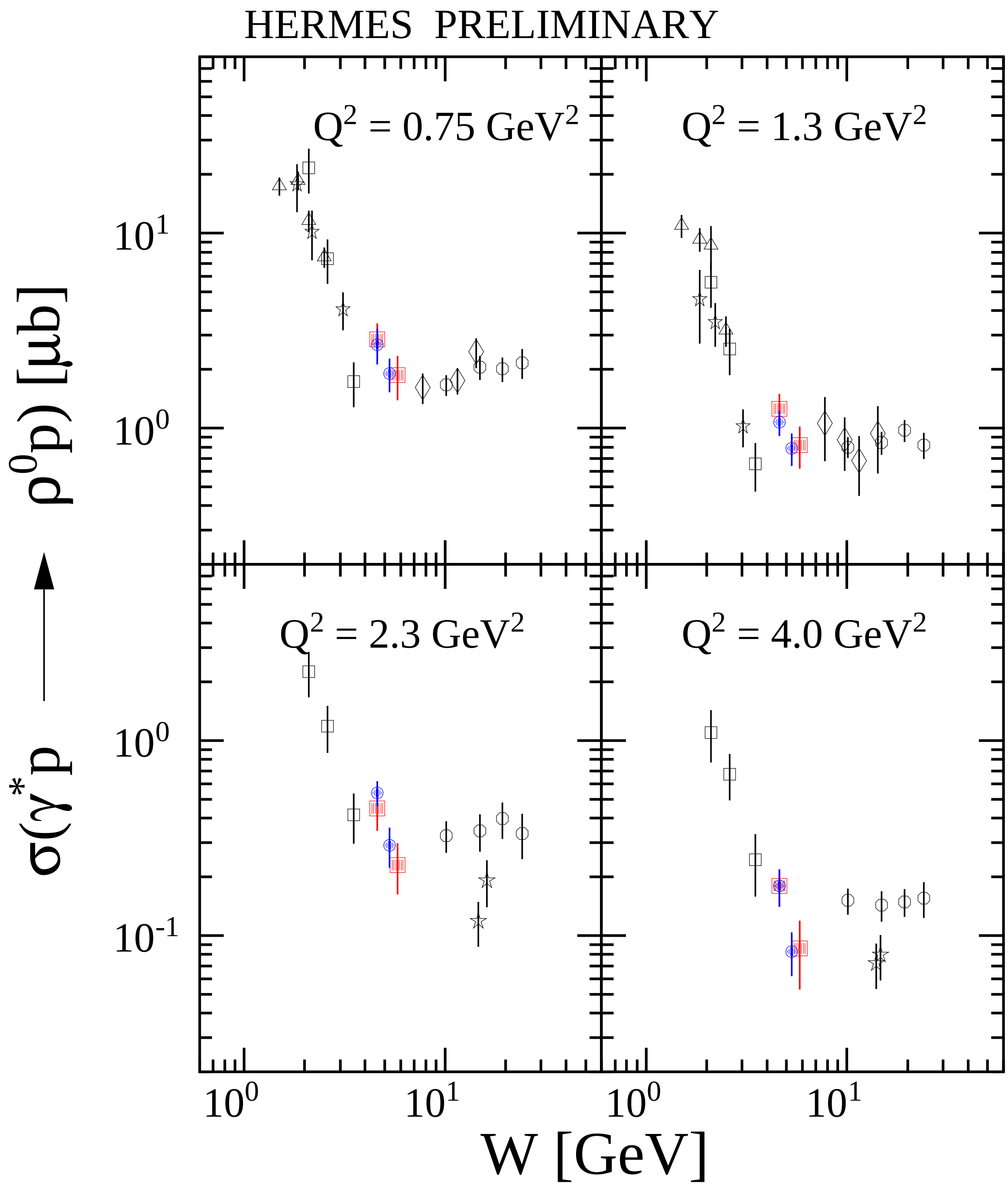
$$A_1^{\rho} = 0.30 \pm 0.11(\mathrm{stat}) \pm 0.04(\mathrm{sys}) \pm 0.05(\mathrm{theor})$$

$\Rightarrow$ Evidence of non-trivial spin structure in this reaction

- A_1^{ϕ} and $A_1^{J/\psi}$ consistent with zero within stat. errors

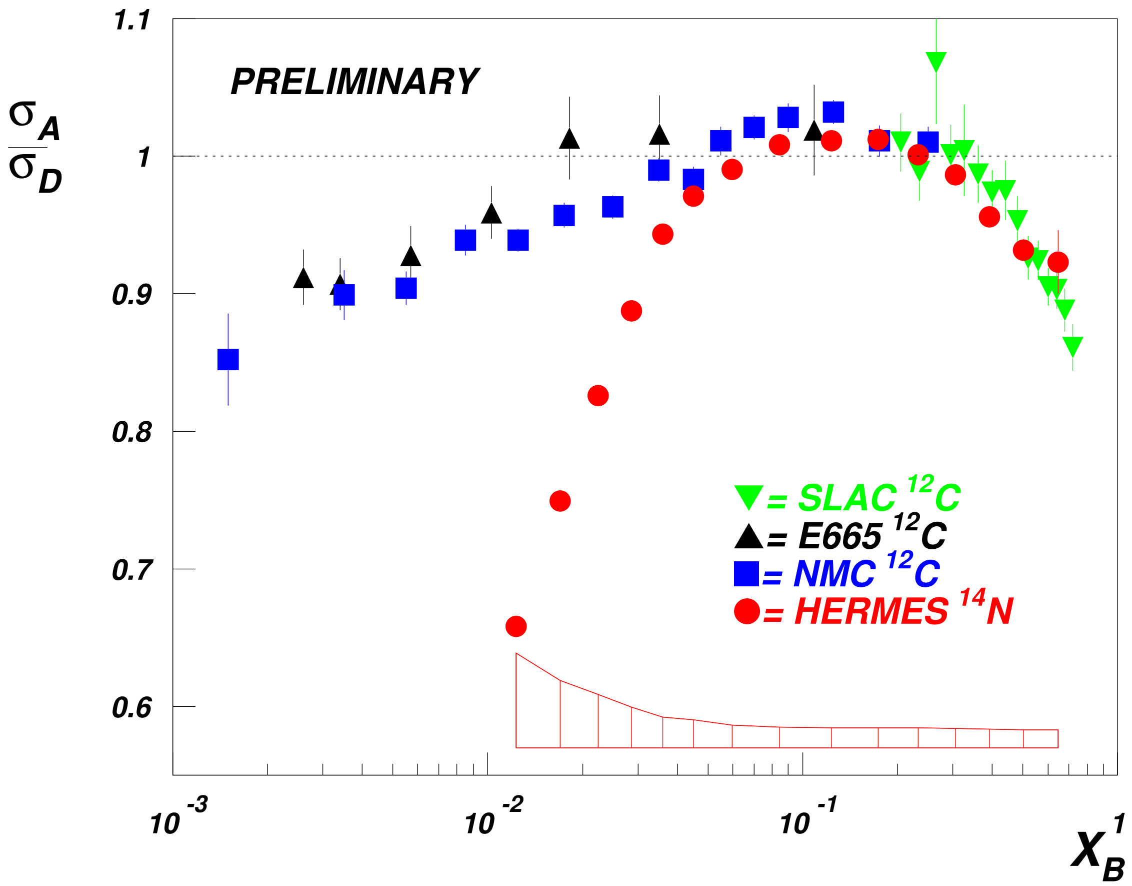
  For J/ψ scattered positron is not detected $\Rightarrow$ kinematics not fully known, possible inelastic contribution

ρ^0 Photoproduction Cross Section



Cross section ratio ^{14}N/D

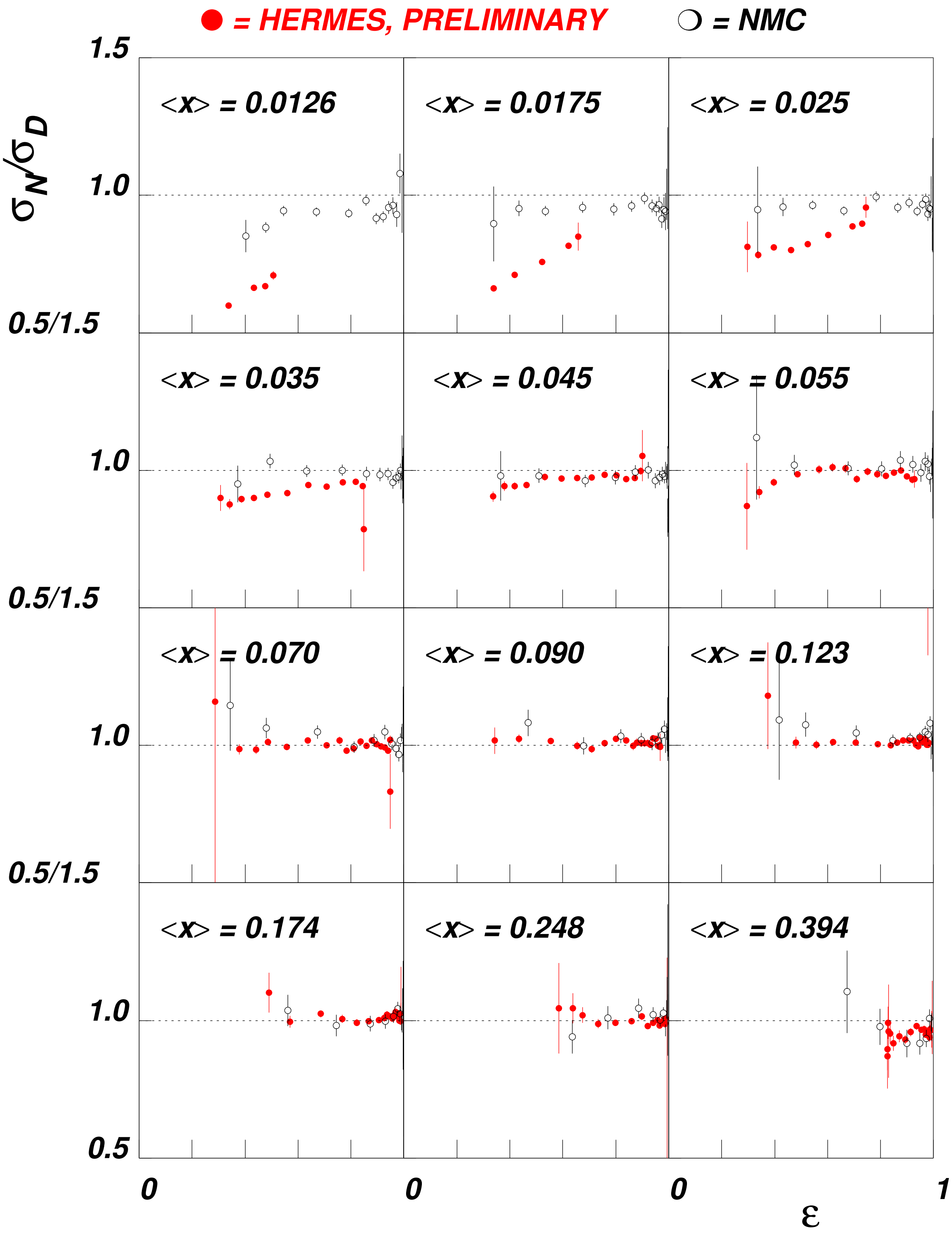
$$\frac{\sigma_A}{\sigma_D} = \frac{F_2^A}{F_2^D} \frac{(1+\epsilon R_A)(1+R_D)}{(1+R_A)(1+\epsilon R_D)}$$



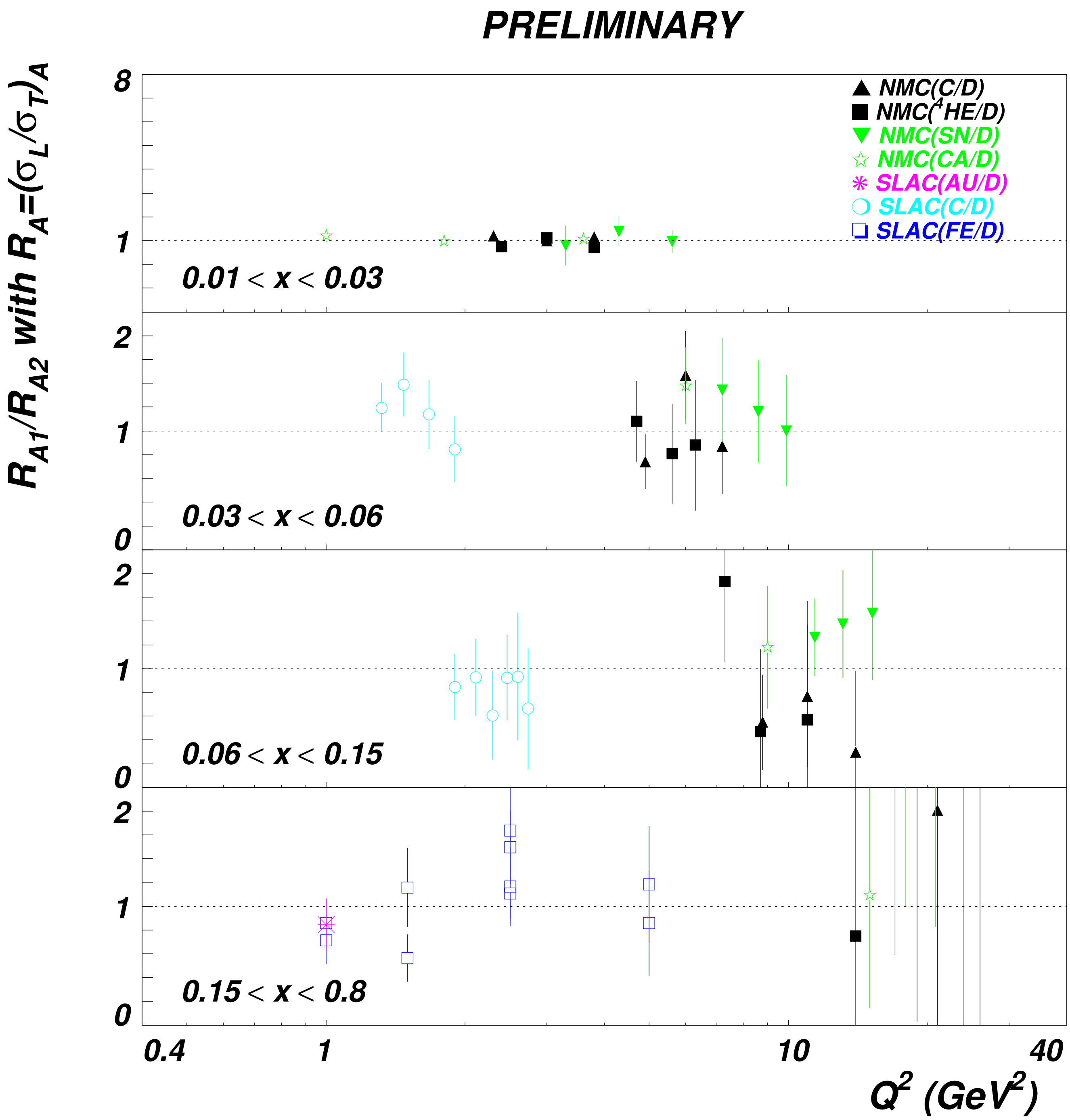
HERMES and NMC data points overlap in x and Q^2, but cover different ranges in ϵ (γ polarization parameter)

$\rightarrow$ possible sensitivity to A-dependence of $R = \sigma_L/\sigma_T$

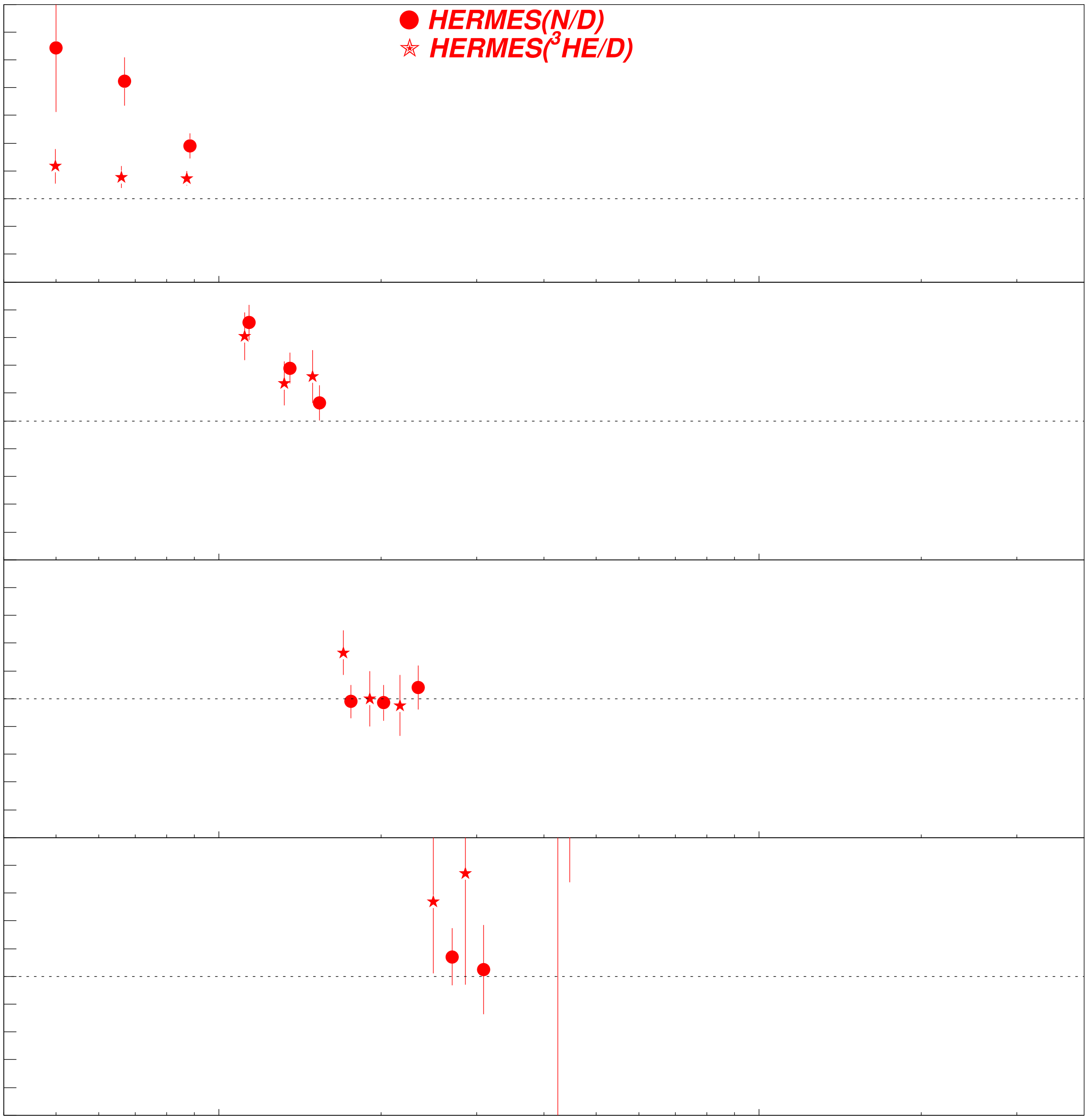
Cross section ratio vs ϵ



HERMES and NMC points are at different Q^2 values



All errors are statistical + systematical



HERMES(N/D)
HERMES(^{3}HE/D)