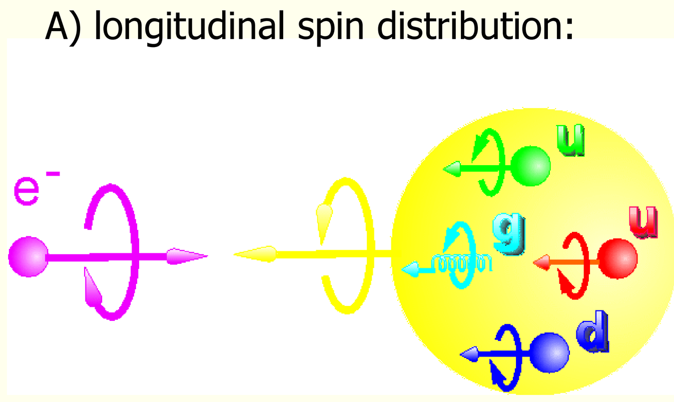
Azimuthal Single-Spin Asymmetries in Semi-Inclusive Deep-Inelastic Scattering

C. Schill for the HERMES Collaboration
Fakultät für Physik, Universität Freiburg, D-79104 Freiburg, Germany

Spin Structure of the Nucleon

Spin structure of the nucleon

A) longitudinal spin distribution:



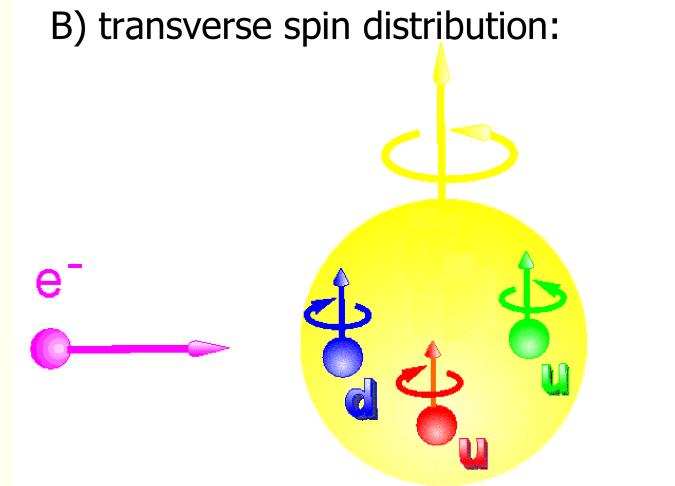
$$\frac{1}{2} = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_g$$

$$\Delta\Sigma = \Delta u + \Delta d + \Delta s + \Delta\bar{u} + \Delta\bar{d} + \Delta\bar{s}$$

measured in deep-inelastic scattering of leptons off the nucleon:
HERMES: $\Delta\Sigma = 0.30 \pm 0.04 \pm 0.09$

Spin structure of the nucleon

B) transverse spin distribution:



- gluons have no transverse polarisation since they are massless

Quarks: transversity distribution δq
structure function h_1

$$h_1 = \frac{4}{9}(\delta u + \delta\bar{u}) + \frac{1}{9}(\delta d + \delta\bar{d} + \delta s + \delta\bar{s})$$

- experimental access in semi-inclusive deep-inelastic scattering: azimuthal distribution of the produced hadrons

Transversity δq

- for non-relativistic quarks:

$$\delta q = \Delta q$$

➡ by comparing δq und Δq the relativistic nature of quarks in the nucleon can be explored.

- sum rule: $\delta\Sigma =$ tensor charge of the nucleon

$$\delta\Sigma = \sum_{q=u,d,s} \int_0^1 dx\,(\delta q - \delta\bar{q})$$

QCD-calculations on the lattice give:
$\delta\Sigma = 0.562 \pm 0.088$ (Q^2=2 GeV^2)

Aoki et al. Phys. Rev D 56:433 (1997)

- upper limit:

$$|\delta q(x)| \le q(x)$$

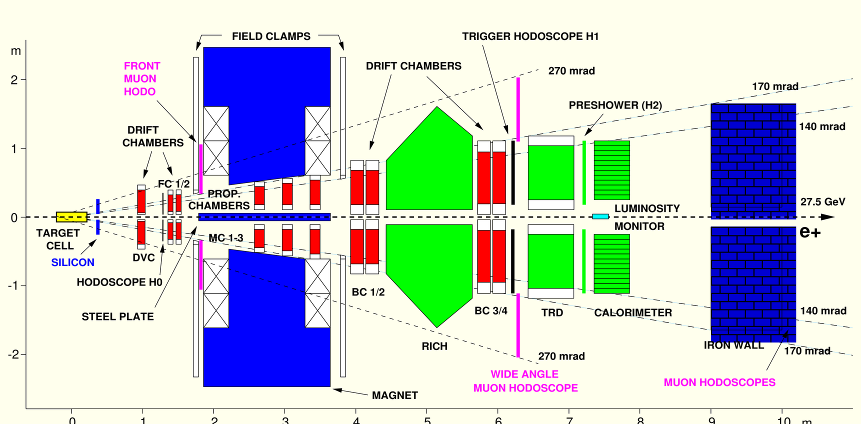
- Soffer-bound:

$$|\delta q(x)| \le \frac{1}{2}[q(x) + \Delta q(x)]$$

The HERMES Experiment — Asymmetries

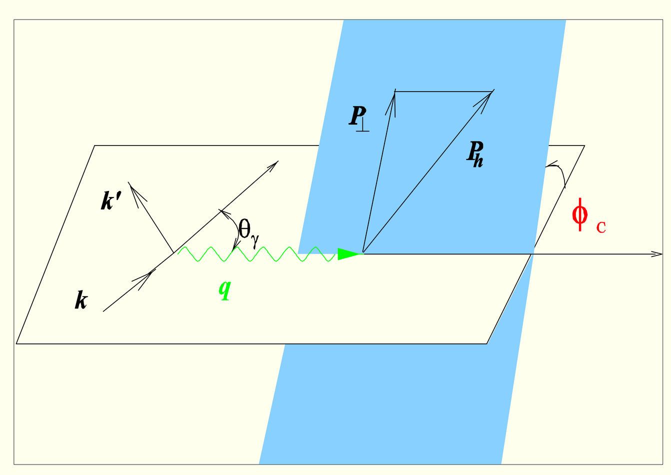
Measurement of δq

- HERMES-experiment at DESY:



- 27 GeV electrons/positrons
- longitudinally polarized hydrogen/deuteron-target
- detection of the scattered electron and the hadrons from the fragmentation process in a semi-inclusive measurement

Kinematics of semi-inclusive scattering



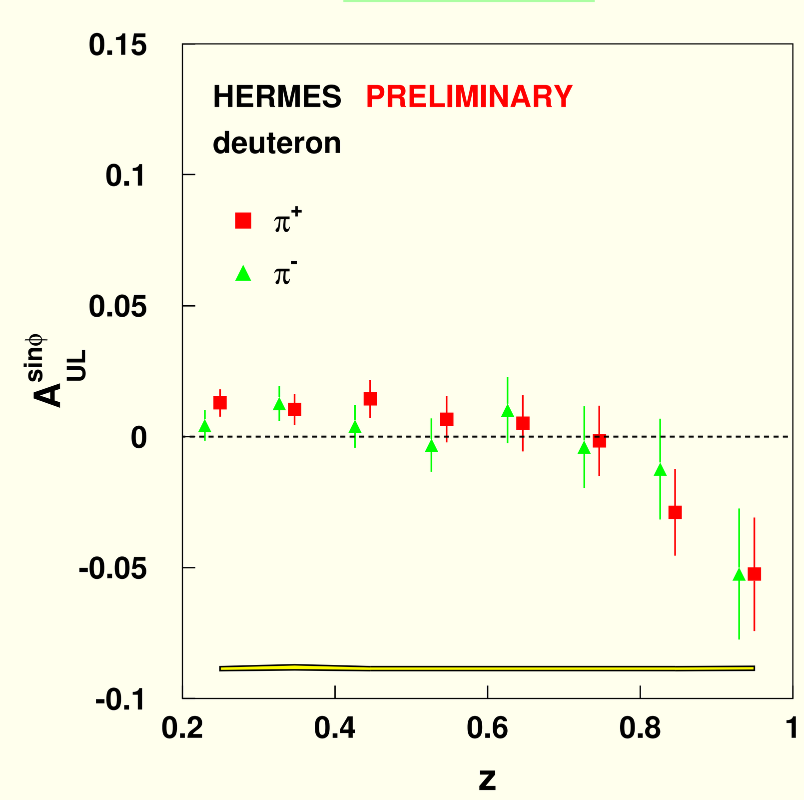
- azimuthal angle ϕ of the scattered hadron in semi-inclusive scattering
- target-spin asymmetry:

$$A_{UL}(\phi) = \frac{1}{|P_{Target}|} \cdot \frac{N^{\rightarrow}(\phi) - N^{\leftarrow}(\phi)}{N^{\rightarrow}(\phi) + N^{\leftarrow}(\phi)}$$

Measurement of single-spin asymmetries on the deuteron

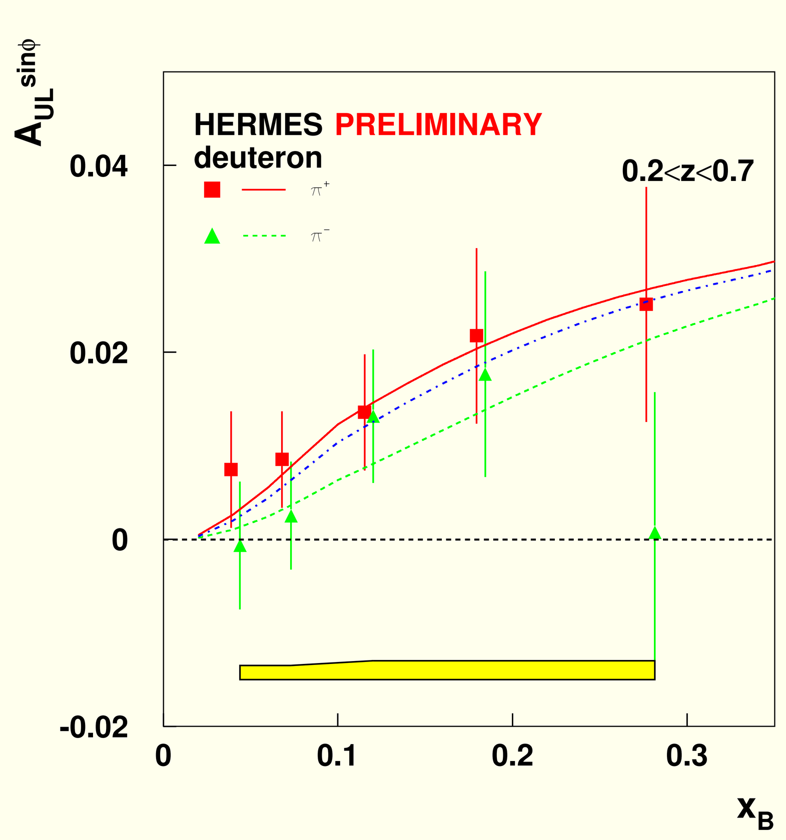
$$A_{UL}^{\sin\phi} \propto \frac{\sum_q e_q^2 \delta q(x) H_1^{\perp q}(z)}{\sum_q e_q^2 q(x) D_1^q(z)}$$

$$e\,\vec{d} \rightarrow e'\,\pi\,X$$



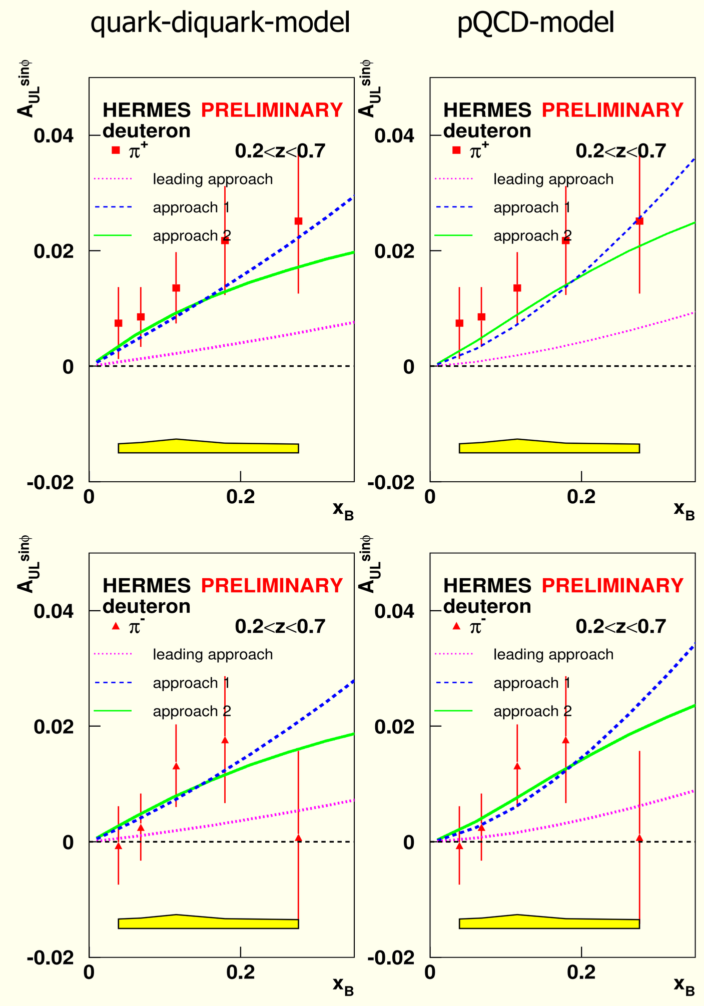
Comparison with Theoretical Models

Pion single-spin asymmetry



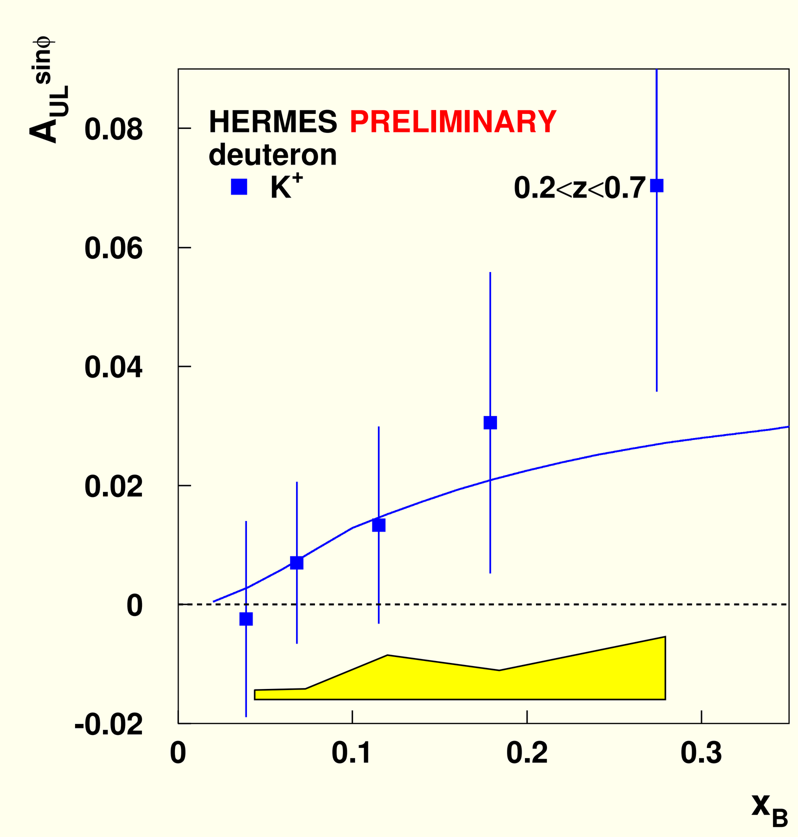
chiral quark-soliton model
(Efremov et al. PLB 478:94 (2000))

Comparison with theory predictions



Ma et al., Phys.Rev.D65:034010 (2002)

Kaon single-spin asymmetry



chiral quark-soliton model
(Efremov et al. PLB 478:94 (2000))