Nucleon spin structure at HERMES

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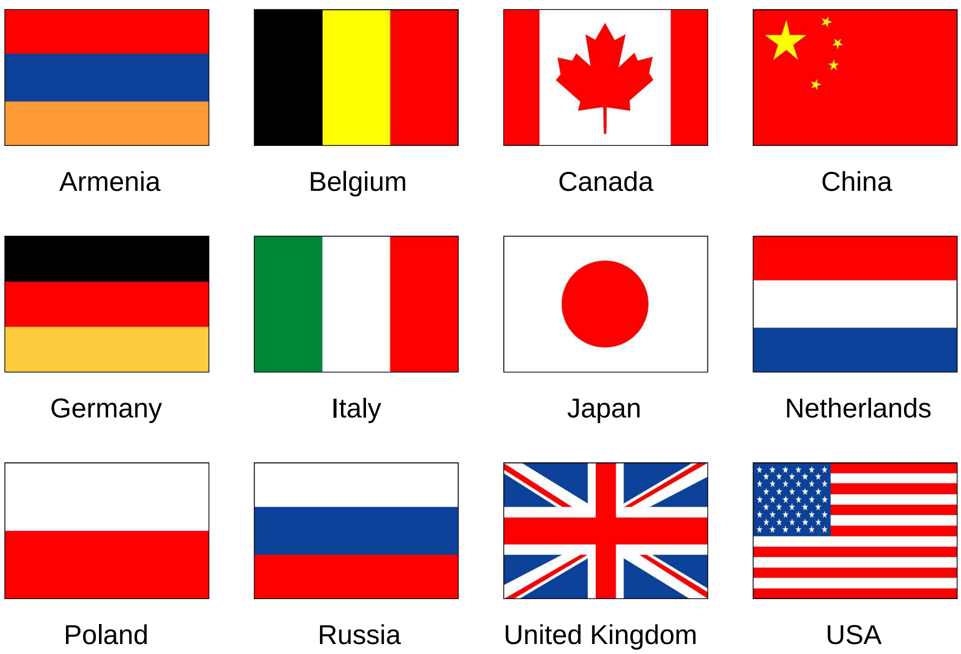
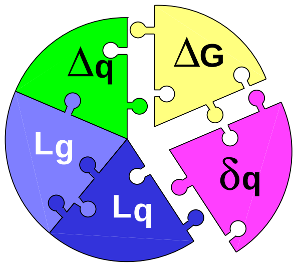
On behalf of the **HERMES** collaboration



Polarized anti-quark distribution status



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

LO $g_1(x, Q^2)$

$$F_1^{p(n)}(x) = \frac{1}{2}\sum_q e_q^2 q(x) \quad \Leftrightarrow \quad g_1^{p(n)}(x) = \frac{1}{2}\sum_q e_q^2 \Delta q(x)$$

QCD fits to $g_1(x, Q^2)$ at NLO

$$g_1^{p(n)} = \frac{1}{9}\left(C_{NS} \otimes \left[\pm\frac{3\Delta q_3}{4} + \frac{\Delta q_8}{4}\right] + C_S \otimes \Delta\Sigma + 2N_f C_g \otimes \Delta g\right)$$

By exploiting the different Q^2-dependent behavior of each term, one *could* separate the following PDF's.

$$\Delta q_3(x, Q^2) = \Delta u - \Delta d$$

$$\Delta q_8(x, Q^2) = \Delta u + \Delta d - 2\Delta s$$

$$\Delta\Sigma(x, Q^2) = \Delta u + \Delta d + \Delta s \qquad \Delta g$$

However the precision and range of g_1 data is presently inadequate. Data from neutron and hyperon β decay must be used.

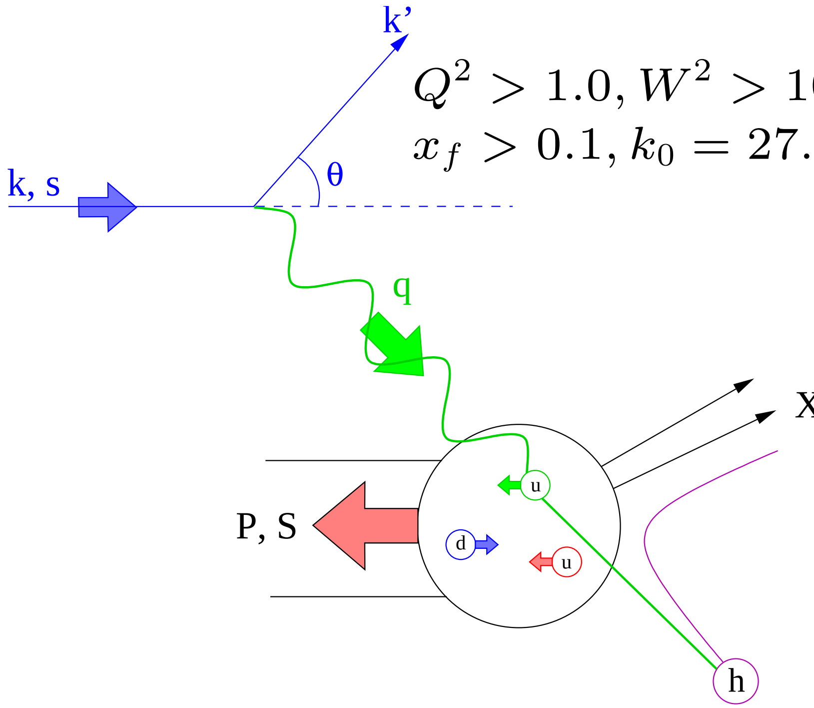
$a_3 = (G_A/G_V) = g_A$ (Bjorken sum rule)

$a_8 = 3F - D = 0.585 \pm 0.02$

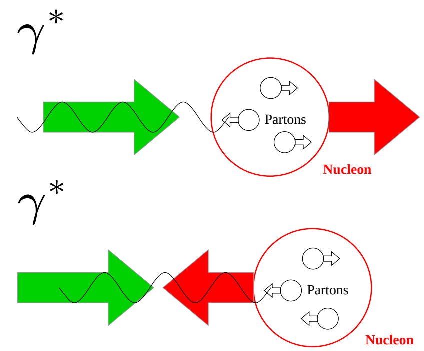
$$0.47 \leq a_8 \leq 0.70$$

a_8	$(\Delta s + \Delta\bar{s})$
0.40	-0.02 ± 0.01
$3F - D$	-0.06 ± 0.01
0.86	-0.15 ± 0.02

Semi-Inclusive Polarized Deep Inelastic Scattering



$Q^2 > 1.0, W^2 > 10$
$x_f > 0.1, k_0 = 27.5 Gev$



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

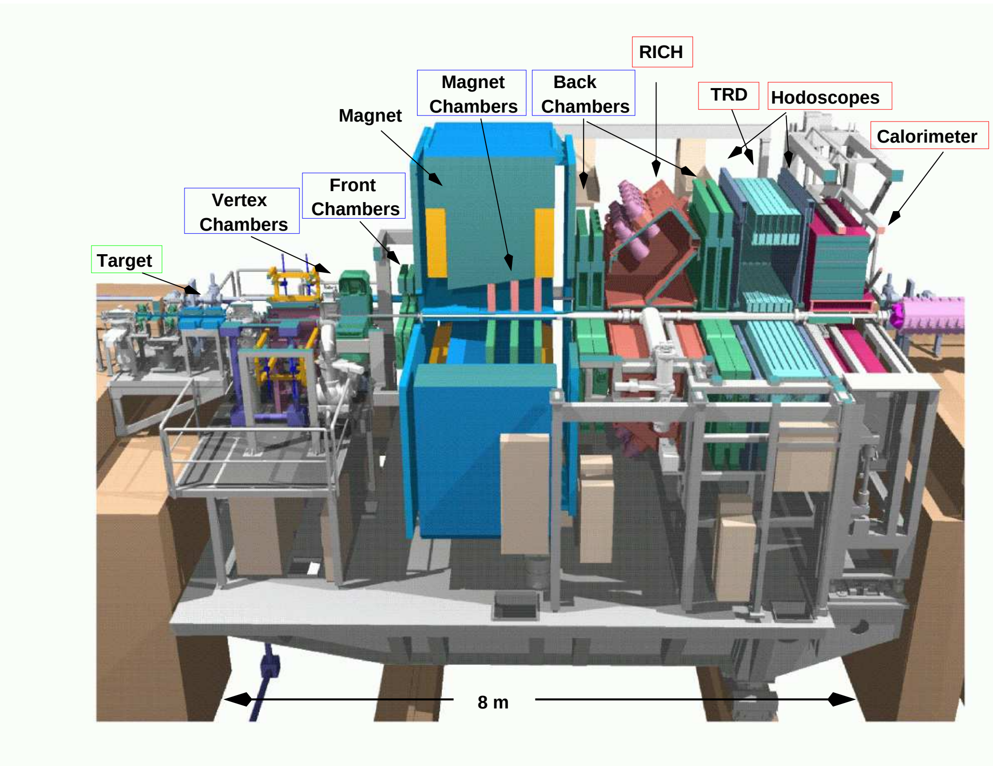
$\sigma_{1/2} \sim q^+(x)$

- SIDIS: $e + N \rightarrow e' + h + X$
  - ⋆ flavor tagging from hadron.
    - $\Rightarrow$ distinguish Δq from $\Delta \bar{q}$.
  - ⋆ sensitive to $\Delta q(x) = q^+(x) - q^-(x)$.

$$A_1^h(x) = \frac{1}{\langle P_b P_t \rangle (1 + \eta\gamma) D} \frac{(N^h/L)^{\uparrow\downarrow} - (N^h/L)^{\uparrow\uparrow}}{(N^h/L)^{\uparrow\downarrow} + (N^h/L)^{\uparrow\uparrow}}$$

$$\overset{g_2=0}{\approx} \frac{\sum_q e_q^2 \Delta q(x) \int_{z_{min}}^{z_{max}} dz D_q^h(z)}{\sum_{q'} e_{q'}^2 q'(x) \int_{z_{min}}^{z_{max}} dz D_{q'}^h(z)}$$

The HERMES Spectrometer

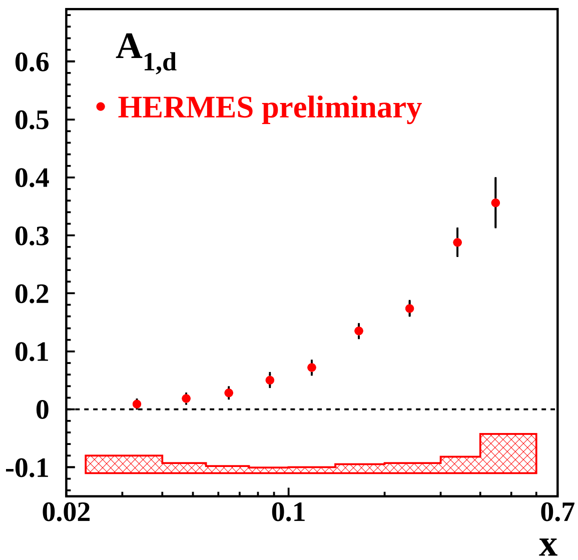


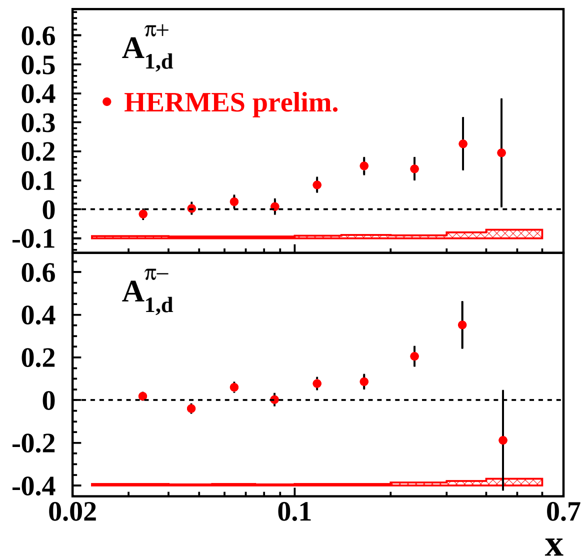
- HERA polarized lepton $< P_B >= 0.55$
- Longitudinally polarized gas target $\langle P_t \rangle \approx 0.88(0.82)$. ($\vec{H}$, $\vec{D}$)
- Data taken from 1996 to 2000 with Longitudinal target.
- Čerenkov replaced by a RICH detector, until 1997 $\pi^{\pm}$ after 1998 $\pi^{\pm}$, $K^{\pm}$ and $p/\bar{p}$
- Lepton ID efficiency $\sim 98\%$ with $< 1\%$ hadron contamination

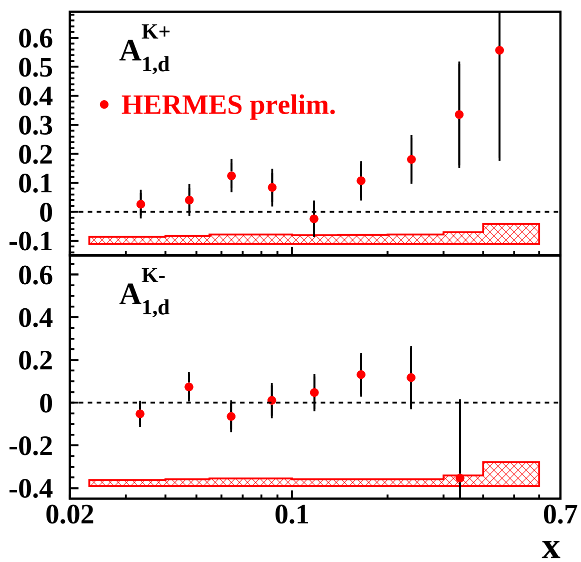
year	**DIS** $(\times 10^6)$	**target**	**PID**
1996	0.650	H	Čerenkov
1997	1.72	H	Čerenkov
1998	1.11	D	RICH
1999	1.25	D	RICH
2000	6.69	D	RICH

Measured Asymmetries

- ⋆ Proton - inclusive, $\pi^{\pm}$
- ⋆ Deuteron - inclusive, $\pi^{\pm}$, $K^{\pm}$ (RICH)







All-sea nature of $K^{-}(\bar{u}s)$ asymmetry demonstrates how much more information can be gained from seperation of different hadron flavors. This asymmetry is very important for getting a handles on the sea quark distributions.

Purity Analysis

⋆ Rewrite asymmetry as:

$$A_1^h = \sum_q \frac{e_q^2 q(x) \int_{z_{min}}^{z_{max}} dz D_{q'}^h(z)}{\sum_{q'} e_{q'}^2 q'(x) \int_{z_{min}}^{z_{max}} dz D_{q'}^h(z)} \frac{\Delta q(x)}{q(x)}$$

$$= \sum_q P_q^h \frac{\Delta q}{q}$$

$$\vec{A} = \begin{pmatrix} A_{1,p} \\ A_{1,p}^{\pi+} \\ A_{1,p}^{\pi+} \\ \vdots \\ A_{1,d}^{K+} \end{pmatrix}$$

⋆ Purity contains fragmentation function...

1. use parametrization
2. use model (e.g. Lund Monte-Carlo)

$$\mathbb{P} = \begin{pmatrix} P_{u,p} & P_{d,p} & \dots \\ P_{u,p}^{\pi+} & P_{d,p}^{\pi+} & \dots \\ \vdots & \vdots & \\ P_{u,d}^{K+} & P_{d,d}^{K+} & \dots \end{pmatrix}$$

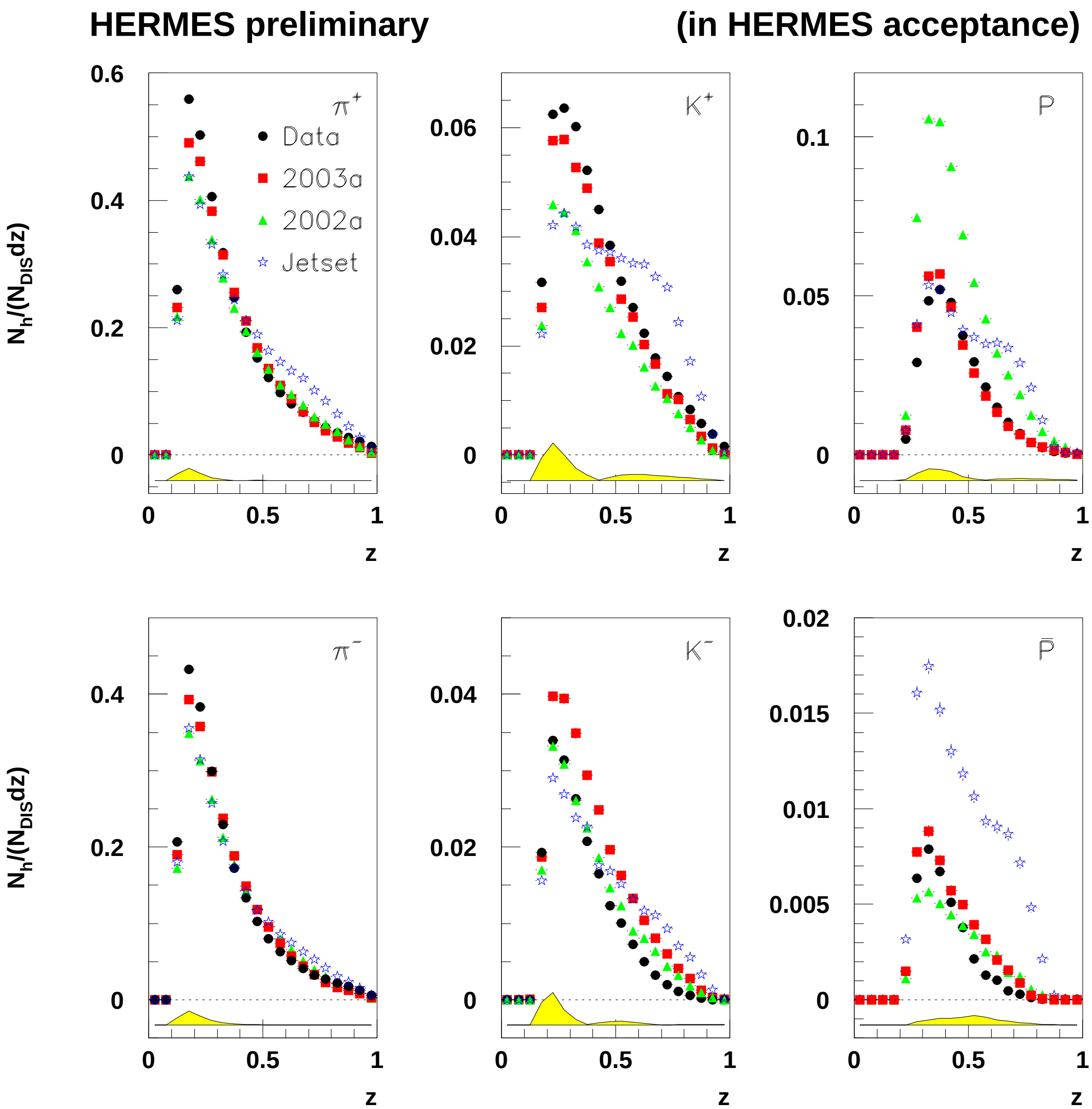
⋆ Solve by minimizing χ^2 by varying $\Delta q(x)$

$$\chi^2 = (\vec{A} - \mathbb{N}\mathbb{P}\vec{Q})^{-1}\mathbb{C}_A^{-1}(\vec{A} - \mathbb{N}\mathbb{P}\vec{Q})$$

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

Fragmentation Model Tuning

⋆ Data vs. Monte Carlo multiplicity comparison.

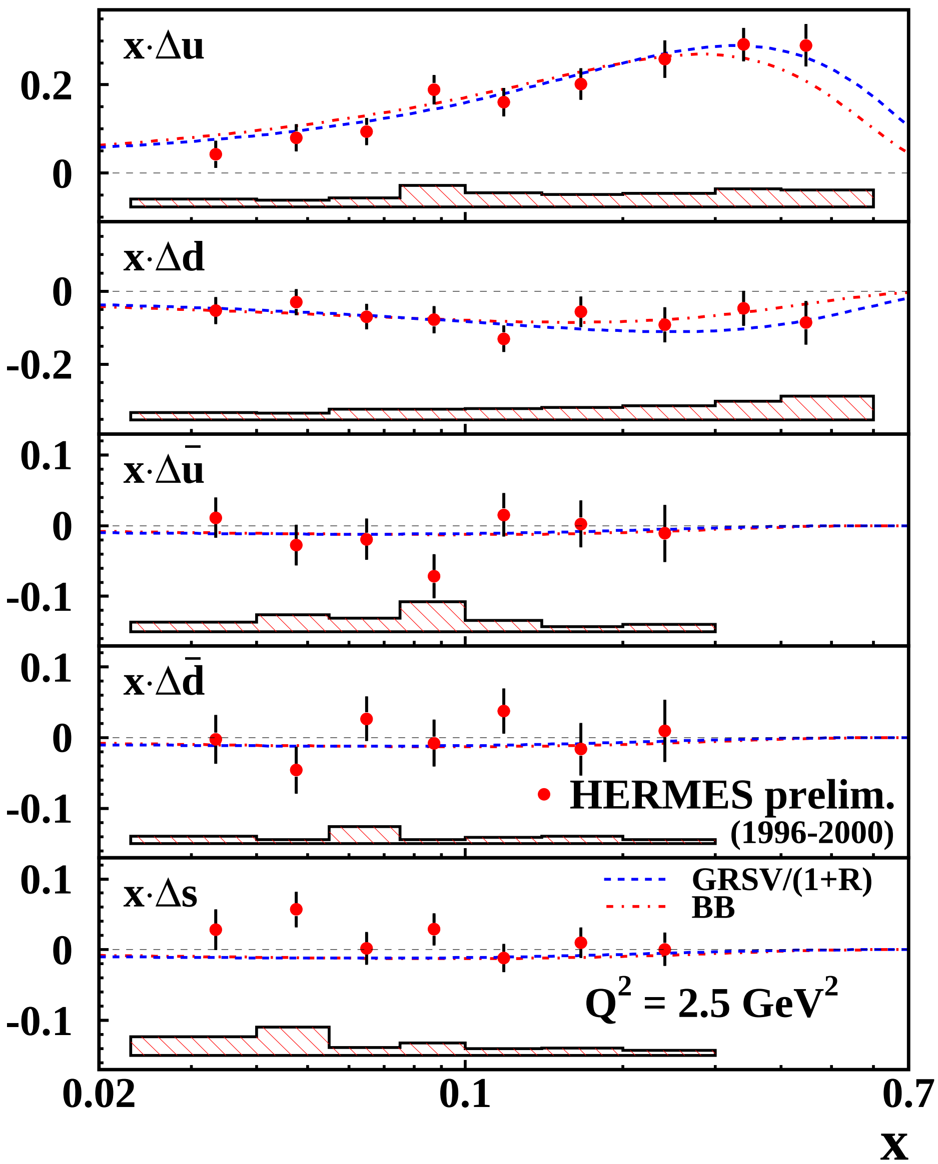


⋆ Tuned to unpolarized data using a genetic algorithm.

⋆ Purities only contain q(x) fit, LUND model and are our main source of systematic error in the anti-quark plarizations.

Polarized Quark Densities

First 5-flavor extraction Δu, Δd, $\Delta \bar{u}$, $\Delta \bar{d}$, $\Delta s = \Delta \bar{s}$.

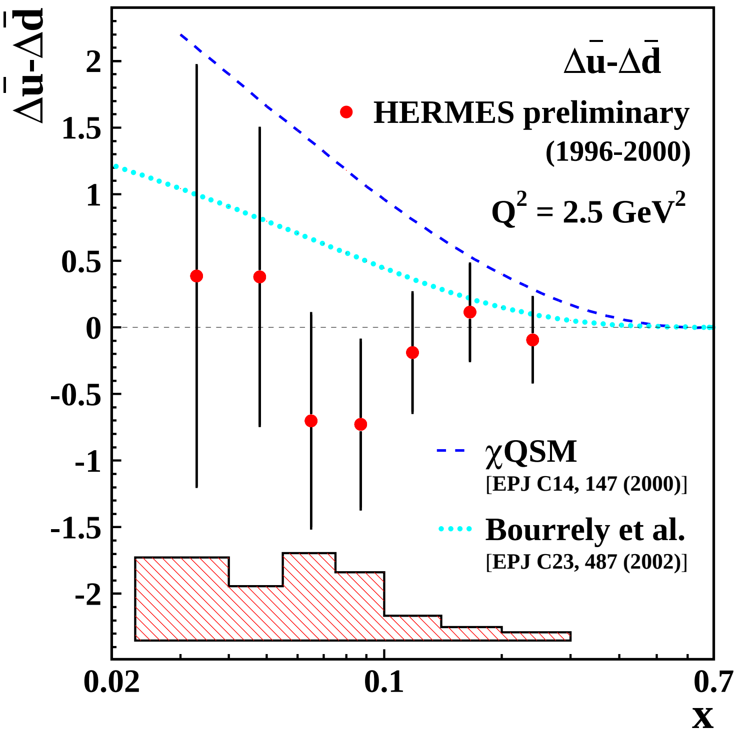


- ⋆ Excellent agreement of $\Delta u / \Delta d$ with fits from inclusive data.
- ⋆ No significant polarization of anti-quark sea.
- ⋆ No evidence for negative strange sea polarization.

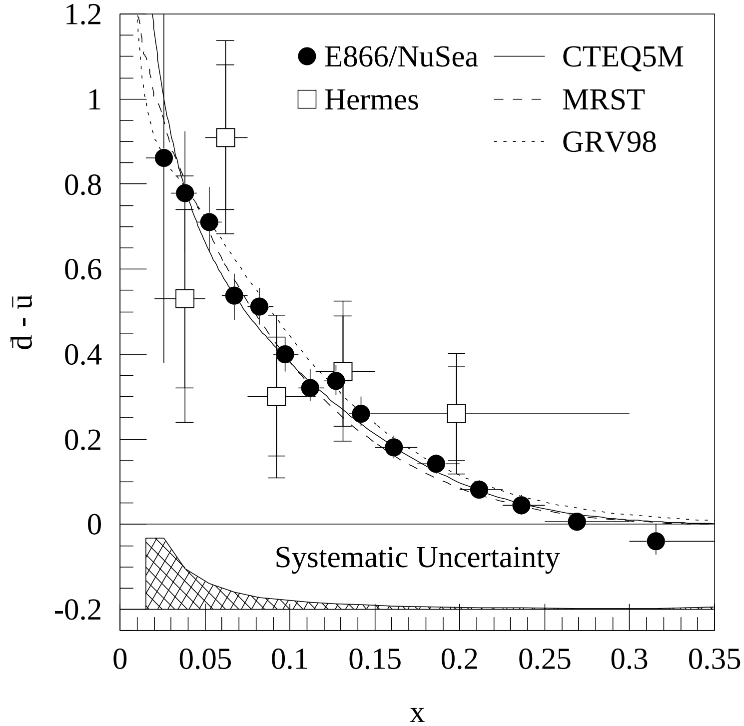
$\Rightarrow$ result consistent with zero

Light Sea Polarization

Polarized $\Delta\bar{u} - \Delta\bar{d}$



Unpolarized $\bar{u} - \bar{d}$



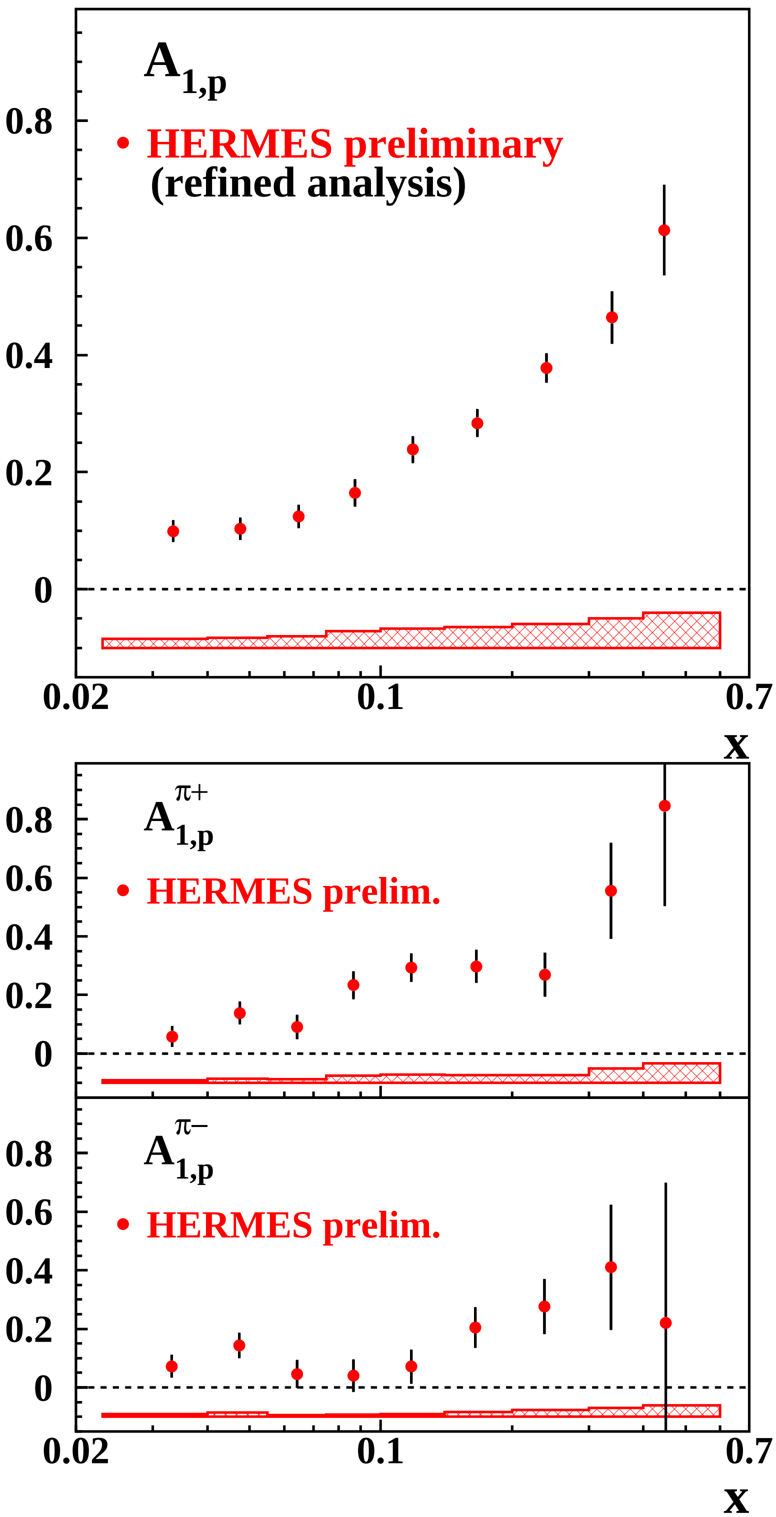
⇒ light anti-quark polarizations small

⇒ no evidence of isospin breaking

Conclusions and Outlook

- First 5-flavor extraction of polarized quark densities (LO)
- Δu, Δd in good agreement w/ NLO QCD fits to inclusive data.
- No breaking of the flavor symmetry in the light sea within statistics
- No evidence for negative strange sea polarization (expected from inclusive g_1 + hyperon/neutron decay data)
- Possibility to obtain kaon data from proton in the future.
- Systematic error due to fragmentation under study.

Proton Asymmetries



- Threshold Čerenkov only made $\pi^{\pm}$ discernible

$\Rightarrow$ Future data may include kaon asymmetry for proton.