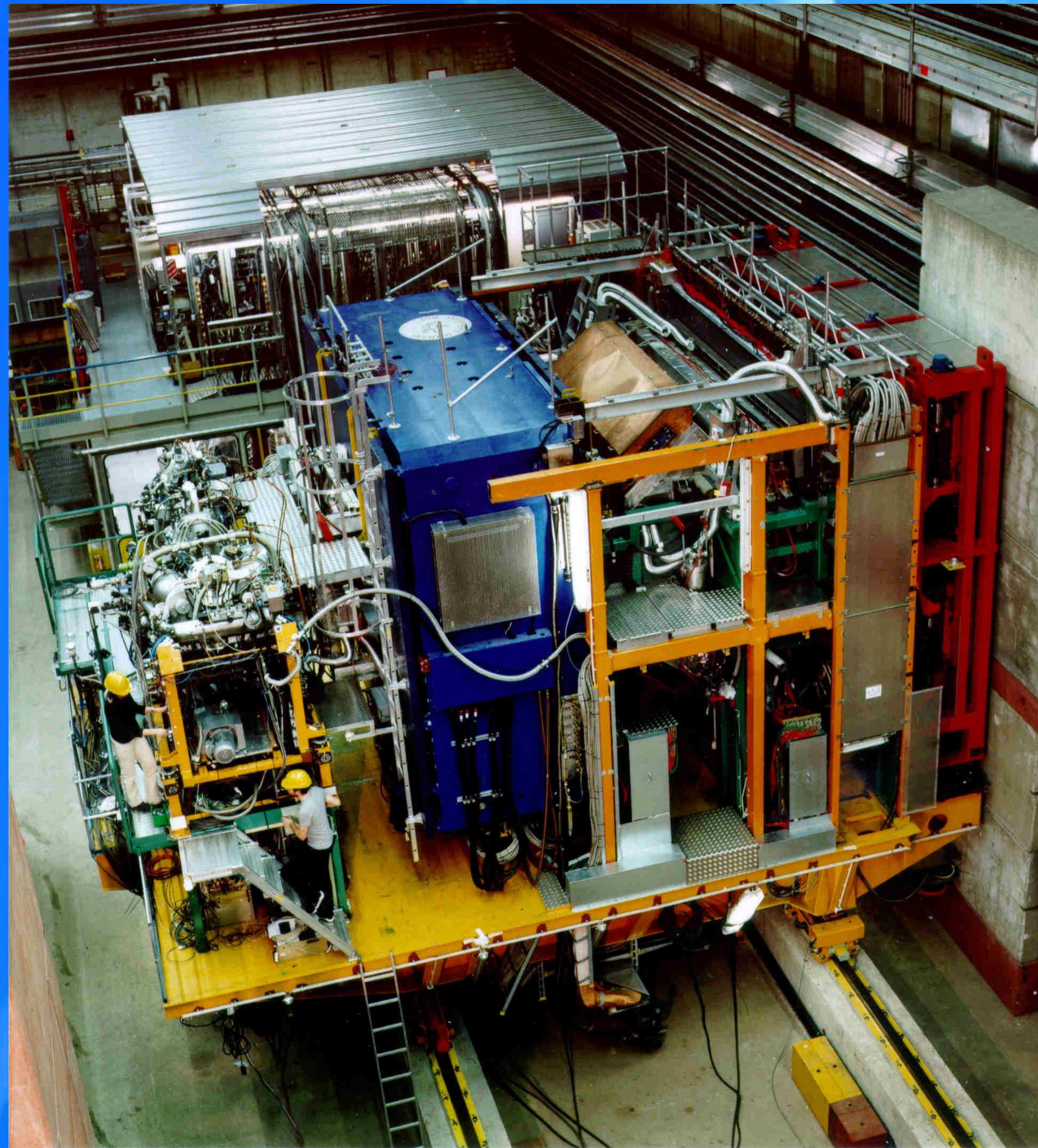
Neueste Ergebnisse von HERMES

E.C. Aschenauer

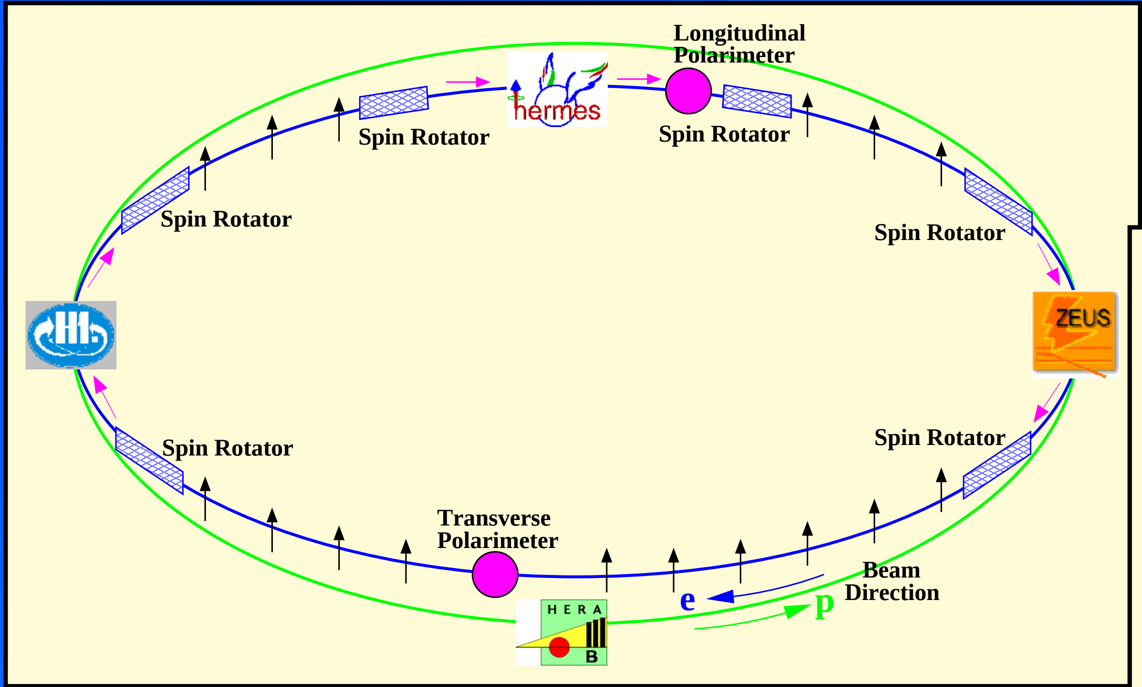
DESY-ZEUTHEN

für die hermes Kollaboration

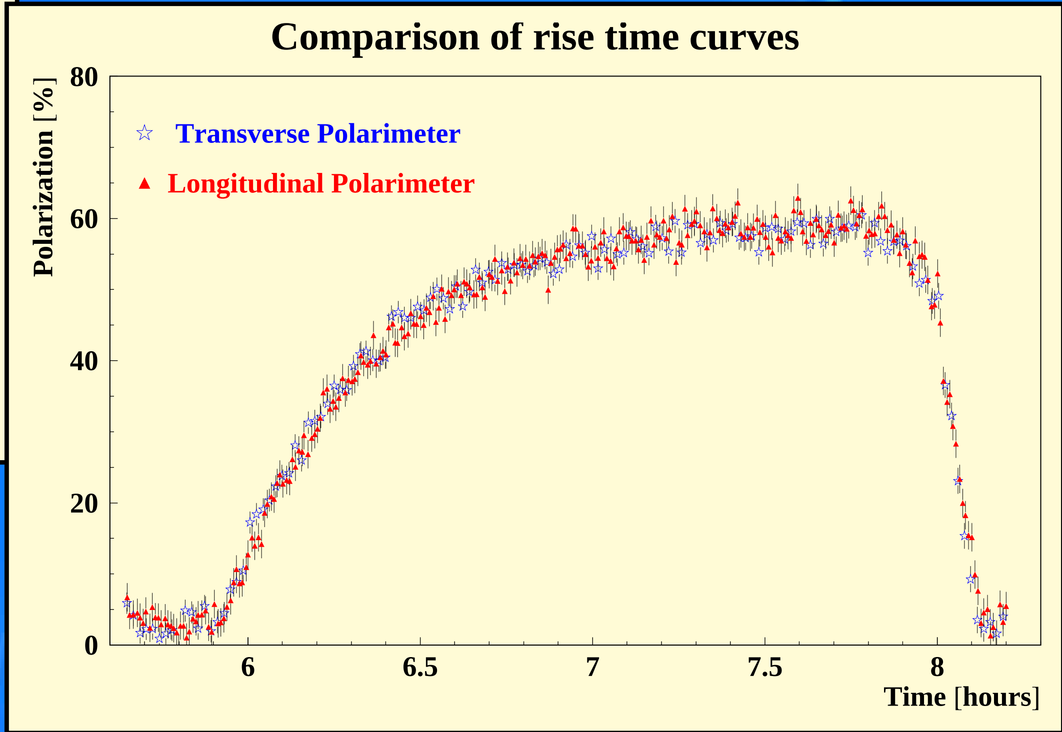
Das HERMES Experiment bei HERA



Der HERA Leptonenstrahl



- **Echtzeitmessung der Strahlpolarisation mit zwei Compton Rückstreupolarimetern**

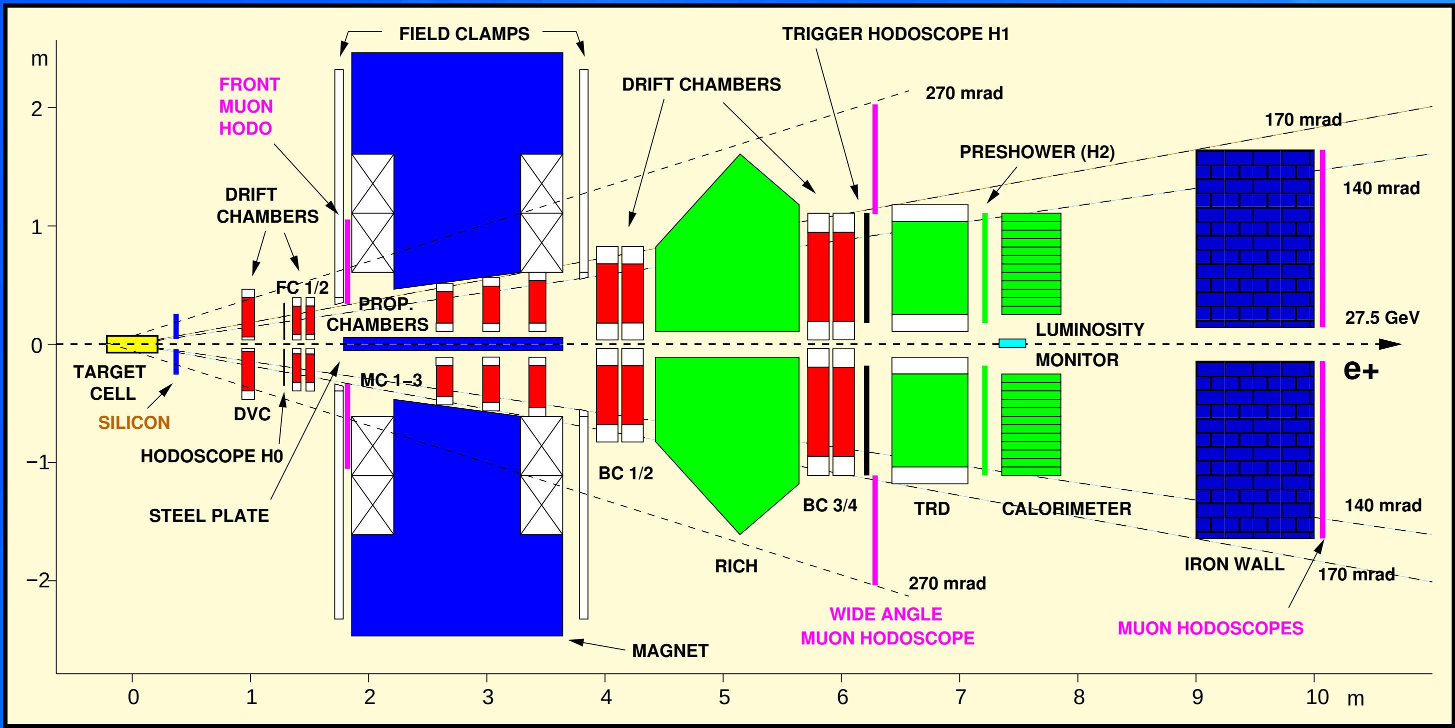


- **HERA-e ist selbst-polarisierend durch Emission von Synchrotronstrahlung**
  $\longrightarrow$ **Transversale Polarisation**
- **Longitudinale Polarisation bei HERMES durch Spinrotatoren**

Strahlpolarisation $<\mathrm{P_B}>\sim 55\%$

$\Delta \mathrm{P_B}/\mathrm{P_B} = 1.8 - 3.4\%$

Der HERMES Detektor



Kinematischer Bereich: 0.02 $\leq$ x $\leq$ 0.8 bei Q^2 $\geq$ 1GeV^2 und W $\geq$ 2GeV

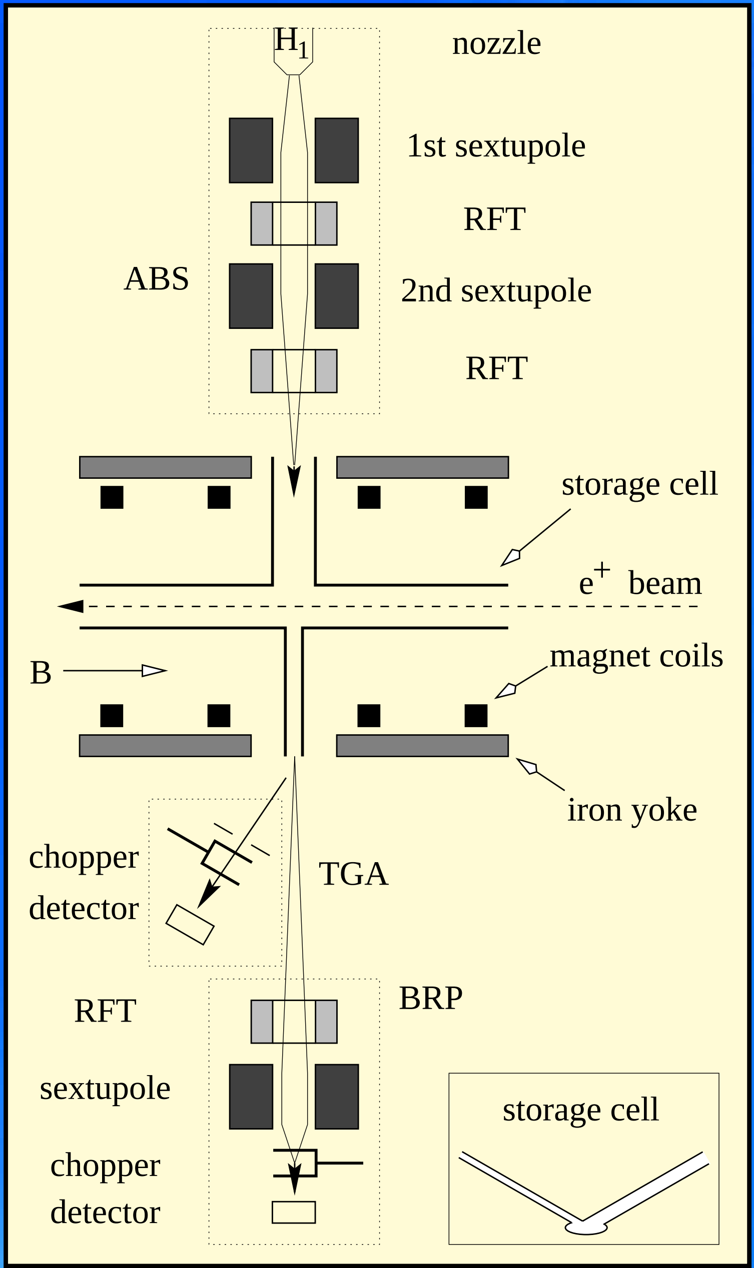
Rekonstruktion: δp/p 0.7 - 1.3%, $\delta\Theta \leq$ 0.6mrad

Internes Gastarget: $\overrightarrow{\mathrm{H}e}$,$\overrightarrow{\mathrm{D}}$, $\overrightarrow{\mathrm{H}}$,H$^\uparrow$; unpol: H$_2$, D$_2$, He, N$_2$, Ne, Kr

Teilchenidentifikation: TRD, Preshower, Kalorimeter

$\rightarrow$ 1997: $\check{C}$erenkov 1998 $\rightarrow$: RICH + Muon-ID

Das Polarisierte HERMES Gastarget



- **Zellwände 75μ Aluminium Drifilm beschichtet**
- **Zelltemperatur 35...260 K Helium gekühlt**
- **Haltefeld: 0...350 mT $\Delta B/B \approx$ 0.015**
- **alle 90s wird der Polarisationszustand geändert**
- **Polarisation: Wasserstoff $< P_T >$: 0.85 $\pm$ 0.032 Deuterium $< P_T >$: 0.84 $\pm$ 0.029**

für mehr Details: P.Tait HK 18.8

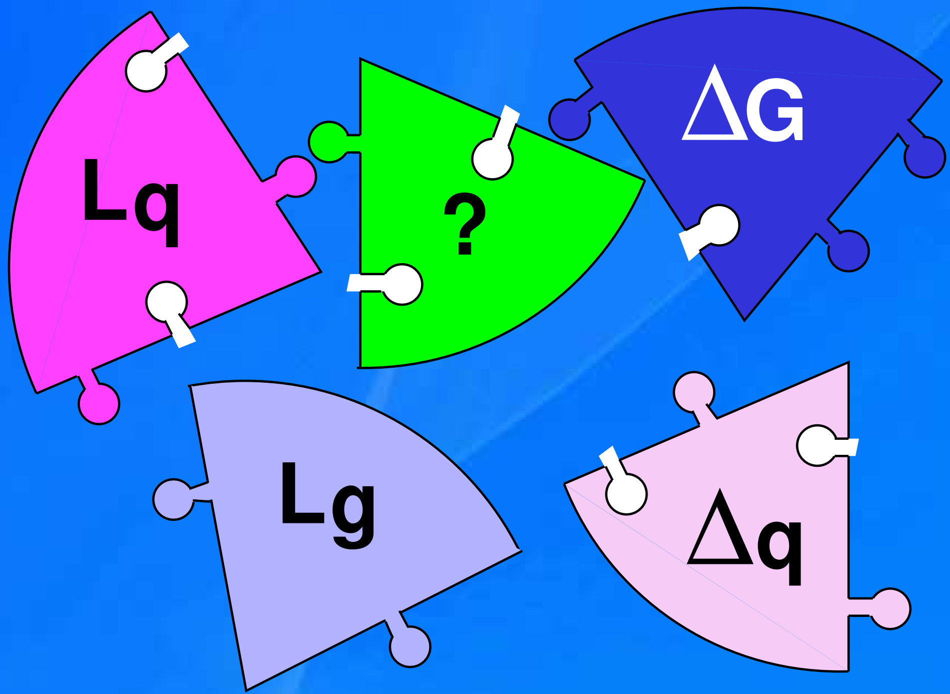
Die Spinstruktur des Nukleons

$$\frac{1}{2} = \underbrace{\frac{1}{2}(\Delta u + \Delta d + \Delta s)}_{\downarrow} + \underset{\downarrow}{\Delta G} + \underbrace{L_q + L_g}_{\downarrow}$$

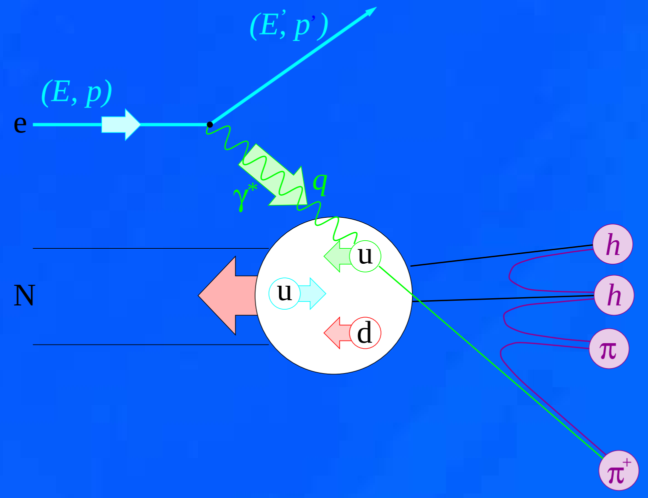
Inklusiv: g$_p^1$, g$_n^1$, g$_d^1$ $\rightarrow \Delta\Sigma$
Semiinkl.: Quark Separation

isoliere PGF
Open Charm
"high-p$_t$" Hadronen

exklusiv: π, γ
Produktion



Polarisierte Tiefinelastische Streuung



Wichtige Variablen:

$$Q^2 \stackrel{lab}{=} 4EE'\sin^2\left(\frac{\theta}{2}\right) \qquad x \stackrel{lab}{=} \frac{Q^2}{2m\nu}$$

$$z \stackrel{lab}{=} \frac{E_h}{\nu}$$

Wirkungsquerschnitt: $\frac{d^2\sigma}{d\Omega dE^2} = \frac{\alpha^2 E'}{Q^2 E} L_{\mu\nu} W^{\mu\nu}$

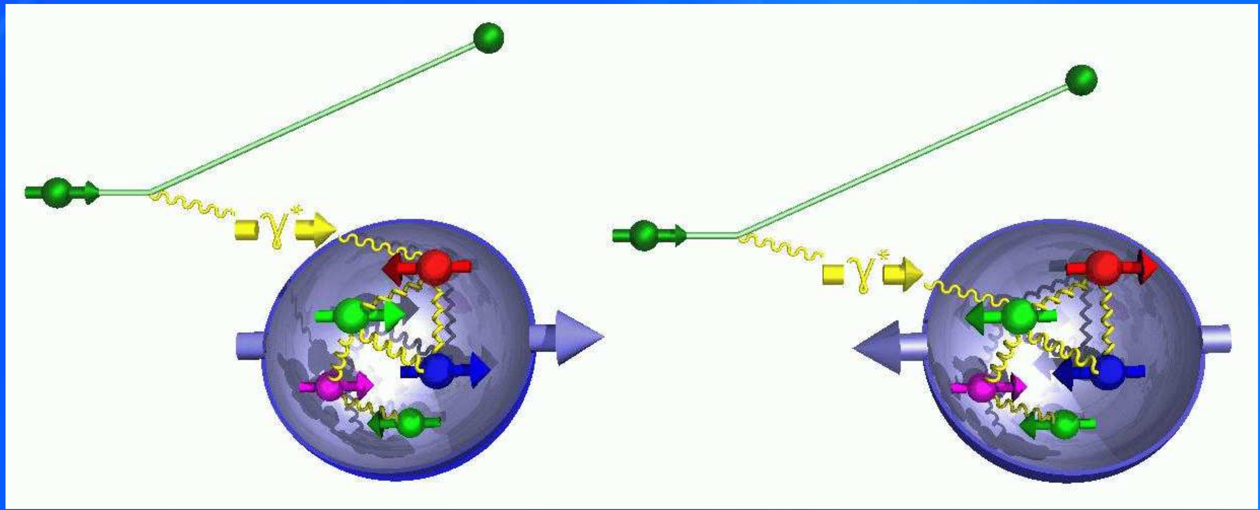
$L_{\mu\nu}$: **nur elektromagnetisch** $\longrightarrow$ **berechenbar**

$W^{\mu\nu} \sim F_1\left(x,Q^2\right) + F_2\left(x,Q^2\right) + g_1\left(x,Q^2\right) + g_2\left(x,Q^2\right)$

(für spin 1) $-b1\left(x,Q^2\right) + \frac{1}{6}b2\left(x,Q^2\right) + \frac{1}{2}b3\left(x,Q^2\right) + \frac{1}{2}b4\left(x,Q^2\right)$

F_1, F_2 / g_1, g_2 $\Longrightarrow$ unpolarisierte / polarisierte **Strukturfunktionen**

Die Virtuelle Photonen-Asymmetrie



Polarisierte Photonen können nur mit Quarks mit entgegengesetztem Spin zum eigenem wechselwirken.

$\vec{S}_\gamma$ + $\vec{S}_N$ = 3/2

$\sigma_{3/2} \sim q^-(x)$

$\vec{S}_\gamma$ + $\vec{S}_N$ = 1/2

$\sigma_{1/2} \sim q^+(x)$

unpolarisiertes Target + Strahl

polarisiertes Target + Strahl

"flipping" Targetspin

Quarkdichteverteilungen:

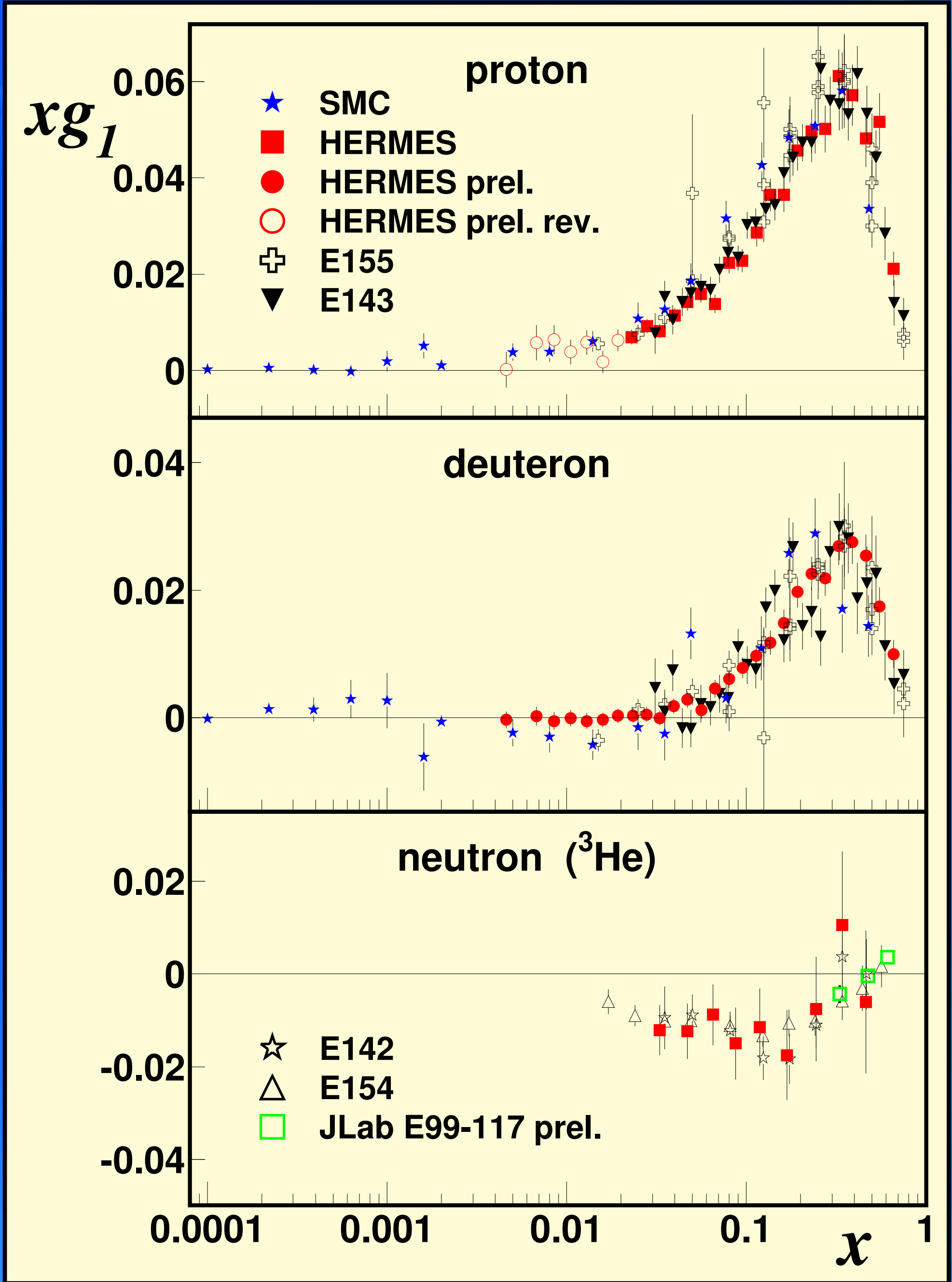
$$\boxed{q_f(x) := q_f^+(x) + q_f^-(x)}$$

Polarisierte Quarkdichteverteilungen:

$$\boxed{\Delta q_f(x) := q_f^+(x) - q_f^-(x)}$$

Unterschiedliche Targets $\longrightarrow$ Sensitivität auf verschiedene Quarks

$g_1(x, Q^2)$ *Weltdatensatz*



Daten für gemessenes $< Q^2 >$: 0.02 - 58 GeV^2

Virtuelle Photonen-Asymmetrie:

$$A_1 = \frac{\sigma_{\frac{1}{2}} - \sigma_{\frac{3}{2}}}{\sigma_{\frac{1}{2}} + \sigma_{\frac{3}{2}}} \sim \frac{g_1}{F_1}$$

$$F_1(x) = \frac{1}{2}\sum_i e_i^2 (q_i^+(x) + q_i^-(x))$$
$$= \frac{1}{2}\sum_i e^2 q_i(x)$$

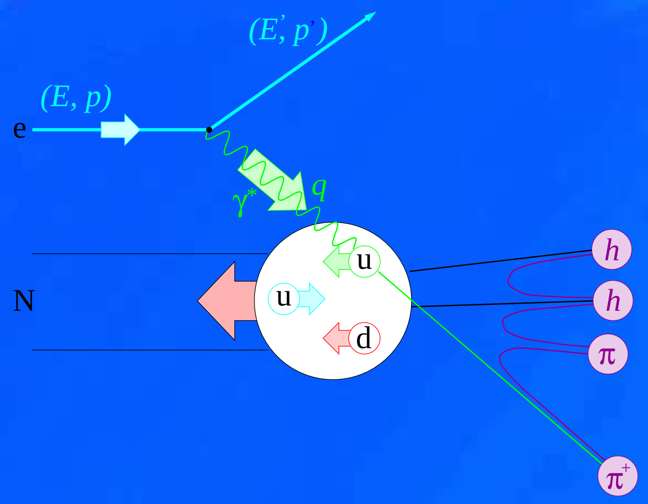
2xF_1: Impulsverteilung

$$g_1(x) = \frac{1}{2}\sum_i e_i^2 (q_i^+(x) - q_i^-(x))$$
$$= \frac{1}{2}\sum_i e^2 \Delta q_i(x)$$

g_1: Spindichteverteilung

für mehr Details: M.Ehrenfried HK 38.5

Semiinklusive DIS



Korrelation zwischen nachgewiesenem Hadron und getroffenem Quark q_f

$\longrightarrow$ Trennung nach Quarks

Inklusive DIS: $\Delta\Sigma = (\Delta u + \Delta\bar{u} + \Delta d + \Delta\bar{d} + \Delta s + \Delta\bar{s})$

Semiinklusive DIS: Δu, $\Delta\bar{u}$, Δd, $\Delta\bar{d}$, Δs, $\Delta\bar{s}$

In LO-QCD:

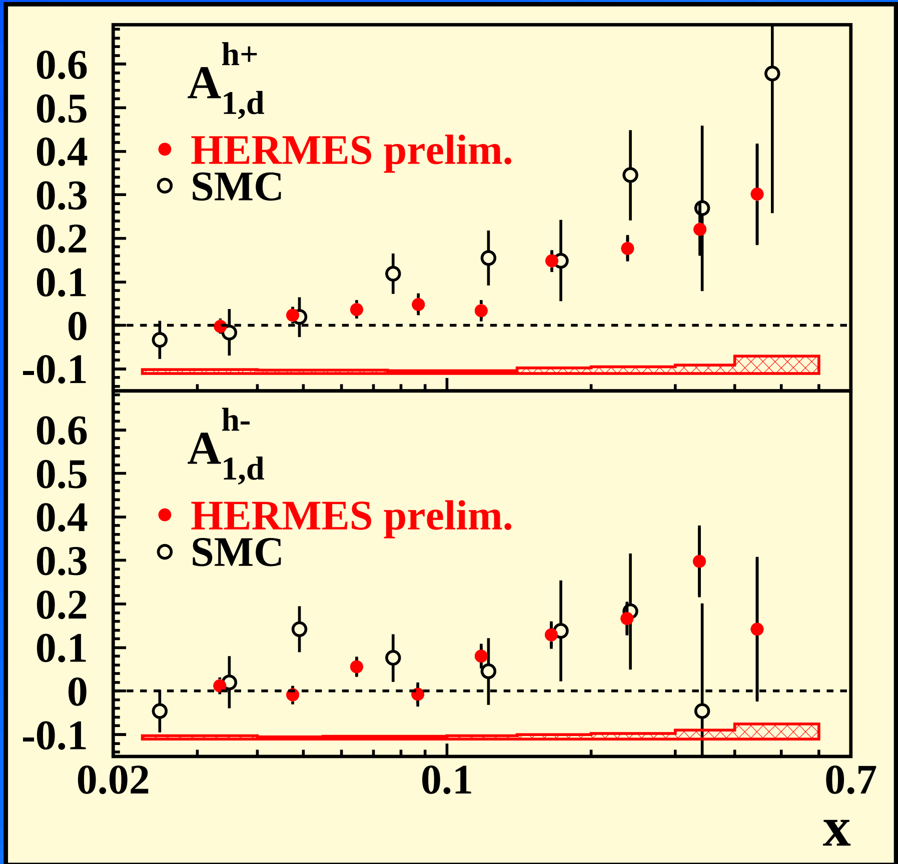
$$A_1^{\mathrm{h}}(x,Q^2) = \frac{\sigma^h_{1/2}-\sigma^h_{3/2}}{\sigma^h_{1/2}+\sigma^h_{3/2}} \sim \frac{\sum_f e_f^2 \Delta q_f(x,Q^2) \int dz\, D_f^{\mathrm{h}}(z,Q^2)}{\sum_f e_f^2 q_f(x,Q^2) \int dz\, D_f^{\mathrm{h}}(z,Q^2)}$$

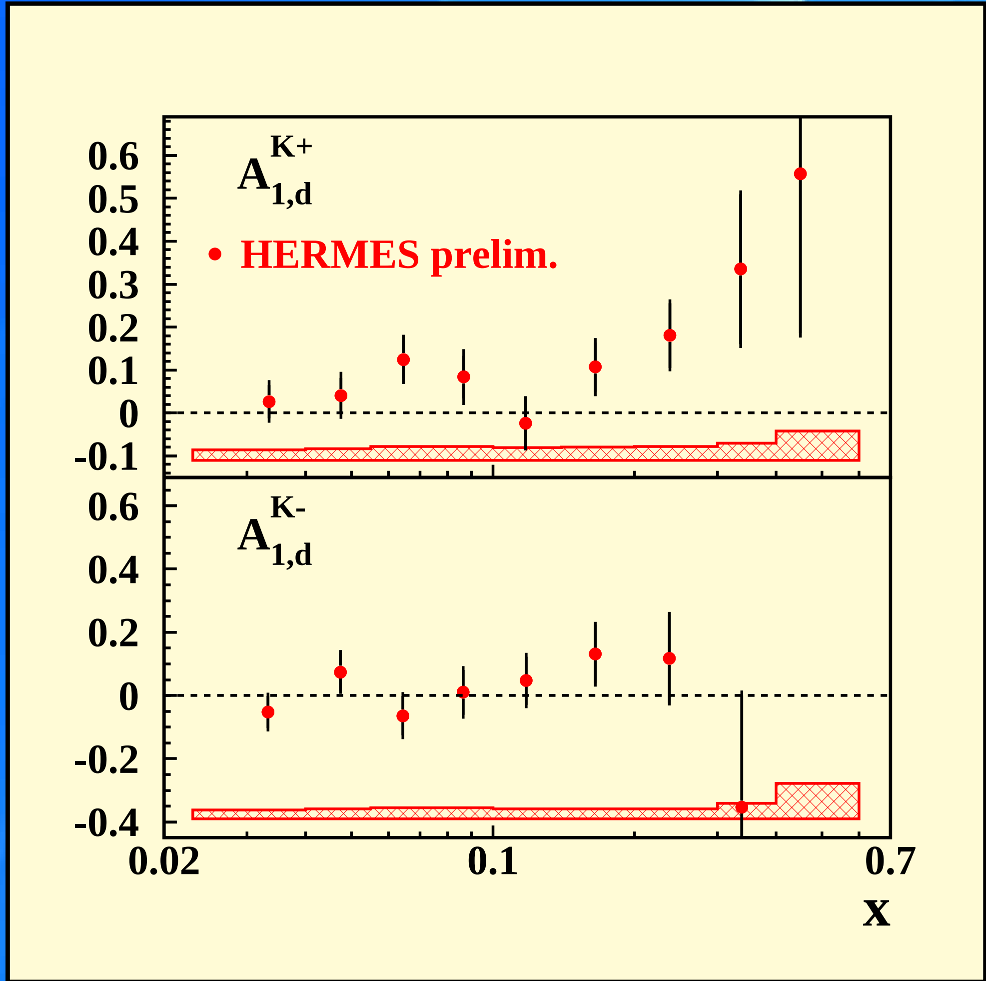
$(\Delta q_f), q_f$ **(Polarisierte) Quarkdichteverteilungen**

$D_f^{\mathrm{h}}(z)$ **Fragmentationsfunktion:**

Wahrscheinlichkeit, daß ein (gestreutes) Quark der Sorte f in ein Hadron des Typs h fragmentiert.

Hadron-Asymmetrien am Deuteron





- **HERMES selektiert Hadronen nach den folgenden Kriterien:**
  - $0.2 \leq z = E_h/\nu \leq 0.8$ **und** $x_F \geq 0.1$ **und** $W^2 \geq 10GeV^2$
  - **HERMES-Deuteriumdaten:** $\pi^{\pm}$ **und** $\mathrm{K}^{\pm}$ **Daten mit RICH-Identifikation**

Δq-Extraktion

- **Photon-Nukleon Asymmetrie**

$$\mathbf{A_1^h(x)} \overset{\mathbf{g_2=0}}{\simeq} \mathbf{C} \cdot \sum_{\mathbf{q}} \underbrace{\frac{e_q^2 q(x) \int dz D_q^{\mathrm{h}}(z)}{\sum_{q'} e_{q'}^2 q'(x) \int dz D_{q'}^{\mathrm{h}}(z)}}_{P_q^h(x,z)} \frac{\mathbf{\Delta q(x)}}{\mathbf{q(x)}}$$

- $P_q^h(x,z)$ **Purity: Wahrscheinlichkeit, daß ein Hadron h aus der Streuung an einem Quark f hervorging**
  - **Effektive Größen berücksichtigen Detektoreffekte**
  - **berechnet aus einem Monte Carlo, das auf dem JetSet Fragmentationsmodel beruht.**

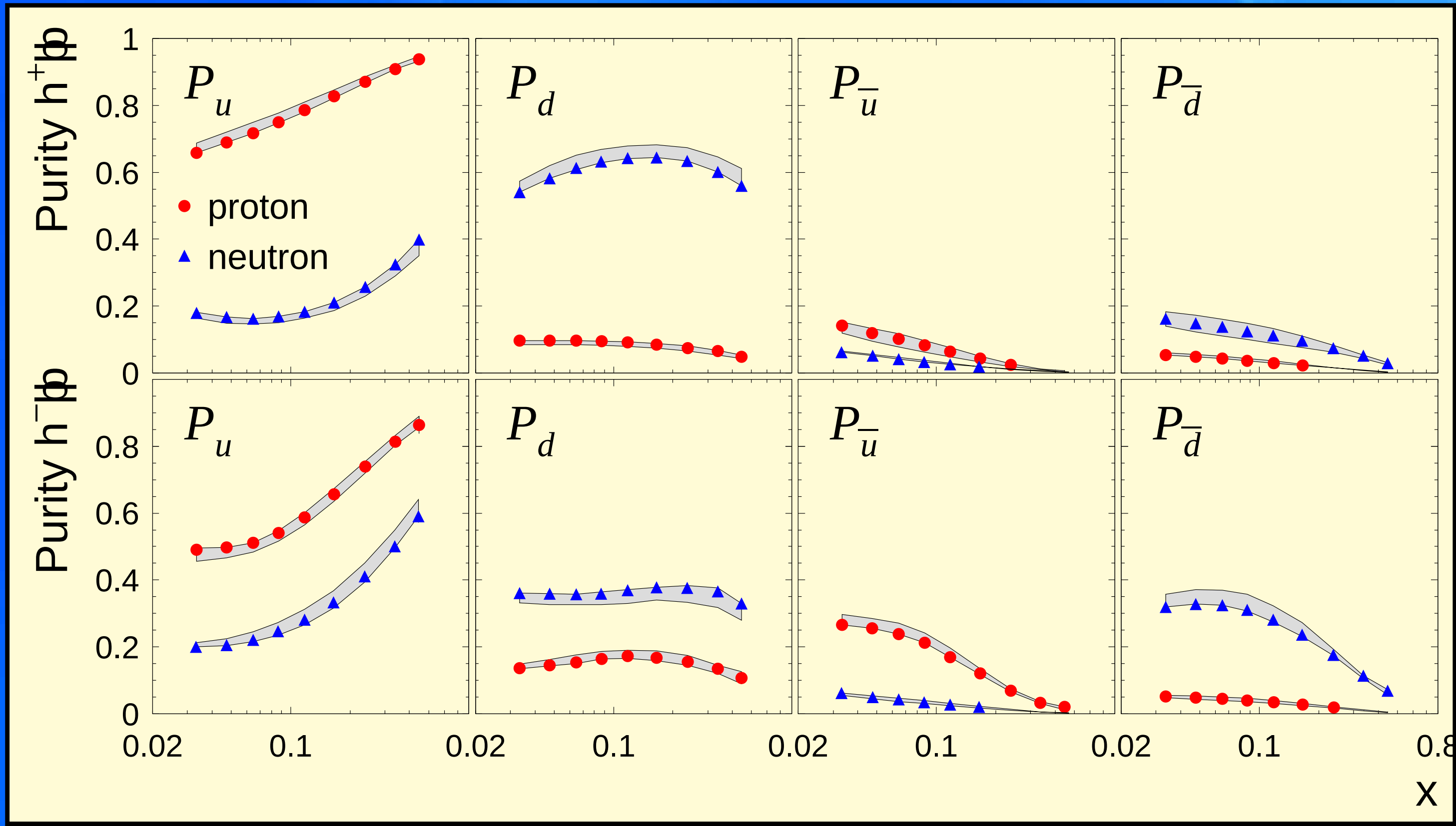
- **Lösen eines linearen Gleichungssystems mit**

$$\vec{\mathbf{A}} = (\mathbf{A_{1,p}(x)}, \mathbf{A_{1,d}(x)}, \mathbf{A_{1,p}^{\pi^\pm}(x)}, \mathbf{A_{1,d}^{\pi^\pm}(x)}, \mathbf{A_{1,d}^{K^\pm}(x)})$$

$$\vec{\mathbf{Q}} = (\frac{\mathbf{\Delta u}}{\mathbf{u}}, \frac{\mathbf{\Delta d}}{\mathbf{d}}, \frac{\mathbf{\Delta \bar{u}}}{\mathbf{\bar{u}}}, \frac{\mathbf{\Delta \bar{d}}}{\mathbf{\bar{d}}}, \frac{\mathbf{\Delta s + \Delta \bar{s}}}{\mathbf{s + \bar{s}}})$$

$$\boxed{\vec{\mathcal{A}} = \mathcal{P}\vec{\mathcal{Q}}}$$

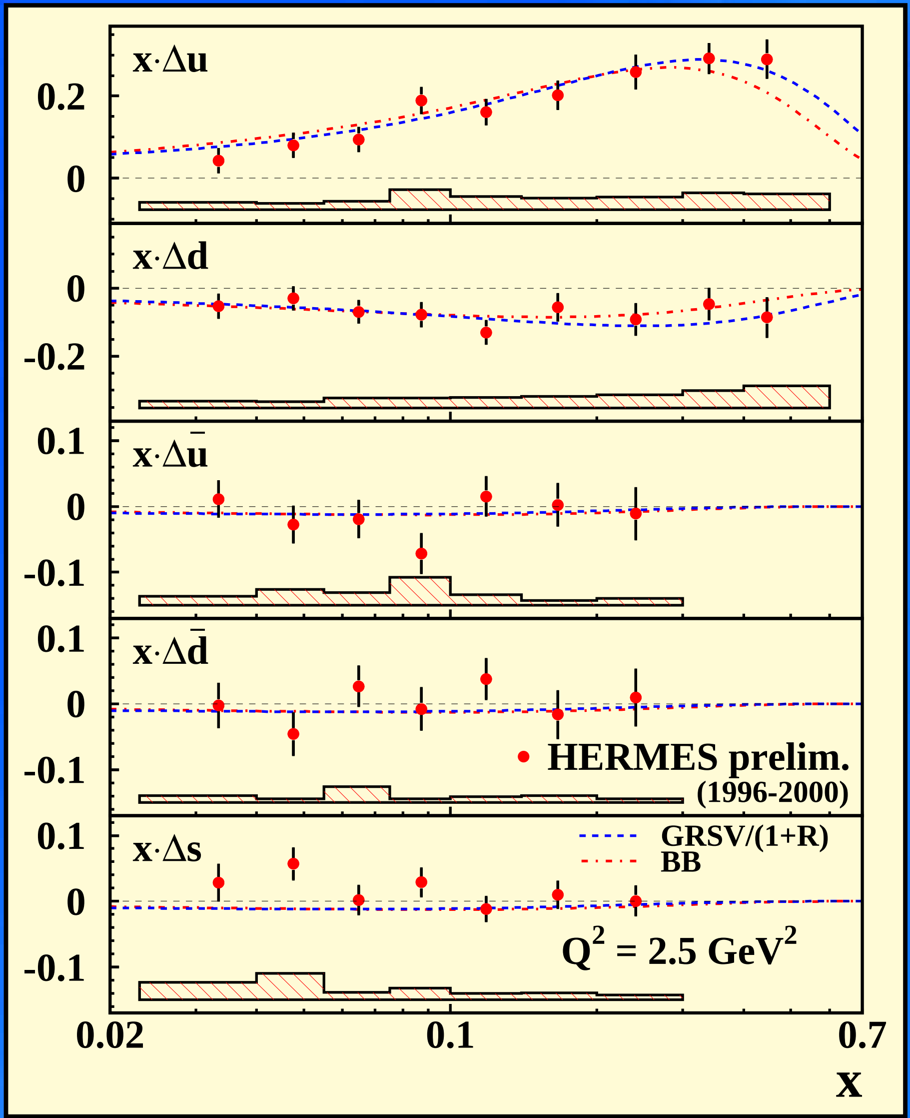
Purities für geladene Hadronen

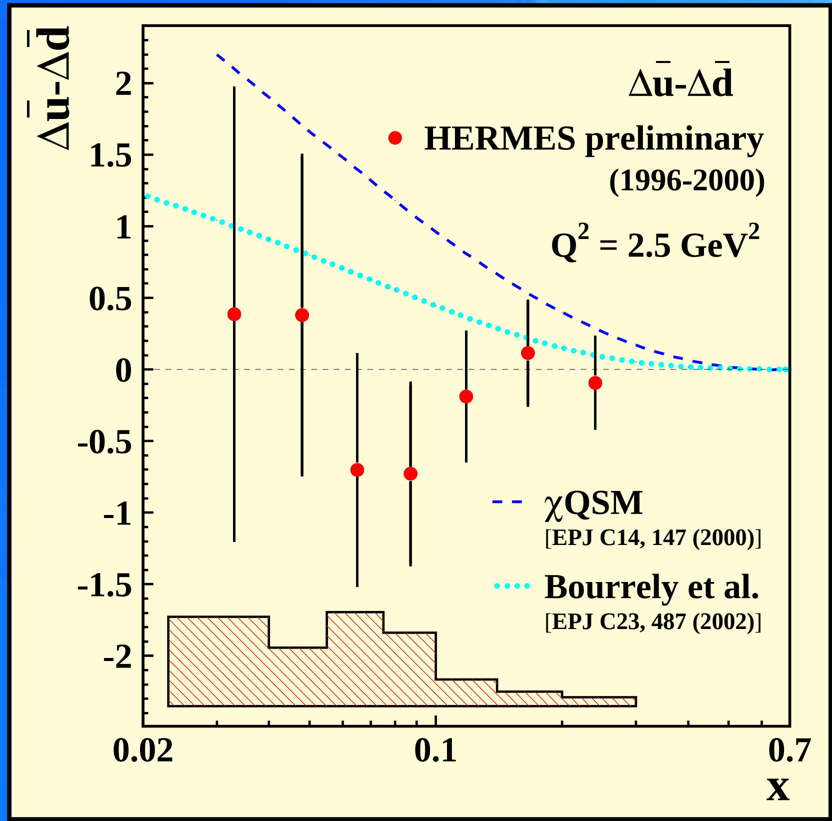


Schattierte Bänder geben systematische Unsicherheiten an

- **Komplementarität wird erreicht**
  - u **versus** d **von h**$+$
  - **Valenz versus See durch Hadronladung**
  - $\bar{u}$ **versus** $\bar{d}$ **von h**$-$
- **Kaonen haben zusätzlich eine 10% Sensitivität auf Strange-Quarks**

Polarisierte Quarkdichteverteilungen in LO



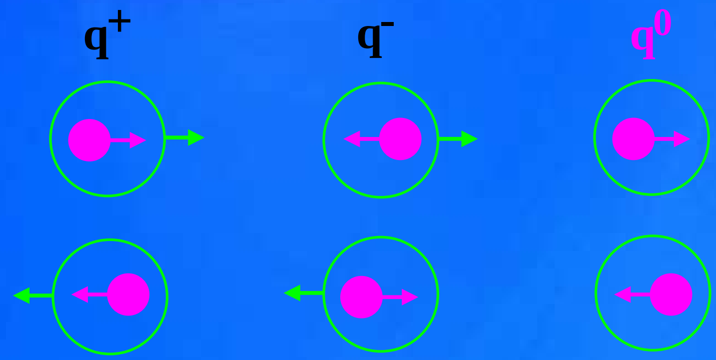


Polarisation des s-Sees $\Delta s \geq 0$

Hermes Daten konsistent mit:

- **$SU(3)_f$ Symmetrie in der Polarisation des leichten Quarksees**
- **Daten folgen nicht den Vorhersagen des χQSM von Dressler et al.**

Die Deuteron-Tensor-Strukturfunktion b_1^d

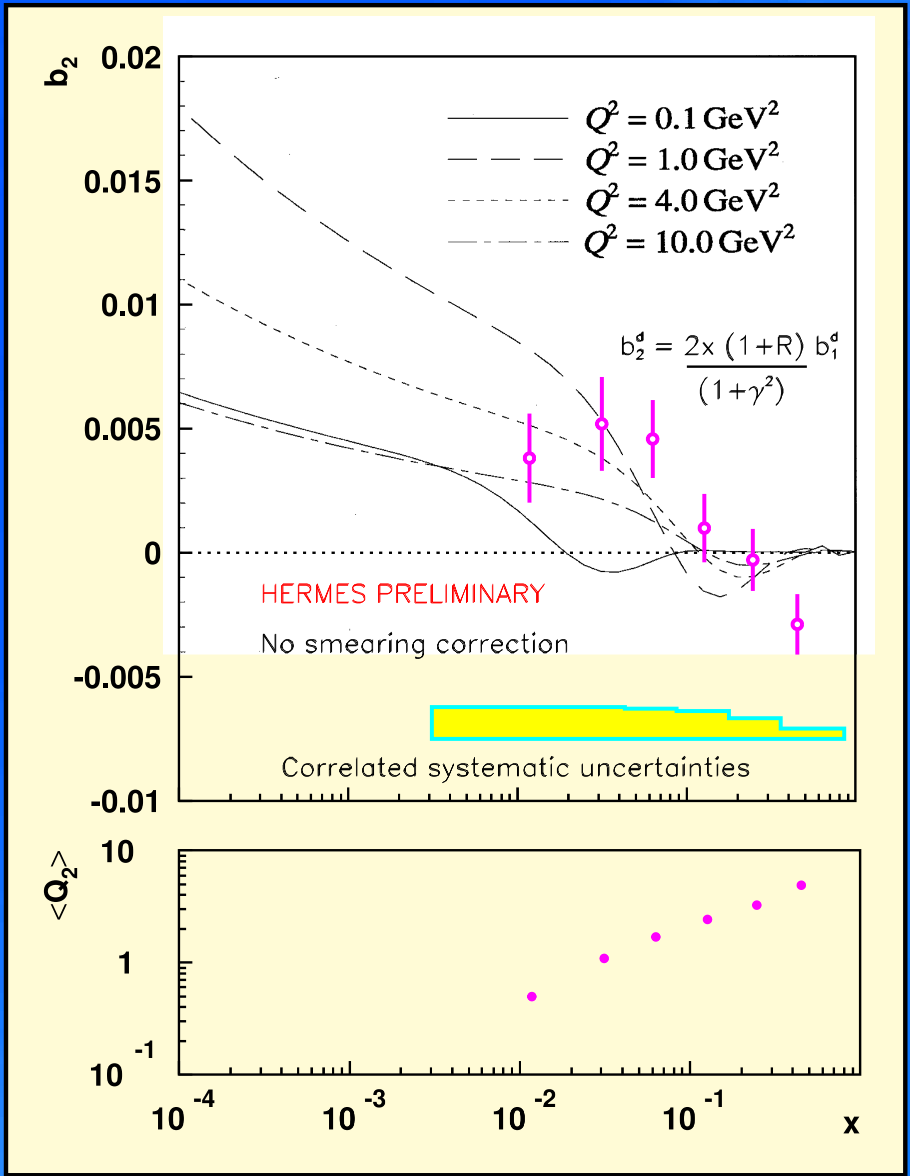


	Proton	Deuteron
$F_1(x):$	$\frac{1}{2}\sum_i e_i^2(q_i^+(x)+q_i^-(x))$	$\frac{1}{3}\sum_i e_i^2(q_i^+(x)+q_i^-(x)+q_i^0(x))$
$g_1(x):$	$\frac{1}{2}\sum_i e_i^2(q_i^+(x)-q_i^-(x))$	$\frac{1}{2}\sum_i e_i^2(q_i^+(x)-q_i^-(x))$
$b_1(x):$		$\frac{1}{2}\sum_i e_i^2(2q_i^0(x)-(q_i^+(x)+q_i^-(x)))$

Im Partonenmodell mißt b_1^d den Unterschied in der Impusverteilung der Quarks für ein Target mit Helizität 1 oder 0

Nur mit einem Gastarget meßbar

Ergebnisse für b_1^d



Für mehr Details: C.Riedl HK 24.4

$$A_T = \frac{(\sigma^+ + \sigma^-) - 2\sigma^0}{\sigma^+ + \sigma^- + \sigma^0}$$

$$= \frac{1}{T} \cdot \frac{\frac{N^+}{L^+} + \frac{N^-}{L^-} - 2\,\frac{N^0}{L^0}}{\frac{N^+}{L^+} + \frac{N^-}{L^-} + \frac{N^0}{L^0}}$$

T: Targetpolarisation $< T >= 0.83 \pm 0.03$

$L^{+/-/0}$: totzeitkorrigierte Luminosität

$$b_1 = -\frac{3}{2} \cdot A_T \cdot F_1^d$$

$$b_1 = \frac{1+\gamma^2}{2 \cdot x(1+R)} \cdot b_2$$

mit:

- $$F_1^d = \frac{1+\gamma^2}{2 \cdot x(1+R)} \cdot F_2^d$$
  $$F_2^d = F_2^p\left(1 + \frac{F_2^n}{F_2^p}\right)$$
- **keine "higher twist" Effekte**
  b_3, b_4 = 0

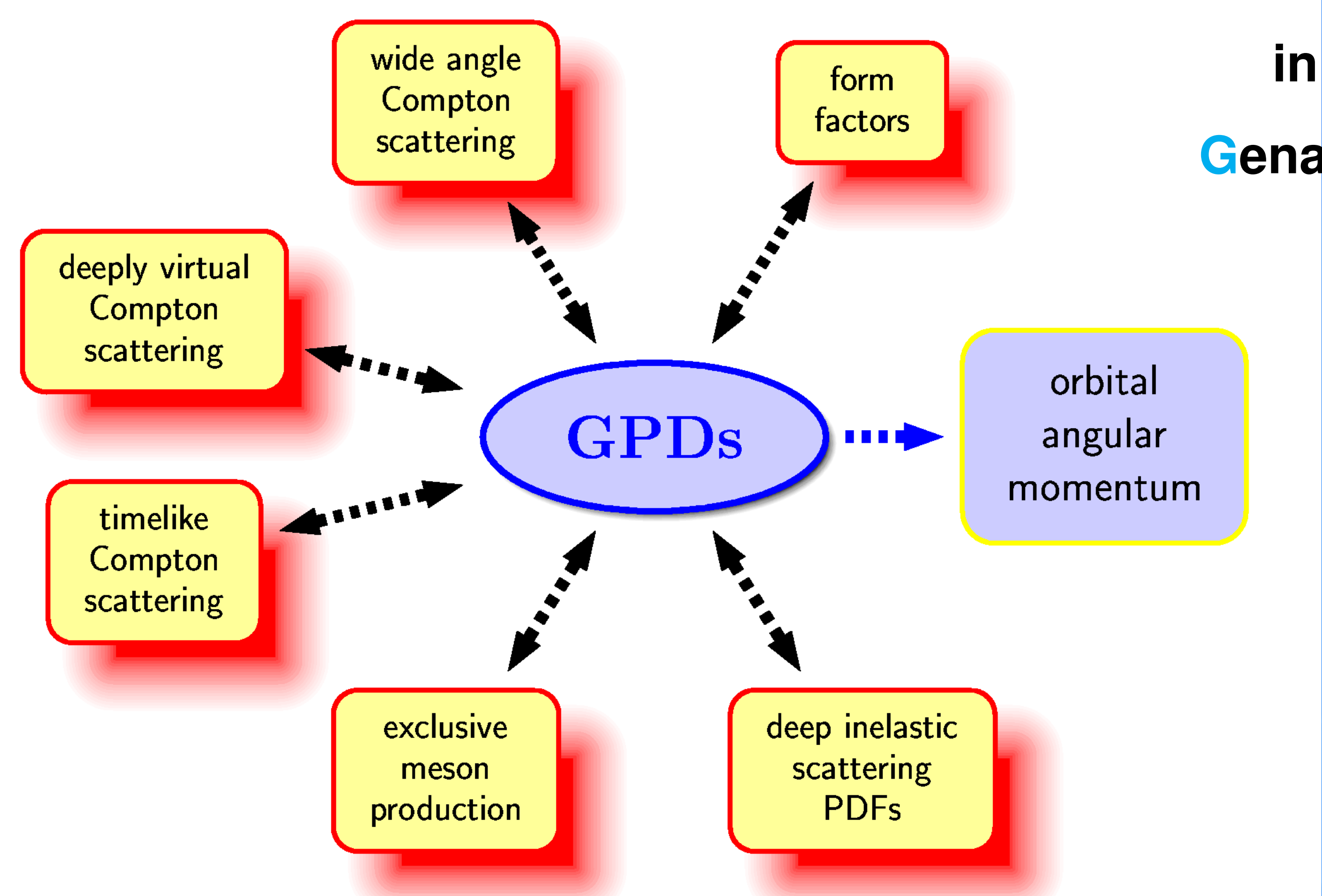
K.Bora & R.L. Jaffe Phys.Rev.D57 (1998) 6906

Einführung in GPDs

Neue Observablen
in harten exklusiven Prozessen

Genaralised Parton Distributions

$H, E, \tilde{H}, \tilde{E}$



$\Rightarrow$ **Möglicher Zugang zum Drehimpuls**

$$\boxed{\int x\mathrm{d}x\,(H + E) = J_q}$$

Quantenzahl des Endzustands exklusiver Prozesse $\rightarrow$ unterschiedliche GPDs

DVCS:	$H, E, \tilde{H}, \tilde{E}$	
Vektormesonen:	H, E	**(hep-ex/0004023)**
Pseudoskalare Mesonen:	$\tilde{H}, \tilde{E}$	**(hep-ex/0112022)**

DVCS Azimutale Asymmetrien

$$d\sigma \propto |\mathcal{T}_{BH}|^2 + |\mathcal{T}_{DVCS}|^2 + (\mathcal{T}^*_{BH}\mathcal{T}_{DVCS} + \mathcal{T}^*_{DVCS}\mathcal{T}_{BH})$$

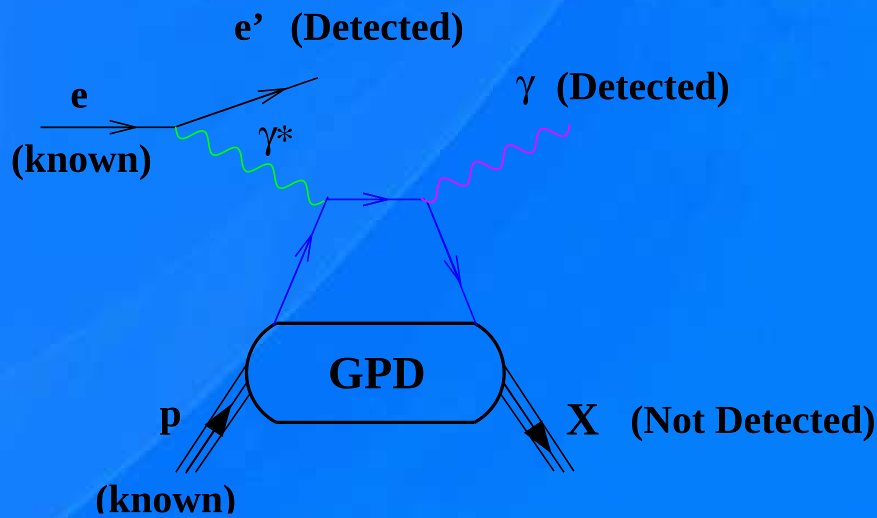
isolieren des BH-DVCS Interferenzterms:

- **Imaginärteil $\propto$ Strahlhelizitätsasymmetrie:**

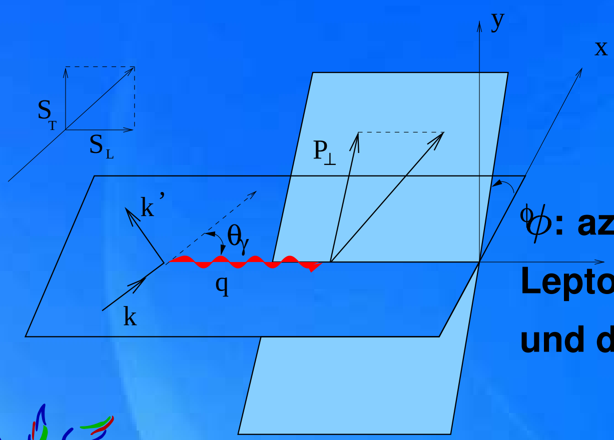
$$d\sigma_{\overleftarrow{e^+}} - d\sigma_{\overrightarrow{e^+}} \propto \mathrm{Im}\,(\mathcal{T}_{BH}\mathcal{T}_{DVCS}) \propto \sin\phi$$

- **Realteil $\propto$ Strahlladungsasymmetrie:**

$$d\sigma_{e^+} - d\sigma_{e^-} \propto \mathrm{Re}\,(\mathcal{T}_{BH}\mathcal{T}_{DVCS}) \propto \cos\phi$$

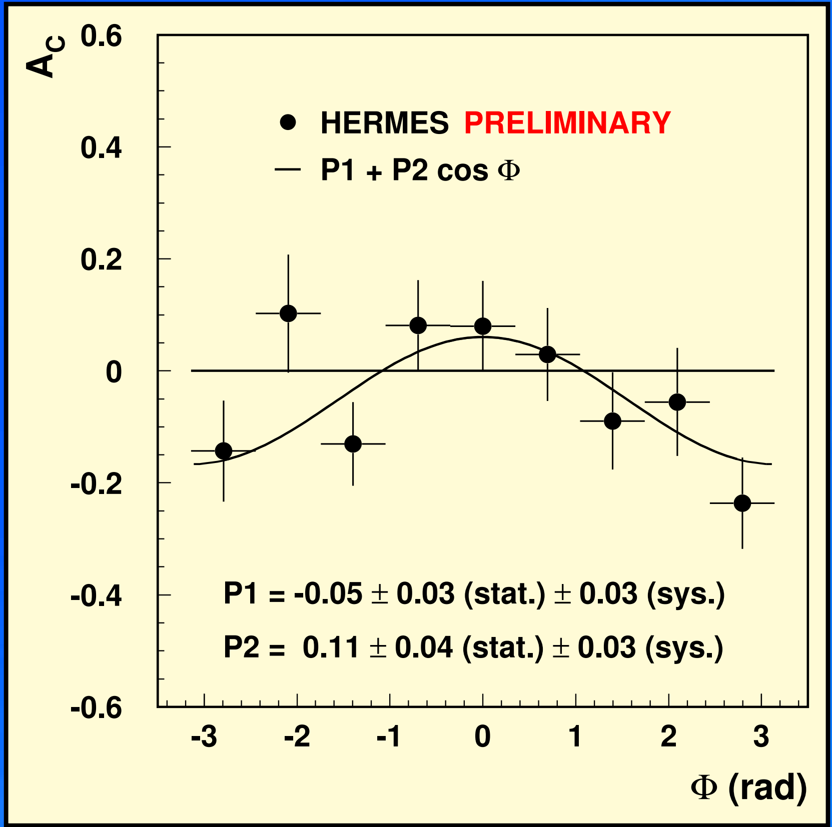


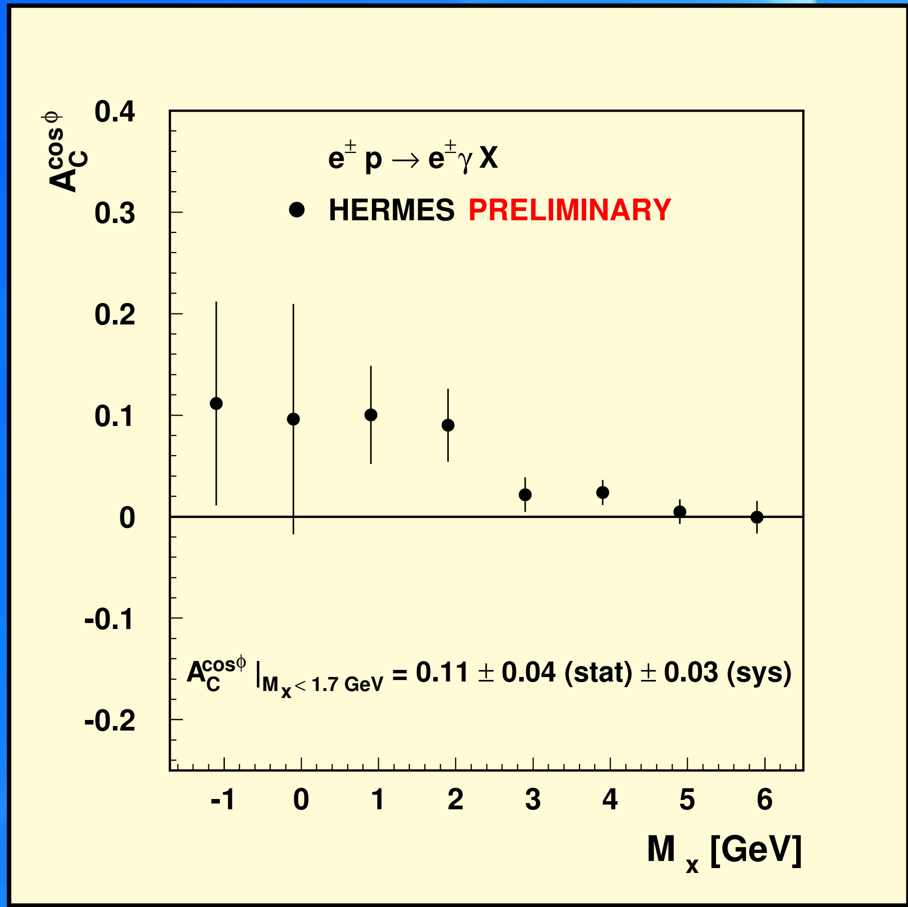
$\Rightarrow$ **Messung beider Asymmetrien mit HERMES**



ϕ: azimutaler Winkel zwischen Leptonen-Streuebene und der $\gamma^*\gamma$ - Ebene

DVCS Strahlladungsasymmetrie (BCA)



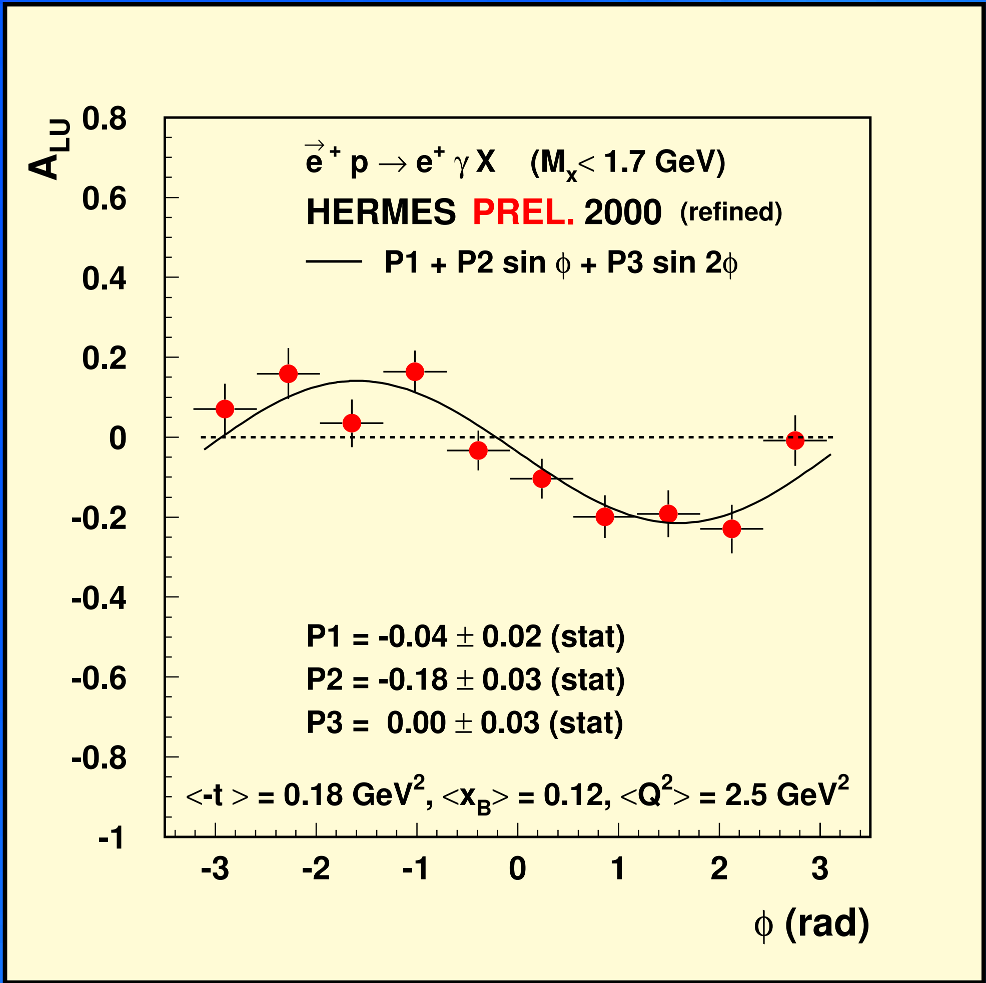


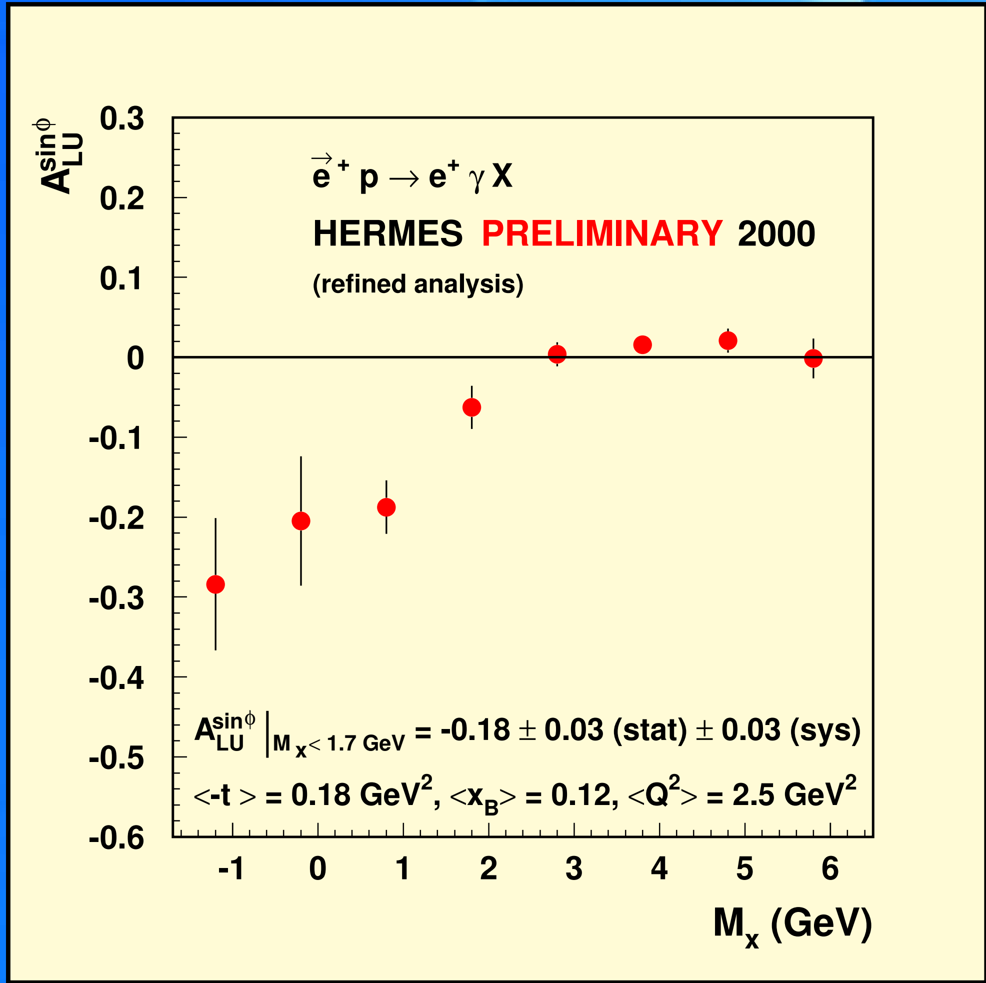
$$A_C(\phi) = \frac{N_{e^+}(\phi) - N_{e^-}(\phi)}{N_{e^+}(\phi) + N_{e^-}(\phi)}$$

$$A_C^{cos\phi} = \frac{1}{N^{e+}} \sum_{i=1}^{N^{e+}} cos(\phi_i) - \frac{1}{N^{e-}} \sum_{i=1}^{N^{e-}} cos(\phi_i)$$

exklusiver Bereich: -1.5 $<$ M$_x$ $<$ 1.7 GeV

DVCS Strahlspinasymmetrie





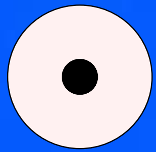
$$A_{LU} = \frac{1}{<|P_l|>} \cdot \frac{(N^+(\phi) - N^-(\phi))}{(N^+(\phi) + N^-(\phi))}$$

$$A_{LU}^{\sin\phi} = \frac{2}{N} \sum_{i=1}^{N} \frac{\sin(\phi_i)}{(P_l)_i}$$

96/97: [PRL87 (2001), 182001]

für mehr Details: B.Kraus HK 11.8

Die 3. Twist-2 Strukturfunktion

$f_1^q =$ 

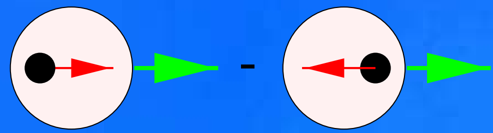
Unpolarisierte
Quarks und Nukleonen

vector charge:

$< PS|\bar{\psi}\gamma^\mu\psi|PS >=$
$\int_0^1 dx q(x) - \bar{q}(x)$

q(x): Spin gemittelt

gut bekannt

$g_1^q =$ 

Longitudinal polarisierte
Quarks und Nukleonen

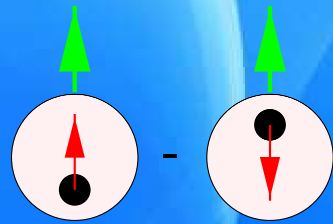
axial charge:

$< PS|\bar{\psi}\gamma^\mu\gamma_5\psi|PS >=$
$\int_0^1 dx \Delta q(x) + \Delta\bar{q}(x)$

Δq(x): Helizitätsdifferenz

bekannt

HERMES 1995-2000

$h_1^q =$ 

Transversal polarisierte
Quarks und Nukleonen

tensor charge :

$< PS|\bar{\psi}\sigma^{\mu\nu}\gamma_5\psi|PS >=$
$\int_0^1 dx \delta q(x) - \delta\bar{q}(x)$

δq(x): Helizitätsflip

UNG. CHIRALITÄT
unbekannt

HERMES 2002. . .

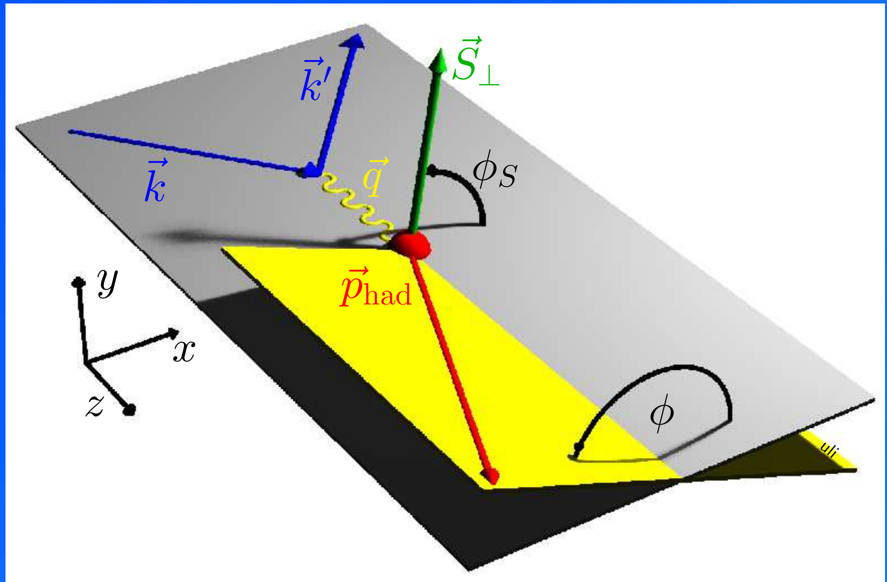
Transversal Polarisierte Targetspinasymmetrien

$$ep^{\uparrow} \longrightarrow e'\pi X$$

$$\sigma^{ep\to ehX} = \sum_q f^{H\to q} \otimes \sigma^{eq\to eq} \otimes D^{q\to h}$$

$\Downarrow$ **ungerade Chiralität** **DF**

$\Downarrow$ **ungerade Chiralität** **FF**



$\Phi = \phi + \phi_s$ **Collins-Winkel**

$$A_{UT}^{\sin\Phi} \propto \frac{\sum_{i=1}^{N^+} \sin\Phi - \sum_{i=1}^{N^-} \sin\Phi}{\frac{1}{2}(N^+ + N^-)}$$

$$A_{UT}^{\sin\Phi} \propto \frac{\sum_q e_q^2 \delta q(x) H_1^{\perp,q}(z)}{\sum_q e_q^2 q(x) D_1^q(z)}$$

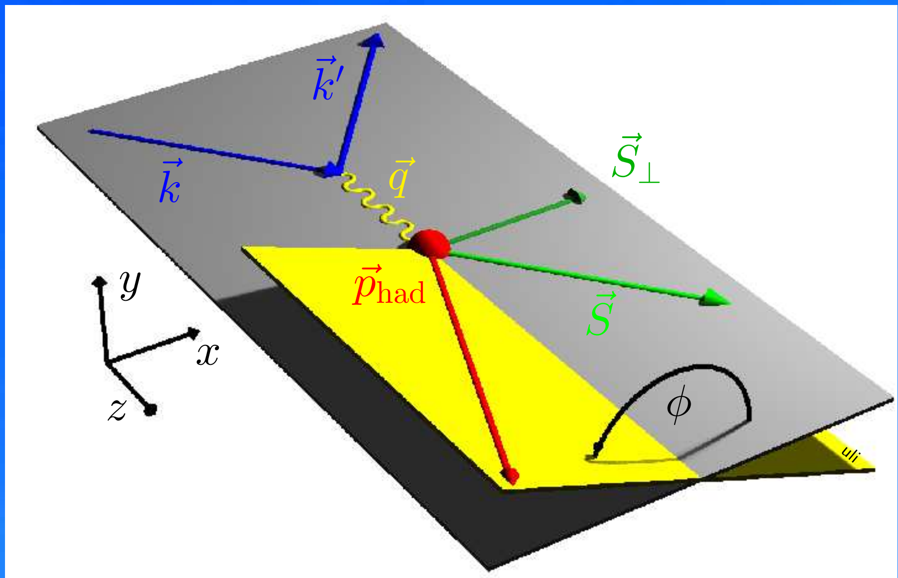
$H_1^{\perp}(z)$ **Collins Fragmentationsfunktion**

Der Erste Blick auf Transversity ?!

Longitudinal polarisiertes Deuteriumtarget

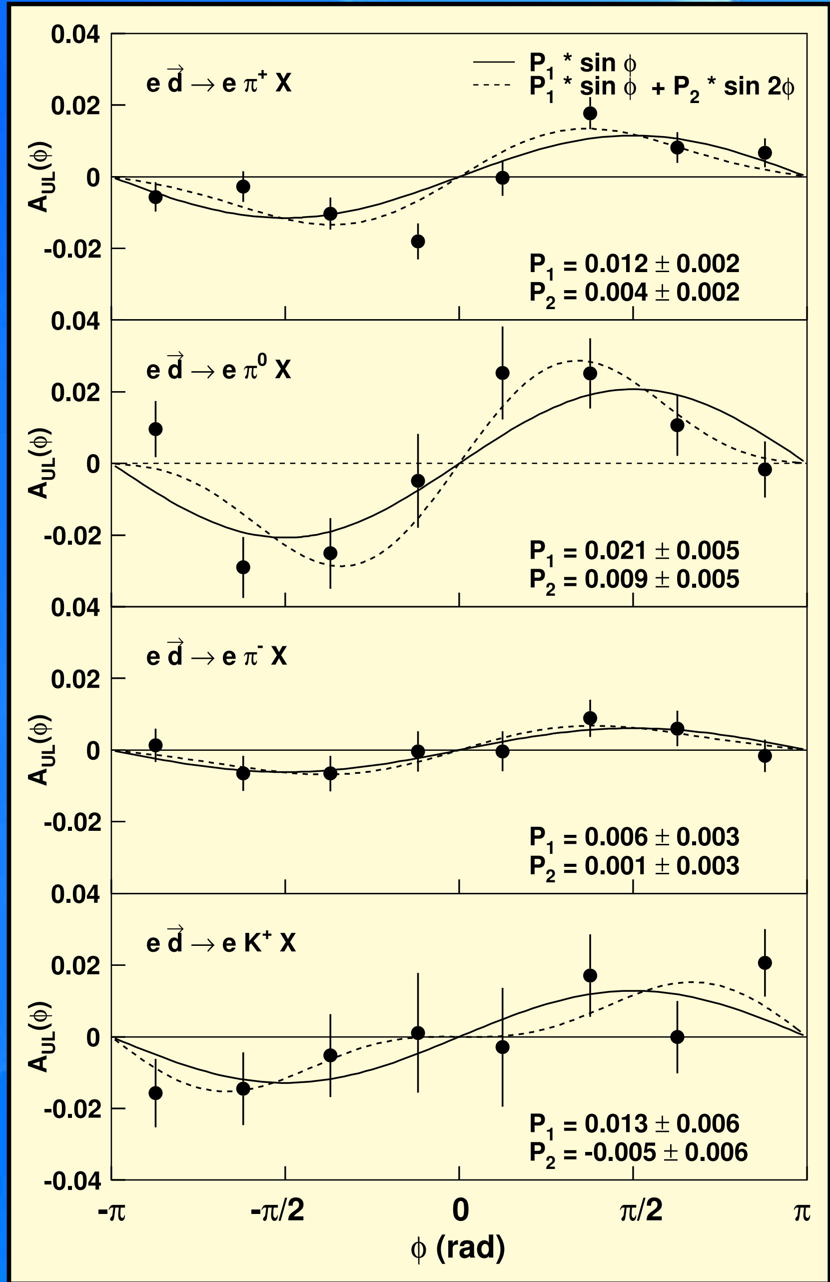
$$A_{UL}(\phi) = \frac{1}{\langle P \rangle} \cdot \frac{N^+(\phi) - N^-(\phi)}{N^+(\phi) + N^-(\phi)}$$

$$S_\perp \propto \sin\Theta_\gamma \simeq \frac{2Mx}{Q}\sqrt{1-y} \sim \mathbf{0.15}$$



longitudinal polarisiertes Wasserstofftarget

π^0: hep-ex/0104005, $\pi^\pm$: hep-ex/9910062



Interpretationsmöglichkeiten

Erklärungsmöglichkeiten der Asymmetrie am longitudinal polarisierten Target:

- **Collins Effekt (χQSM Efremov et al. Eur.Phys.J. C24 (2002) 407)**
- **Siversfunktion (Sivers, Mulders et al)** $\langle \sin\phi \rangle_{\mathbf{UL}} \sim \mathbf{f_{1T}^{\perp(1)} D_1}$

Longitudinal polarisiertes Target $\Rightarrow$ Sivers und Collins Effekt ununterscheidbar

Transversel polarisiertes Target

- $\langle \sin\phi \rangle_{UT}$ **wird dominant**
- **Sivers und Collins unterscheidbar**

$\swarrow$ $\searrow$

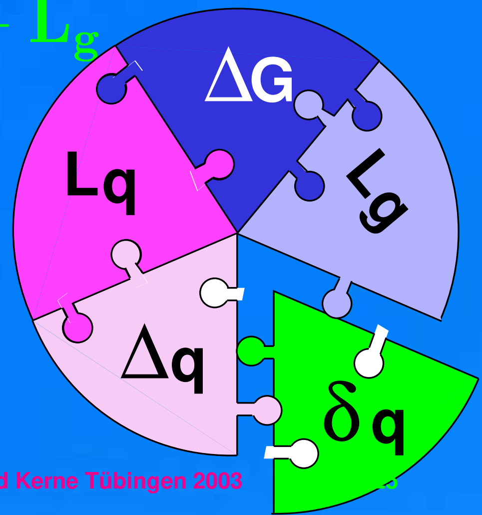
$\langle \sin(\phi_{\mathbf{h}}^{\mathbf{l}} - \phi_{\mathbf{s}}^{\mathbf{l}}) \rangle$ **Moment** $\langle \sin(\phi_{\mathbf{h}}^{\mathbf{l}} + \phi_{\mathbf{s}}^{\mathbf{l}}) \rangle$ **Moment**

für mehr Details über SSA: R.Seidl HK 24.3, U.Elschenbroich HK 24.5

Zusammenfaßung

- **Inklusiv**
  - **Sehr präzise Datenfür $g_1(x, Q^2)$ am Proton und Deuterium**
  - **Erste Messung von b1(x)**
- **Semiinklusiv**
  - **Gute Übereinstimmung von $\Delta u, \Delta d$ mit Resultaten von NLO-Fits an inklusive Daten**
  - **Mehr Information $\longrightarrow$ $\Delta s(\bar{s})$ und $\Delta \bar{u} - \Delta \bar{d}$**
- $L_q + L_g$
  - **Exklusive Reaktionen experimentell gesichert**

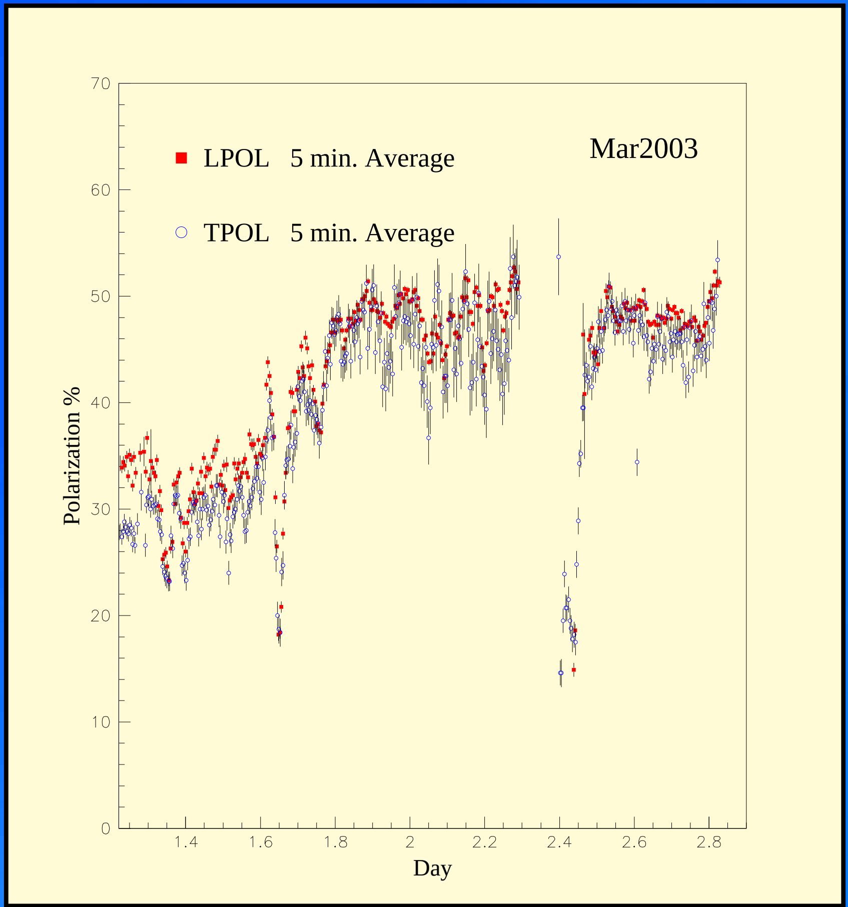
  $\longrightarrow$ **noch viel Arbeit bis zur Extraktion von $L_q + L_g$**
- **Transversity**
  - **Erste Resultate sind bald zu erwarten**



Aussichten

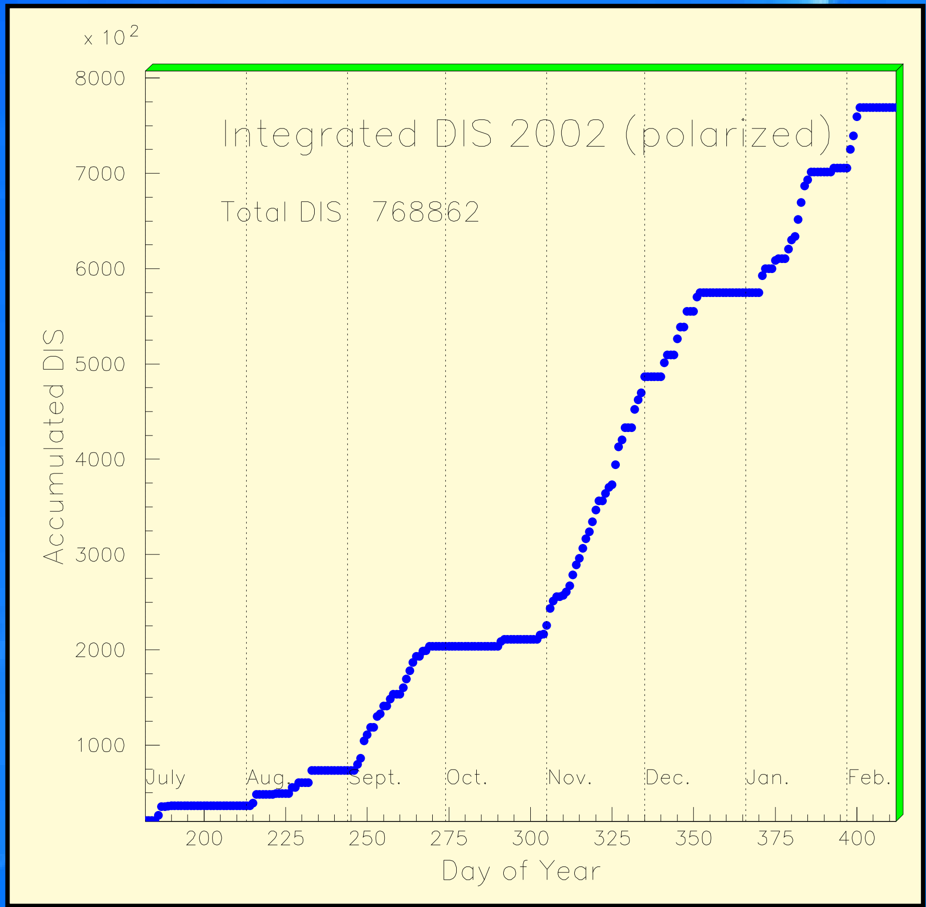
STRAHL

Erstmals longitudinale Polarisation gleichzeitig bei HERMES, H1 und ZEUS



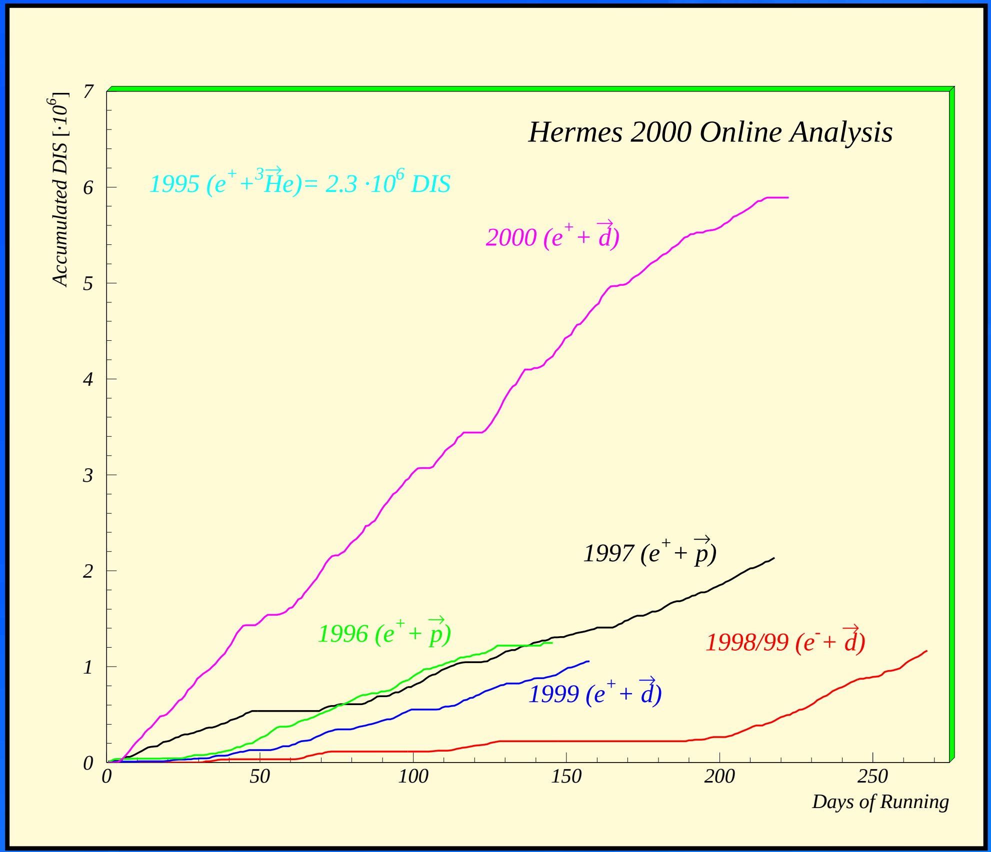
DATEN

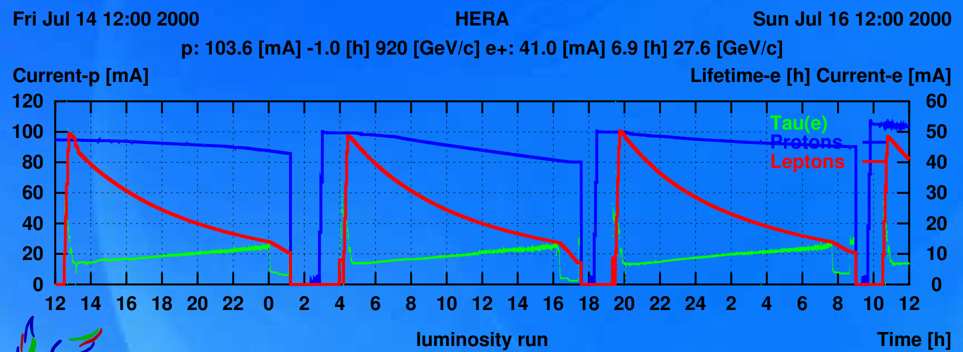
Gemessene transversale Daten 2002

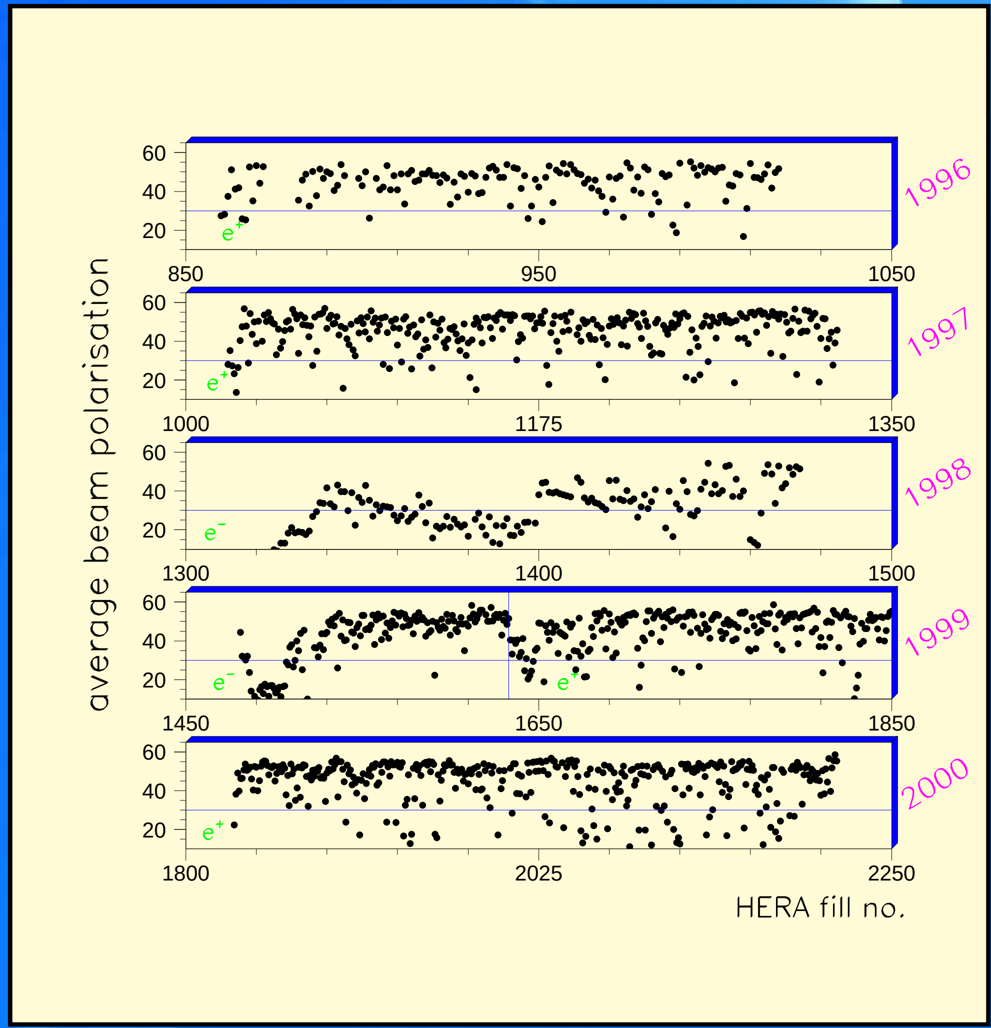


Gute Aussichten für 2003 ++

HERMES Run I







2000:

50% more polarized target density

Perfect performance of HERA

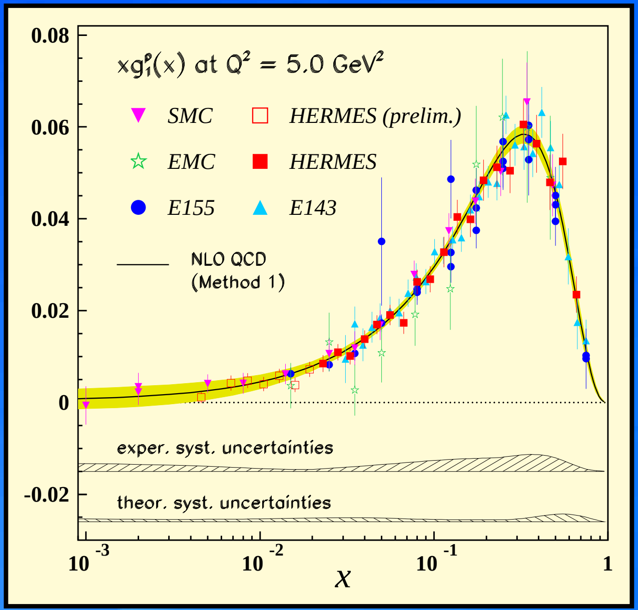
NLO pQCD Fits to $g_1(x,Q^2)$

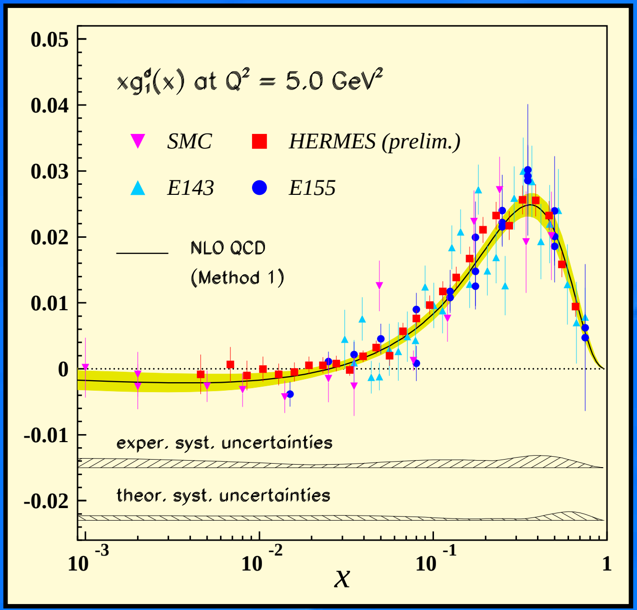
Describe $xg_1(x,Q^2)$ **with:**

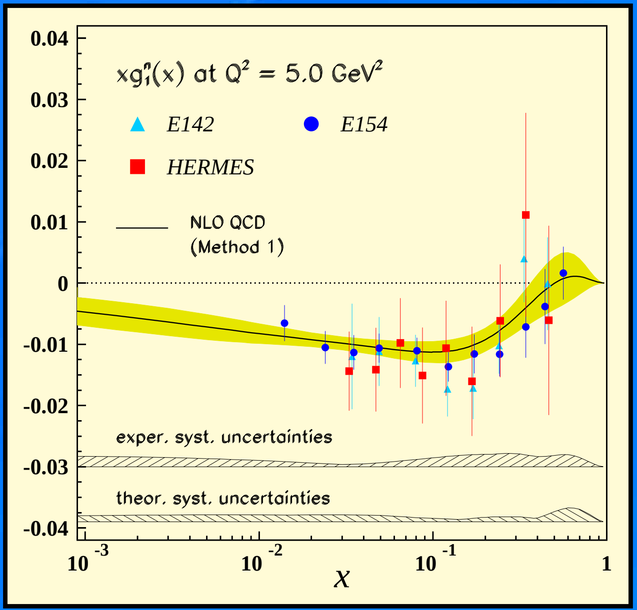
$$\mathbf{x\Delta q_i(x,Q_0^2)} = \eta_i \mathbf{A_i} \underbrace{x^{a_i}}_{\textbf{lox } x} \overbrace{(1+\gamma_i x+\rho_i x^{\frac{1}{2}})}^{\textbf{medium } x} \underbrace{(1-x)^{b_i}}_{\textbf{high } x}$$

Assumptions: SU(3) flavor symmetric polarized sea

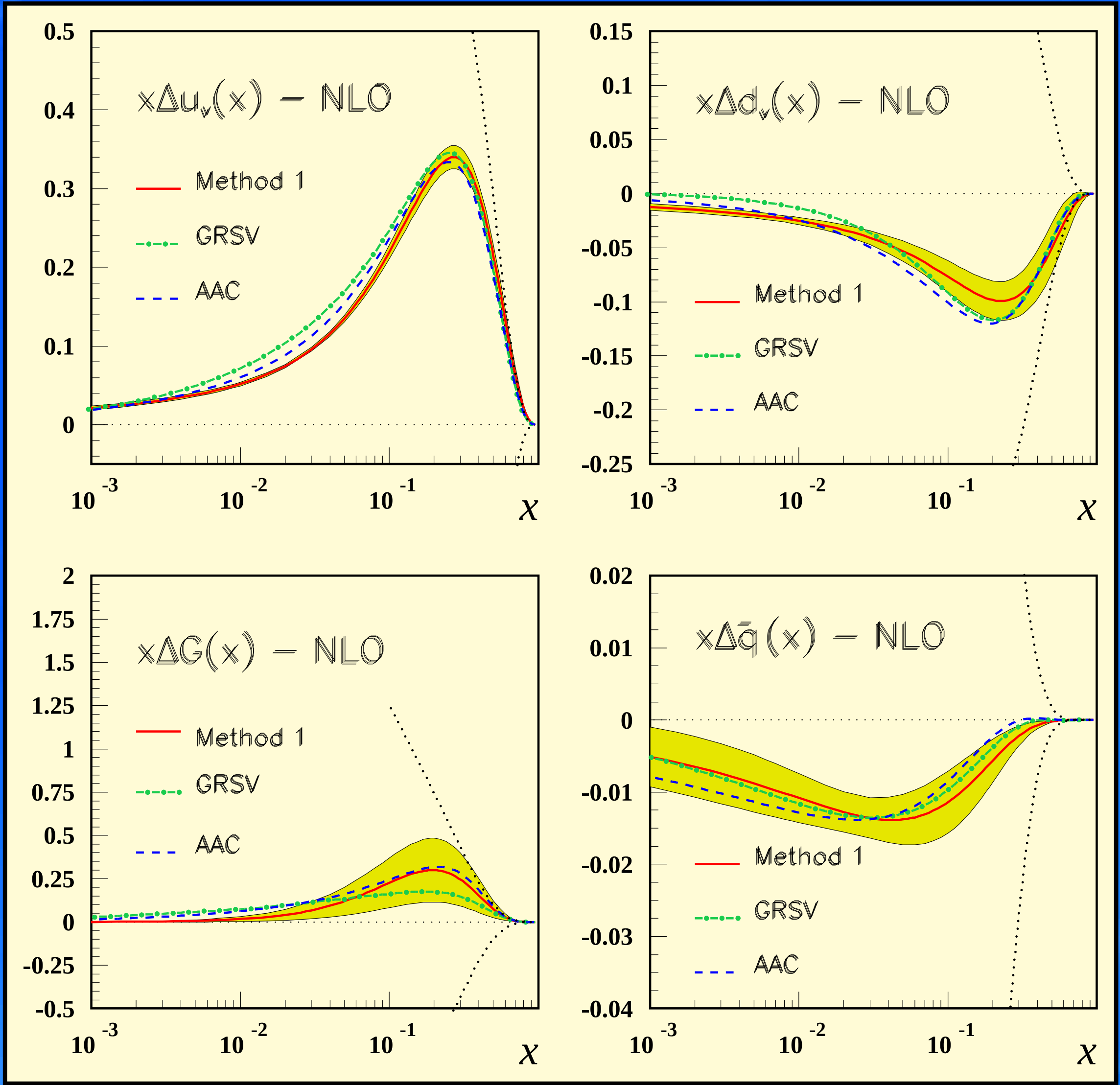
$$\Delta q_s = \Delta u_s = \Delta \bar{u} = \Delta d_s = \Delta \bar{d} = \Delta s = \Delta \bar{s}$$







NLO-QCD fit for different flavors



at Q^2 = 4 GeV^2

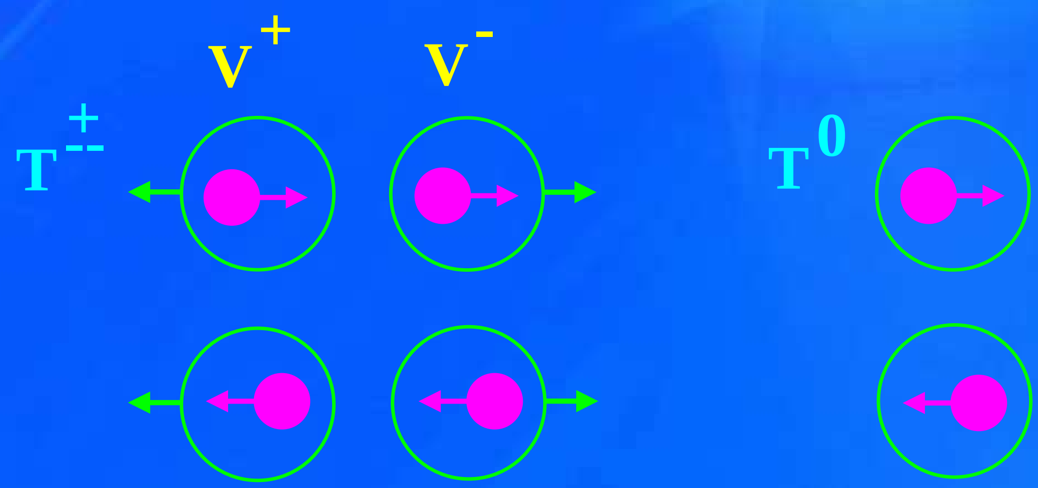
$\Delta s(\bar{q})$ = -0.070 $\pm$ 0.028 (stat.) < 0
BUT SU(3) flavor symmetry breaking for **unpolarized** sea

ΔG = 0.616 $\pm$ 0.388 (stat.) > 0
BUT Big error $\longrightarrow$ small Q^2 lever arm

GRSV: Glück et al. hep/ph 0011215
AAC: Goto et al. hep/ph 0001046

more direct access to ΔG and Δq_s desirable

Deuterium - Tensor Polarization

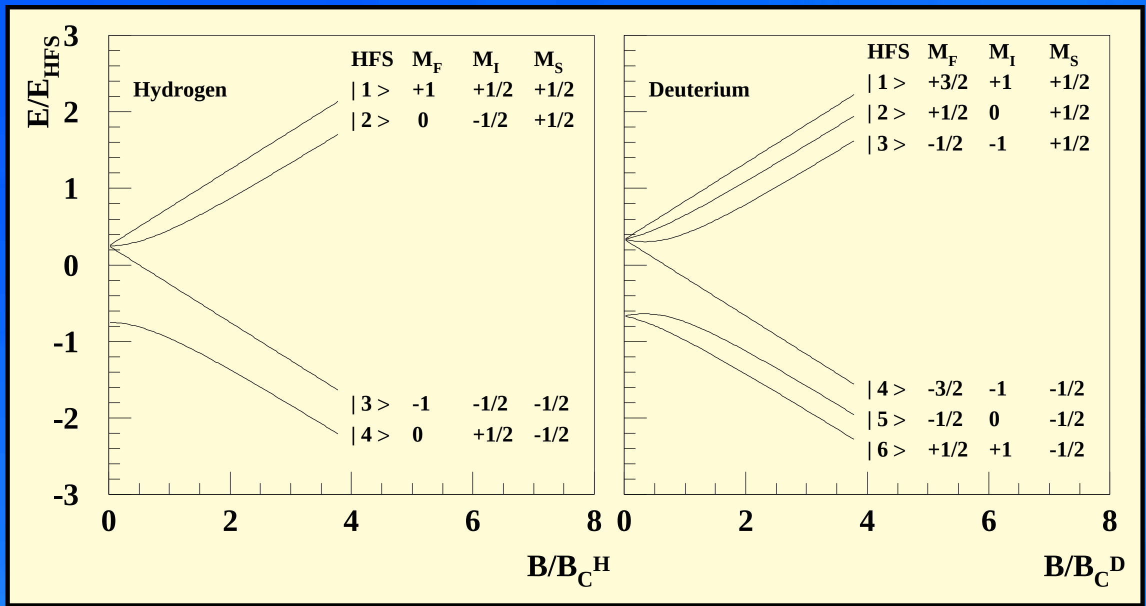


Tensor Polarization:

$$T = 1 - 3N^0$$

$$= \frac{N^+ + N^- - 2N^0}{N^+ + N^- + N^0}$$

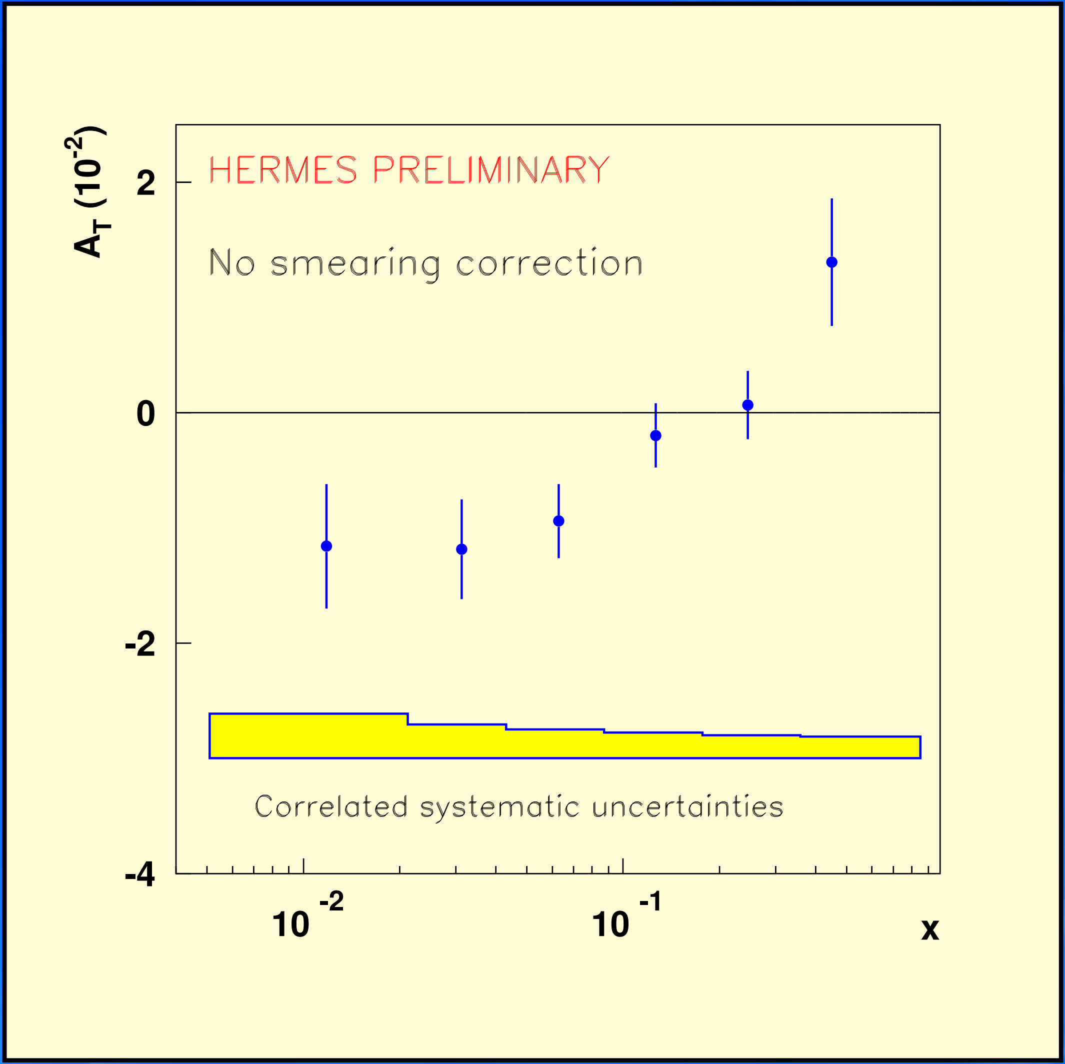
$$= \frac{N^{\pm} - 2N^0}{N^{\pm} + N^0}$$



State	Injected		V	T
Vector +	$\|1> + \|6>$	N^+	1	1
Vector -	$\|3> + \|4>$	N^-	-1	1
Tensor $\pm$	$\|3> + \|6>$	$N^{\pm}$	0	1
Tensor 0	$\|2> + \|5>$	N^0	0	-2

Only possible with a gas target

Tensor Asymmetry



b_1^d

enters in the symmetric part of $W^{\mu\nu}$

$\longrightarrow$ not sensitive to P_B

$$A_T = \frac{(\sigma^+ + \sigma^-) - 2\sigma^0}{\sigma^+ + \sigma^- + \sigma^0}$$

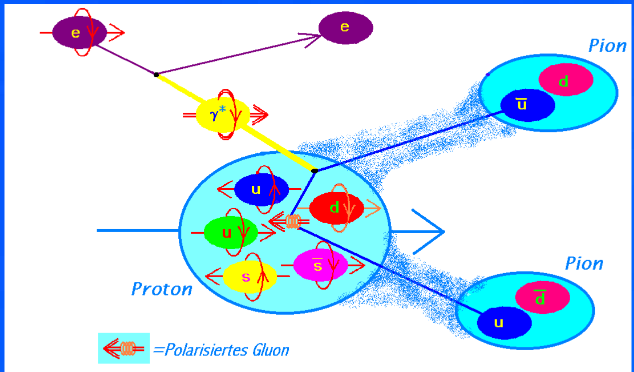
$$= \frac{1}{T} \cdot \frac{\frac{N^+}{L^+} + \frac{N^-}{L^-} - 2\frac{N^0}{L^0}}{\frac{N^+}{L^+} + \frac{N^-}{L^-} + \frac{N^0}{L^0}}$$

T: target polarization $< T >= 0.83 \pm 0.03$

$L^{+/-/0}$: dead-time corrected luminosities

Direct Measurements of ΔG

Isolate the photon-gluon fusion process (PGF)

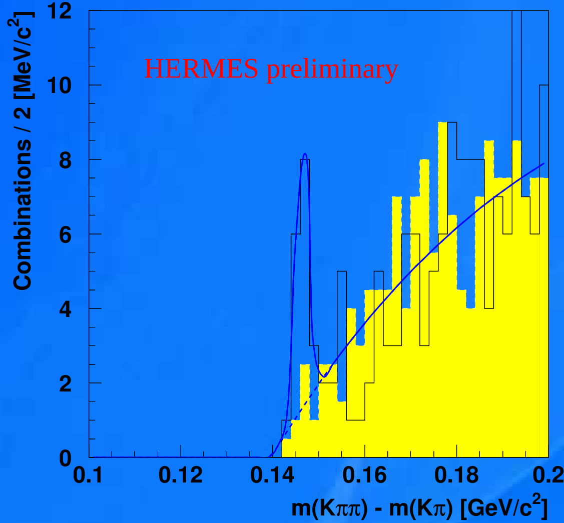


OPEN CHARM

reconstruct D^*, D^0

$$A_{||} = \frac{N_{c\bar{c}}^{\rightleftarrows} - N_{c\bar{c}}^{\rightrightarrows}}{N_{c\bar{c}}^{\rightleftarrows} + N_{c\bar{c}}^{\rightrightarrows}}$$

$$A^{\gamma p \rightarrow c\bar{c}} \sim \Delta G/G$$



$$D^* \rightarrow K + \pi + \pi_{slow}$$

HIGH-P_T

pairs of high-P_T hadrons

$$A_{||} = \frac{N_{h^\pm}^{\rightleftarrows} - N_{h^\pm}^{\rightrightarrows}}{N_{h^\pm}^{\rightleftarrows} + N_{h^\pm}^{\rightrightarrows}}$$

$$A^{\gamma p \rightarrow h^+ h^-} \sim \Delta G/G$$

additionally:

use identified hadrons

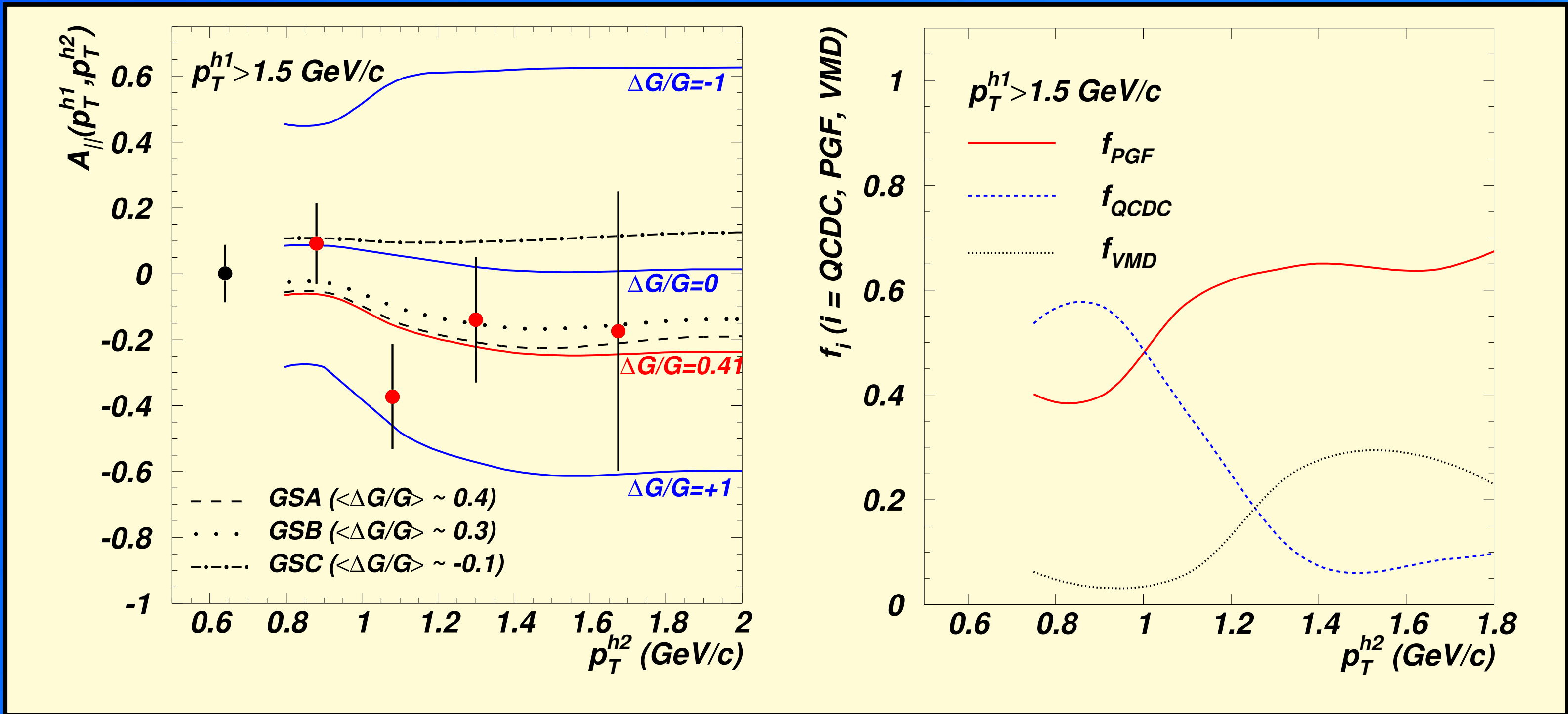
pairs of high-P_T Pions

pairs of high-P_T Kaons

Pairs of high-P_T Hadrons
within LO pQCD and PYTHIA5 MC model

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

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



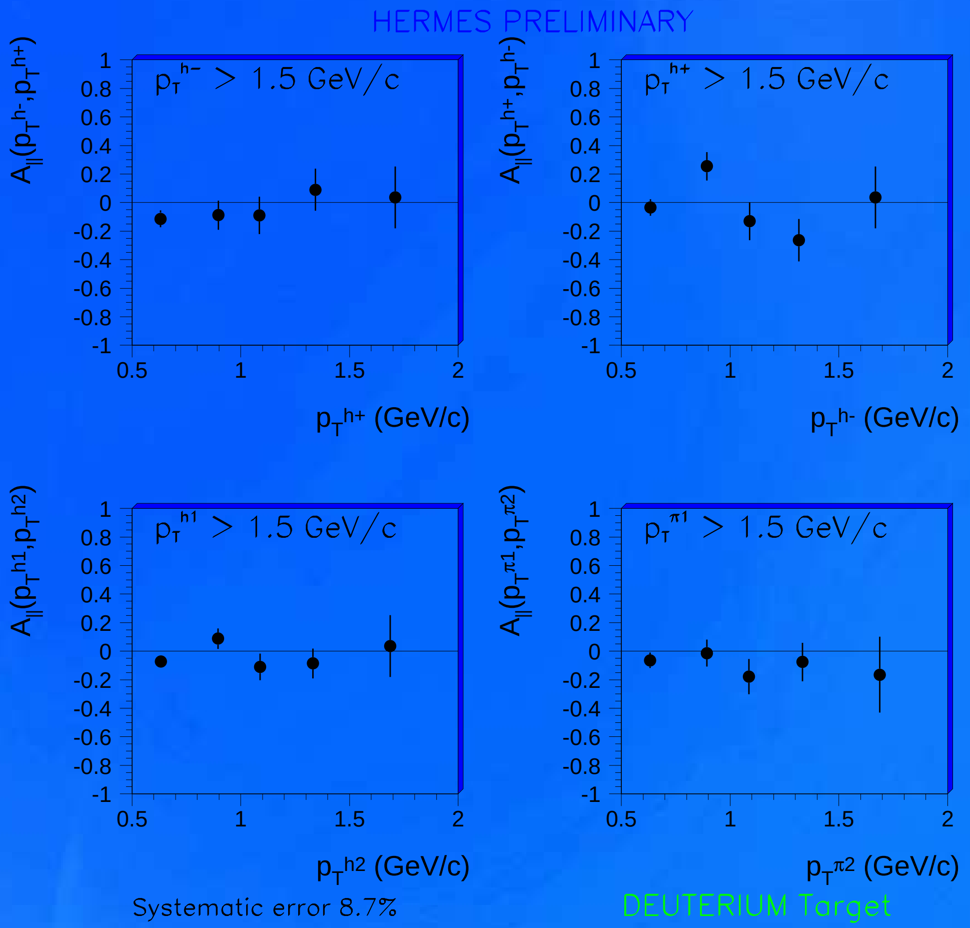
A. Airapetian et al, Phys. Rev. Lett. 84 (2000) 2584

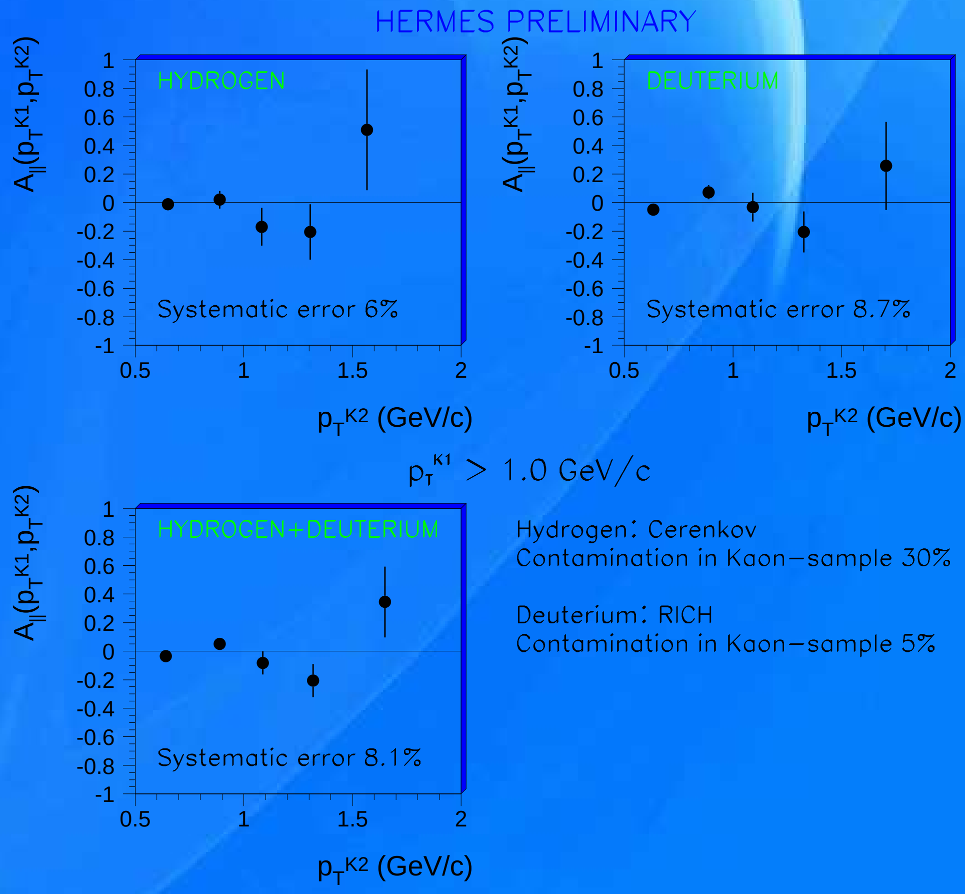
Target: Hydrogen

Extraction strongly Model dependent

Deuterium Results

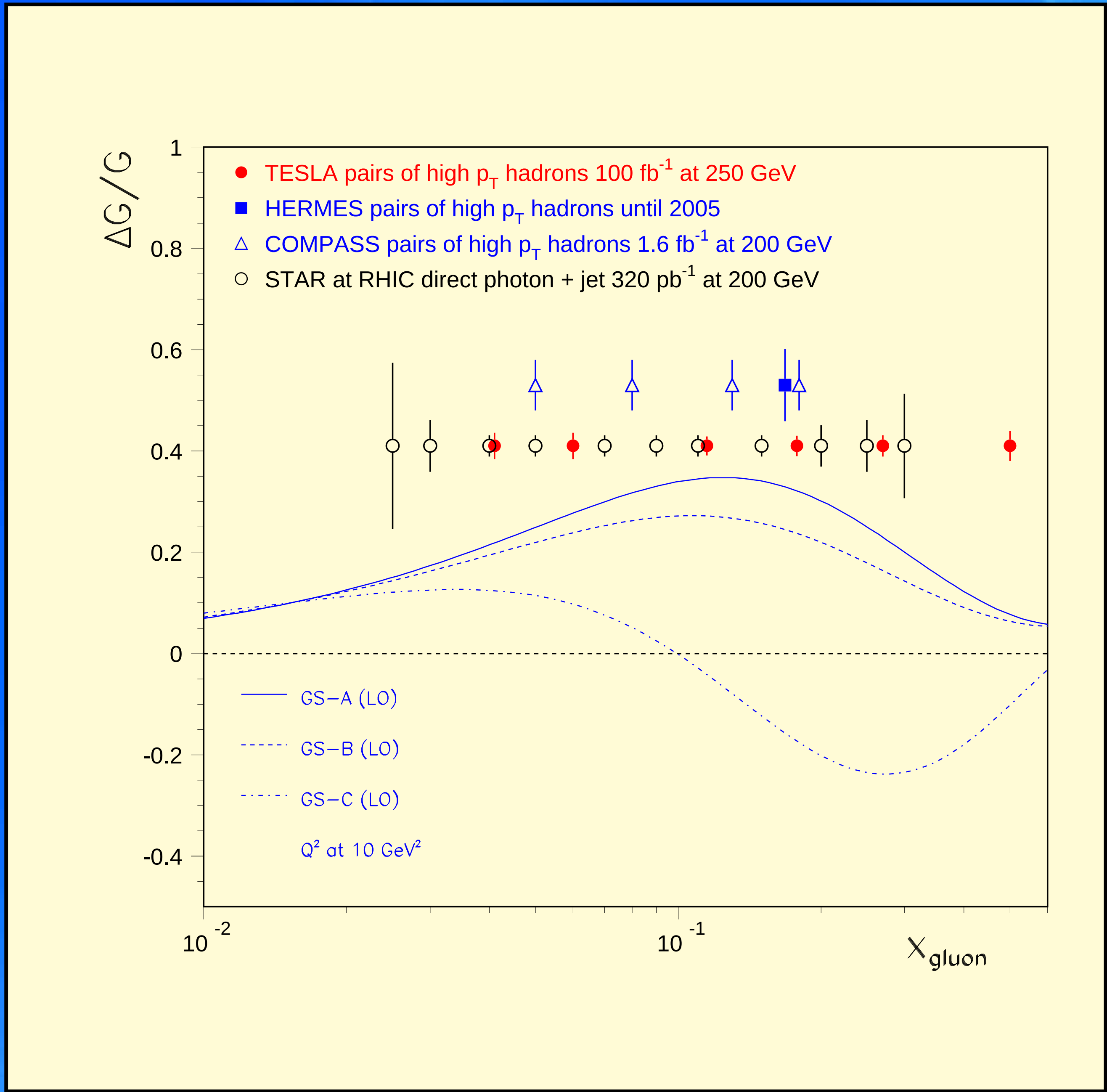
Statistics: $\sim$ 3 x hydrogen statistics



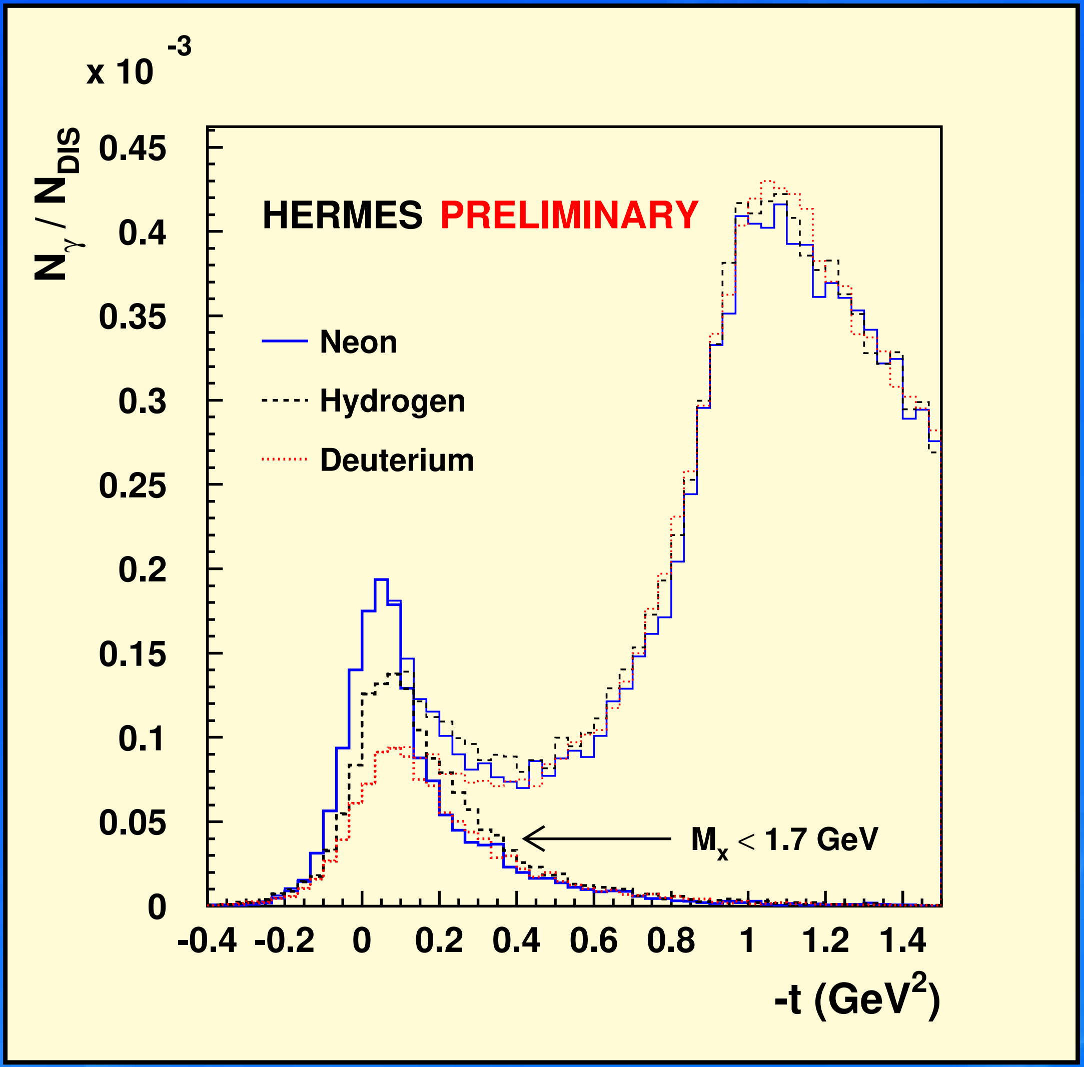


$\Delta G/G$ Extraction still under way

$\Delta G/G$ *in 2010*



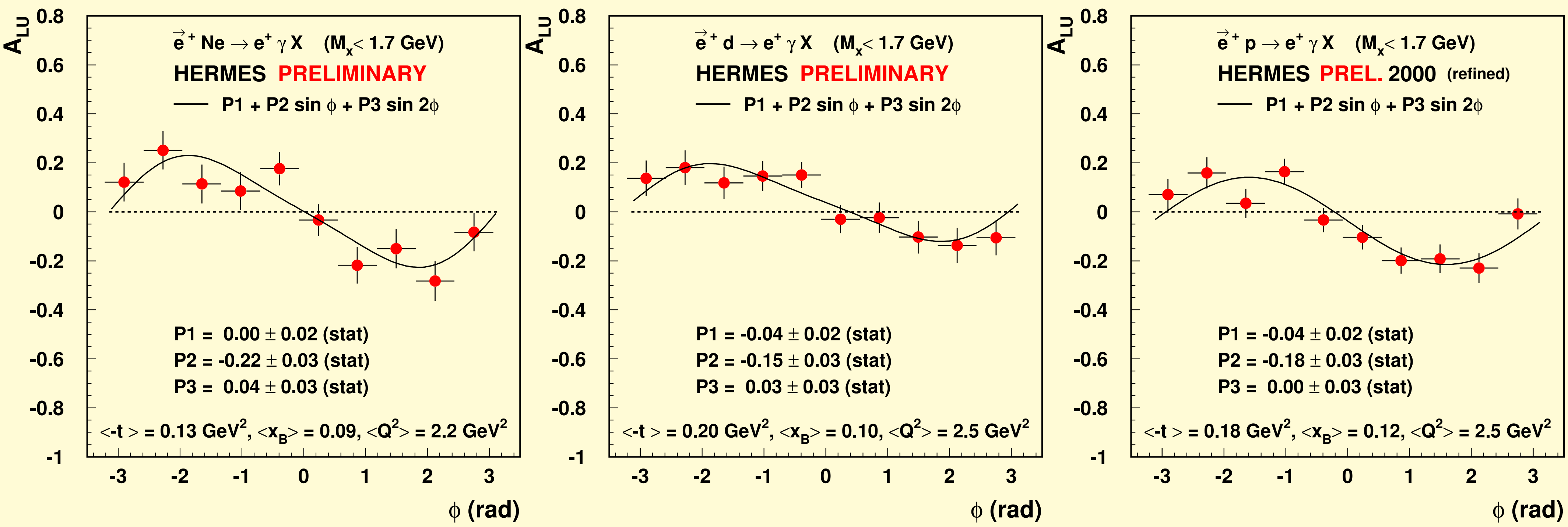
DVCS on Nuclear Targets



Proportional to :

- **Charge of the Nucleus**
- **Formfactor of the Nucleus**

DVCS SSA on Nuclear Targets



Predictions by A.V. Belitsky et al. (hep-ph/0112108):

Deuterium: $A_{LU} \sim -0.13 \cdot \sin(\Phi)$ **at** $Q^2 = 4GeV^2 x = 0.1, t = -0.3GeV^2$

Hydrogen: $A_{LU} \sim -0.16 \cdot \sin(\Phi)$

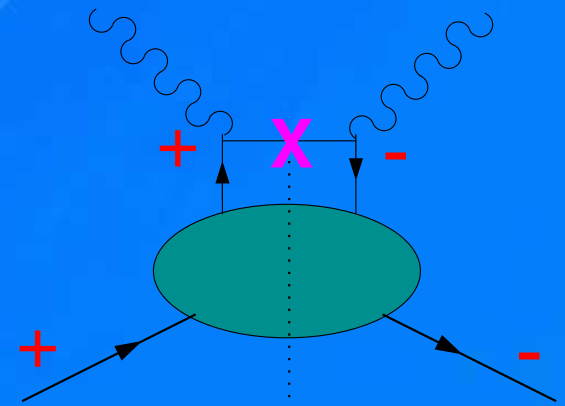
First Hint for coherent scattering on the nucleus.

Characteristics of Transversity

- **Non-relativistic quarks:** $\Delta q(x) = \delta q(x)$
  $\Rightarrow$ δq **probes relativistic nature of quarks**
- **Angular momentum conservation**
  $\Rightarrow$ **Transversity has no gluon component**
  $\Rightarrow$ **different** Q^2 **evolution than** $\Delta q(x)$
- q **and** $\bar{q}$ **contribute with opposite sign to** $\delta q(x)$
  $\Rightarrow$ **predominantly sensitive to valence quark polarization**
- **Bounds:**
  $\Rightarrow$ $|\delta q(x)| \leq q(x)$
  $\Rightarrow$ **Soffer bound:** $|\delta q(x)| \leq \frac{1}{2}[q(x) + \Delta q(x)]$

- **Transversity distribution CHIRAL ODD**

$\Rightarrow$ **No Access in Inclusive DIS**
$\Rightarrow$ **Need another chiral-odd object!**
δ**q(x) accessible in semi-inclusive DIS**



Attempt of Interpretation

- **observe non-vanishing $\langle \sin\phi \rangle$-moments**
- **$\langle \sin 2\phi \rangle$-moment small (consistent with zero)**

Attribute asymmetry to Collins fragmentation and Transversity:

$$A^{\sin\phi}_{U L L} \sim S_L \langle \sin\phi \rangle_{U L L} - S_T \langle \sin\phi \rangle_{U T T}$$

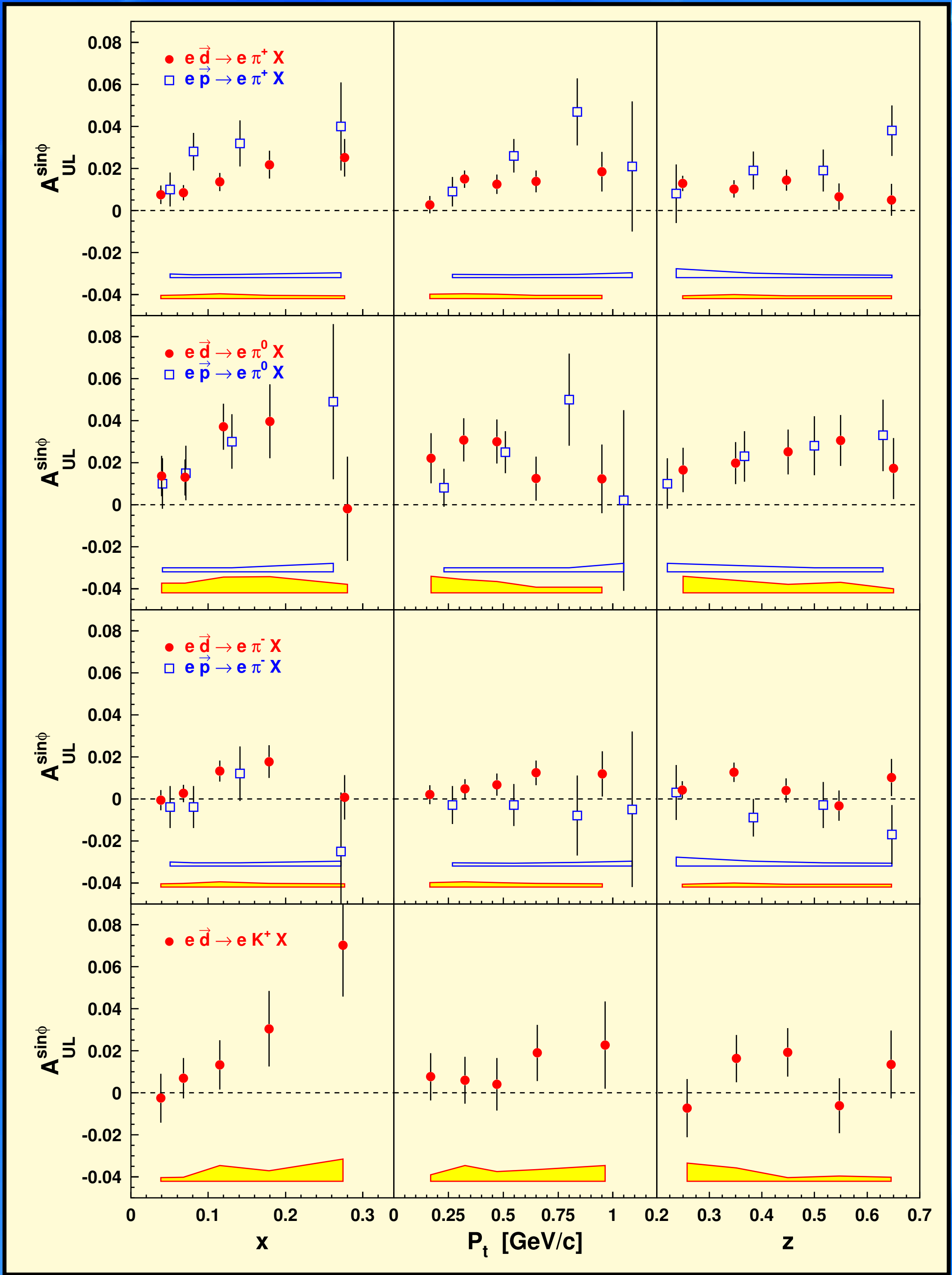
***L*ongitudinally polarized in experiment (along beam direction)**

L/T polarized in theory (along virtual gamma direction

$$\langle \sin\phi \rangle_{UL} \sim \frac{1}{Q} \sum_q e_q^2 (h_L^q(x) H_1^{\perp(1),q}(z) - \frac{1}{z} h_{1L}^{\perp(1),q}(x) \tilde{H}(z))$$

$\langle \sin\phi \rangle_{UT} \sim \sum_q e_q^2 x h_1^q(x) H_1^{\perp(1),q}(z)$ **but $S_T \sim \frac{1}{Q}$ like twist-3**

$$\langle \sin 2\phi \rangle_{UL} \sim \sum_q e_q^2 x h_{1L}^{\perp(1),q}(x) H_1^{\perp(1),q}(z)$$



hep-ex/0212039

$\sin\phi$ *Moments*

Original predictions by Collins:

- **Proton Target**
  Larger for π^+, π^0 than for π^-
  (u-quark dominance)
- **Raise with x$_{bj}$**
  (valence quark dominance)
- **Grow with $p_\perp$, peak around 1 GeV**
  ($\frac{H_1^\perp}{D_1} \propto \frac{M_c M_h}{M_c^2 + p_\perp^2}$ with $M_c \simeq$1 GeV)
- **First SSA for Kaons**