Flavor Decomposition of the Nucleon's Spin at HERMES

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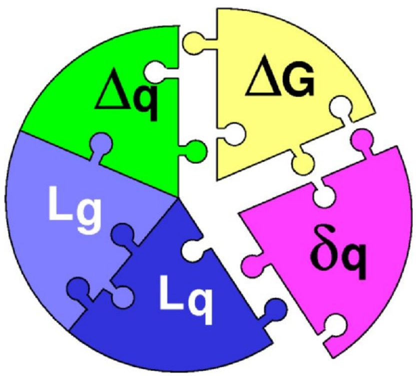
On behalf of the HERMES collaboration

The Motivation for Measuring Δq

$$\langle N,S|\gamma^{\mu}|N,S\rangle \Rightarrow q(x)$$

$$\langle N,S|\gamma^{5}\gamma^{\mu}|N,S\rangle \Rightarrow \Delta q(x)$$ ← Subject of this talk

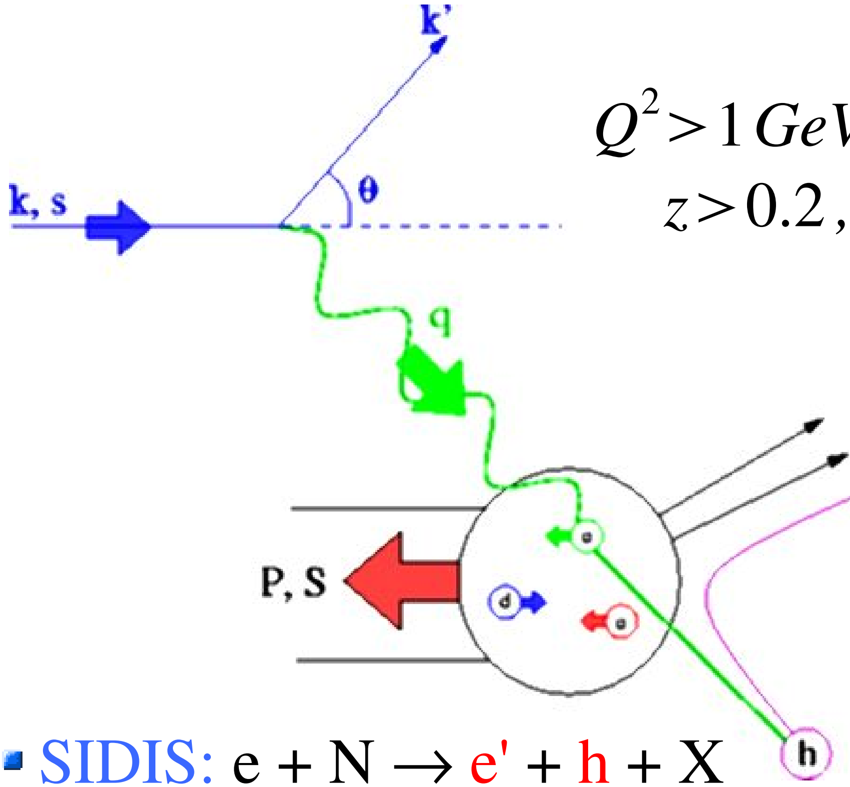
$$\langle N,S|\sigma^{\mu\nu}|N,S\rangle \Rightarrow \delta q(x)$$



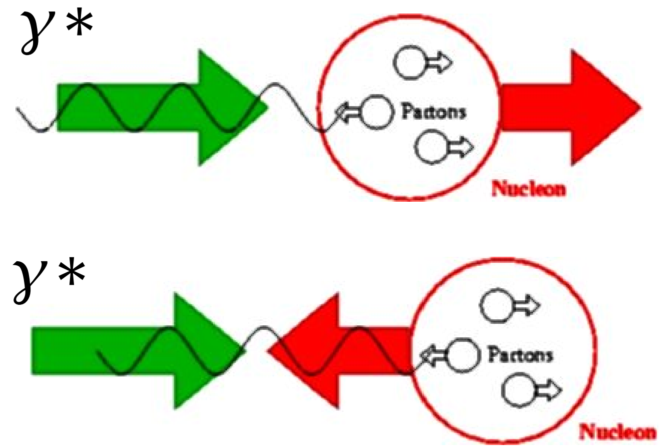
$$\frac{1}{2}=J_q+J_g \quad \Rightarrow \quad J_q=\Delta q+L_q$$

- Only ~30 % of the spin from the quarks. (1980's)
- Comparison w/ non-perturbative theoretical calculations (i.e. LQCD)
- Parton helicity distributions are fundamental property of QCD bound state.

Semi-Inclusive polarized DIS



$$Q^2 > 1\,GeV^2,\ W^2 > 10\,GeV^2$$
$$z > 0.2,\ k_0 = 27.5\,GeV$$

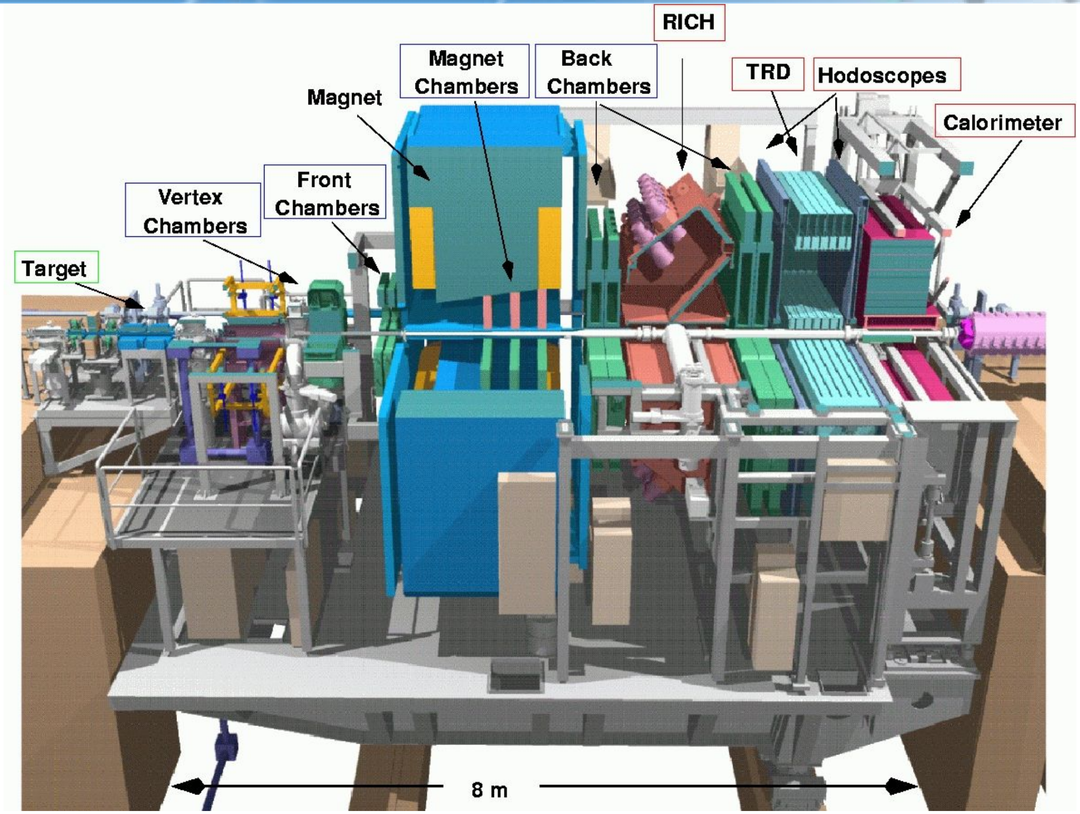


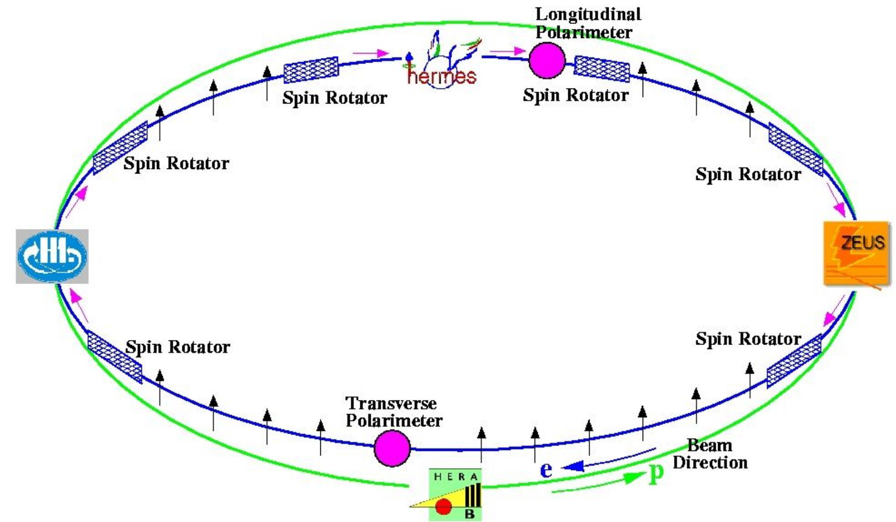
$$\sigma_{\frac{3}{2}} \sim q^-$$
$$\sigma_{\frac{1}{2}} \sim q^+$$

- SIDIS: e + N → e' + h + X
  - → flavor tagging from hadron
  - → sensitive to $\Delta q(x) = q^+(x) - q^-(x)$

$$A_1^{(h)}(x) = \frac{\sigma_{\frac{1}{2}}^{(h)} - \sigma_{\frac{3}{2}}^{(h)}}{\sigma_{\frac{1}{2}}^{(h)} + \sigma_{\frac{3}{2}}^{(h)}} = \frac{1}{<P_B P_t>(1+\eta\gamma)D}\left(\frac{N^{\uparrow\downarrow(h)}\mathcal{L}^{\uparrow\uparrow} - N^{\uparrow\uparrow(h)}\mathcal{L}^{\uparrow\downarrow}}{N^{\uparrow\downarrow(h)}\mathcal{L}^{\uparrow\uparrow} + N^{\uparrow\uparrow(h)}\mathcal{L}^{\uparrow\downarrow}}\right)$$

The HERMES Spectrometer

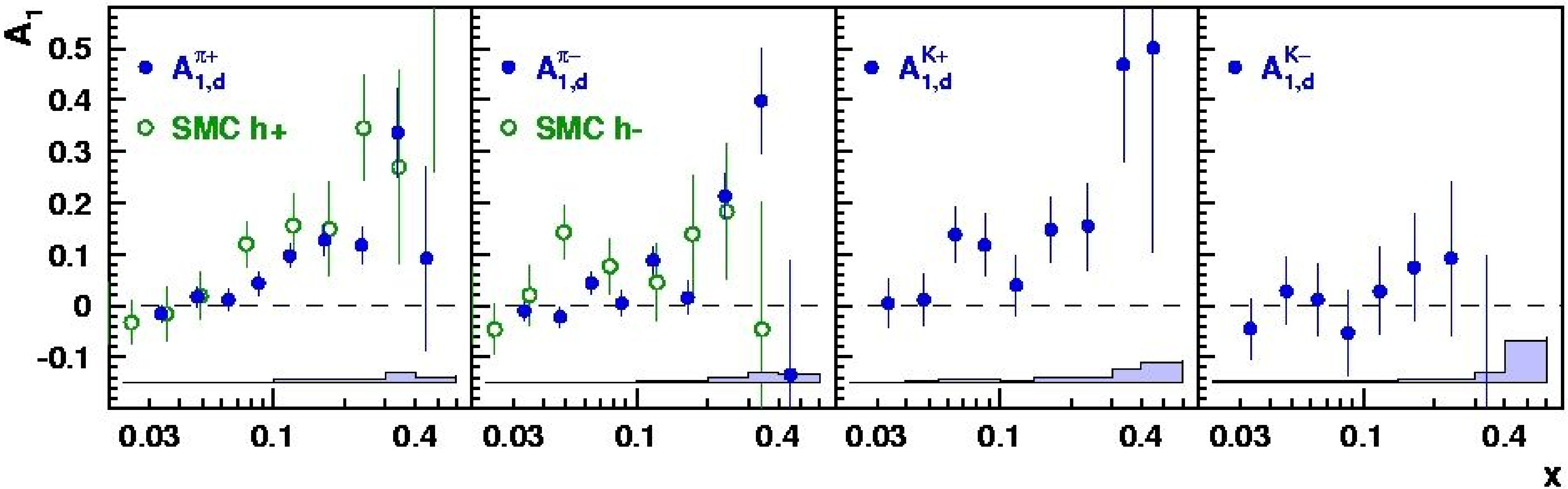




year	DIS (mil)	target	PID
1996	0.65	H	TC
1997	1.72	H	TC
1998	1.11	D	RICH
1999	1.25	D	RICH
2000	6.69	D	RICH
2002			
2003			
2004			

- HERA polarized beam $<P_B>=0.55$.
- Longitudinally polarized gas target $<P_t>=0.88(0.82)$ H(D).
- Lepton ID efficiency 98% < 1% hadron contamination.
- Transverse target since 2002.

SIDIS Deuteron Asymmetries



- Ring Imaging Cerenkov allows separation of π and K.
- K^- window directly into the sea distributions.
- Acceptance/Smearing unfolding method. (error inflation)
- Azimuthal acceptance and charge symmetric background corrections.
- Proton inclusive, and π asymmetries (not shown)
- Future data on proton with RICH is possible.

Purity Method

SIDIS Asymmetries

$$\vec{A}_1 = P \cdot \vec{Q} \quad \Rightarrow$$

$$\chi^2 = \left(\vec{A}_1 - C_R N P \vec{Q}\right)^T v_A^{-1} \left(\vec{A}_1 - C_R N P \vec{Q}\right)$$

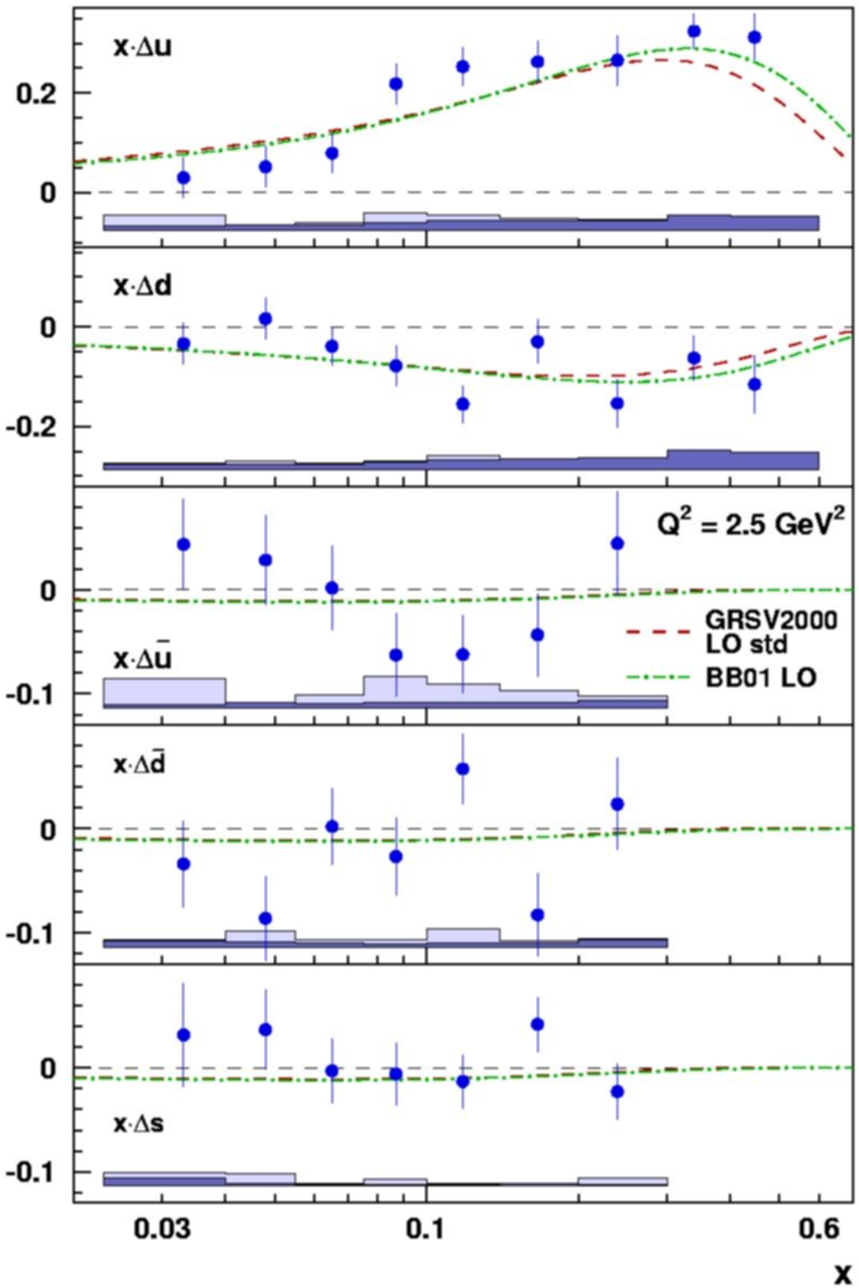
Δq

LUND based Purities

kin. & R(x,Q^2)

- To exploit the "flavor tagging" technique one must have access to the flavor and hadron specific fragmentation functions.
- In our case these are simulated using the LUND string model. (CTEQ5L)

Δq 5 Flavor Extraction

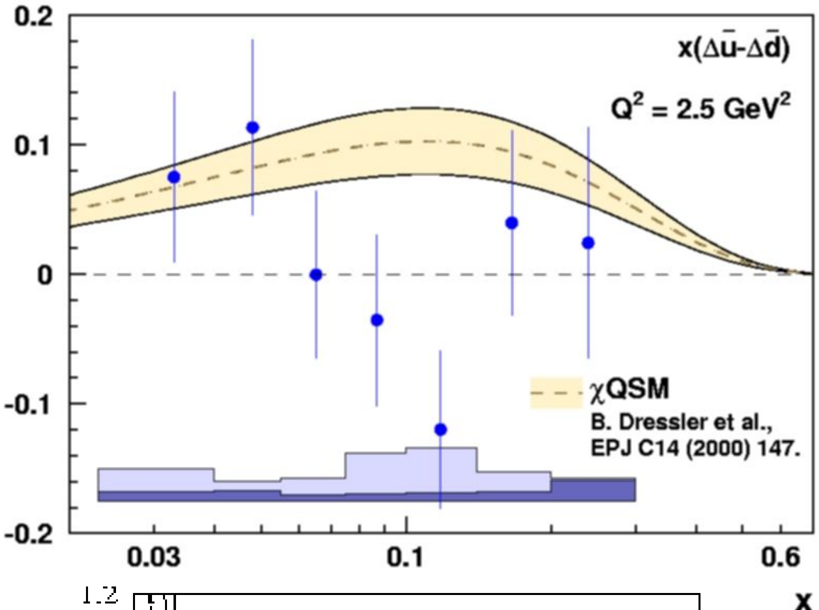


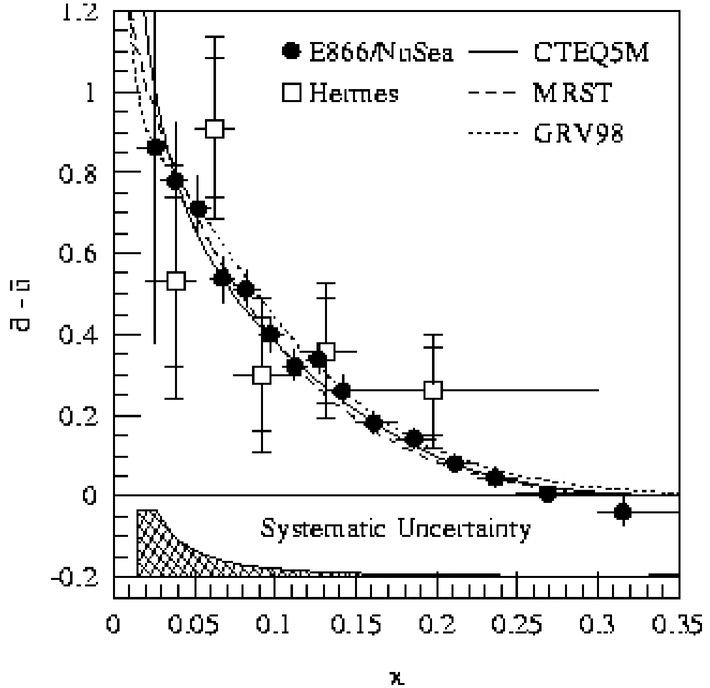
$$Q(x)=\left(\frac{\Delta u}{u},\frac{\Delta d}{d},\frac{\Delta \bar{u}}{\bar{u}},\frac{\Delta \bar{d}}{\bar{d}},\frac{\Delta s}{s}\right)$$

- χ^2 minimization scheme using MINUIT
- Fit all bins and all flavors simultaneously
- $\Delta \bar{s} = 0$ assumed for extraction.
- Symmetric strange sea assumption showed little difference.
- Above x=0.3 set q_s=0
- Unambiguously determined statistical uncertainties

A. Airapetian et al, Phys. Rev. Lett. 92 (2004) 012005

Polarized light sea asymmetry





- Purity analysis with:

$$Q'(x) = \left(\frac{\Delta u}{u}, \frac{\Delta d}{d}, \frac{\Delta \bar{u} - \Delta \bar{d}}{\bar{u} - \bar{d}}, \frac{\Delta \bar{d}}{\bar{d}}, \frac{\Delta s}{s} \right)$$

- No evidence for polarized Isospin breaking. (7.7/7)
- Statistics prevent model "busting."
- Broken symmetry predicted by χQSM. (17.6/7)

Isoscalar method for $\frac{(\Delta s+\Delta \bar{s})}{(s+\bar{s})}$

- $A_{1,d}$ and $A_{1,d}^{K\pm}$ asymmetries only
- 2x2 Purity formalism
- $e^+ e^-$ fragmentation parametrization give purities.
- Does not depend on HERMES Monte Carlo
- Results are consistent with 5 flavor extraction
- λ_s strange suppression factor, major source of error.
- BELLE data could improve the situation

$$D_q^{K^\pm} = \lambda_s D_{e^+ + e^-}^{K^\pm}$$

$$P_q^h(x) = \frac{q(x)\int_{z_{min}}^{z_{max}} dz\, D_q^h(z)}{\Sigma_{q'} e_{q'}^2 q'(x) \int_{z_{min}}^{z_{max}} dz\, D_{q'}^h(z)}$$

Conclusions

- First 5 flavor extraction of polarized quark densities (LO)
- Δu strongly positive and Δd negative
- No evidence of negative strange sea polarization.

(expected from inclusive data)

- No breaking of the light sea flavor asymmetry (within statistics)