

HERMESの偏極深非弾性散乱によ クォークフレーバーごとの 偏極分布関数の測定

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HERMES Experiment

Hermes Spectrometer at DESY-HERA

Longitudinally polarized $e^+(e^-)$ beam

27.6 GeV, polarization $\langle P_B \rangle \sim 60\%$

Internal Target

longitudinally polarized

H (1996,1997), D (1998 ~ 2000) target

Particle Identification :

hadron identification

- **Threshold Cherenkov Counter**

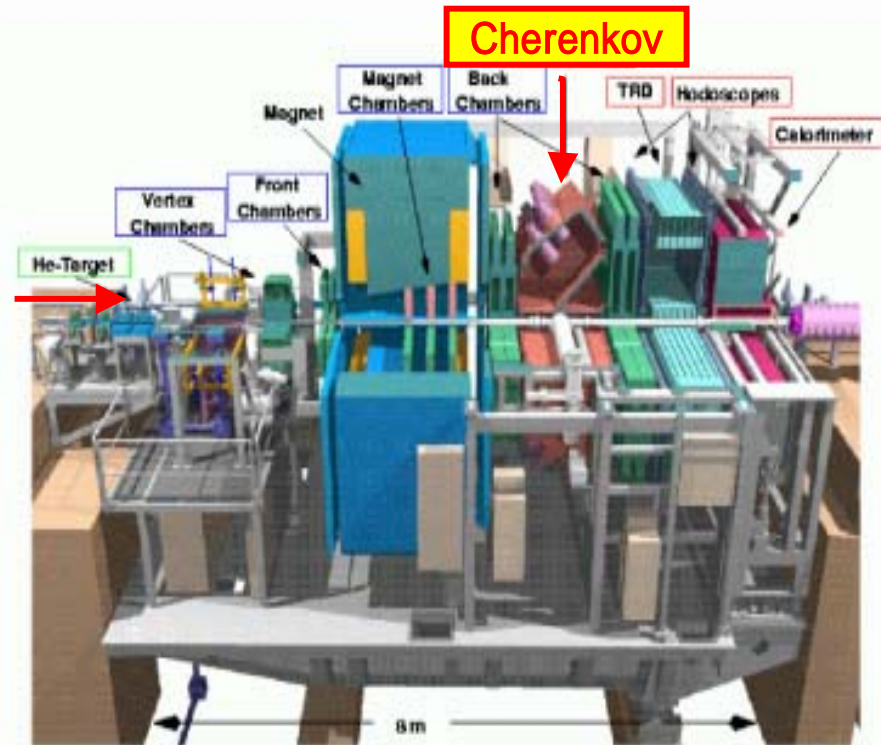
1995 ~ 1997

identification (4.9 ~ 13.5 GeV/c)

- **Ring Imaging Cherenkov Counter (RICH)**

1998 ~

, **K, p** separation (2 ~ 15 GeV/c)



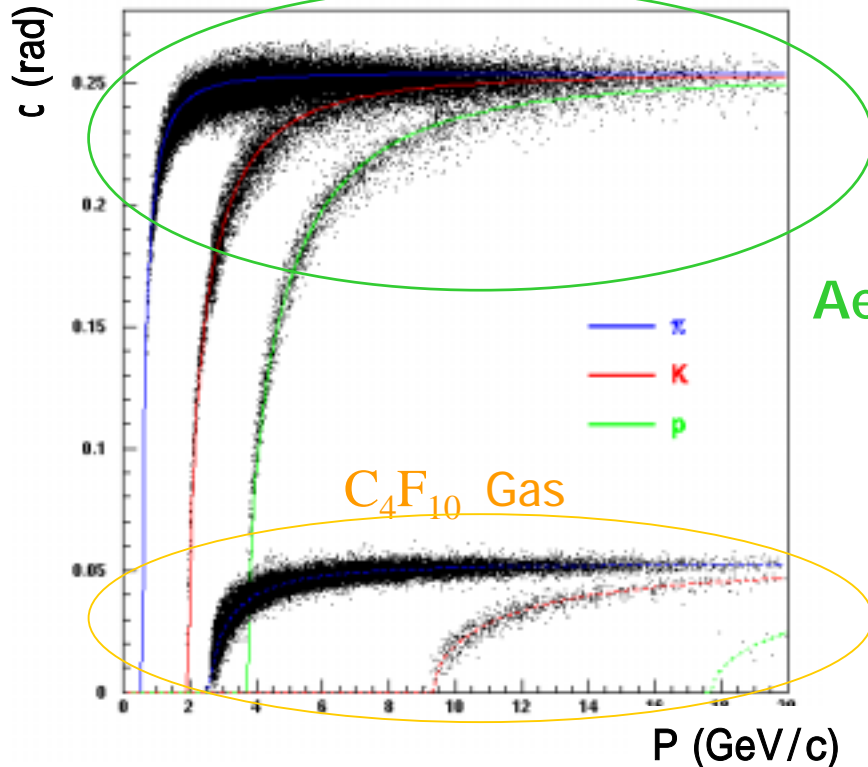


Ring Imaging Cherenov Counter

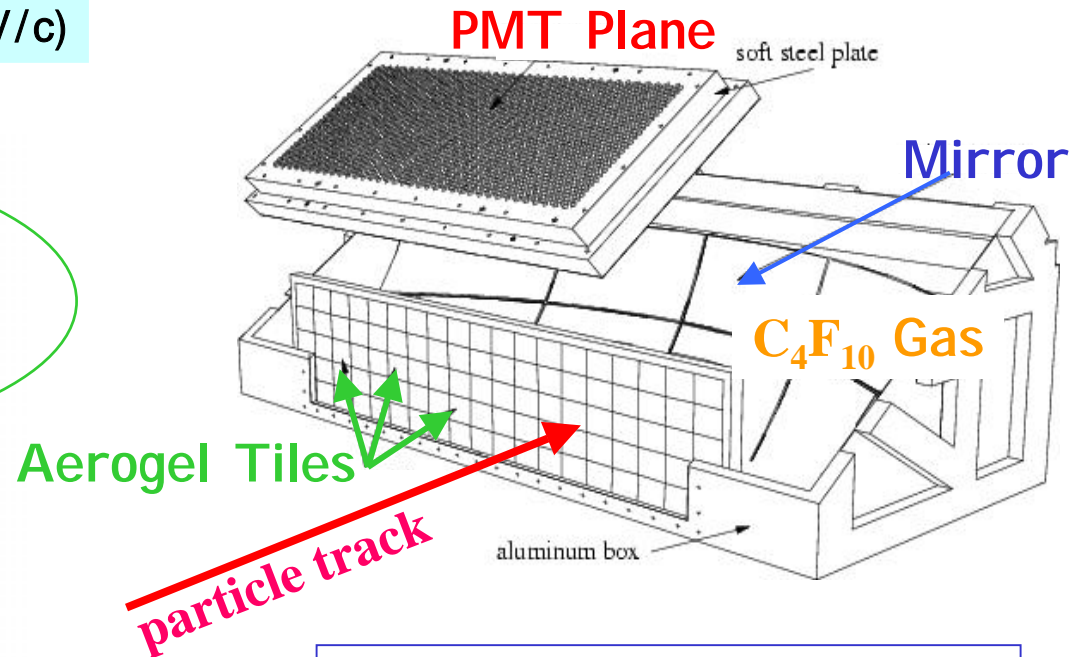
1998 ~ 2000 data

Cherenkov angle(θ_c) vs Momentum (GeV/c)

Aerogel Tiles



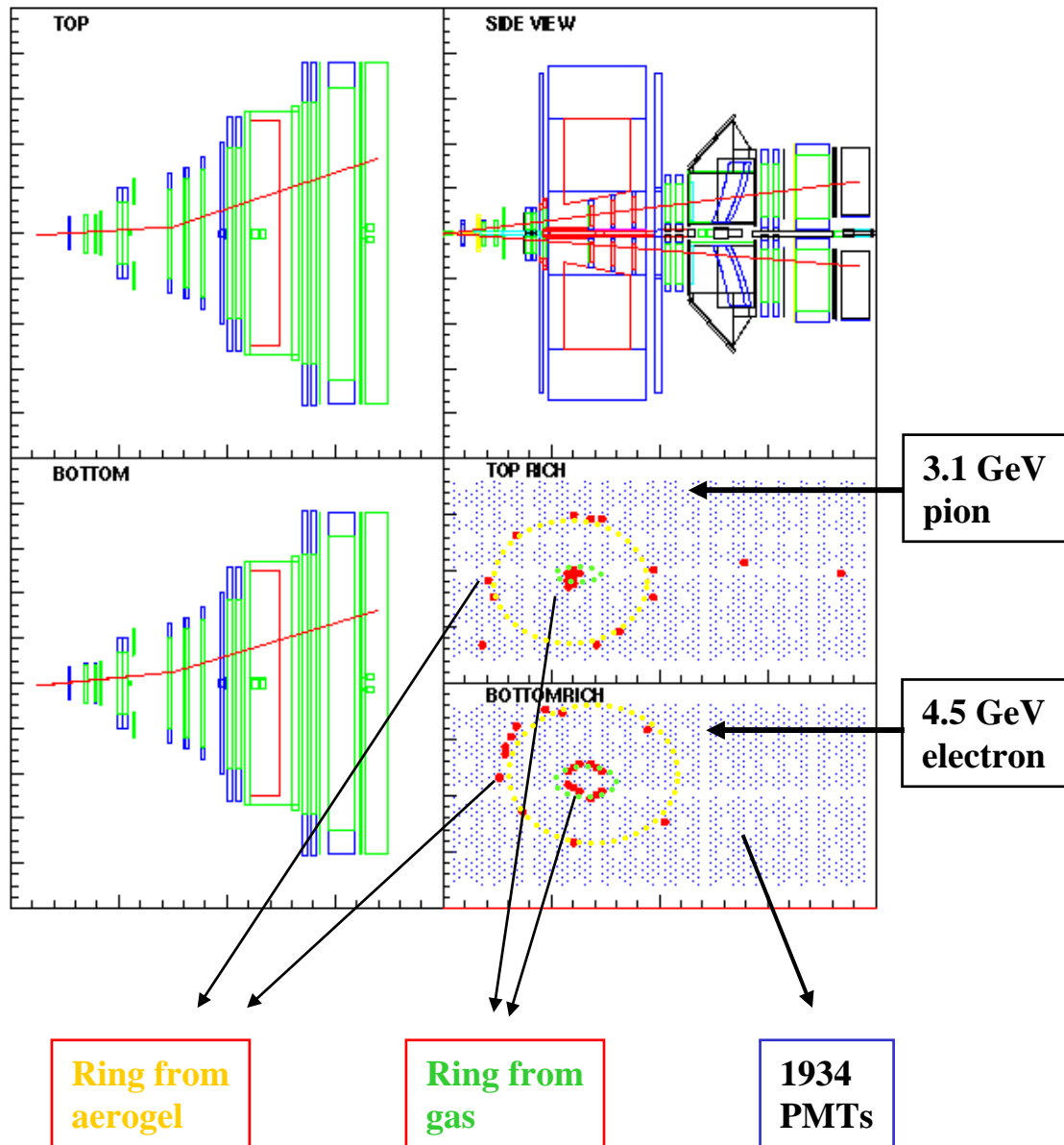
$$\cos \theta_c = \frac{1}{\frac{v}{c} n}$$



- Radiator
 - C_4F_{10} Gas $n=1.0014$
 - Aerogel Tiles $n=1.0303$
- PMT
 - 3/4 inch 1934 PMTs
- Momentum region
 - 2 ~ 15 GeV/c

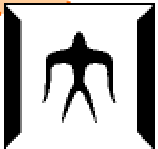
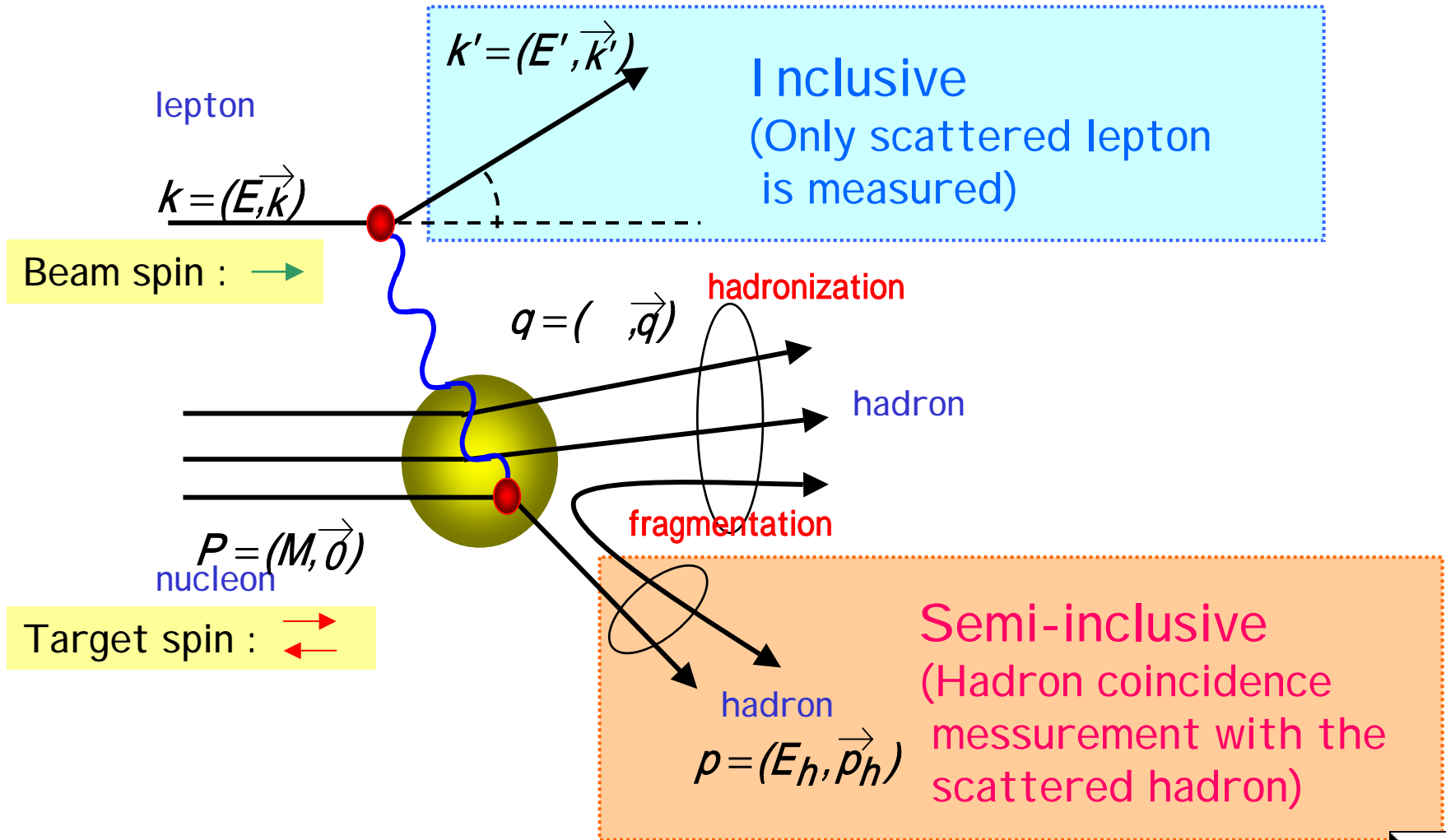


Ring Imaging Cherenkov Counter



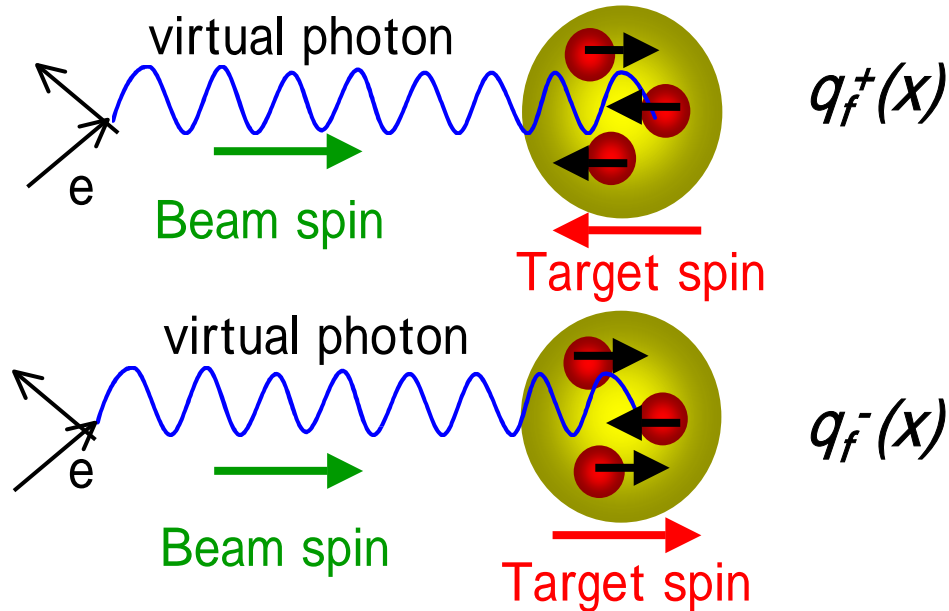


Hadron Coincidence Measurement





Spin Asymmetries



Polarized Quark Distribution
 $q_f(x)$ $q_f^+(x) - q_f^-(x)$

Inclusive/Hadron Spin Asymmetry A_1

$$A_1^{e/h}(x, Q^2) = \frac{N_{e/h}^{\rightarrow\leftarrow} - N_{e/h}^{\leftarrow\rightarrow}}{N_{e/h}^{\rightarrow\rightarrow} + N_{e/h}^{\leftarrow\leftarrow}}$$

$N_{e/h}$: Total number of inclusive leptons/semi-inclusive hadrons





DATA Samples

Year	1996	1997	1996-97
Target	H		
DIS event($\times 10^6$)	0.49	1.28	1.77
$\langle P_B P_T \rangle$	0.4	0.45	0.44

Year	1998	1999	2000	1998-2000
Target	D			
DIS event($\times 10^6$)	0.75	0.92	4.81	6.48
$\langle P_B P_T \rangle$	0.43	0.43	0.45	0.44

All numbers after data quality and kinematic cuts

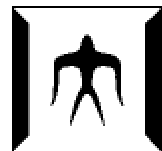
Typical Kinematics and Cuts

$$W^2 > 10 \text{ GeV}^2$$

$$1.0 < Q^2 < 15 \text{ GeV}^2$$

$$z = E_h / \dots > 0.2$$

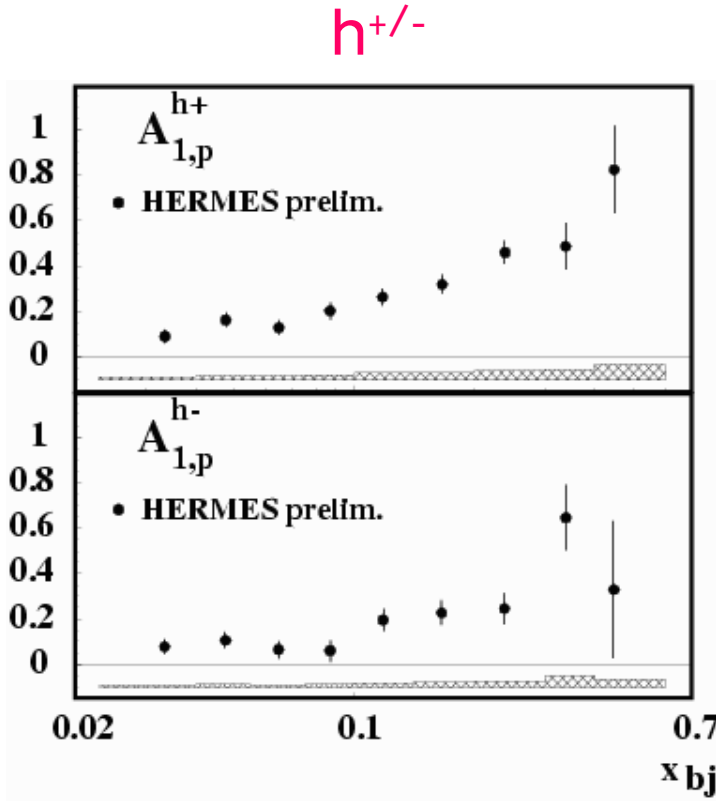
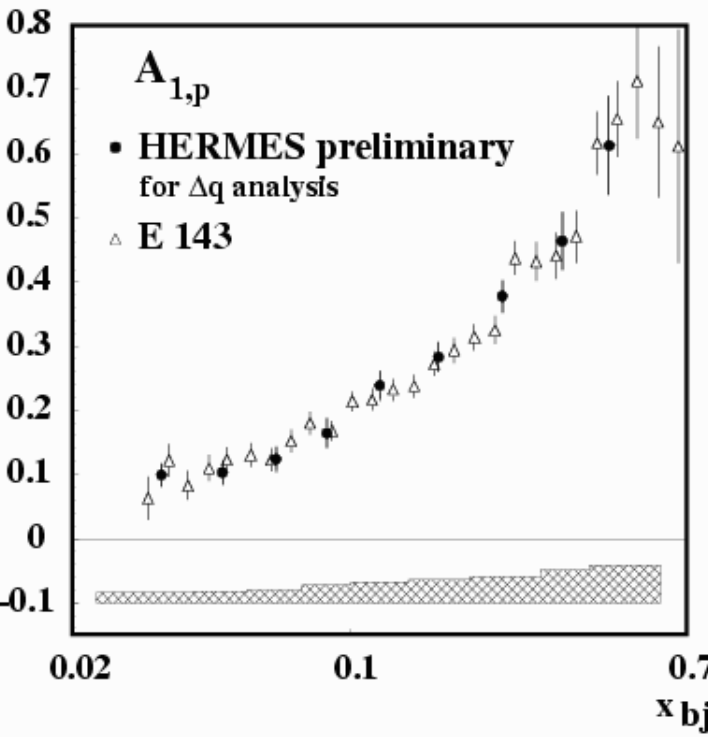
$$x_F > 0.1$$



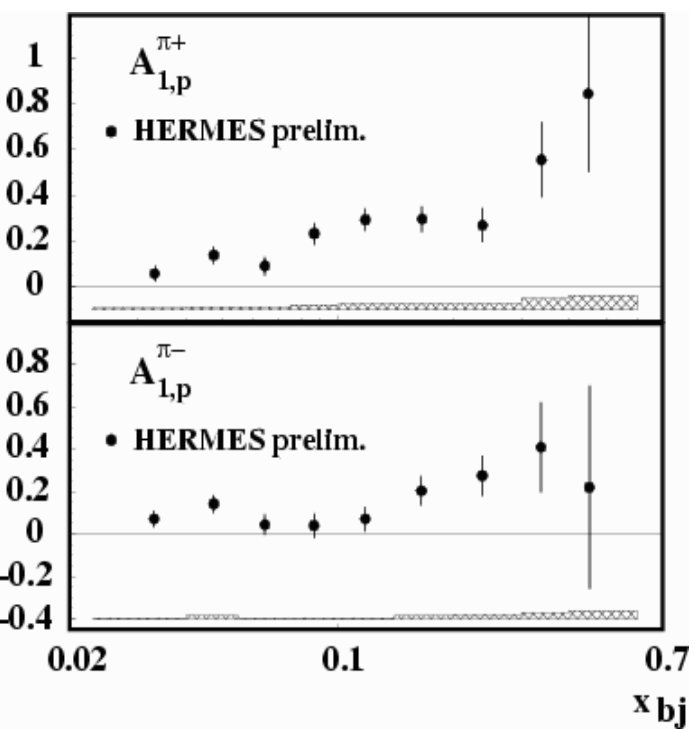


Measured Asymmetries on Proton Target

Inclusive



+/-



1996~1997
data

+/- identification
by

Threshold Cherenkov Counter
in 4.9 ~ 13.5 GeV/c

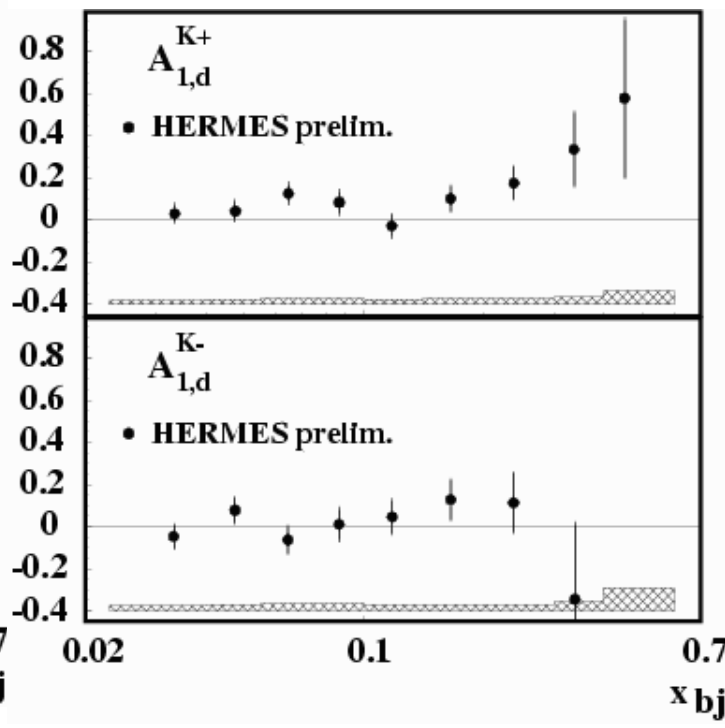
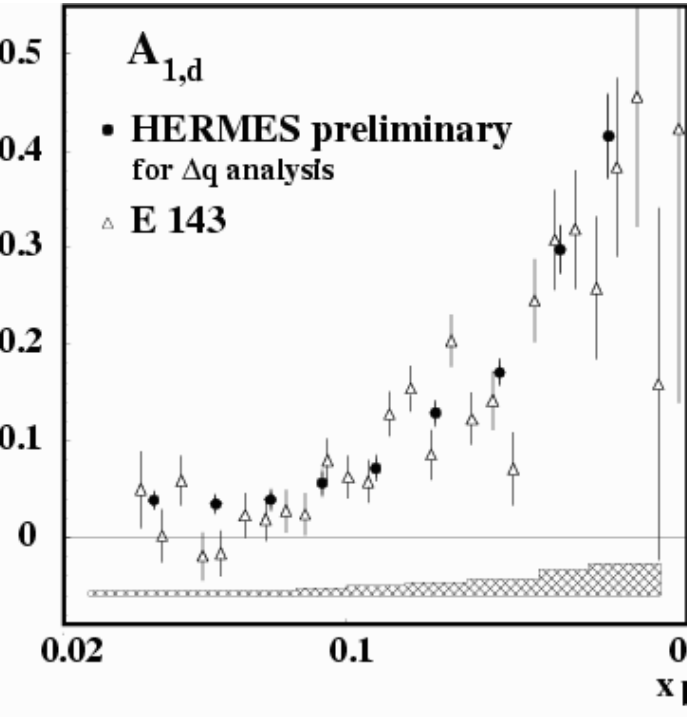




Measured Asymmetries on Deuterium Target

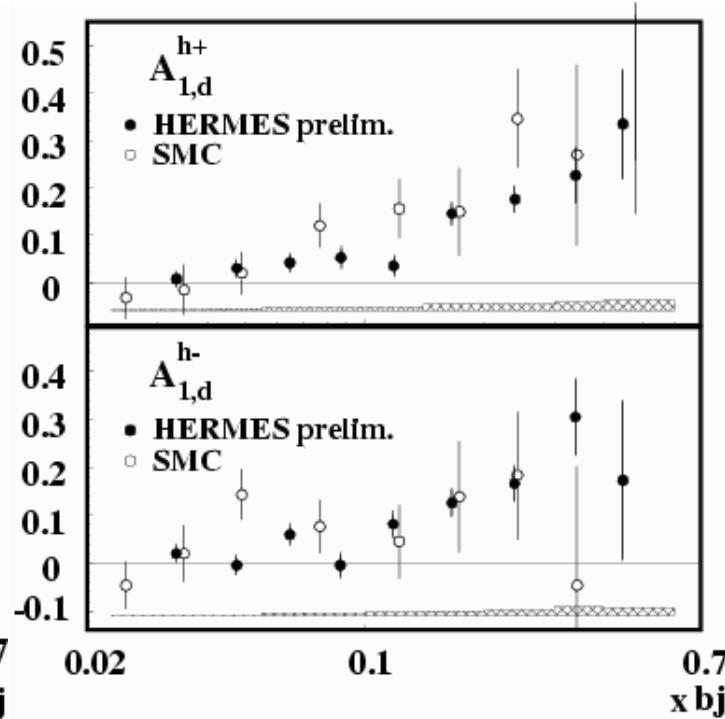
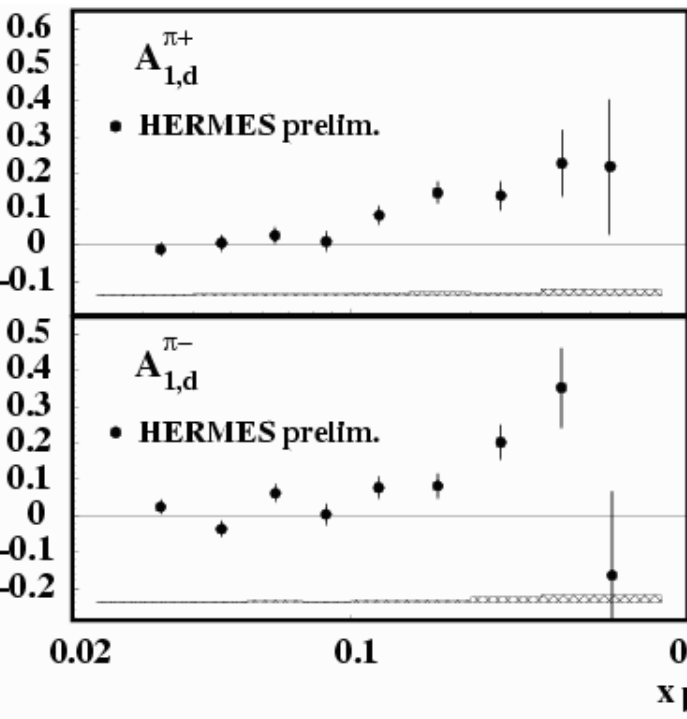
Inclusive

$K^{+/-}$



$+/-$

$h^{+/-}$





Extraction of Quark Polarization using Purity

Measured Spin Asymmetry for hadron h in Quark Parton Model (QPM)

$$A_1^h(x) = \sum_f \frac{e_{q_f}^2 \cdot q_f(x) \cdot \int dz D_{q_f}^h(z)}{\sum_f e_{q_f}^2 \cdot q_f(x) \cdot \int dz D_{q_f}^h(z)} \cdot \frac{q_f(x)}{q_f(x)}$$

$D_{q_f}^h(z)$
Fragmentation function

Purity Matrix Method

Extract the quark polarizations $q/q(x)$

$$A = P \cdot Q$$

$$A = \begin{pmatrix} A_1^{h_1}(x) \\ M \\ A_1^{h_m}(x) \end{pmatrix}$$

$$P = \begin{pmatrix} P_{f_1}^{h_1}(x) & \Lambda & P_{f_n}^{h_1}(x) \\ M & O & M \\ P_{f_1}^{h_m}(x) & \Lambda & P_{f_n}^{h_m}(x) \end{pmatrix}$$

$$Q = \begin{pmatrix} q_1/q_1(x) \\ M \\ q_n/q_n(x) \end{pmatrix}$$

Measured Asymmetries (Input)

Purity Matrix

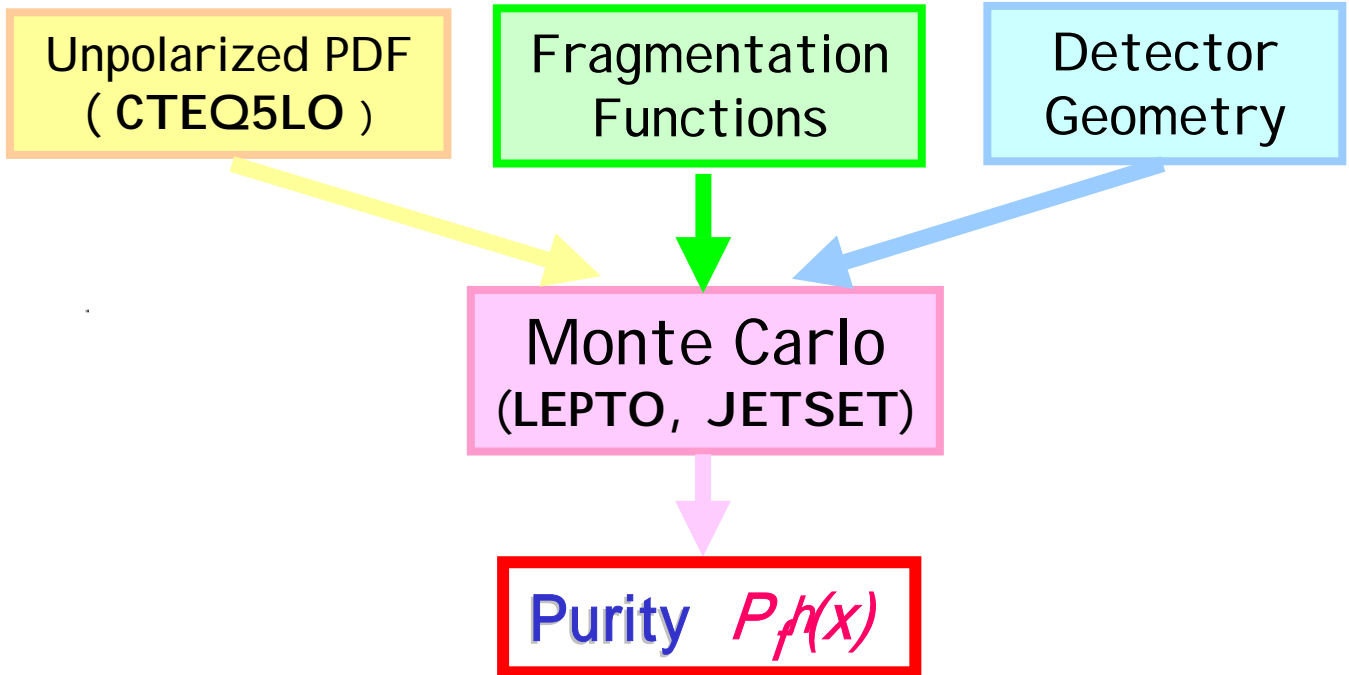
P_{qh} : Correlation between hadron " h " and quark " q ".

Extracted Quark Polarizations
 q/q : polarization
 q : pol. Distribution (Output)



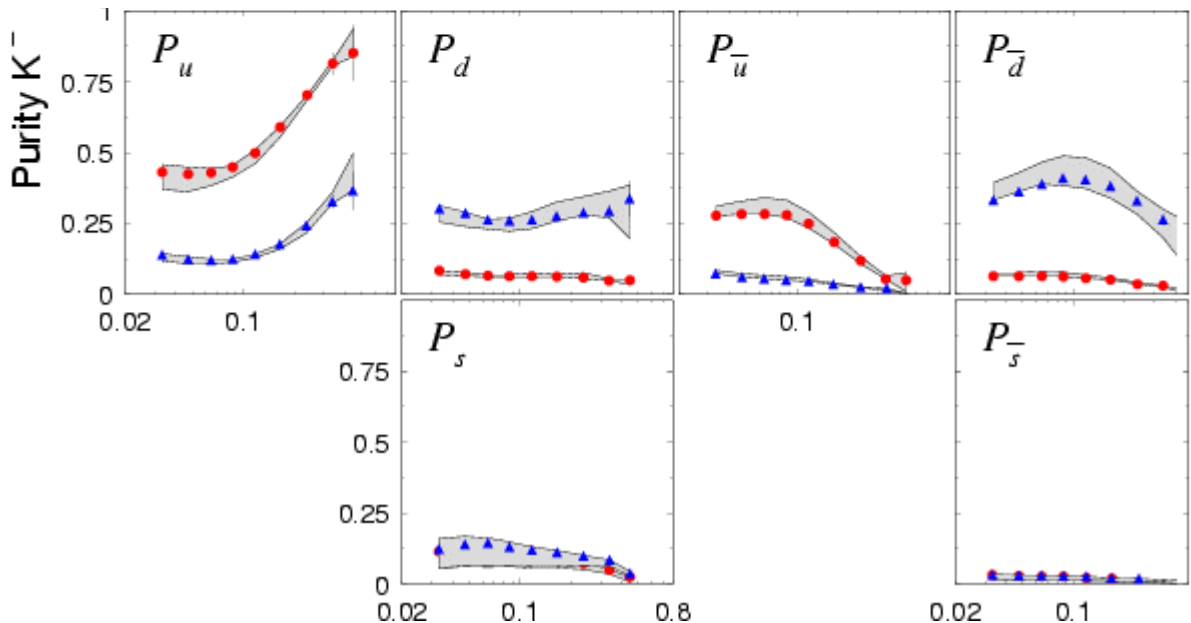
Purity Matrix

Calculated Monte Carlo tuned
for HERMES experiment



Purities Kaon K^-

$$\begin{aligned}
 |K^+ \rangle &= |u \bar{s} \rangle \\
 |K^- \rangle &= |\bar{u} s \rangle
 \end{aligned}$$





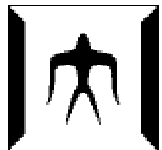
Extraction of Quark Polarization

For quark polarization

Old assumption $\frac{\bar{u}(x)}{\bar{u}(x)} = \frac{\bar{d}(x)}{\bar{d}(x)} = \frac{s(x)}{s(x)} = \frac{\bar{s}(x)}{\bar{s}(x)}$

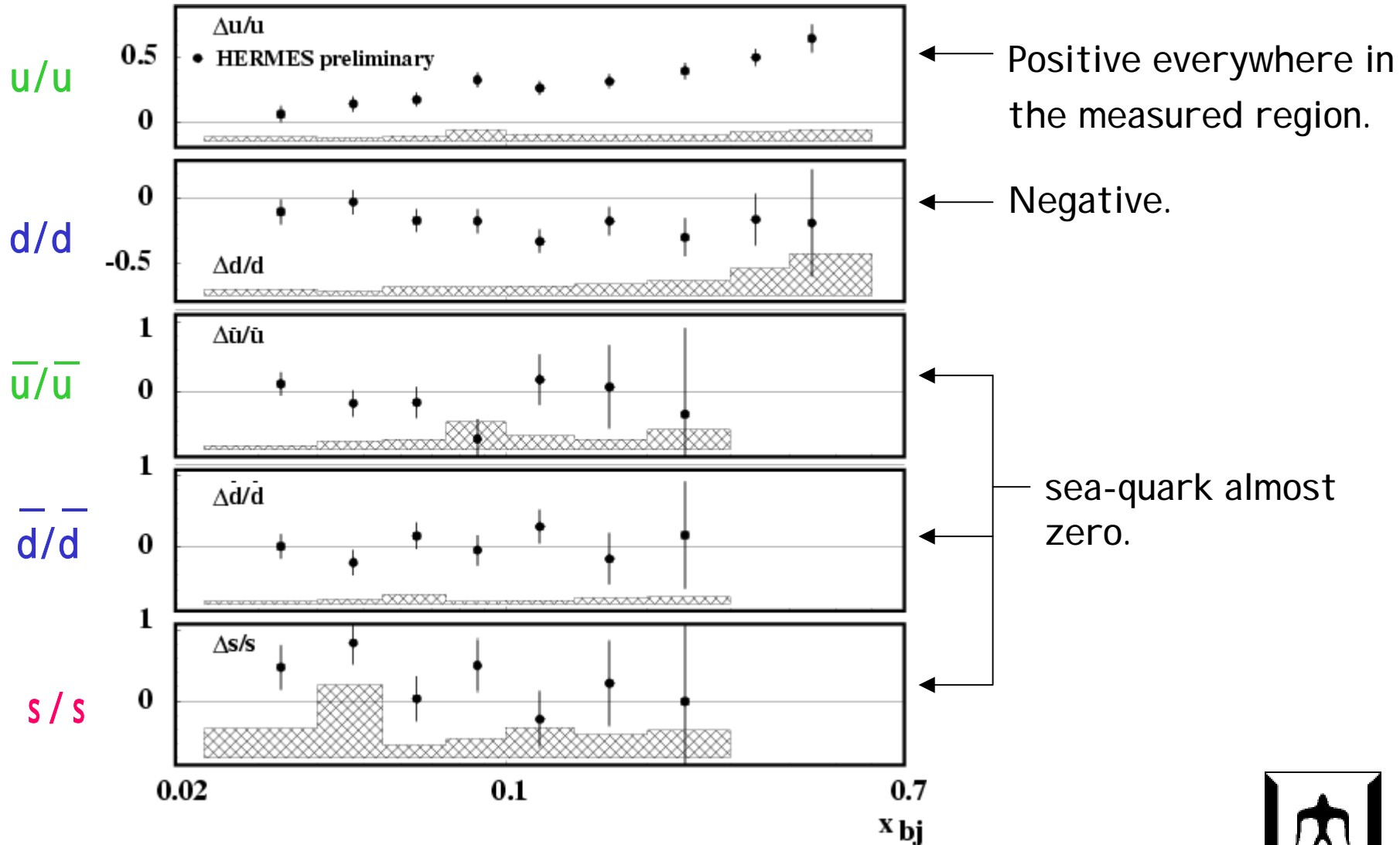
New assumption

~~$\frac{\bar{u}(x)}{\bar{u}(x)} = \frac{\bar{d}(x)}{\bar{d}(x)}, \frac{s(x)}{s(x)} = \frac{\bar{s}(x)}{\bar{s}(x)}$~~





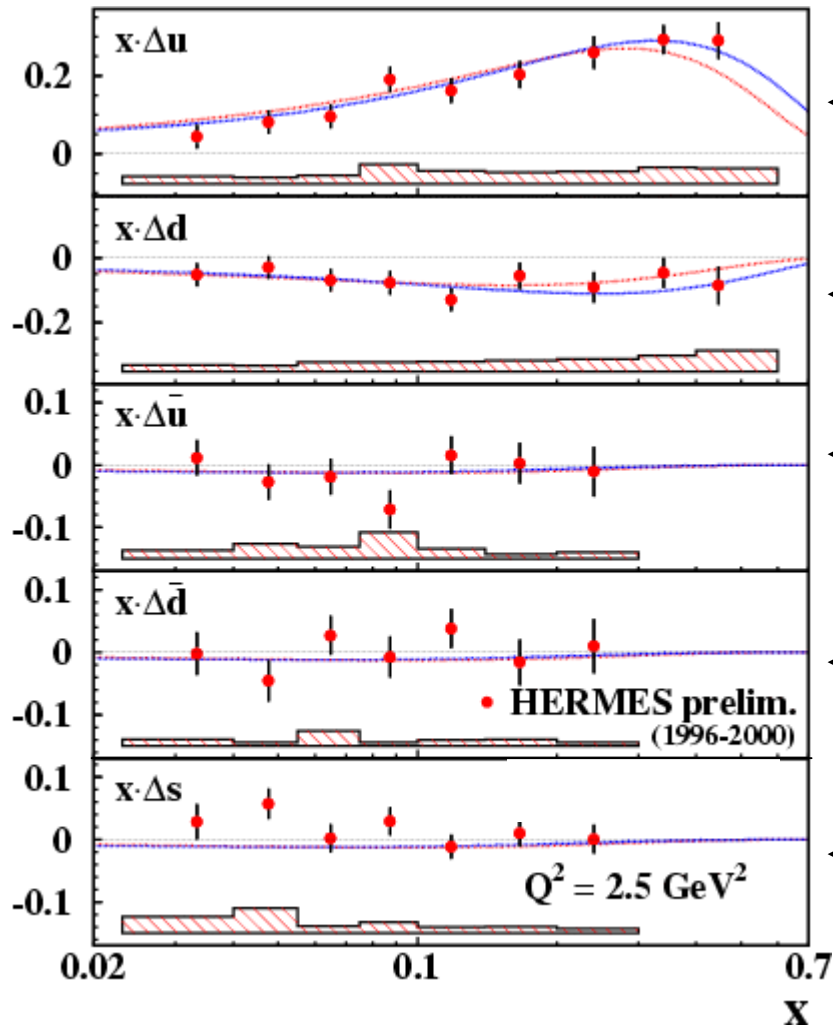
Extracted Quark Polarization





Extracted Quark Polarized

x_{bj} weighted Density



← Positive contribution to nucleon spin in the measured region.

← Negative contribution.

← Sea quark contribution almost zero.

- : GRSV/(1+R)
parameterization Ref. [1]
- : Bluemlein-Boettcher
parameterization Ref. [2]
($Q^2=2.5\text{GeV}^2$)

[1] PHYS. REV. D 53 (1996) 4775, 'STANDARD' SCENARIO, LEADING ORDER

[2] hep-ph/0203155, LEADING ORDER - Scenario 1



Summary and Outlook

1. Polarized quark distributions on H, D target.
2. RI CH detector installation allows to extract Kaon asymmetry.
3. Individual polarized quark distributions
5 parameter decomposition for **the first time**
(**u**, **d**, \bar{u} , \bar{d} , **s** ; except $s = \bar{s}$)
4. Extraction of the strange sea quark polarization and densities for **the first time**.
Zero or slightly positive for **s/s**, **s**.

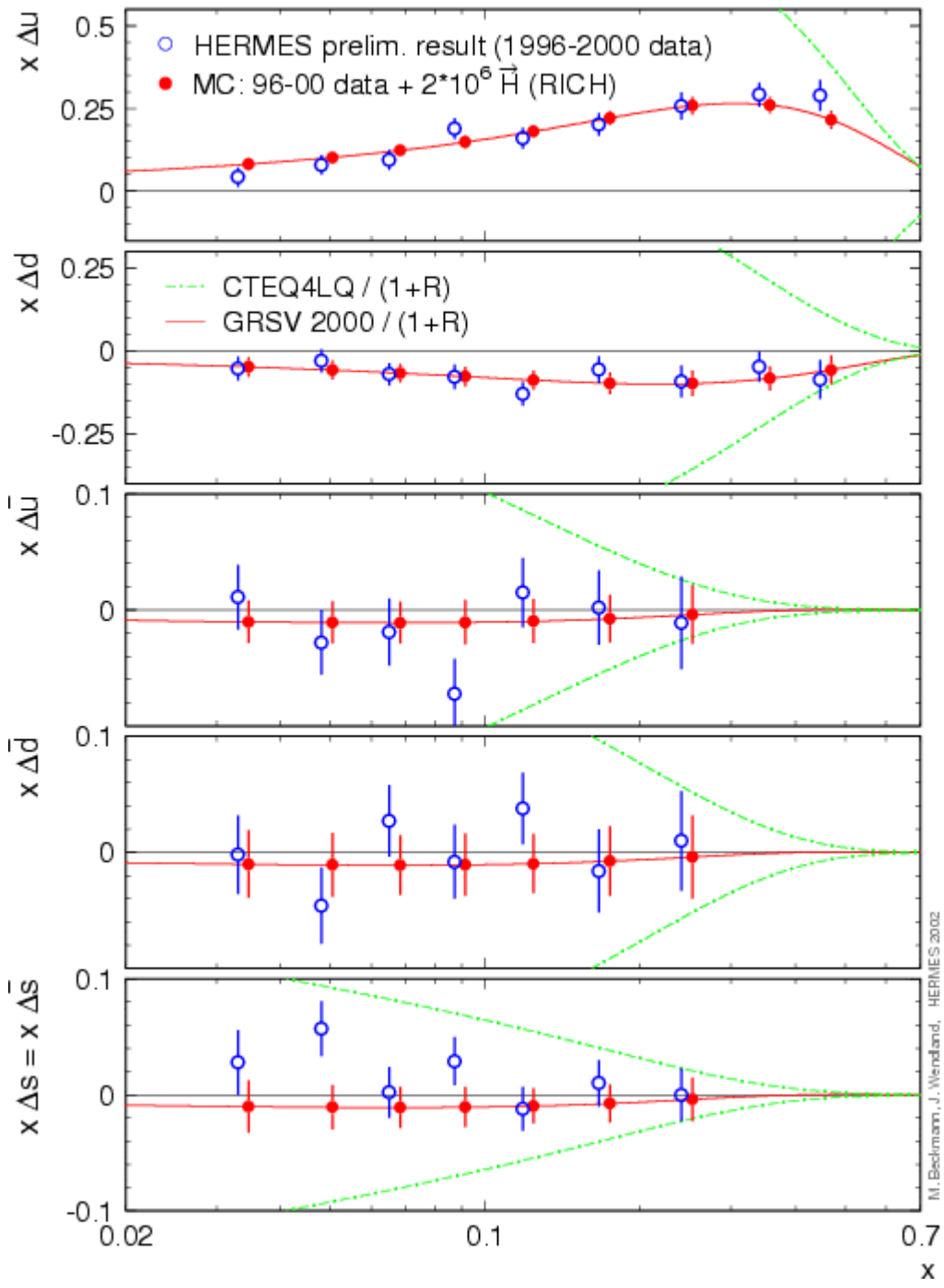
New data of proton target will be added soon, and reduced statistical uncertainties.





Expected statistical precision on $x \ q$ for proton target

HERMES Δq extraction — MC projection



M. Bedjiam, J. Wendland, HERMES 2002

