News from hermes

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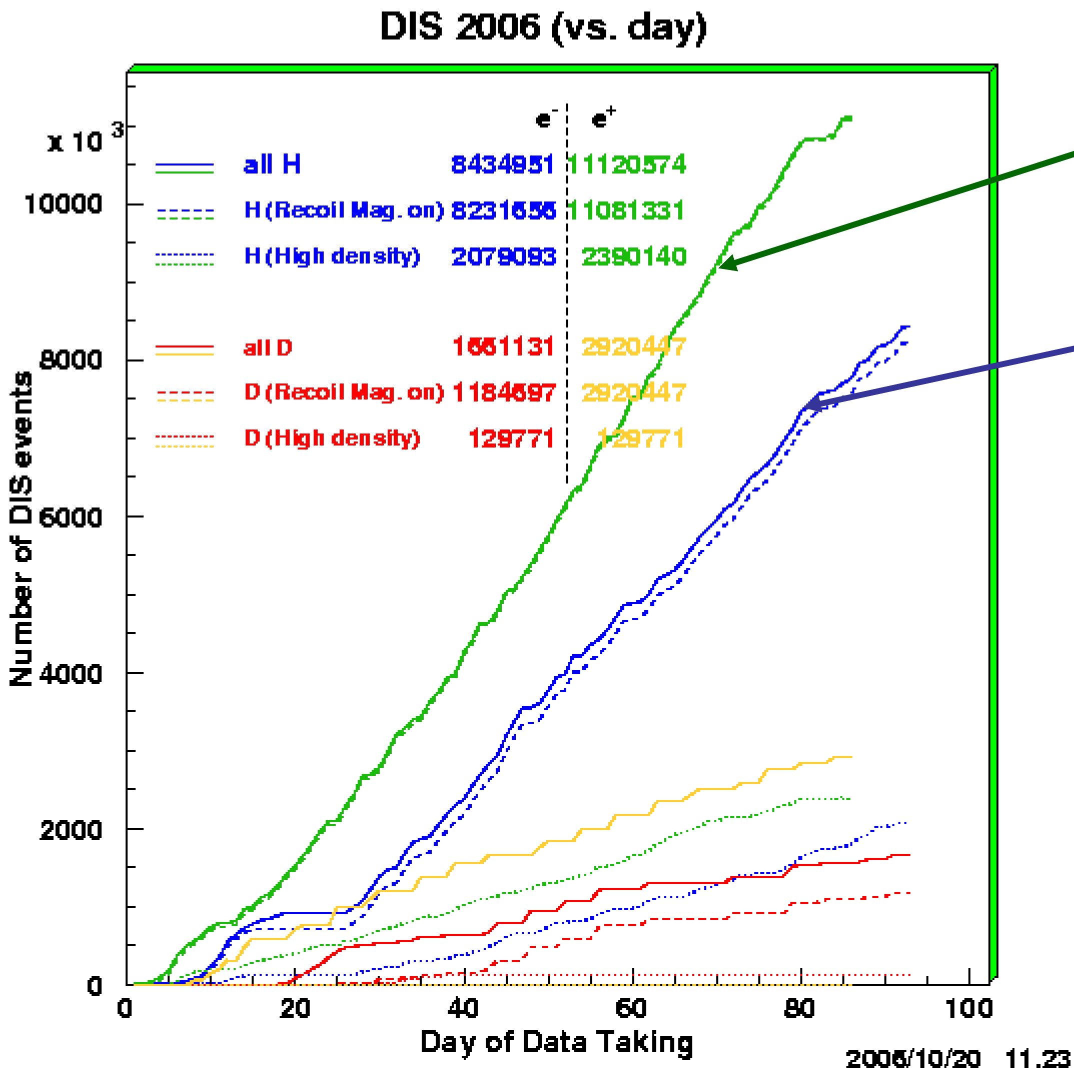
INFN Frascati

62th Physics Research Committee, DESY-Zeuthen Oct 23/24 2006

data taking 2006

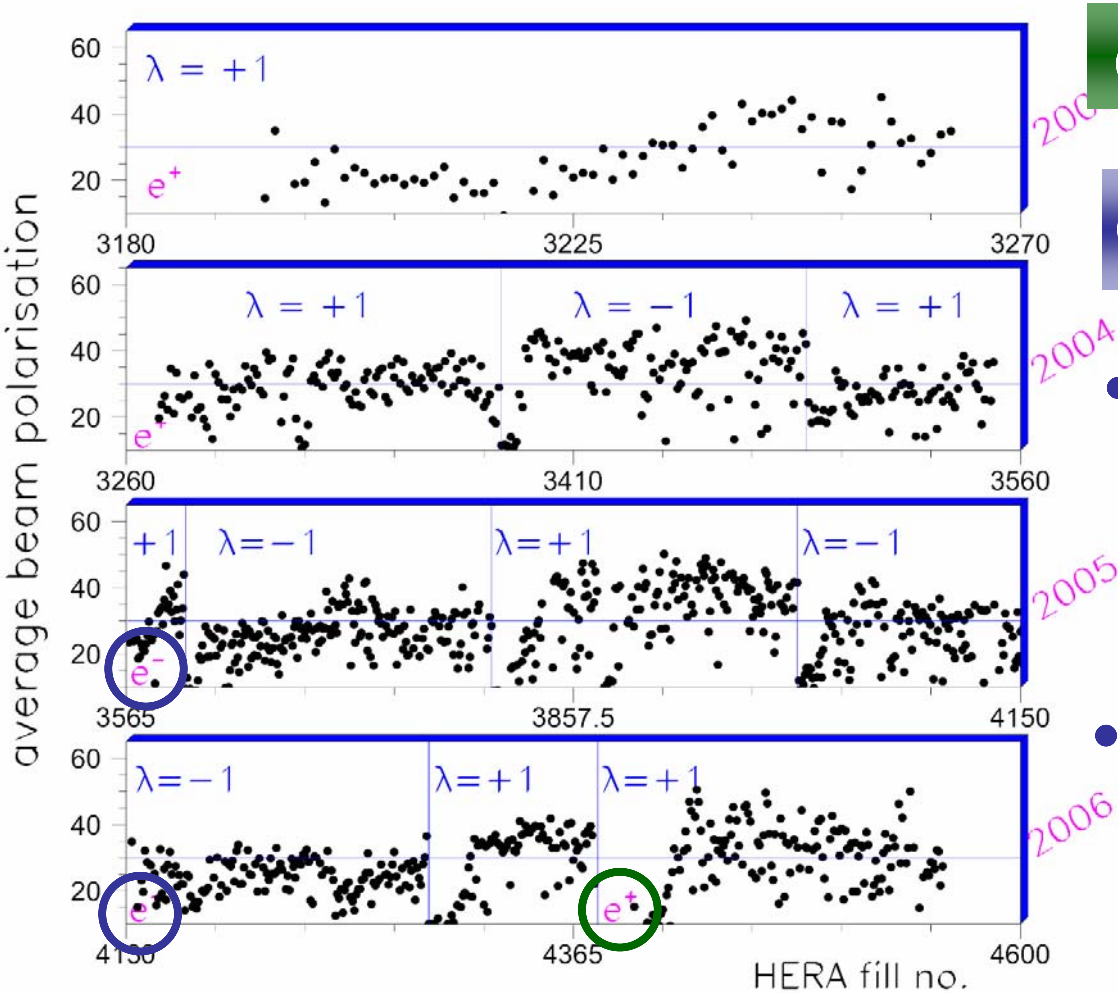


e+ data

e− data

- data taking:
  efficiency >98%
  → spectrometer in excellent shape

data taking 2006



e+ data

e− data

- data taking:
  efficiency >98%
  → spectrometer in excellent shape
- polarisation:
  $P_B^{\lambda=+1} \sim 0.3\text{-}0.4$ ←
  $P_B^{\lambda=-1} \sim 0.2\text{-}0.3$ ←

status of detectors

→ spectrometer in excellent shape

→ target cell + recoil silicon: all problems fixed !

- new target cell installed:
  - → thicker cell walls
  - → improved cooling
- silicon detector:
  - → modules repaired
  - → RF shielding installed

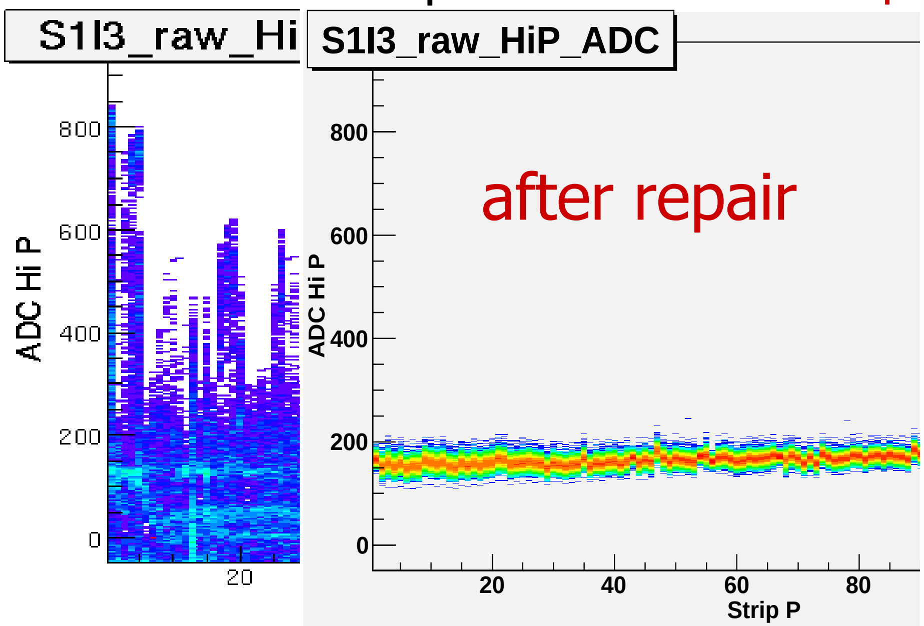
… more details @closed session

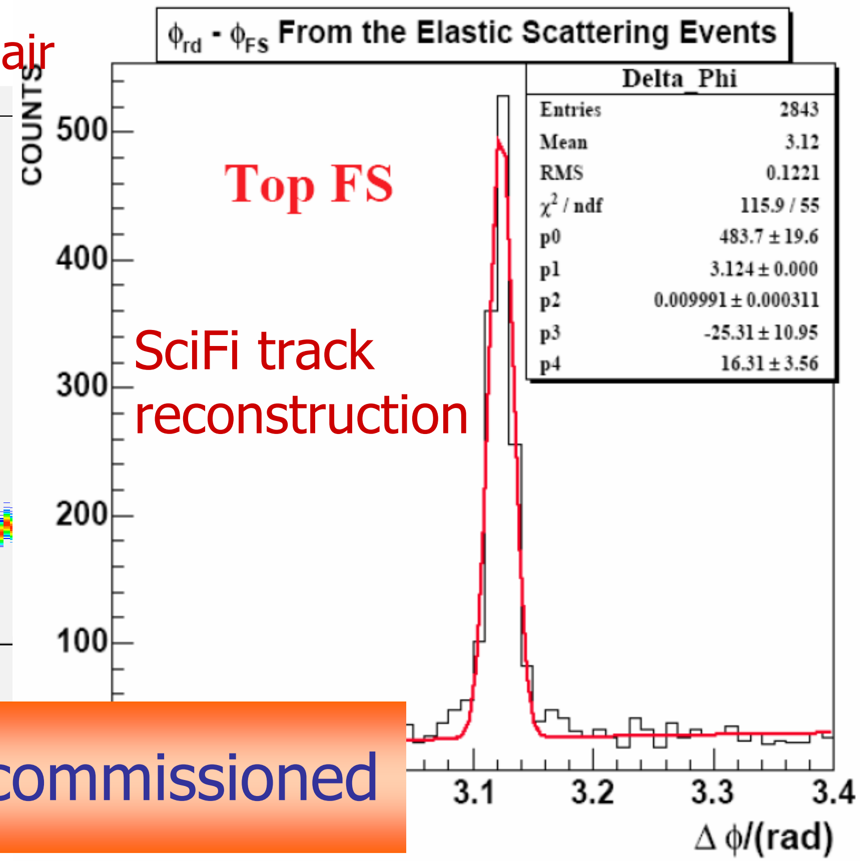
status of detectors

- → spectrometer in excellent shape
- → target cell + recoil silicon: all problems fixed !
- → since July taking data with all recoil components:

silicon ADC spectra

before repair





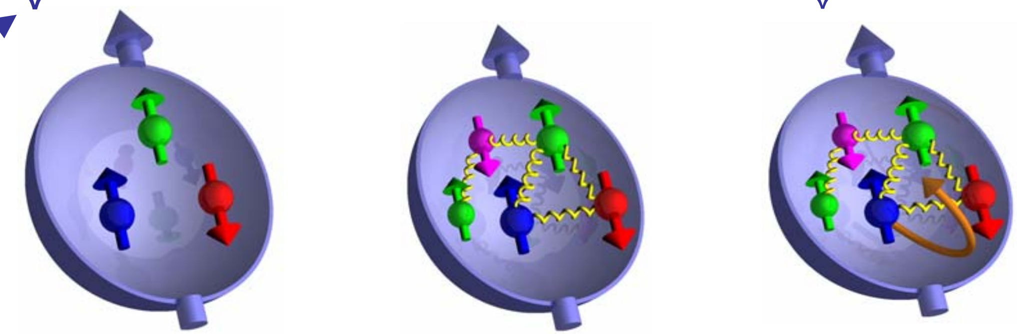
since September: recoil fully commissioned

HERMES @SPIN^{2006}

SPIN 2006 — The 17th International Spin Physics Symposium — Kyoto Japan Oct. 2-7 '06

$$S_z^N = \frac{1}{2} = \frac{1}{2}(\Delta u_v + \Delta d_v + \Delta q_s) + \Delta G + \Delta L_z^q + \Delta L_z^g$$

$\Delta\Sigma$



- → • final results on g_1 for the proton and deuteron
  • flavour decomposition of Δq →talks by L.DeNardo, H.Jackson
- → • new result on ΔG →talk by P. Liebing
- → • news on transversity & friends →talks by M.Diefenthaler, M.Contalbrigo
- → • hunting ΔL: DVCS, excl. ρ^0 →talks by W.D.Nowak, H.Guler, E. Kinney

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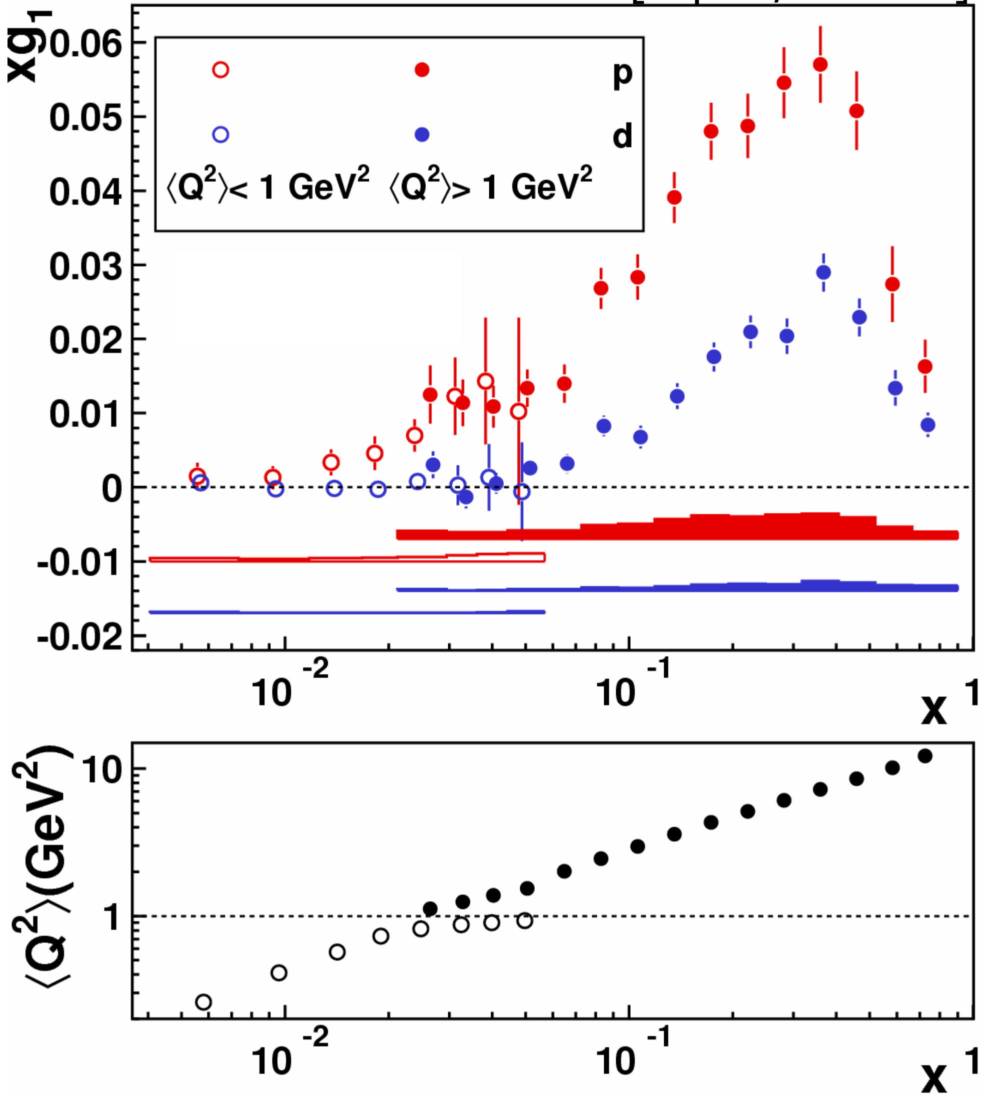
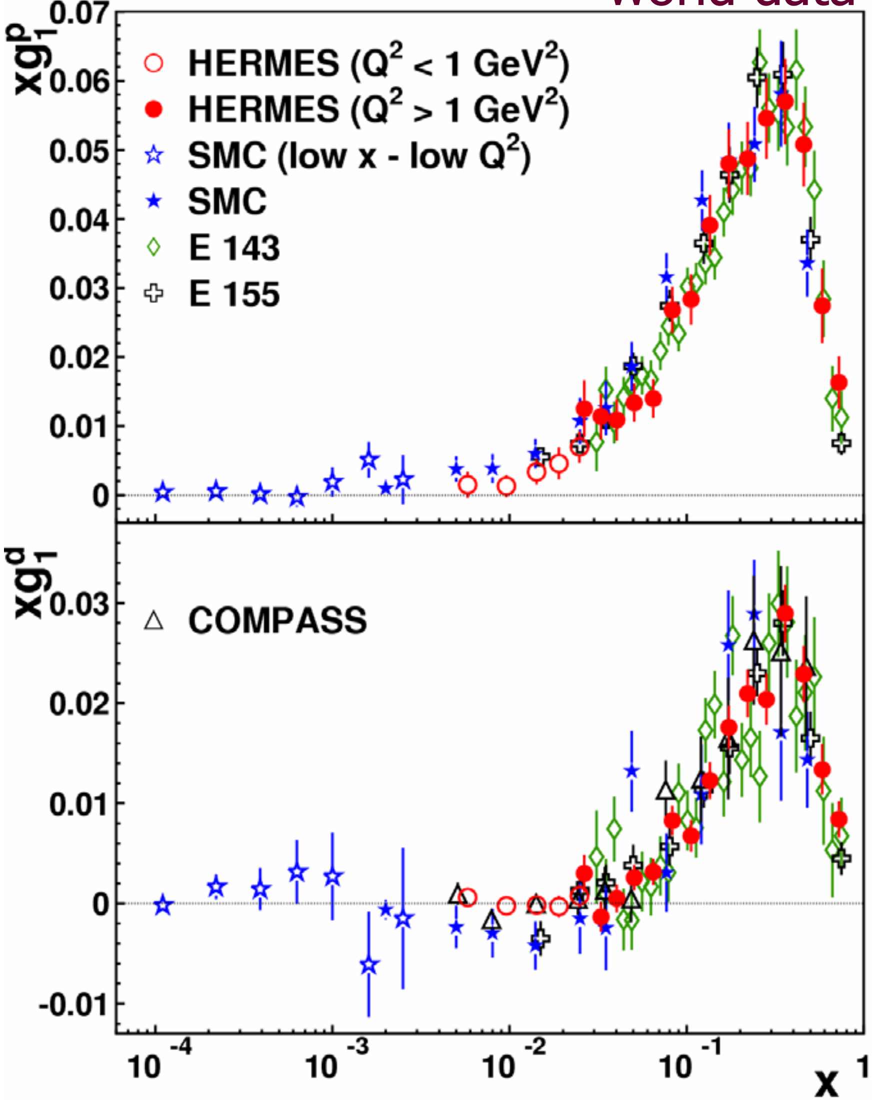
final HERMES result on g_1

[hep-ex/0609039]

world data





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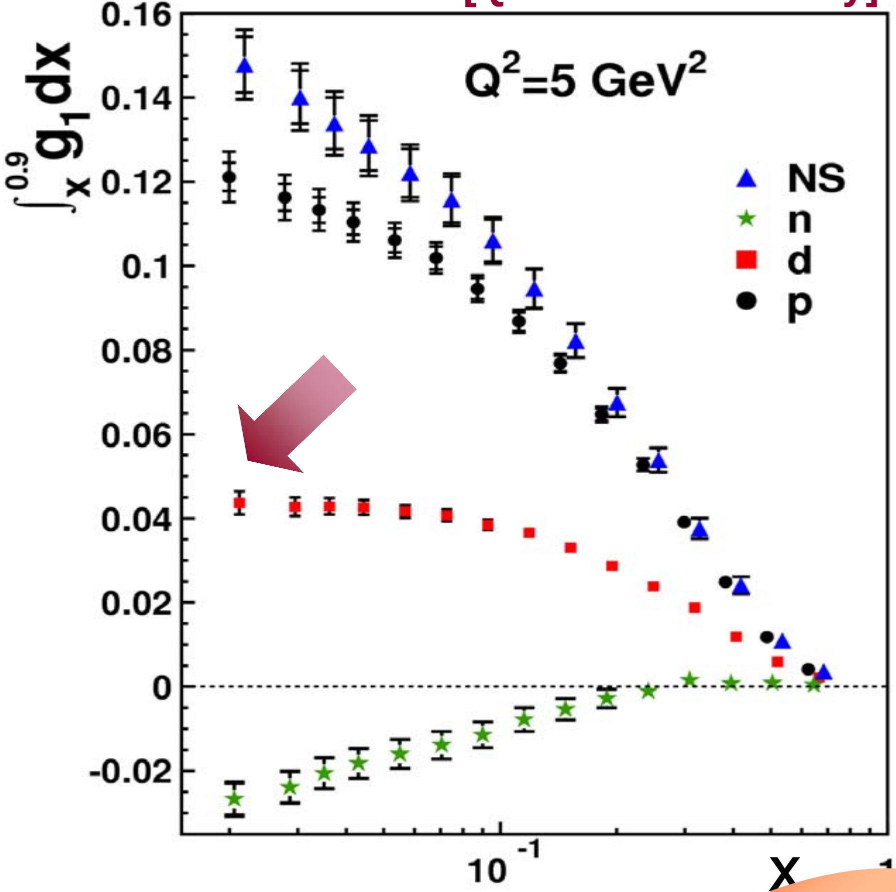
the integral of g_1

[$Q^2>1$ GeV^2 data only]



spin crises

→assume *saturation* of Γ_1^d :

$a_0^{\overline{MS}} = \Delta\Sigma$ (theory) (exp) (evol)

$= 0.330 \pm 0.011 \pm 0.025 \pm 0.028$

COMPASS: **[hep-ex/0609038]**

$a_0^{\overline{MS}} = \Delta\Sigma$

$= 0.35 \pm 0.03^{(stat)} \pm 0.05^{(sys+evol)}$

...EMC (1988) : $\Delta\Sigma = 0.12 \pm 0.17$

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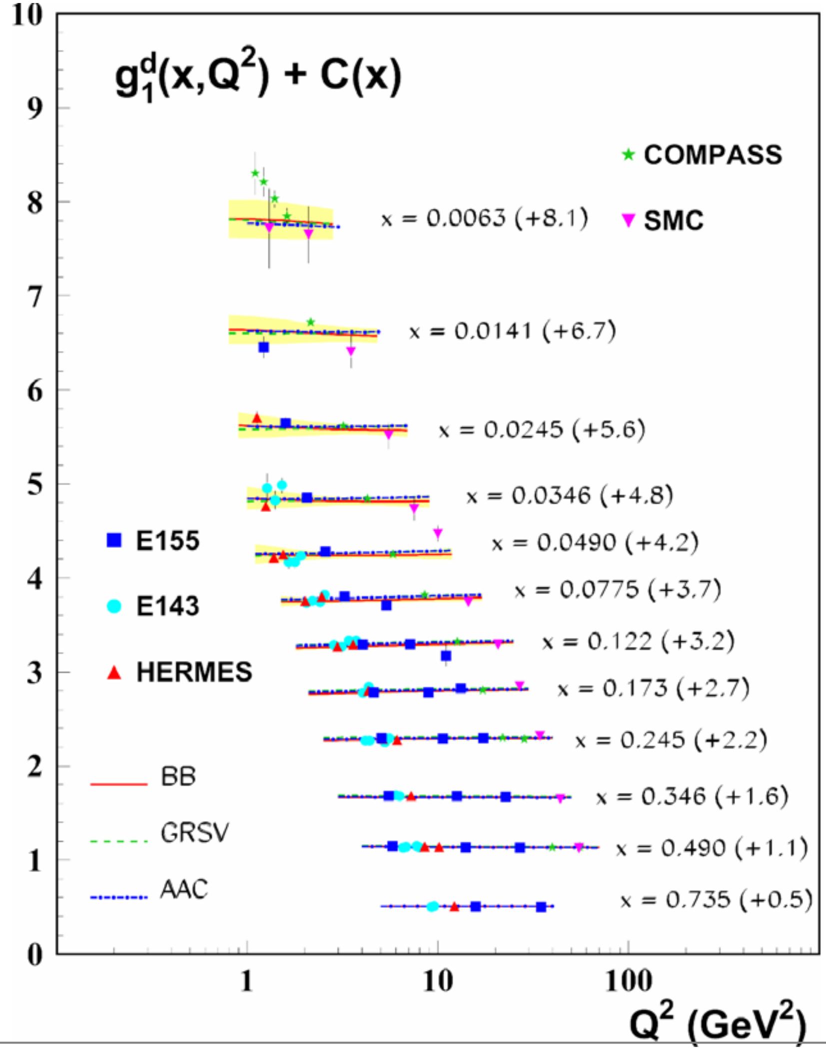
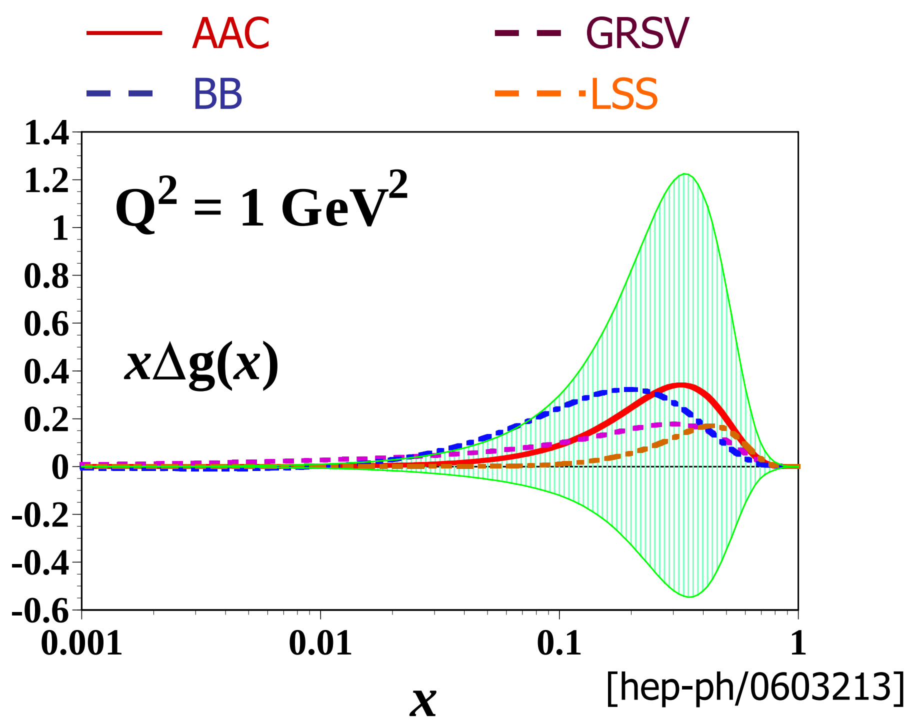
news on ΔG

$$g_1^{NLO}(x,Q^2) = g_1^{LO} + \frac{1}{2}\langle e^2\rangle \sum_q e_q^2 [\Delta q(x,Q^2) \otimes C_q + \Delta g(x,Q^2) \otimes C_g]$$





→need *more direct* probes

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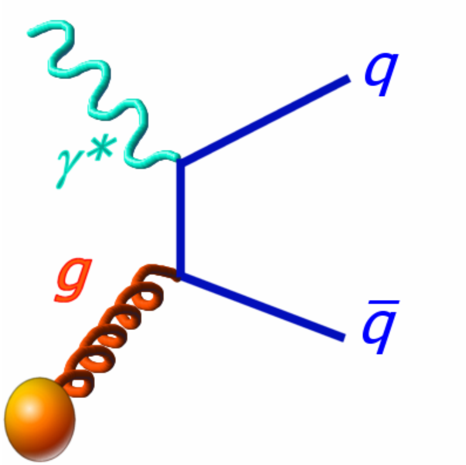
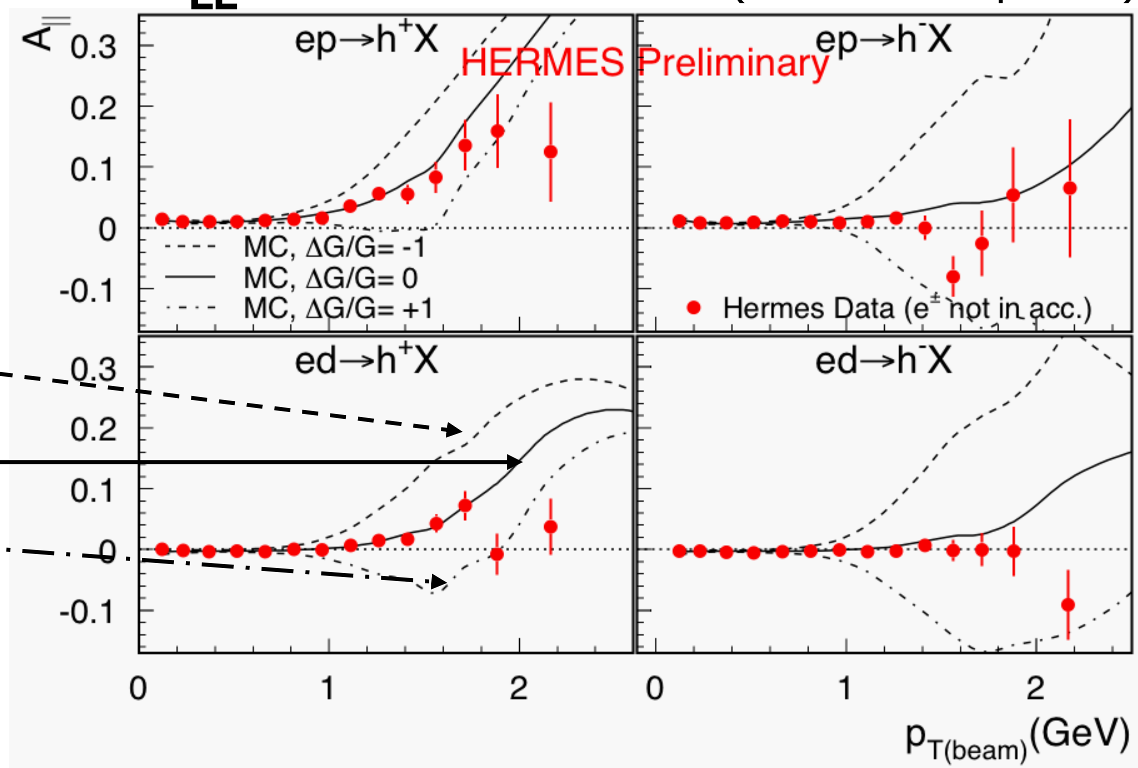
direct measurement of ΔG



- **golden channel: charm production**
- @HERMES: hadron production at high P_T

A_{LL} eN → hX (e′ not in acceptance)



PythiaMC:

$\Delta g/g = -1$

$\Delta g/g = 0$

$\Delta g/g = +1$

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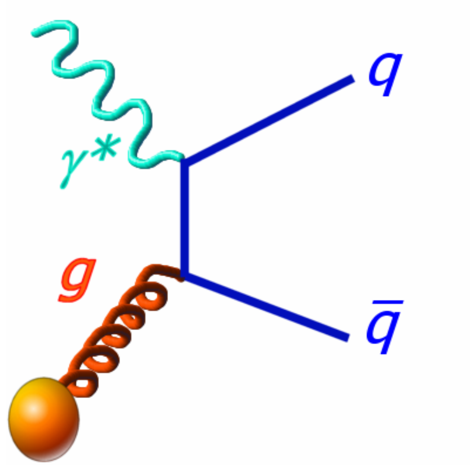
direct measurement of ΔG



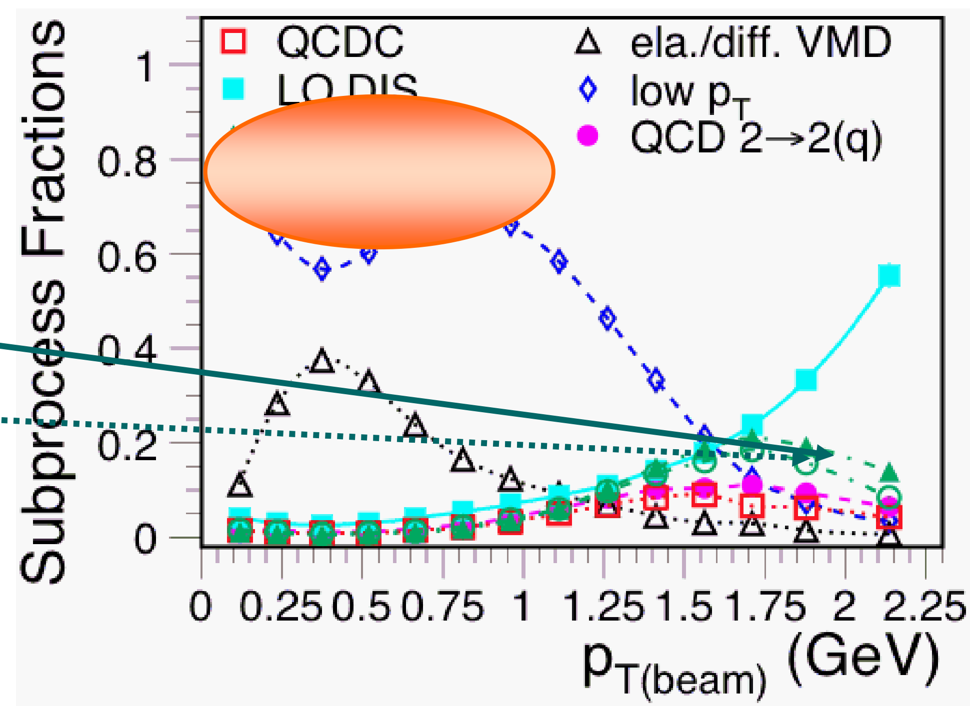
- **golden channel: charm production**
- @HERMES: hadron production at high P_T

$ed \to h^{\pm}X$: direct, resolved, soft processes

signal processes:

PGF

QCD 2→2(g)



$$A_{\parallel} = r^{bg} A_{\parallel}^{bg} + r^{sig} A_{\parallel}^{sig}$$

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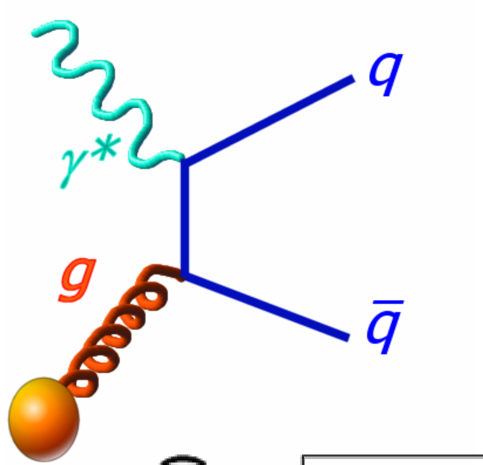
direct measurement of ΔG



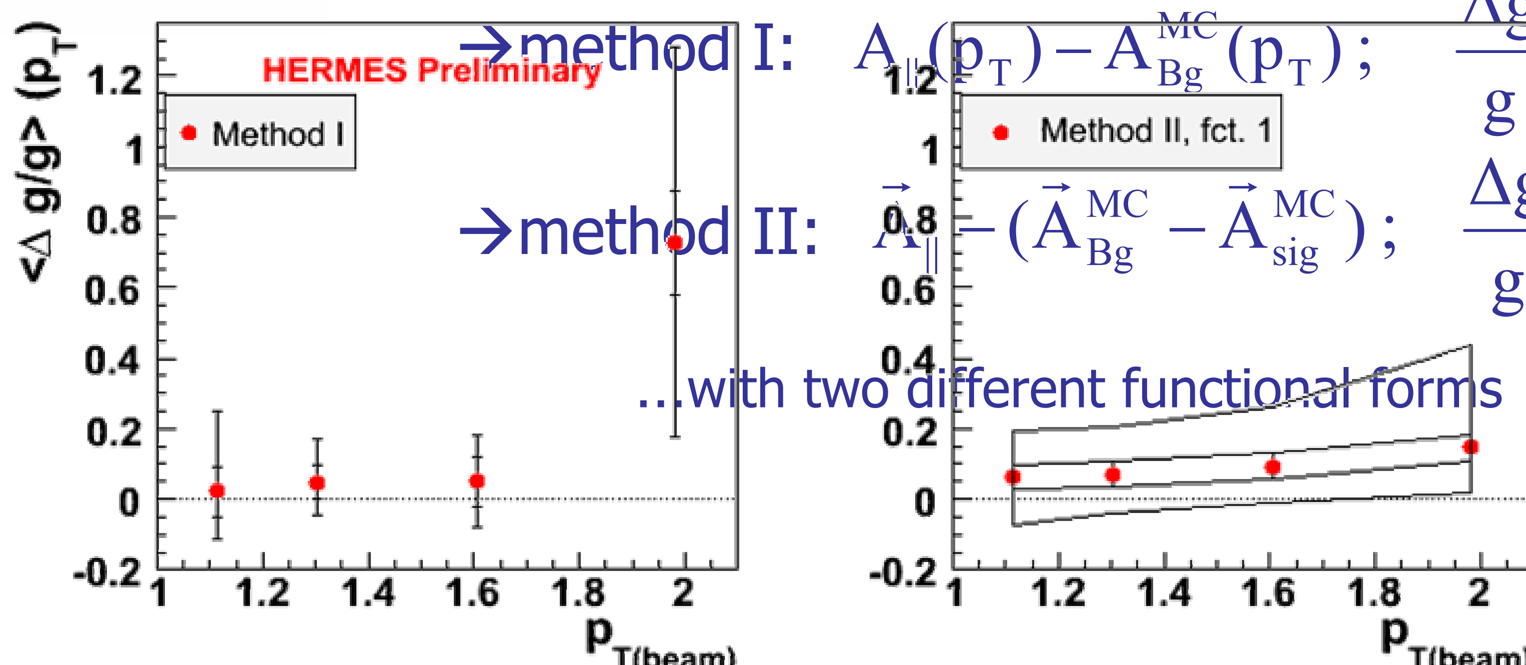
- **golden channel: charm production**
- @HERMES: hadron production at high P_T

$$ed \rightarrow h^{\pm}X$$

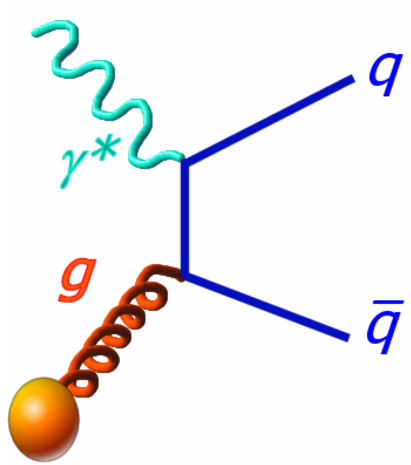
→method I: $A_{\|}(p_T) - A_{Bg}^{MC}(p_T)$; $\dfrac{\Delta g}{g}^{(fac.)}$

→method II: $\vec{A}_{\|} - (\vec{A}_{Bg}^{MC} - \vec{A}_{sig}^{MC})$; $\dfrac{\Delta g}{g}(x)$

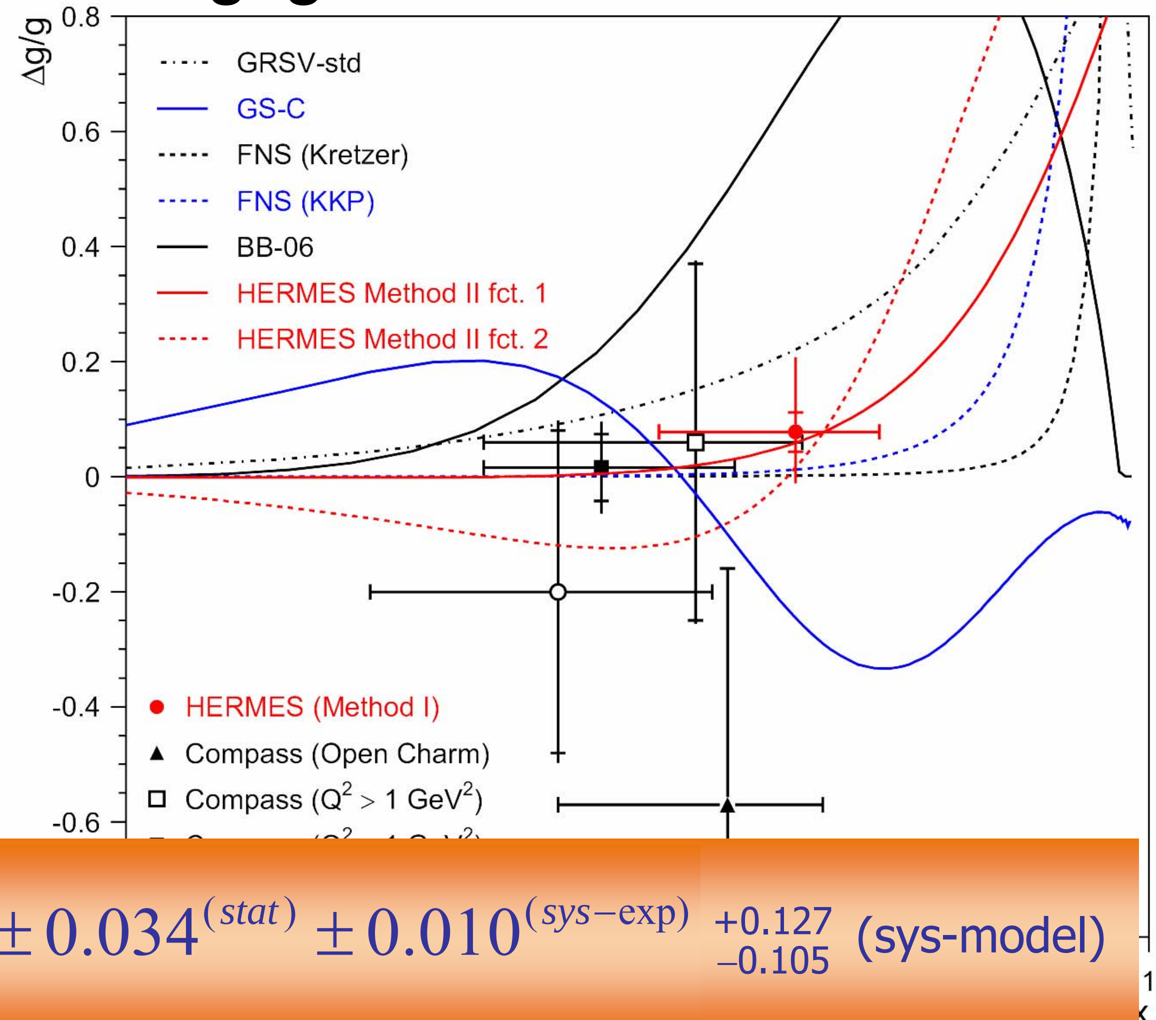
…with two different functional forms



direct measurement of ΔG



$\Delta g / g$



$<\mu^2>=1.35$ GeV^2

$<x_g>= 0.22$

$$\frac{\Delta g}{g}(x,\mu^2) = 0.071 \pm 0.034^{(stat)} \pm 0.010^{(sys-\exp)} \begin{smallmatrix} +0.127 \\ -0.105 \end{smallmatrix} \text{ (sys-model)}$$

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quark structure of the nucleon

$$\Phi^{\mathrm{Tw2}}_{\mathrm{Corr}}(x) = \frac{1}{2}\left\{ f_1(x) + \mathrm{S}_{\mathrm{L}}\, g_1(x)\gamma_5 + h_1(x)\gamma_5\gamma^1 \mathrm{S}_{\mathrm{T}} \right\} n^+$$

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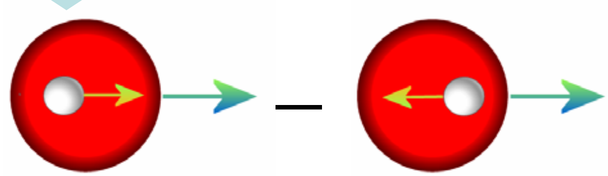
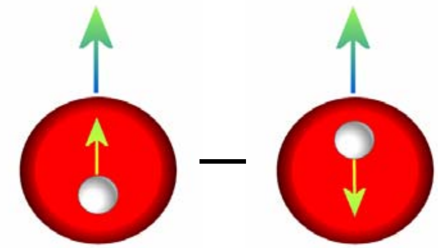
quark structure of the nucleon

$$\Phi^{Tw2}_{Corr}(x) = \frac{1}{2}\left\{ f_1(x) + S_L\, g_1(x)\gamma_5 + h_1(x)\gamma_5\gamma^1 S_T \right\} n^+$$

$f_1^q =$ 

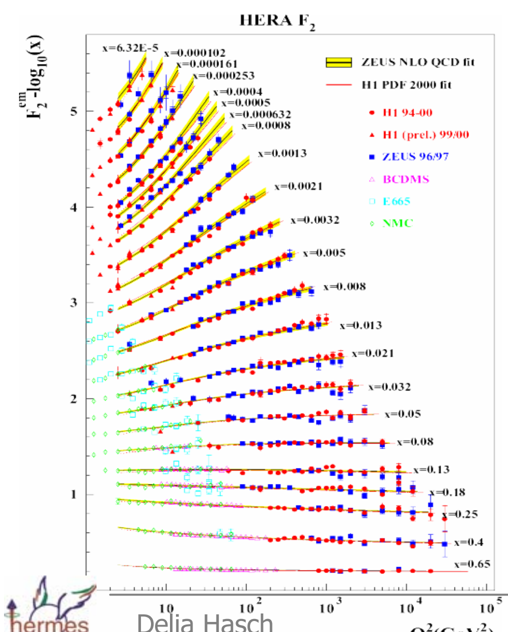
$g_1^q =$ 

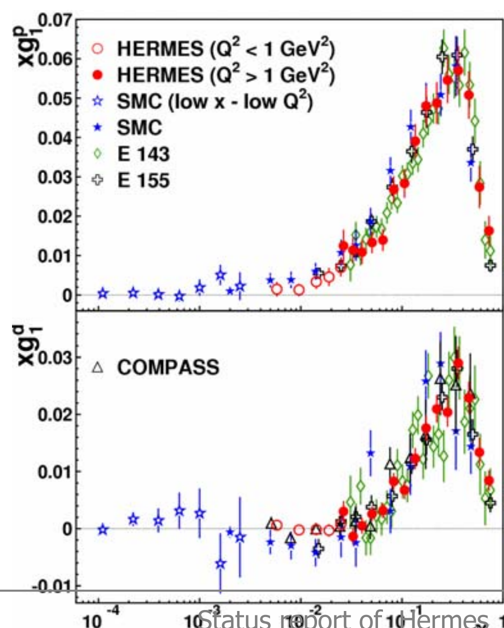
$h_1^q =$ 

unpolarised quarks and nucleons

longitudinally polarised quarks and nucleons

transversely polarised quarks and nucleons





$h_1(x)$: *helicity flip*

chiral-odd → needs a chiral odd partner:

SIDIS: *COLLINS-FF* → azimuthal asymmetry A_{UT}

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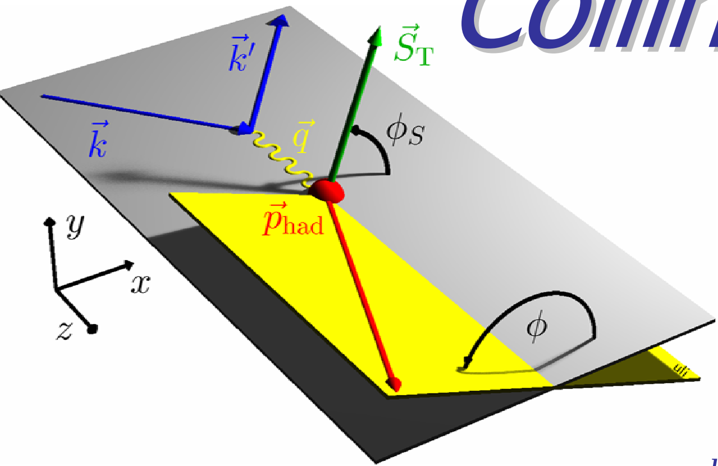
Collins and *Sivers* moments



$$A_{UT}^{h}(\phi,\phi_S) = \frac{1}{|S_T|}\frac{N_h^{\uparrow}(\phi,\phi_S) - N_h^{\downarrow}(\phi,\phi_S)}{N_h^{\uparrow}(\phi,\phi_S) + N_h^{\downarrow}(\phi,\phi_S)} =$$

$$\approx 2\langle\sin(\phi+\phi_S)\rangle_{UT}^{h}\sin(\phi+\phi_S) + 2\langle\sin(\phi-\phi_S)\rangle_{UT}^{h}\sin(\phi-\phi_S) + \cdots$$

distinctive signature

Collins moment

$$\propto h_1(x)H_1^{\perp q}(z)$$

Sivers moment

$$\propto f_{1T}^{\perp q}(x)D_1^{q}(z)$$

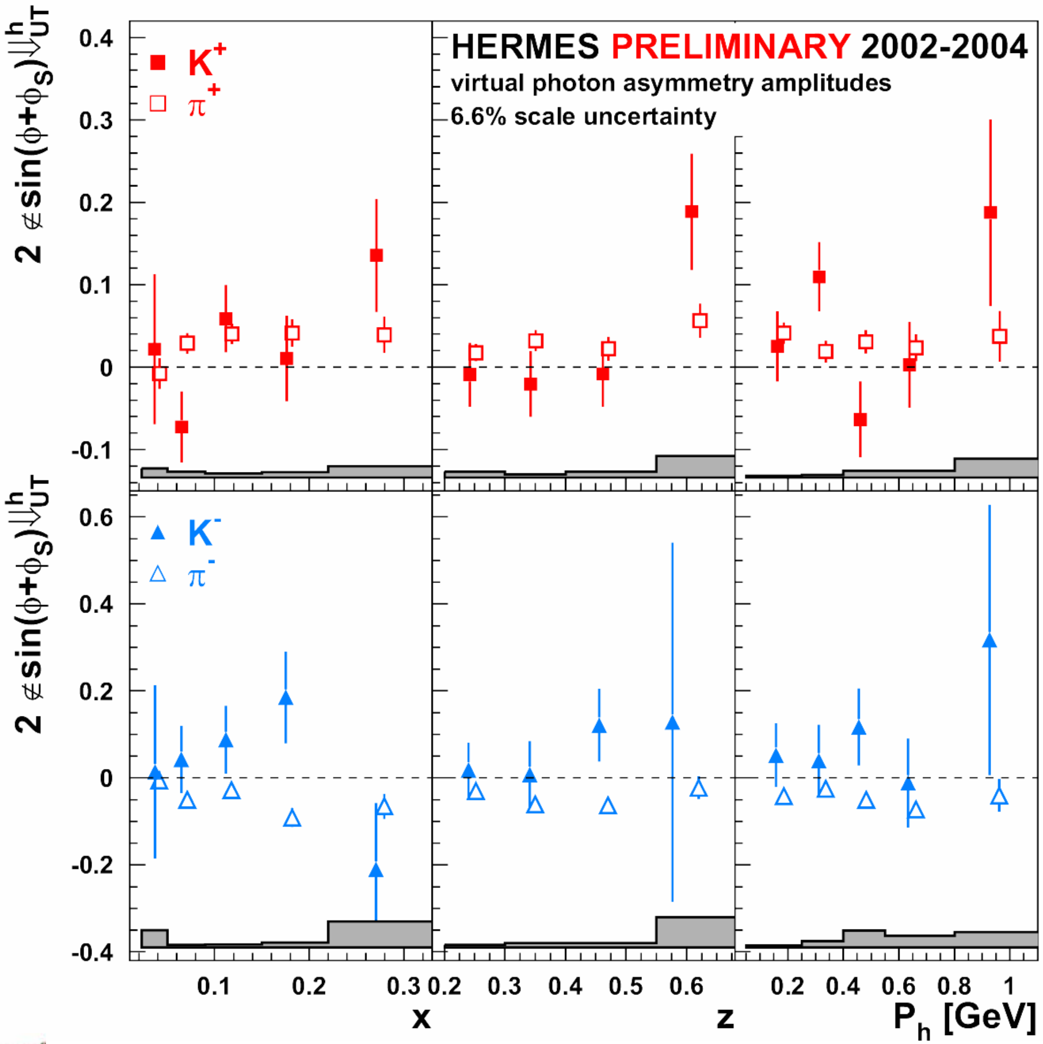
- naïve T-odd DF
- requires *orbital angular momentum*

Collins and Sivers moments extracted by fitting the asymmetry with:

$$A_{UT}^{Fit}(\phi,\phi_S) = P(1)\sin(\phi+\phi_S) + P(2)\sin(\phi-\phi_S) + \ldots$$

Collins moments $\pi^{+/-}$ & K $^{+/-}$

$$A_{coll}(\phi+\phi_S) \propto h_1^q(x) H_1^{\perp q}(z)$$



- significantly *positive* π^+ and *negative* π^- asymmetries
- *unexpected large* π^-
  → role of *unfavoured* fragmentation function?

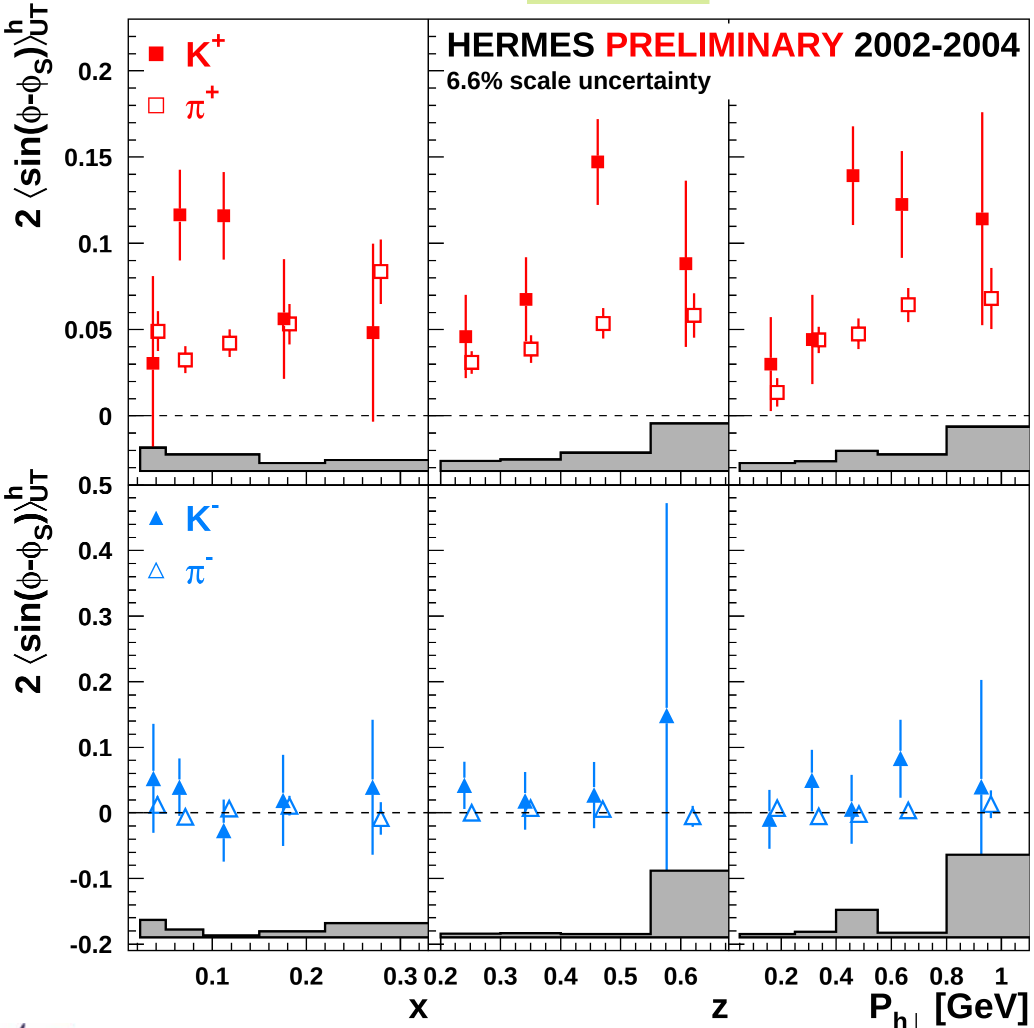
$$H_1^{\perp}(z)_{unfav.} \approx -H_1^{\perp}(z)_{fav.}$$

K$^{+/-}$ amplitudes consistent to $\pi^{+/-}$

- u-quark dominance:
  CollinsFF similar for pions and kaons ?

Sivers moments $\pi^{+/-}$ & $K^{+/-}$

$$A_{siv}(\phi-\phi_S) \propto f_{1T}^{\perp}(x) D_1(z)$$



- significantly positive π^+ and K^+ moments

$K^+ > \pi^+$ in some bins

→ *sea quark* contribution to Sivers moment

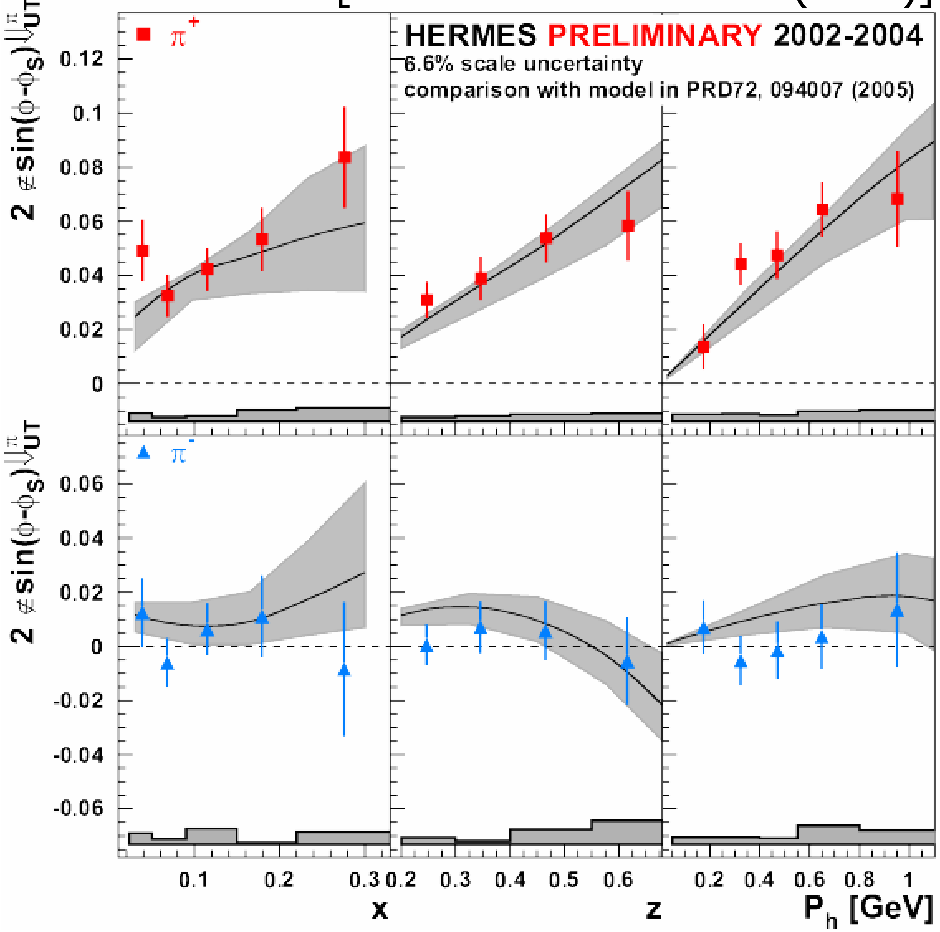
? important ?

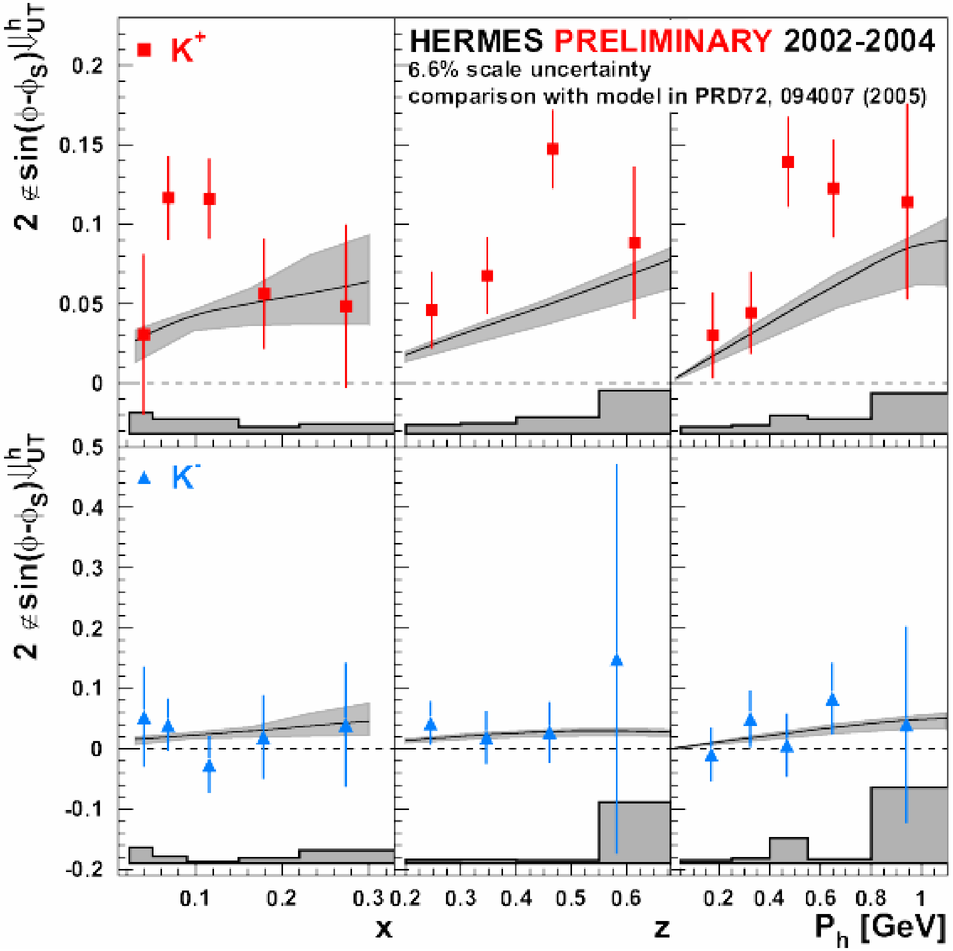
Sivers moments $K^{+/-}$

→ pion data fitted

→ kaon asymmetries predicted

[Anselmino et al. PRD72(2005)]





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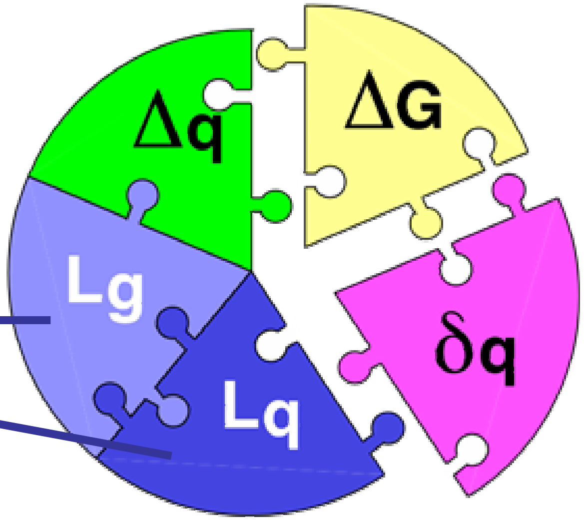
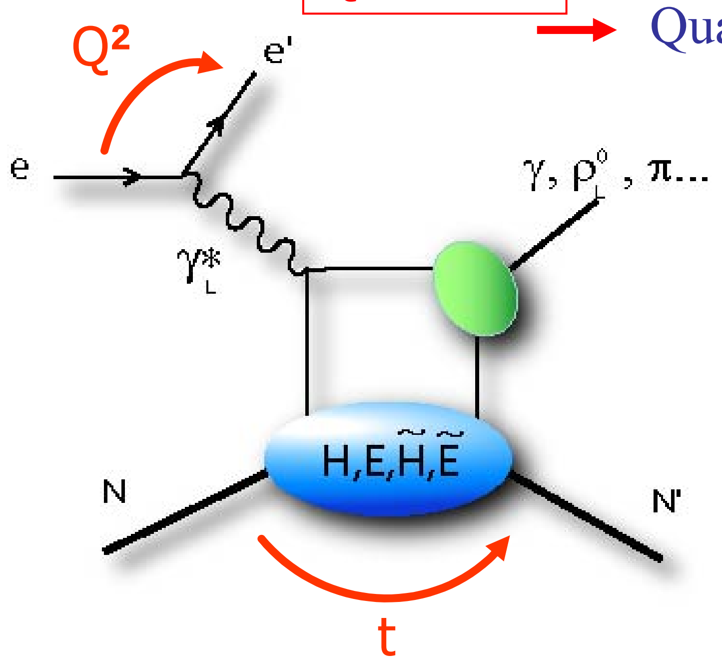
hunting for L_q



→ hard exclusive processes:

Generalised **P**arton **D**istributions



→ Quantum number of final state selects different GPDs:

Vector mesons (ρ, ω, φ): H E

Pseudoscalar mesons (π, η): $\tilde{H}$ $\tilde{E}$

DVCS (γ) depends on H, E, $\tilde{H}$, $\tilde{E}$ ←

$$\int (H + E)\, x\, dx = J_q$$

$$= 1/2\ \Delta\Sigma + L_z$$

10-30%(DIS)

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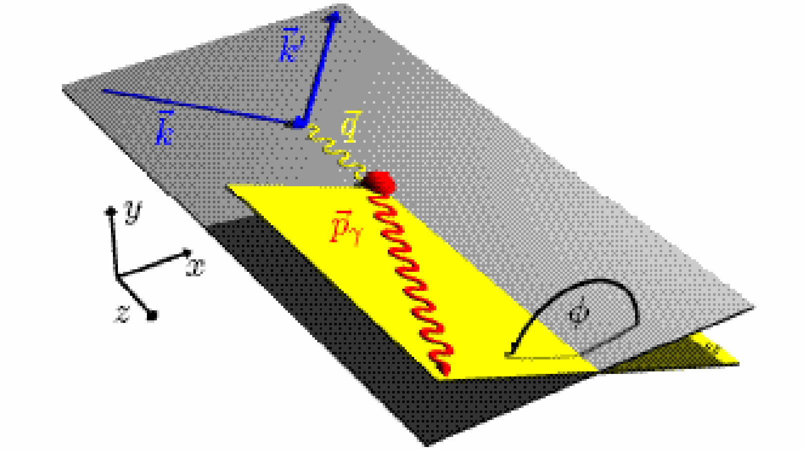
Deeply Virtual Compton Scattering

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



DVCS-BH interference leads to non-zero *azimuthal* asymmetry

$I \sim \Delta\sigma$

@HERMES:

→ different charges: e^+ e^- *(only @HERA!)*: $\Delta\sigma_c$

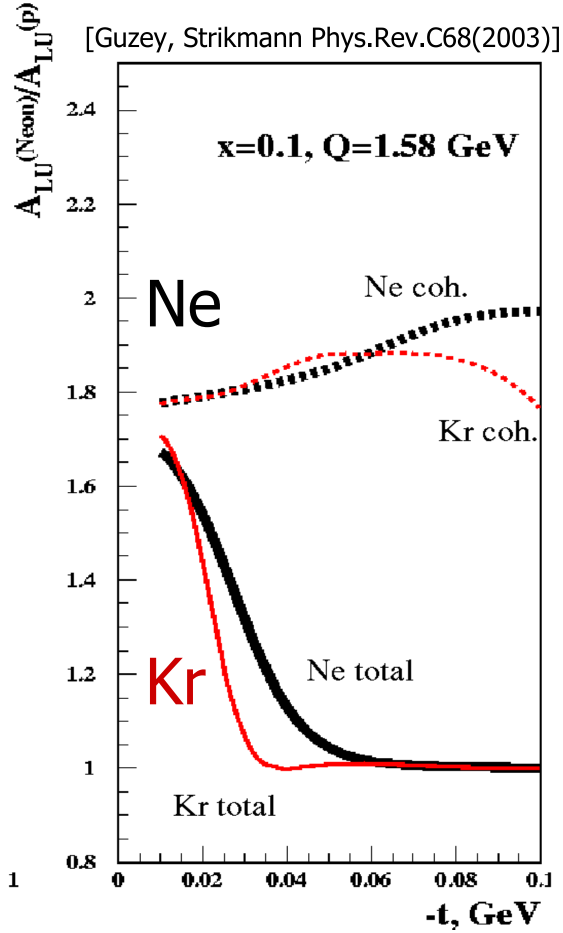
→polarisation observables: $\Delta\sigma_{UL}$, $\Delta\sigma_{UT}$, $\Delta\sigma_{LU}$ @nuclear targets

beam target

DVCS A_{LU} on nuclear targets

GPDs modification in nuclear matter: spatial distribution of energy, angular momentum and shear forces inside the nuclei

[Guzey, Strikmann Phys.Rev.C68(2003)]



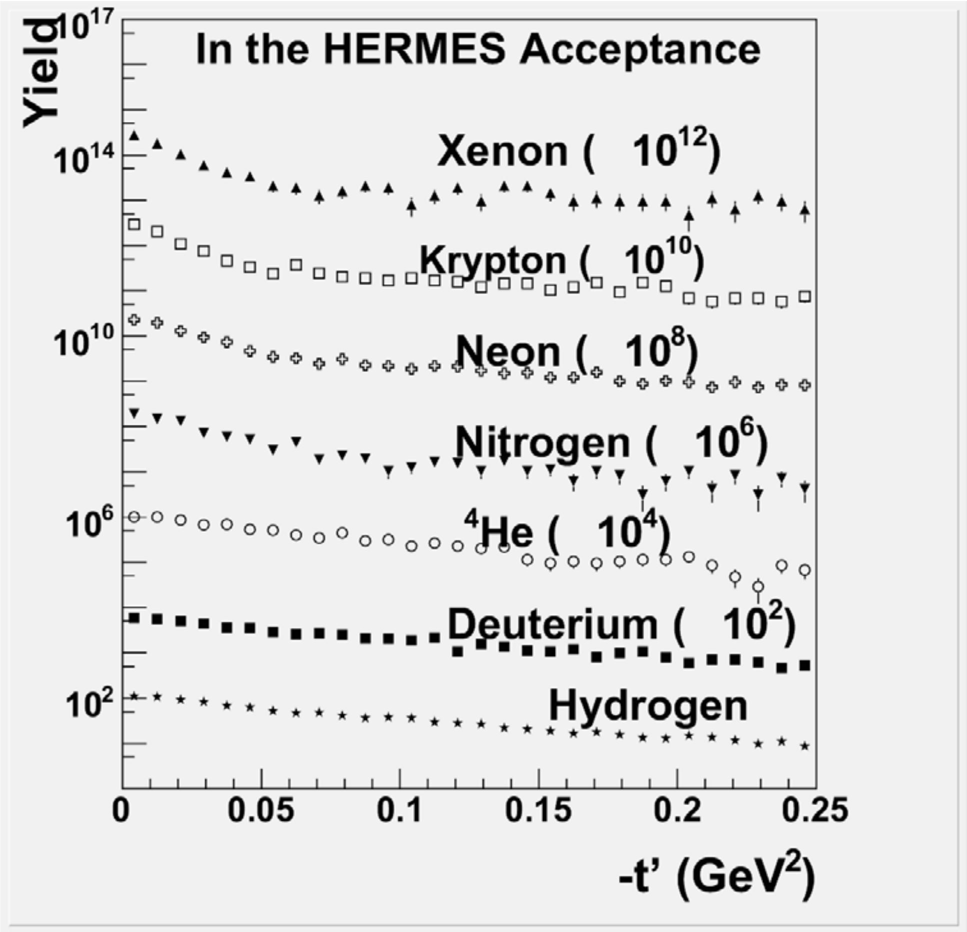
$$\frac{A^{\sin\varphi}_{LU,\,\text{nucleus}}}{A^{\sin\varphi}_{LU,\,\text{proton}}} \propto A^{-0.03}$$

[Guzey,Siddikov,J.Phys.G32(2006)]

→ (1.85…1.95) for A=12…90

DVCS on nuclear targets

GPDs modification in nuclear matter: spatial distribution of energy, angular momentum and shear forces inside the nuclei



$$\frac{A^{\sin\varphi}_{LU,\,\text{nucleus}}}{A^{\sin\varphi}_{LU,\,\text{proton}}} \propto A^{-0.03}$$

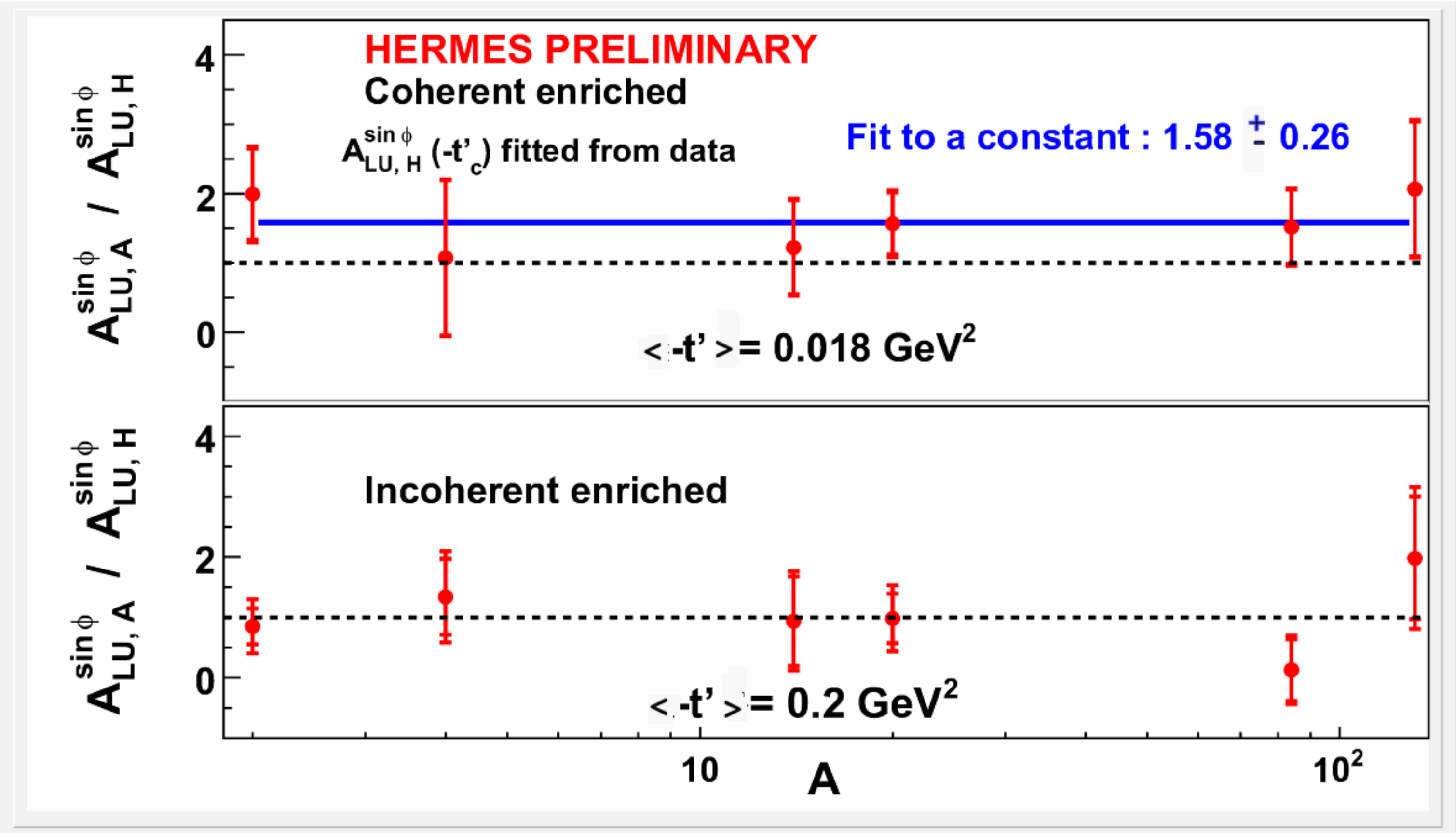
[Guzey,Siddikov,J.Phys.G32(2006)]

→ (1.85…1.95) for A=12…90

- small –t': 'coherent enriched'
- large –t': 'incoherent enriched'

DVCS on nuclear targets

→ 'coherent enriched' : 2σ deviation from unity: 1.58±0.26
(>80% for all A>^{4}He) …in good agreement with models



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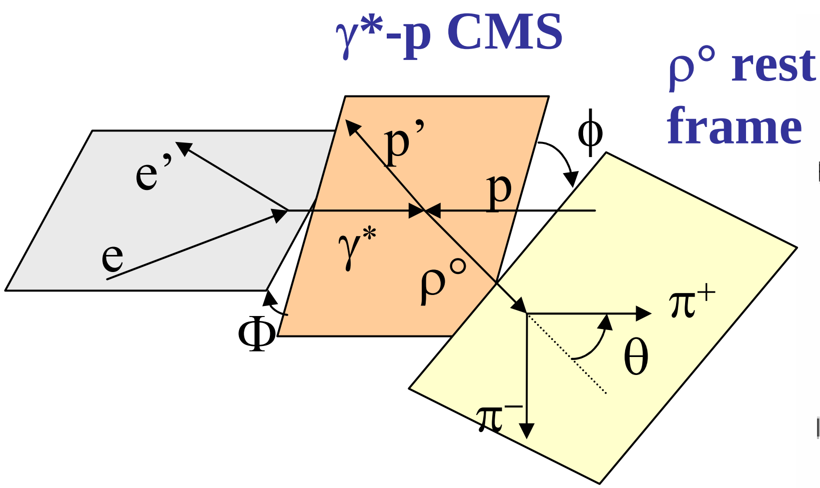
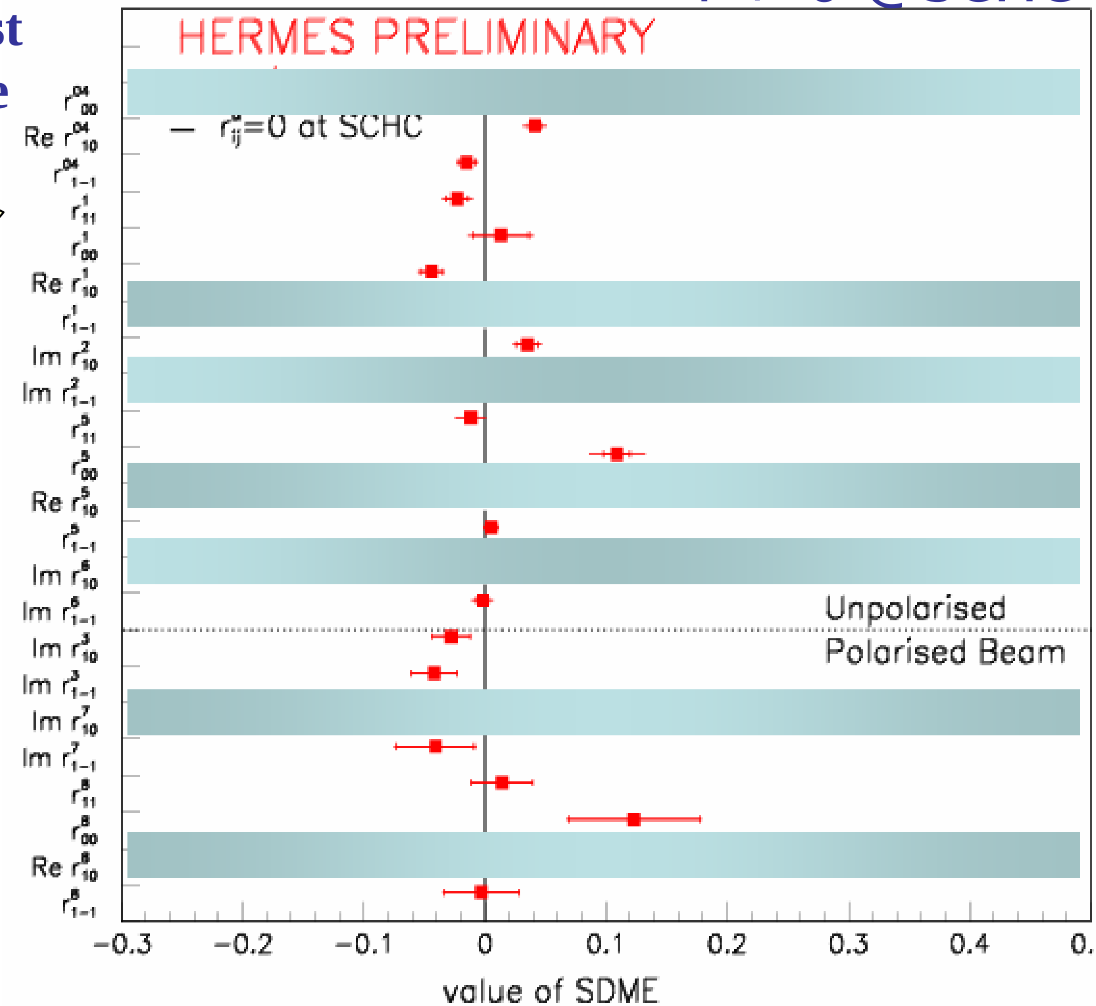
exclusive ρ^0 production



$r \neq 0$ @SCHC



15 unpolarised and
8 polarised Spin Density
Matrix Elements r_{ij}^{kl}
<W>=4.8 GeV

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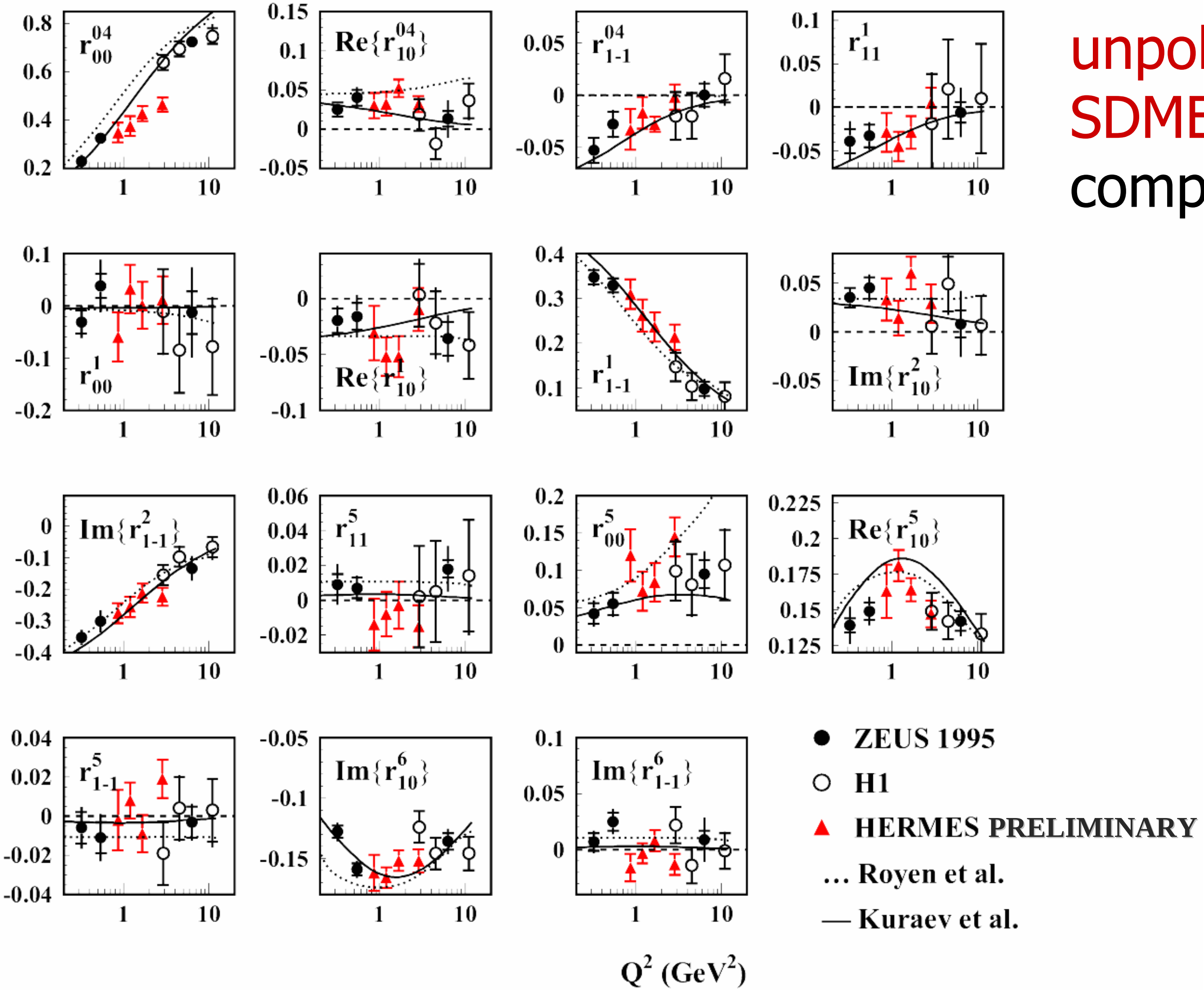
exclusive ρ^0 production



unpolarised HERMES SDMEs

compared to Zeus, H1

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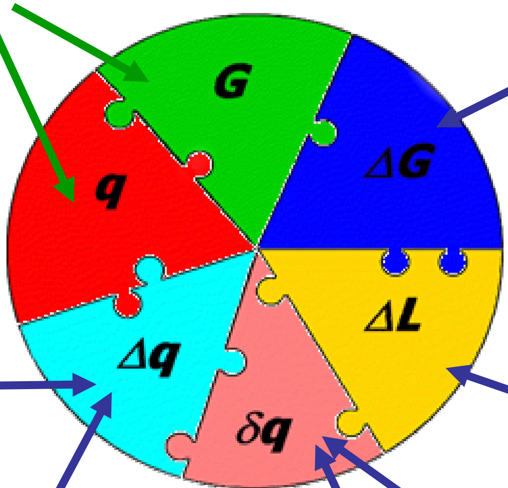
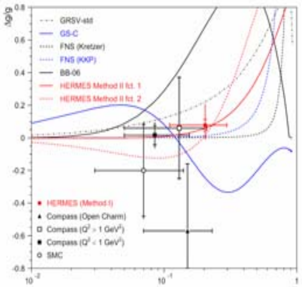
HERMES view at the nucleon spin structure

from unpolarised DIS

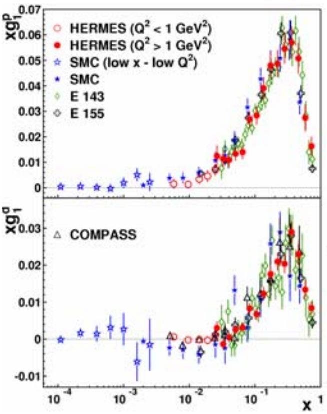
polarised DIS + HERMES:



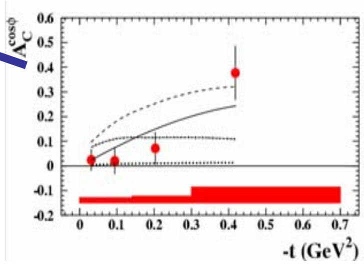
first glimpse

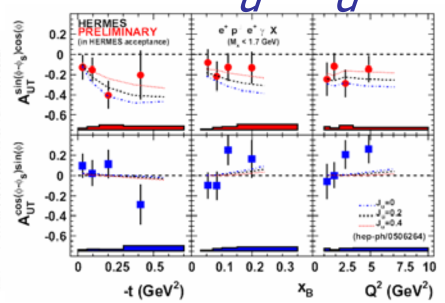


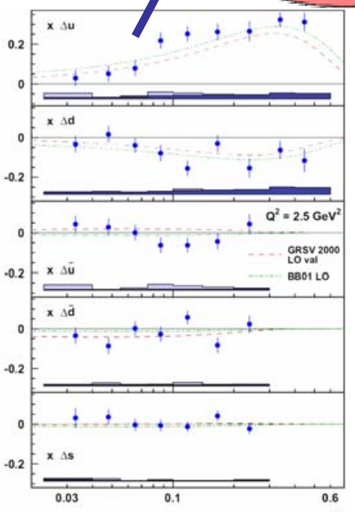
→ a_0 $=0.330\pm0.025^{(exp)}$

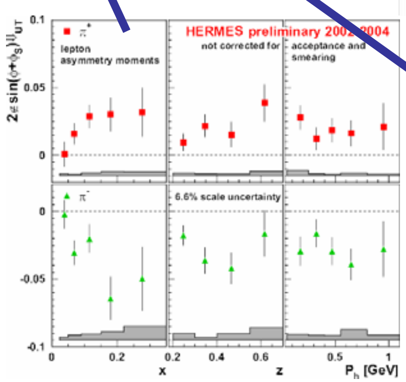


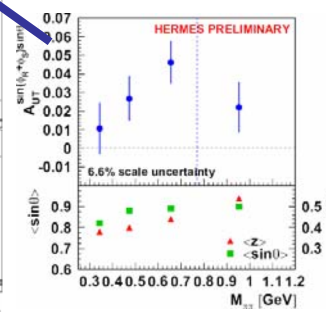
→ signals of GPDs → J_u+J_d











→direct flavour decomp.

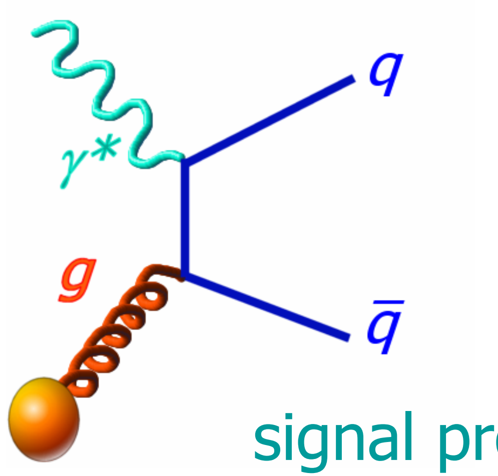
→new constrain on Δs

→transversity is non-zero!

→first T-odd DF in DIS

Back-up slides

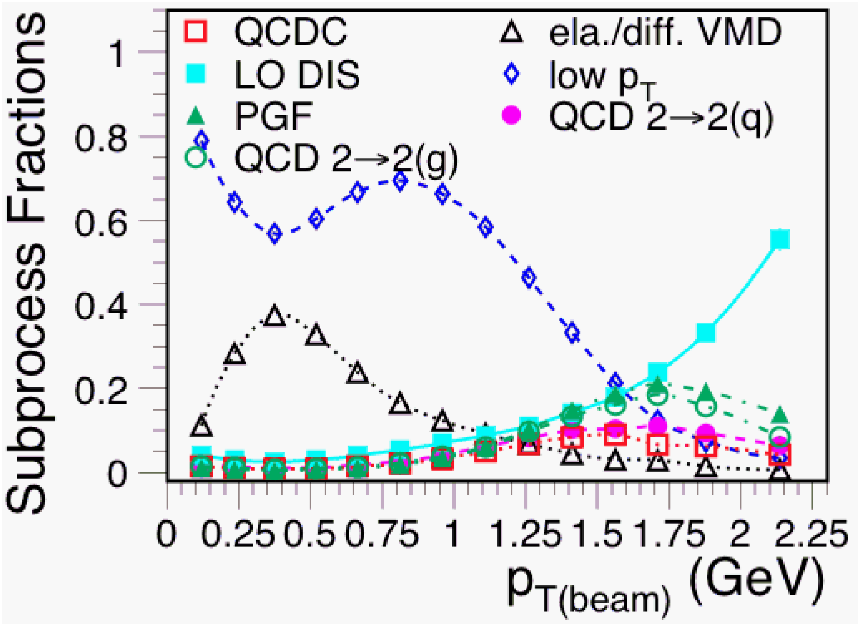
direct measurement of ΔG

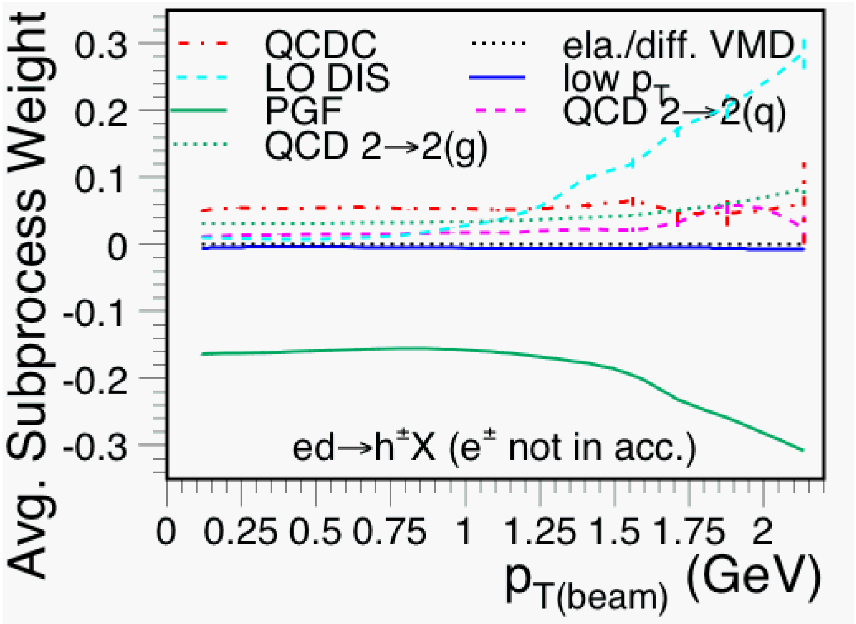


- **golden channel: charm production**
- @HERMES: hadron production at high P_T

$ed \rightarrow h^{\pm}X$: direct, resolved, soft processes

signal processes: **PGF,** QCD 2→2(g)





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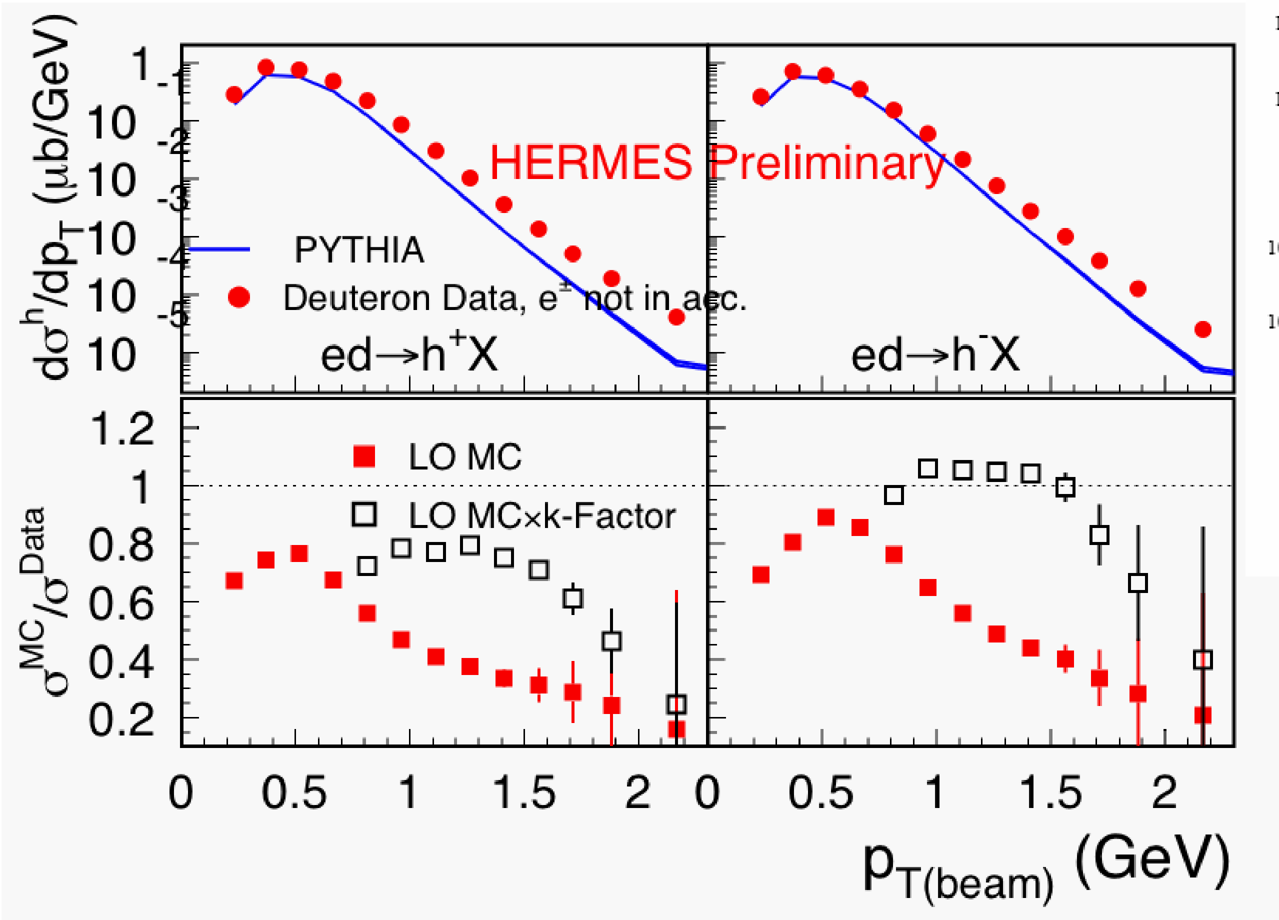
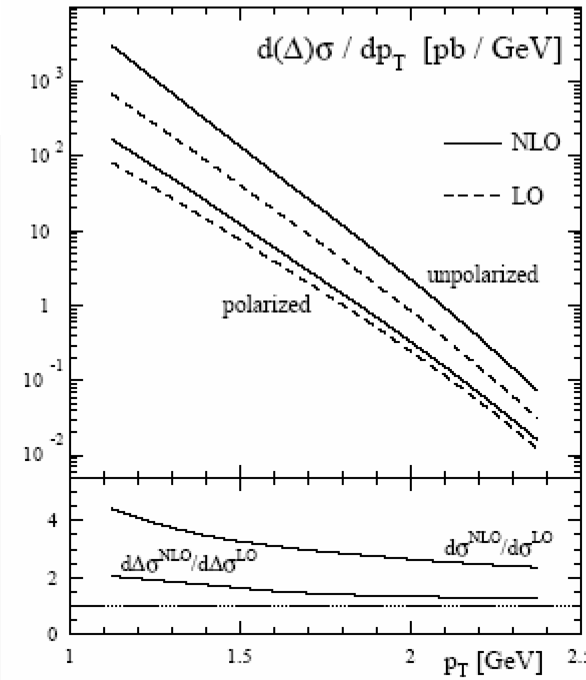
direct measurement of ΔG

Monte Carlo vs Data:





K-factors for hard QCD subprocesses according to B. Jäger et. Al., Eur.Phys. J. C44(2005) 533

direct measurement of ΔG

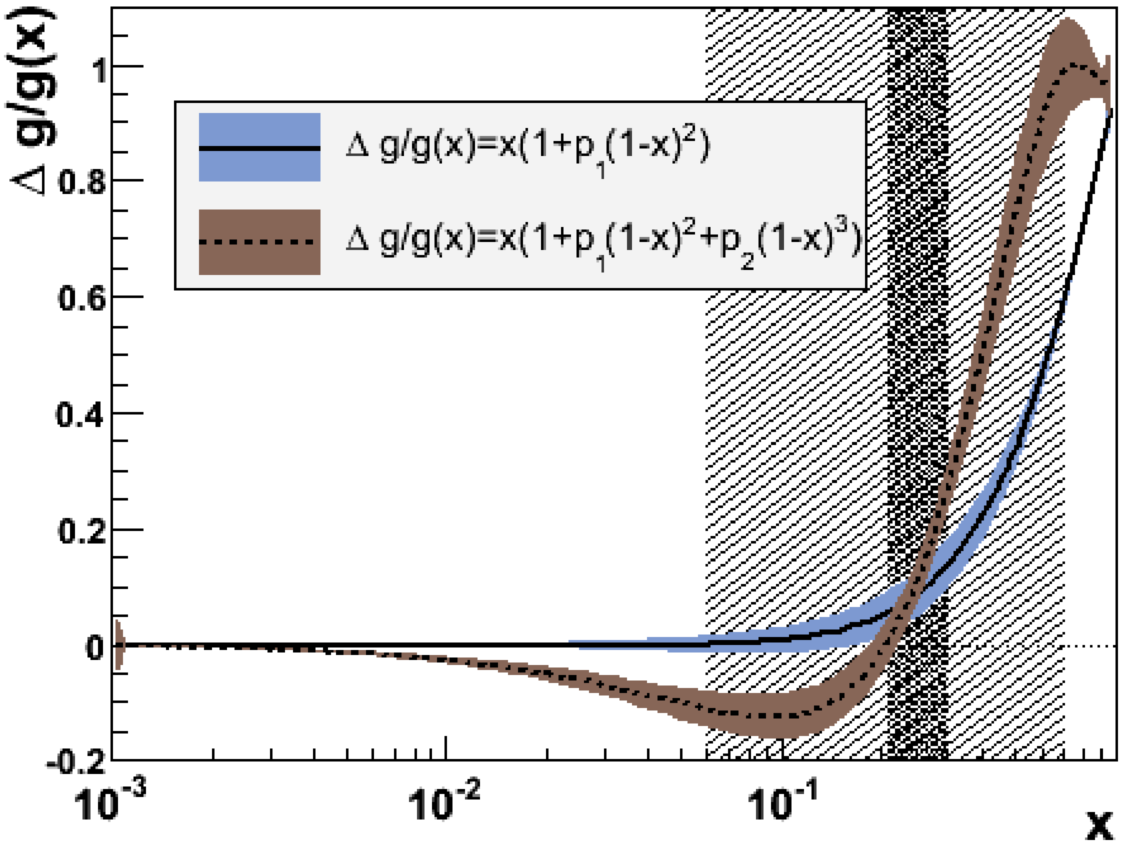
$\Delta g/g$ Systematics

- Uncertainties from each of 3 (4) groups
  - MC parameters
  - Pol./unpol. PDFs
  - Low-p_T asymmetry
  - (Method 2 only) Fit function choice (1 or 2 params.)

Summed linearly to "Models" uncertainty

  - Hopefully this conservative approach would also cover for the unknown uncertainties due to
    - Using a LO approximation
    - Using Pythia as a model
- Experimental (stat.+syst.) added in quadrature
  - syst. uncertainty from 4% scaling uncertainty 14% on $\Delta g/g$

direct measurement of ΔG



functional forms:

- fix $\Delta g/g \rightarrow x$ for $x \rightarrow 0$
- $\Delta g/g \rightarrow 1$ for $x \rightarrow 1$ (Brodsky et al.)
- $|\Delta g/g(x)|<1$ for all x

…difference between functions is systematic uncertainty

•light shaded area: range of data
•dark shaded area: center of gravity for fit

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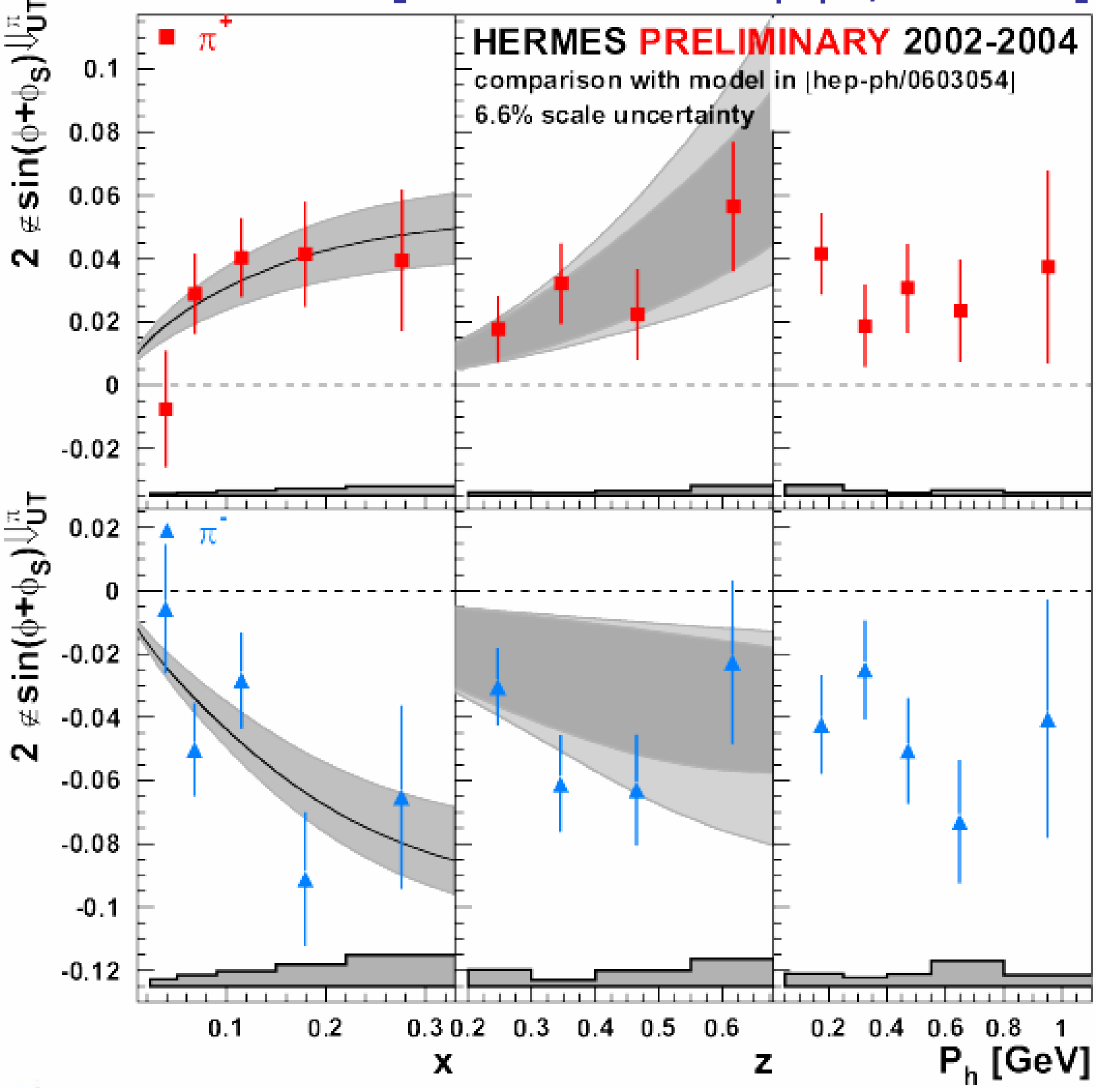
what can we learn from *Collins* A_{UT}?

[Efremov et al. hep-ph/0603054]



→ h_1 from χQSM

→ Collins FF:

x-dependence:

Hermes data fitted to obtain parameters for ansatz for *CollinsFF*

z-dependence:

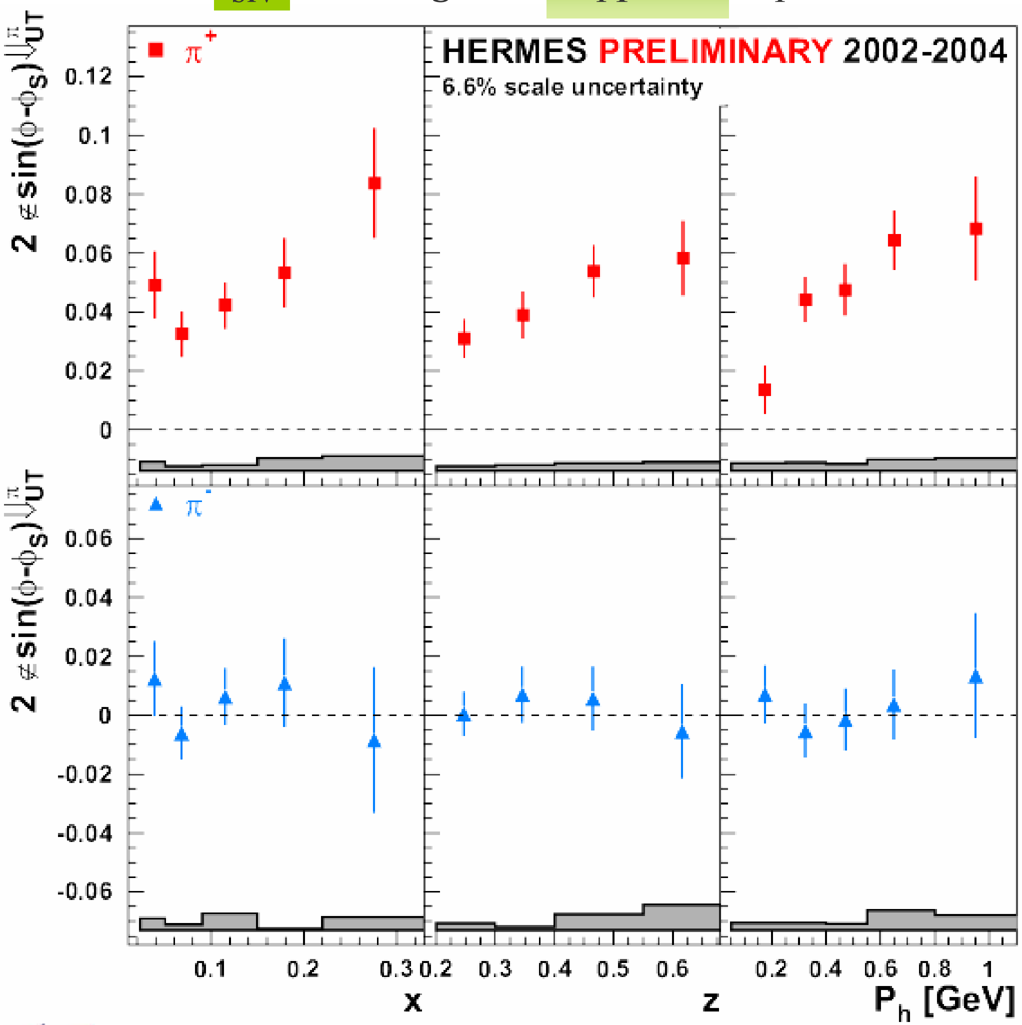
BELLE data fitted and asymmetry for Hermes calculated

→ ***HERMES+BELLE***

data in agreement ☺

Sivers moments $\pi^{+/-}$

$$A_{siv}(\phi-\phi_S) \propto f_{1T}^{\perp}(x) D_1(z)$$



- significantly positive π^+ asymmetry

→ *requires non-zero orbital angular momentum*

→ first hint of naïve T-odd DF from DIS

→ test of universality:

$$f_{1T}^{\perp}(x)_{DIS} = -f_{1T}^{\perp}(x)_{DY}$$

- D_1 known → Sivers DF can be extracted from HERMES data !

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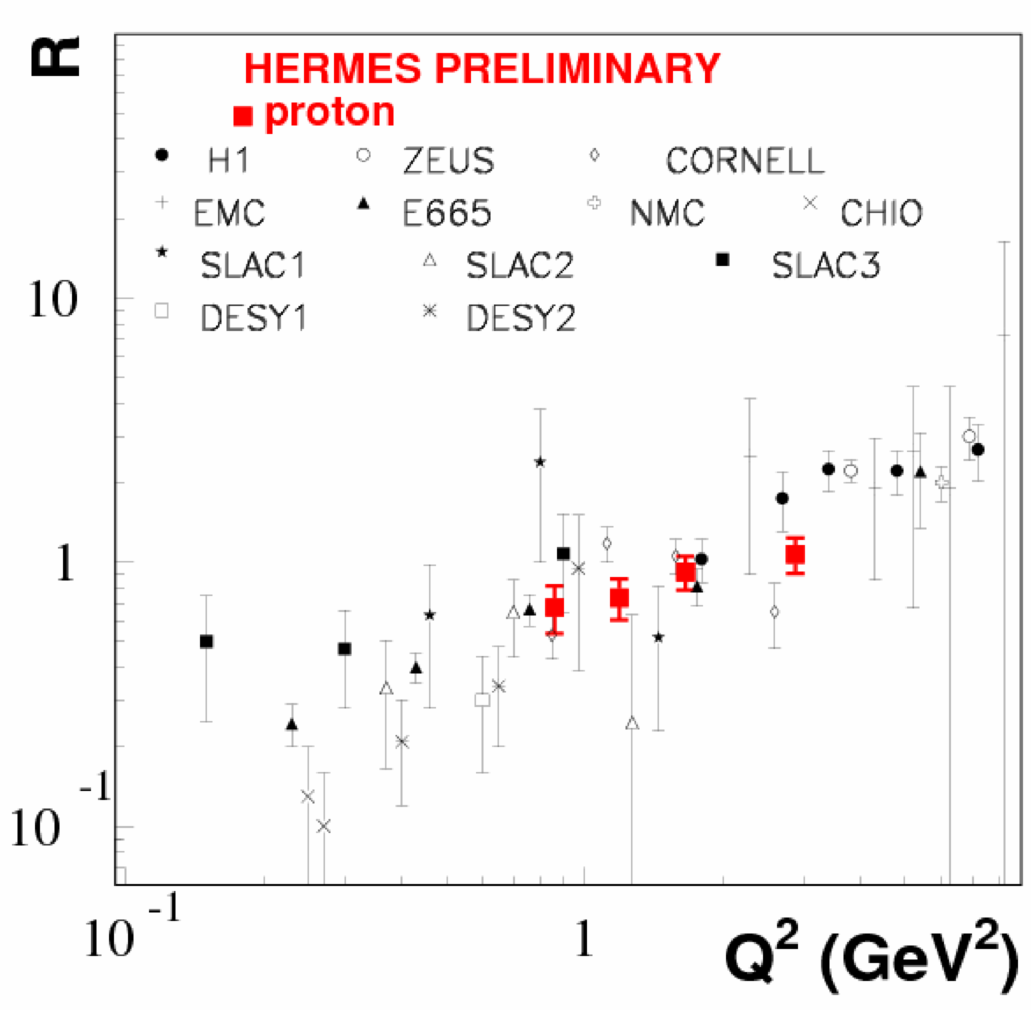
exclusive ρ^0 production

if SCHC holds
(VM retains γ^* helicity):

$$R = \frac{\sigma_L}{\sigma_T} = \frac{1}{\varepsilon}\frac{r_{00}^{04}}{1-r_{00}^{04}}$$

→ at $Q^2 = 2\ \mathrm{GeV}^2$, $\sigma_L = \sigma_T$



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