Recent Spin Physics Results from HERMES and Plans for RHIC

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for the hermes -Collaboration

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Outline:

- *Inclusive measurements*
- *Transversity*
- *Future prospects*

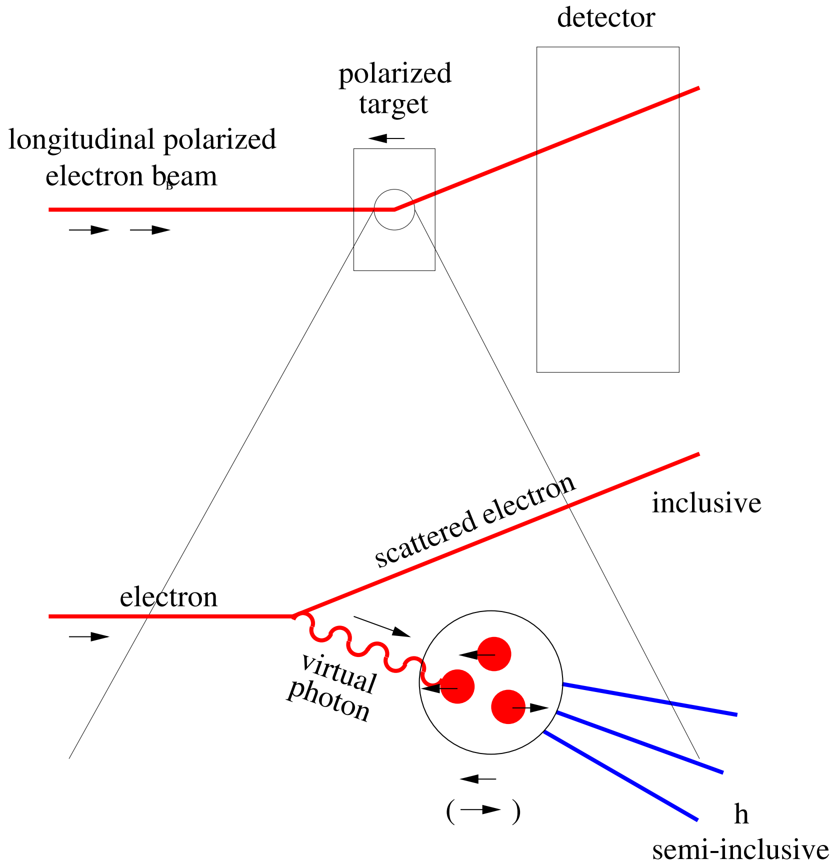
Motivation

$$s_z^N = \frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_G$$

$$\begin{aligned}
\Delta\Sigma &= \Delta u + \Delta d + \Delta s \\
&= \Delta u_v + \Delta d_v + \\
&\quad \Delta u_s + \Delta \bar{u}_s + \Delta d_s + \Delta \bar{d}_s + \Delta s + \Delta \bar{s}
\end{aligned}$$

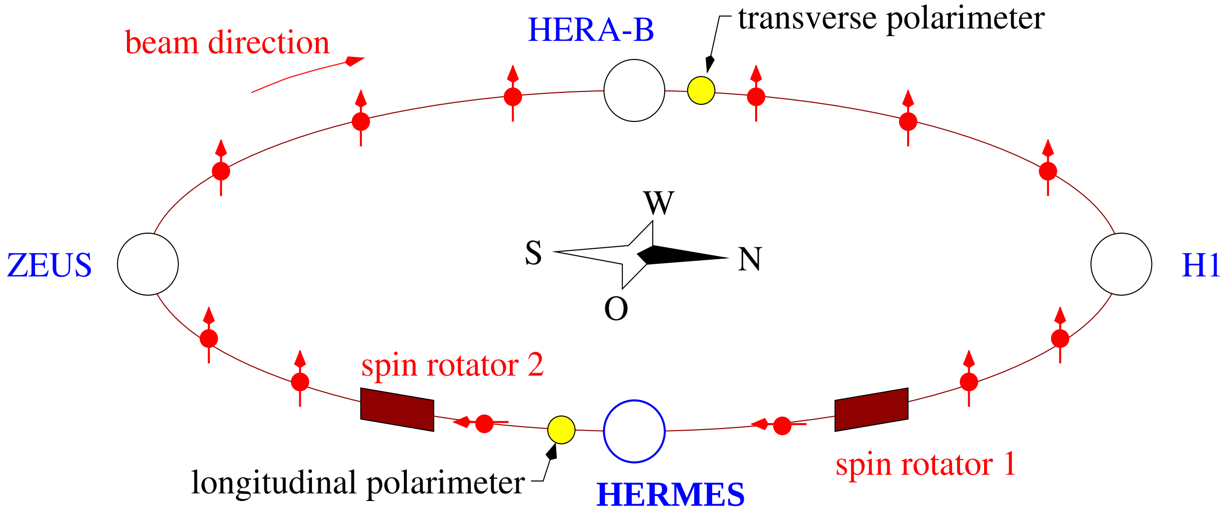
$$\text{Measurement}: \Delta\Sigma \approx 0.2 - 0.3$$

Spin dependent deep inelastic eN scattering



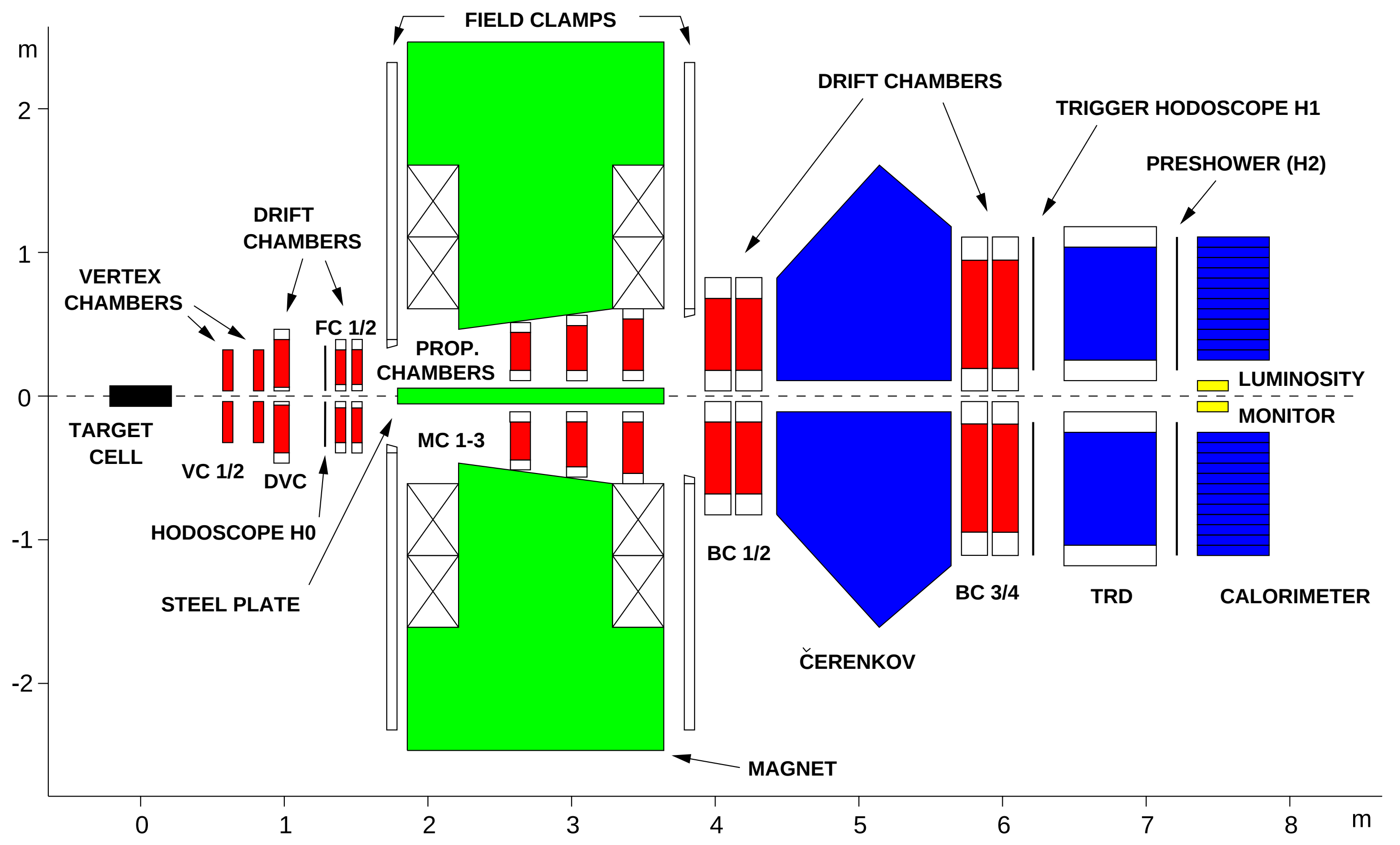
The HERMES–Experiment

Beam: $P_B \approx 50 - 60\%$



Target: Internal polarized gas target
(Hydrogen, Deuterium, ^{3}He)
$P_T(\overrightarrow{H}, \overrightarrow{D}) \approx 90\%$
$P_T(\overrightarrow{^3He}) \approx 50\%$

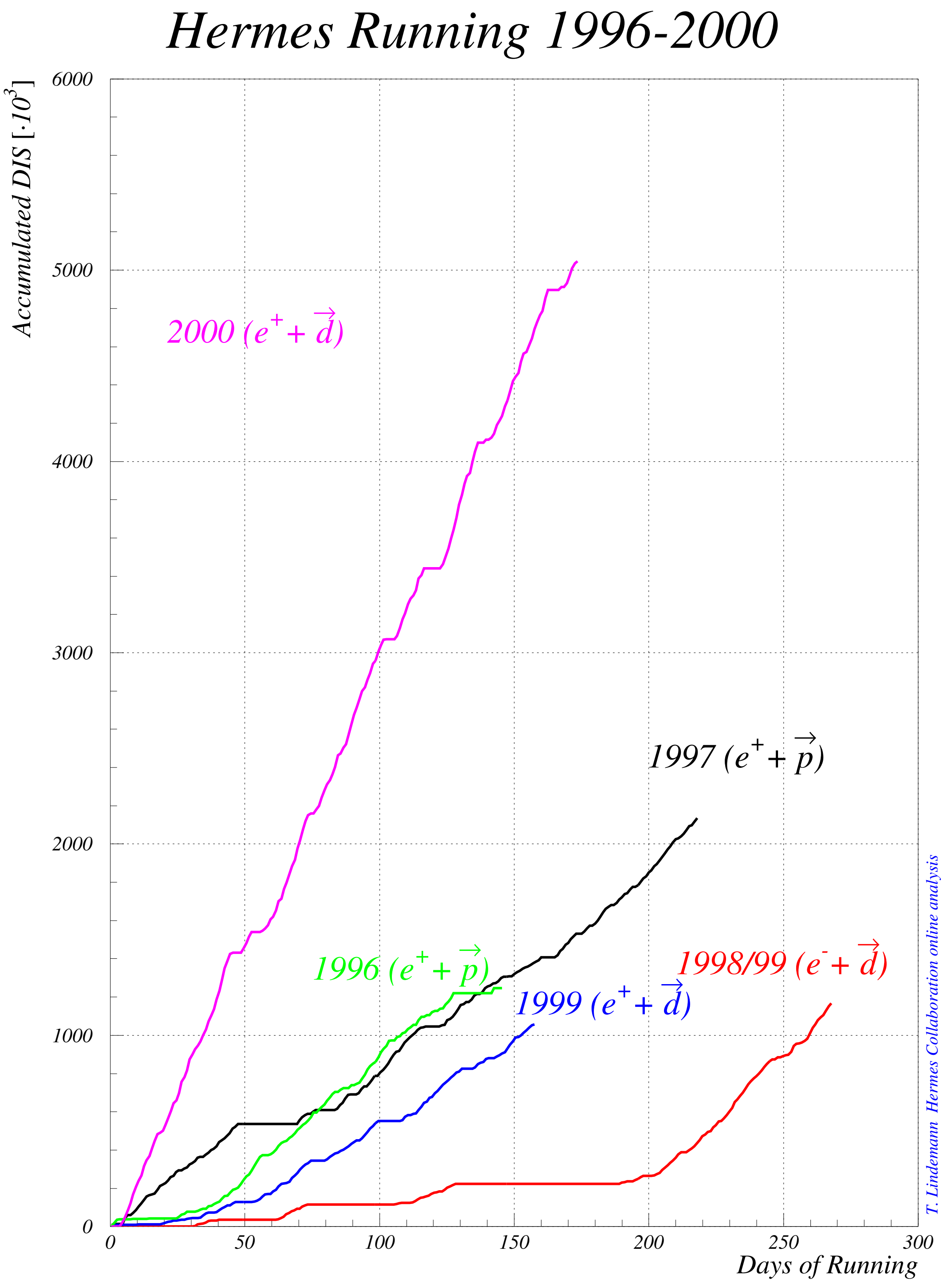
Spectrometer:



(NIM A417 (1998) 230)

HERMES–Running:

1995:	1996:	1997:	1998:	1999:	2000:
$^3\overrightarrow{He}$	$\vec{H}$	$\vec{H}$	$\vec{D}$	$\vec{D}$	$\vec{D}$

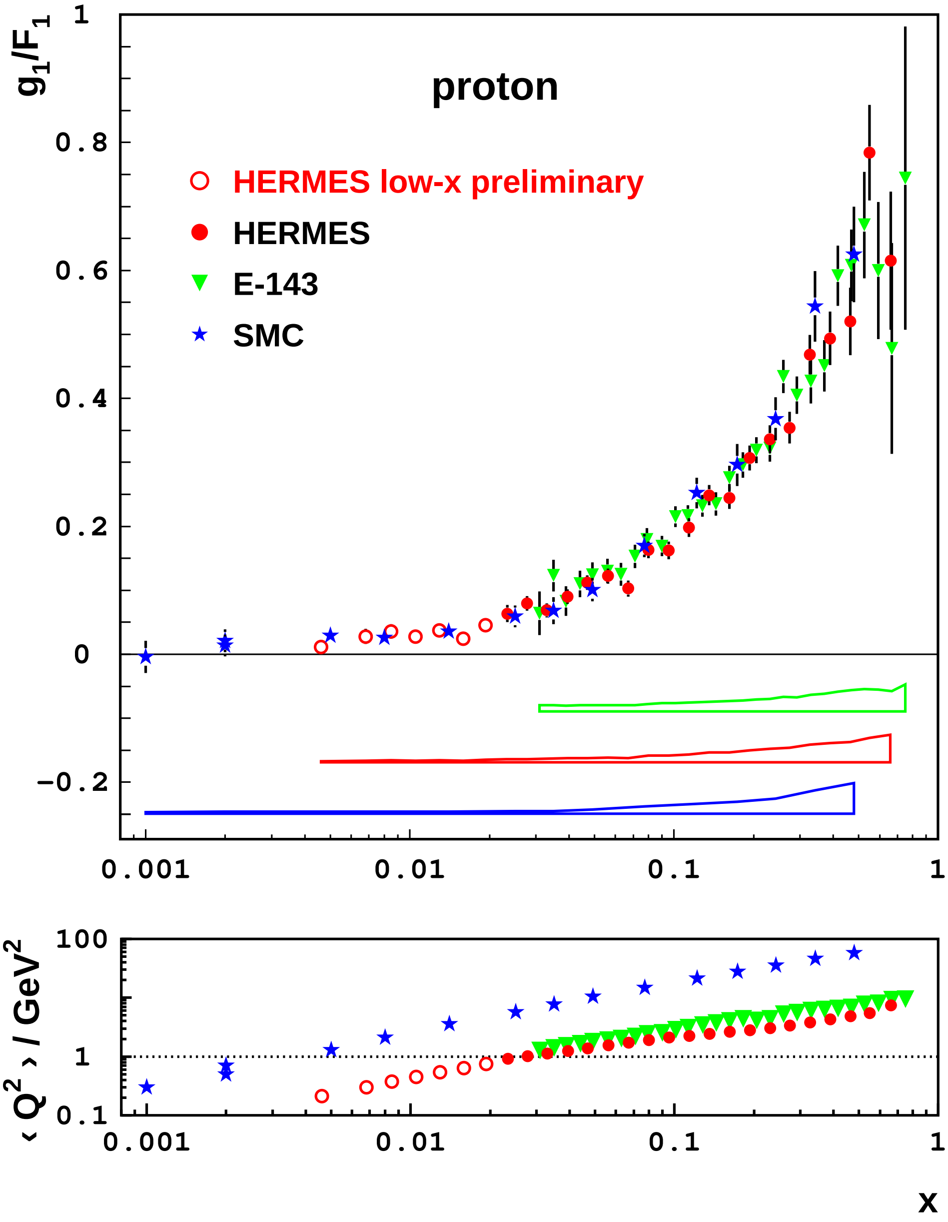


Inclusive Results

The Asymmetry $\frac{g_1^p}{F_1^p}$ of the Proton

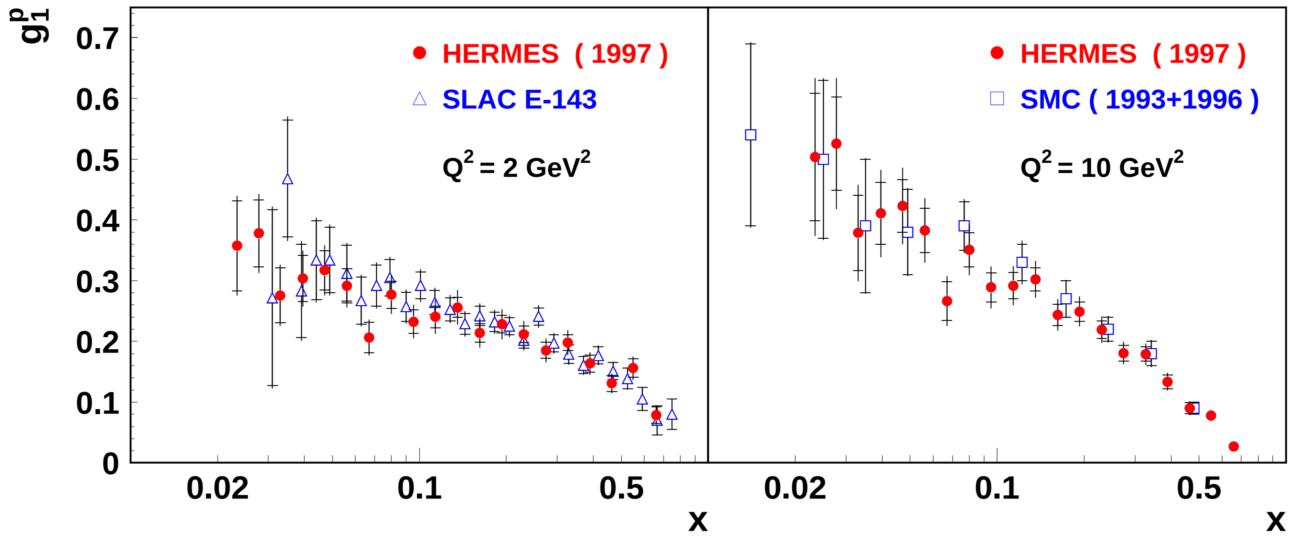
$$A_{||} = \frac{N^{\rightleftarrows} - N^{\rightrightarrows}}{N^{\rightleftarrows} + N^{\rightrightarrows}}, \qquad \frac{g_1}{F_1} = \frac{1}{1+\gamma^2}\left(\frac{A_{||}}{D} - (\eta - \gamma)\, A_2\right)$$

$$F_1(x) = \sum_f \tfrac{1}{2} e_f^2 q_f(x)\ , \qquad g_1(x) = \sum_f \tfrac{1}{2} e_f^2 \Delta q_f(x)$$



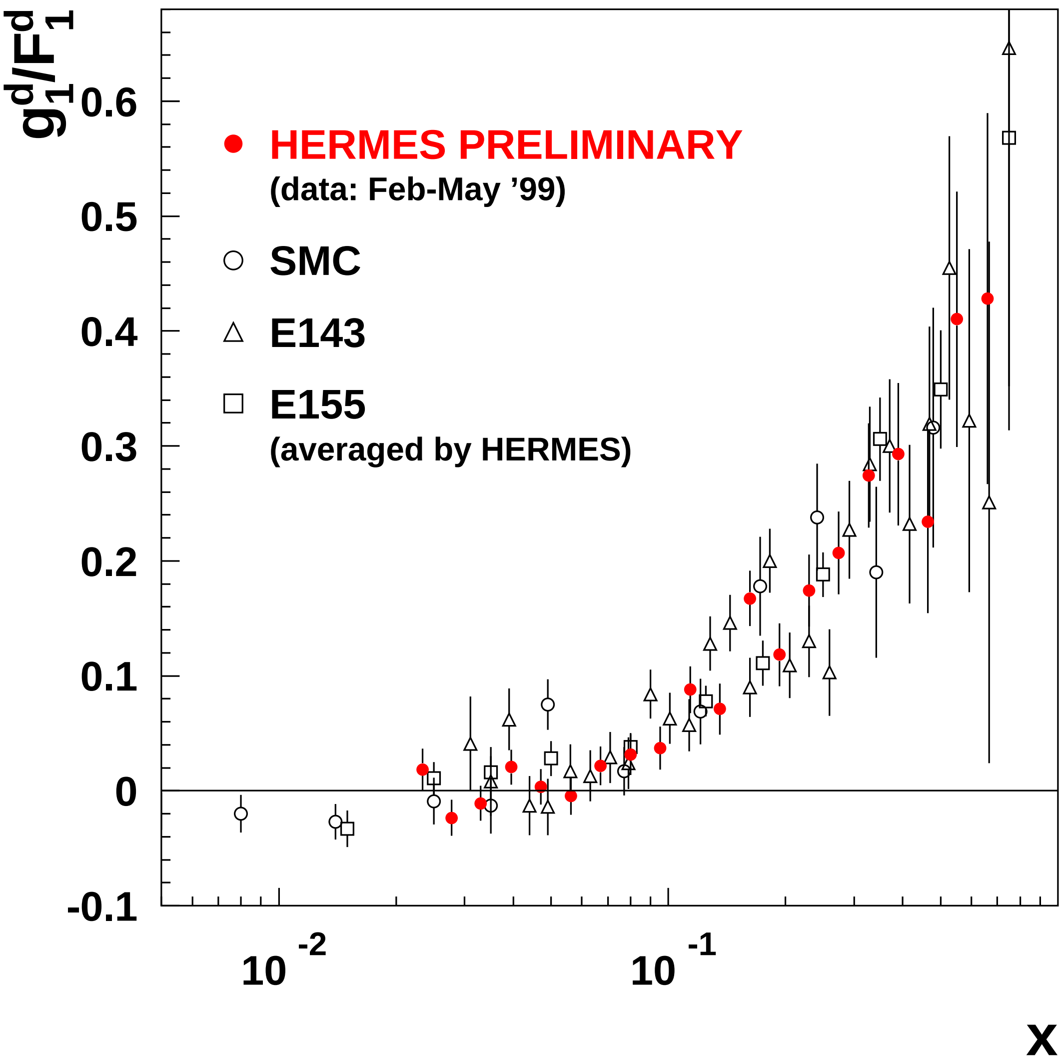
(Phys. Lett. B442 (1998) 484)

Proton Spin Structure Function g_1^p



(Phys. Lett. B442 (1998) 484)

The Asymmetry $\frac{g_1^d}{F_1^d}$ of the Deuteron

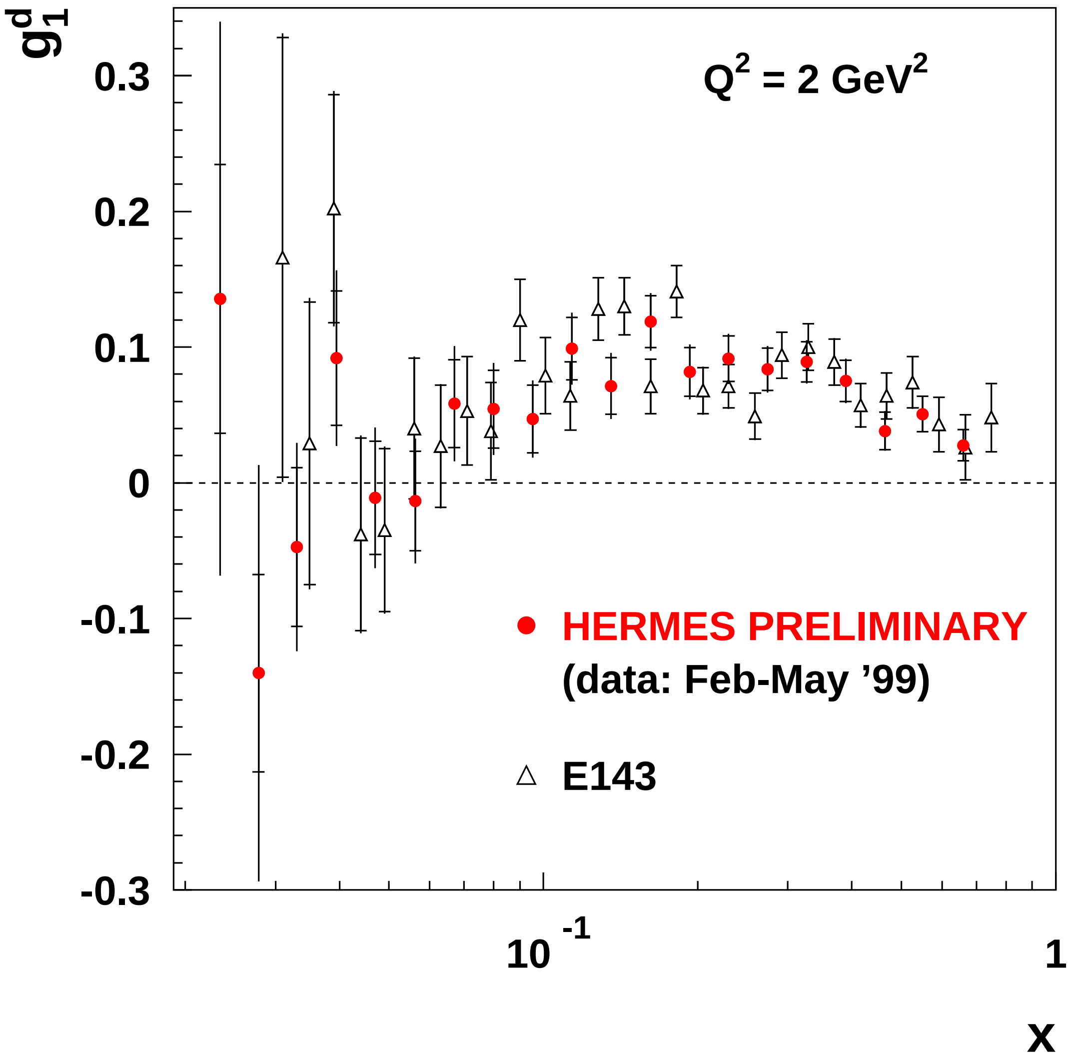


No. of events: 1 million

Final statistic: $\approx$ 8 million

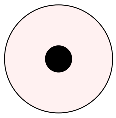
Dilution factor: f=1

Deuteron Spin Structure Function g_1^d

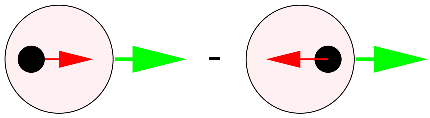


Transversity

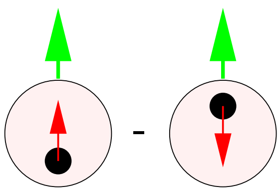
3 Parton distribution functions at leading twist:

f_1 = 

unpolarized quark in unpolarized nucleon

g_{1L} = 

longitudinal polarized quark in longitudinal polarized nucleon

h_1 = 

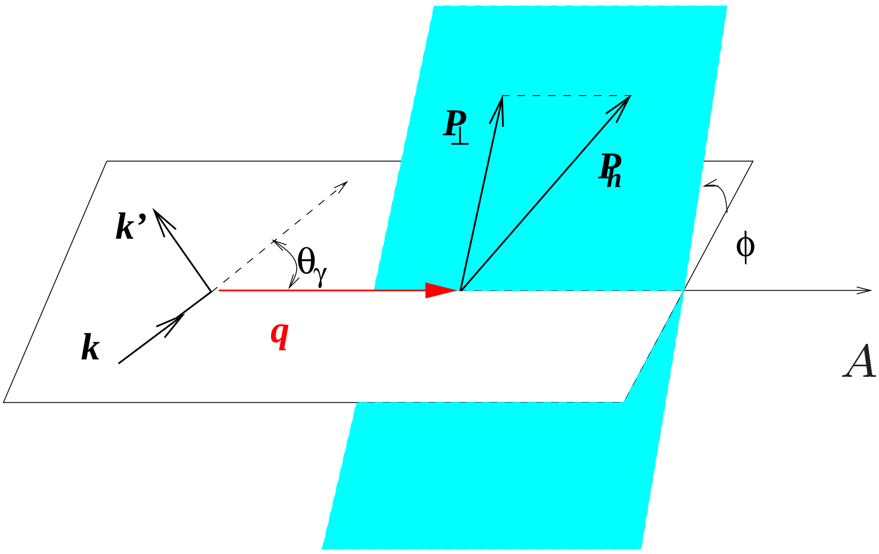
transverse polarized quark in transverse polarized nucleon

- predominantly valence quark object
- gluon polarization does not mix with quark polarization in h_1

$$\Downarrow$$

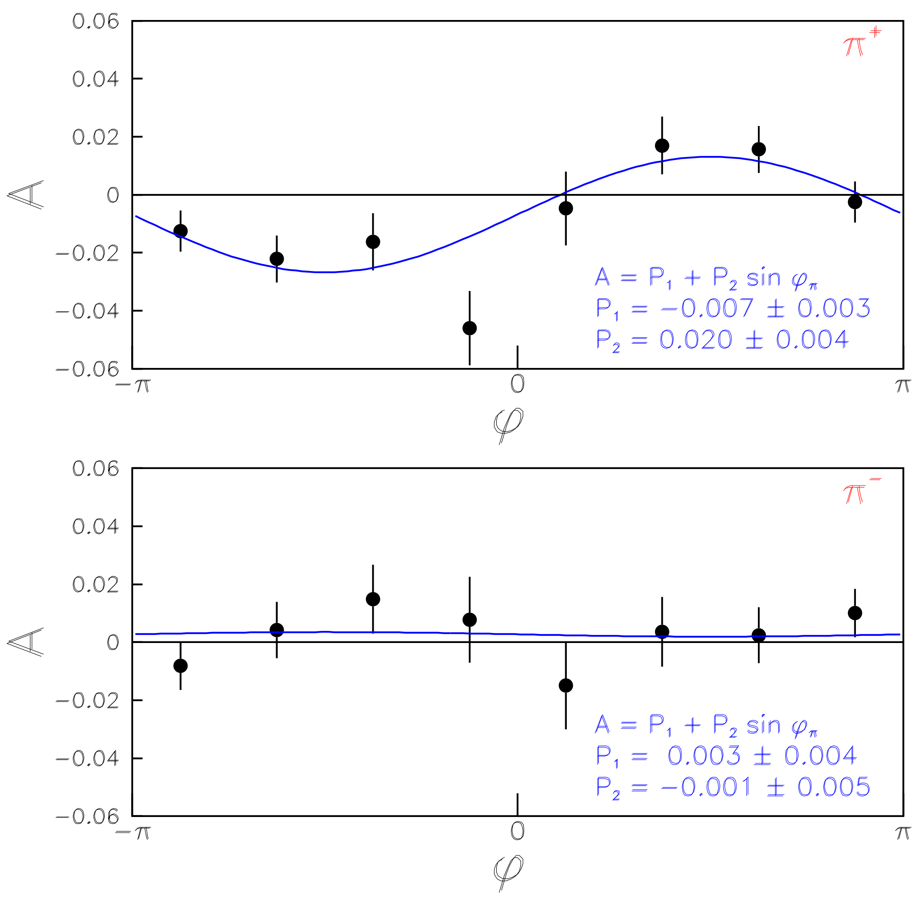
transverse quark polarization densities accessible via single spin azimuthal asymmetries

Single Spin–Azimuthal Asymmetry



Longitudinal target polarization

$$A_{UL}(\phi) = \frac{1}{\langle P \rangle} \cdot \frac{N^{+}(\phi)-N^{-}(\phi)}{N^{+}(\phi)+N^{-}(\phi)}$$



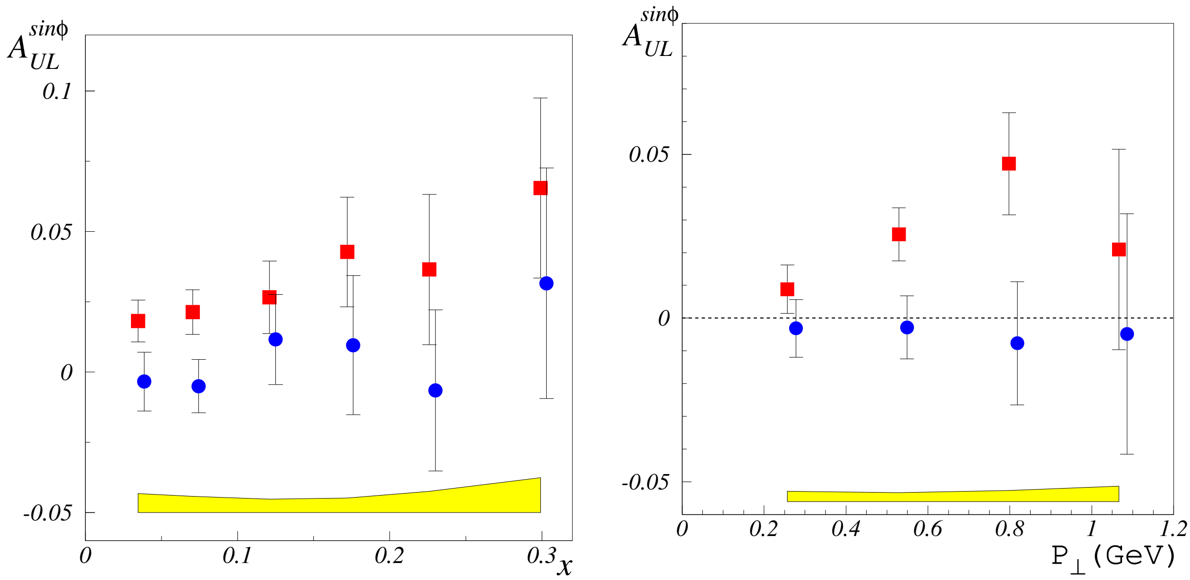
(Phys. Rev. Lett. 84 (2000) 4047)

$A_{UL}^{\sin(\phi)}$ Behaviour

$A_{UL}^{\sin(\phi)}$ = $\langle \sin(\phi) \rangle$ moment of longitudinal target asymmetry

$\rightarrow$ related to product of $h_1(x)$ and $H_1^{\perp}(z)$

($H_1^{\perp}(z) \equiv$ Collins Fragmentation Function)



(Phys. Rev. Lett. 84 (2000) 4047)

Original Predictions of Collins (Collins, Nucl. Phys. B396 (1993) 161)

(?) Effect should be largest at x $\gtrsim$ 0.3

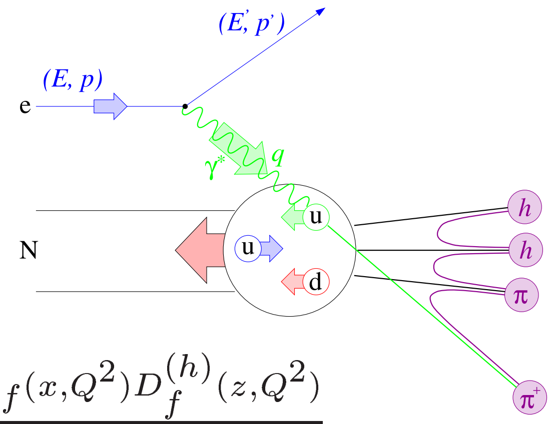
($\surd$) Effect should be stronger for π^+ than π^- (u-quark dominance)

($\surd$) Effect should grow with p_T and peak at p_T≈few100MeV-1GeV

$\Rightarrow$ good prospects for future transversity program with transverse target polarization.

Semi–inclusive Results and Projections

Semi–inclusive Asymmetry $\frac{g_1^{(h)}}{F_1^{(h)}}$



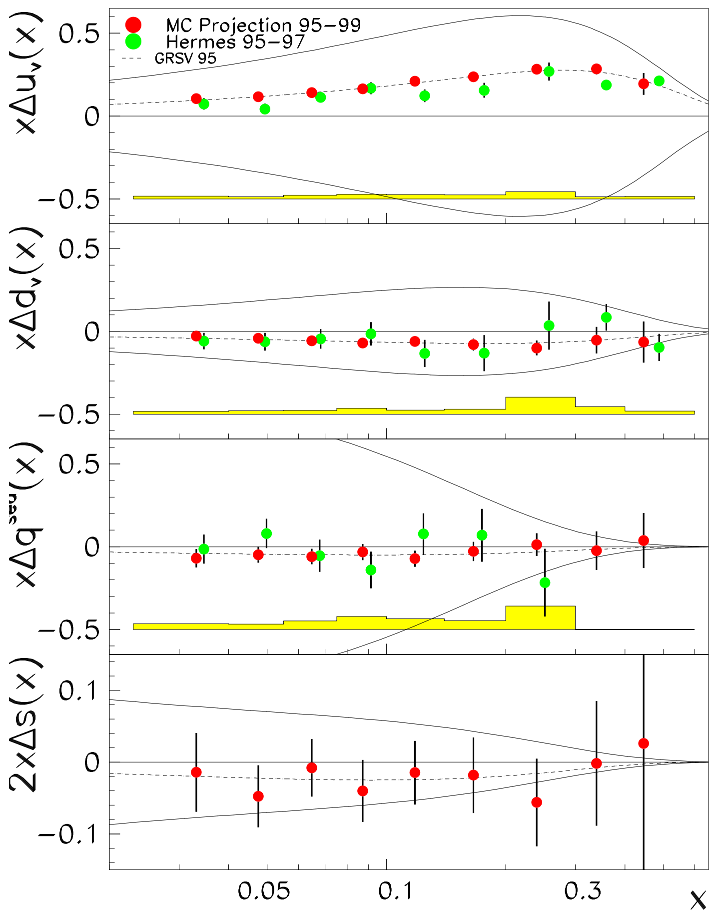
$$A_1^{(h)} \approx \frac{g_1^{(h)}(x,Q^2)}{F_1^{(h)}(x,Q^2)} = \frac{\int \mathrm{d}z \sum_f e_f^2 \Delta q_f(x,Q^2) D_f^{(h)}(z,Q^2)}{\int \mathrm{d}z \sum_f e_f^2 q_f(x,Q^2) D_f^{(h)}(z,Q^2)}$$

98-00: High quality $\vec{D}$ data

- measure pol. sea distribution

Installation of RICH

- direct measurement of sea polarization



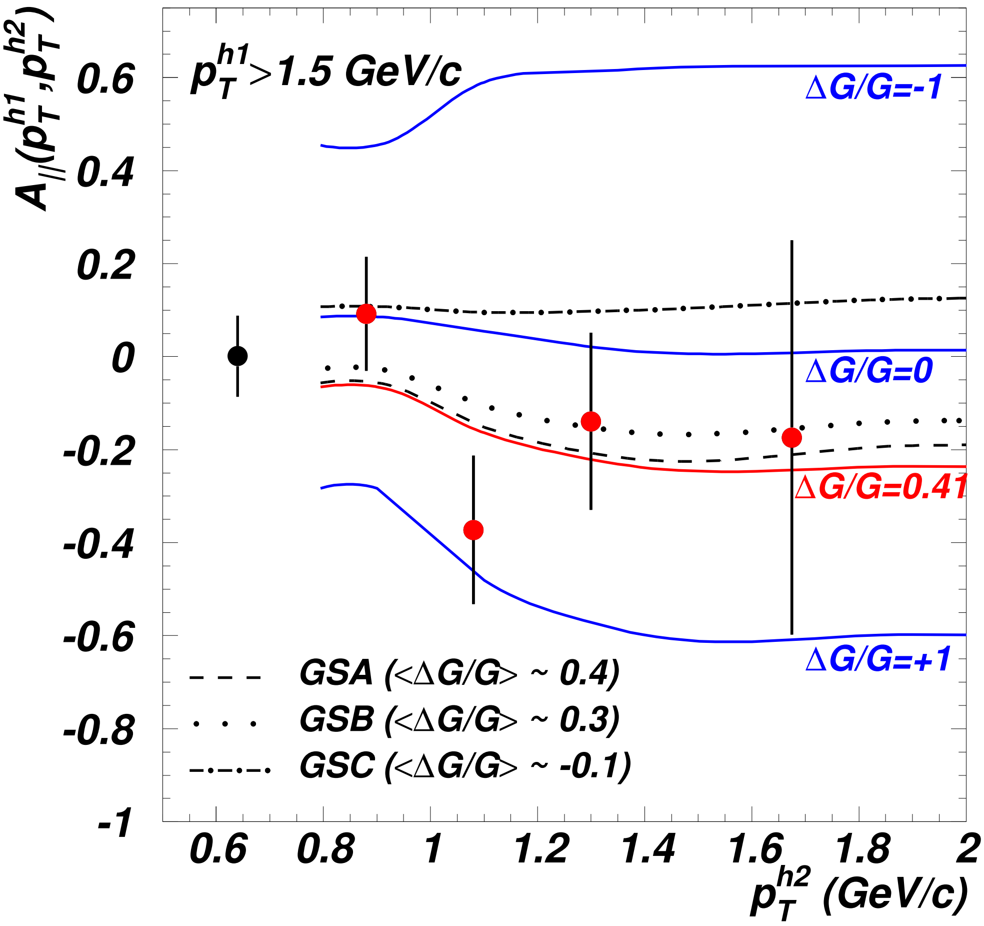
(Phys. Lett. B464 (1999) 123)

$$\Delta\Sigma = 0.30 \pm 0.04 \pm 0.09$$

Other contributions??? $\Rightarrow \Delta G$

Gluon Polarization

Asymmetry of high p_T hadron pairs:



(Phys. Rev. Lett. 84 (2000) 2584)

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

for: $< x_G >= 0.17, \quad < \hat{\mathrm{p}}_{\mathrm{T}}^2 >= 2.1$ GeV^2/c^2

$$\int_{0.06}^{0.28} \frac{\Delta G}{G} G(x) \mathrm{d}x \approx 0.6$$

Installation of RICH + μ-wall in 1998

$\Rightarrow$ ΔG via open charm

Further Highlights

Polarized Physics Program

- Longitudinal Spin Transfer to Λ

  (hep-ex/9911017)
- Spin Asymmetries in Diffractive Vector Meson Production
-
-

Unpolarized Physics Program

- The Flavor Asymmetry of the Light Quark Sea

  (Phys. Rev. Lett. 81 (1998) 5519)
- Fragmentation Functions for light Quarks $\rightarrow \pi, K, p, \Lambda$
- Diffractive Vector Meson Production (Coherence Length Effect, etc.)

  (Phys. Rev. Lett. 82 (1999) 3025, hep-ex/0002016, hep-ex/0004023)
- $F_2^{N/He}/F_2^{D} \rightarrow$ Nuclear Effects on σ_L/σ_T

  (Phys. Lett. B 475 (2000) 386)
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-
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HERMES Run 2: Transversity

2001 transversly polarized target

$\Rightarrow$ transversity, h_1

Projections for statistical accuracy (Proton Target):