Spin-Dependent Deep Inelastic Scattering from the Neutron with HERMES

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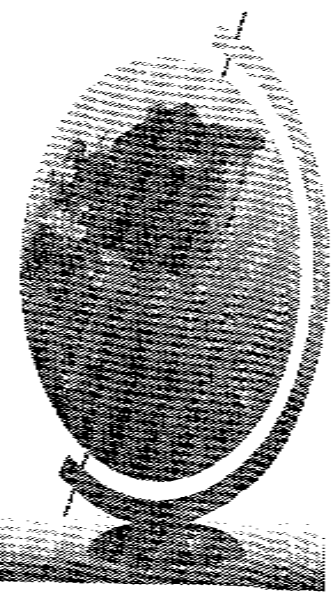
For the HERMES Collaboration

- Introduction / Physics Goals
- HERMES Experiment
- First Results
- Conclusion and Prospects

The HERMES Collaboration

- Alberta
- ANL
- Caltech
- Colorado
- DESY
- Dubna
- Erlangen
- Gent
- Ferrara
- Frascati
- Freiburg
- Heidelberg
- Illinois
- Liverpool
- Madison
- Marburg
- MIT
- Moscow
- Munich
- NMSU
- NIKHEF
- Oregon State
- Pennsylvania
- St. Petersburg
- Rome
- Tokyo
- Triumf/SFU
- Yerevan
- Zeuthen



The HERMES Experiment

GOAL:

Comprehensive Set of Spin Dependent Electron Scattering Measurements

- Proton / Neutron Targets
- Inclusive / Semi-Inclusive Scattering

⇒ Flavor Dependent Valence and Sea Quark and Gluon Contributions to the Nucleon Spin

$$s_z^N = \frac{1}{2} = \frac{1}{2}(\Delta u + \Delta d + \Delta s) + \Delta G + L_q + L_G$$

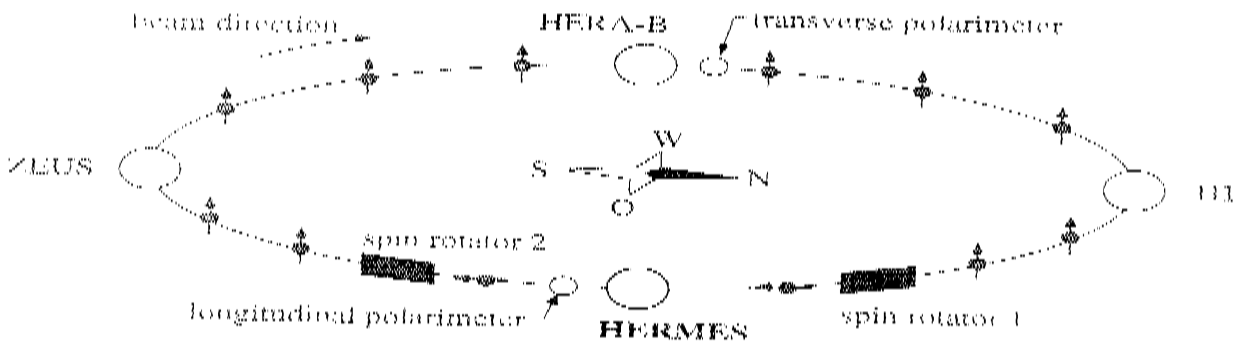
⇑ Valence & Sea ⇑ Gluons ⇑ ⇑ Orbital A.M.

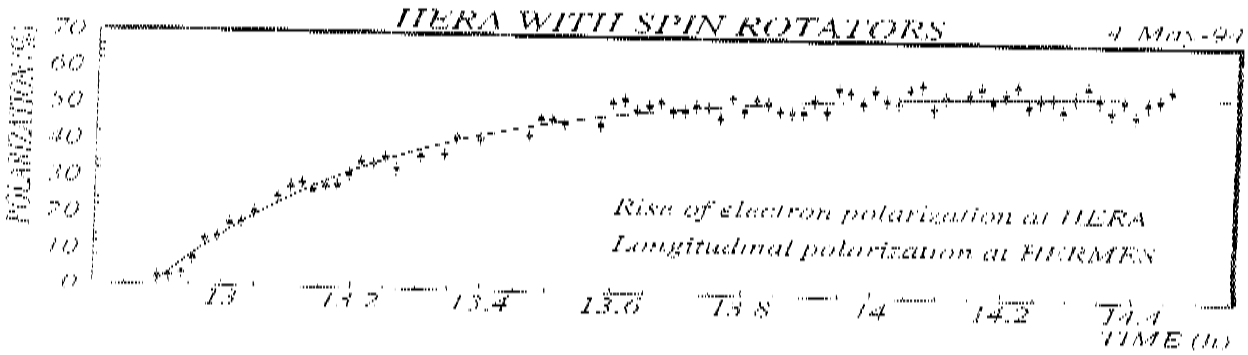
NOVEL EXPERIMENTAL APPROACH:

- Longitudinally Polarized Electron Beam in Storage Ring
  27 GeV e^-'s (e^+'s) in DESY's HERA Ring
- Polarized Internal Targets
  H / D / ^{3}He
- Spectrometer to Detect Final State
  Tracking / Particle ID / Calorimetry

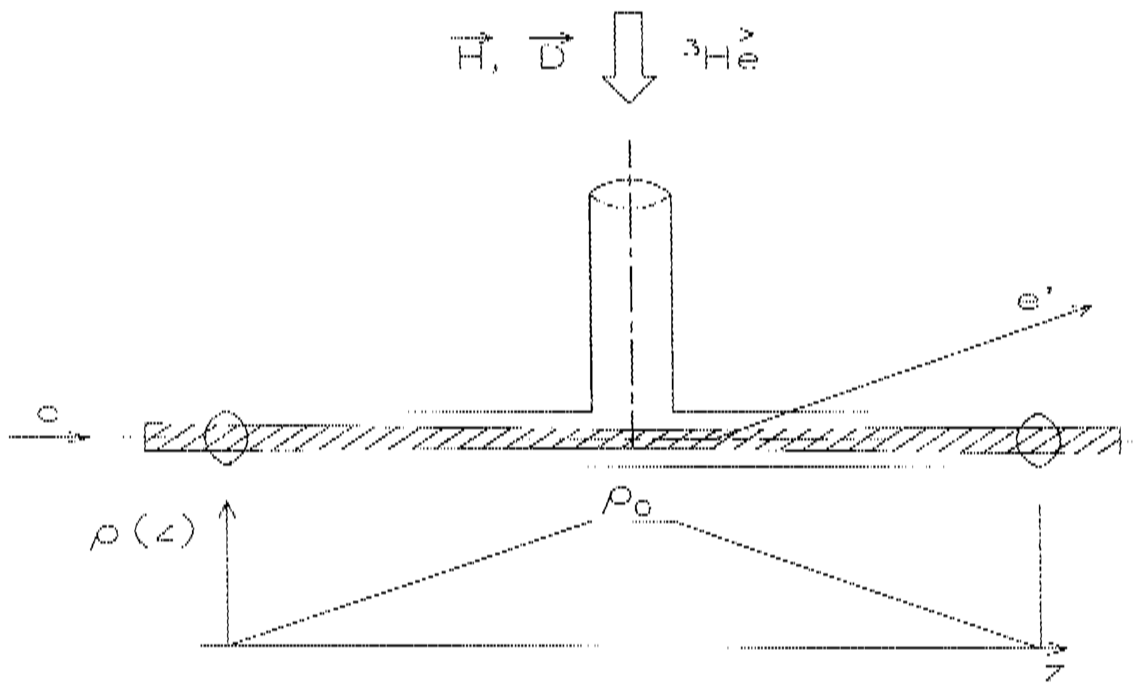
Polarized HERA Beam:

- Self-polarization by Sokolov-Ternov effect
- Spin Rotators — Longitudinal Spin
- $P_B \sim 40 - 60\%$



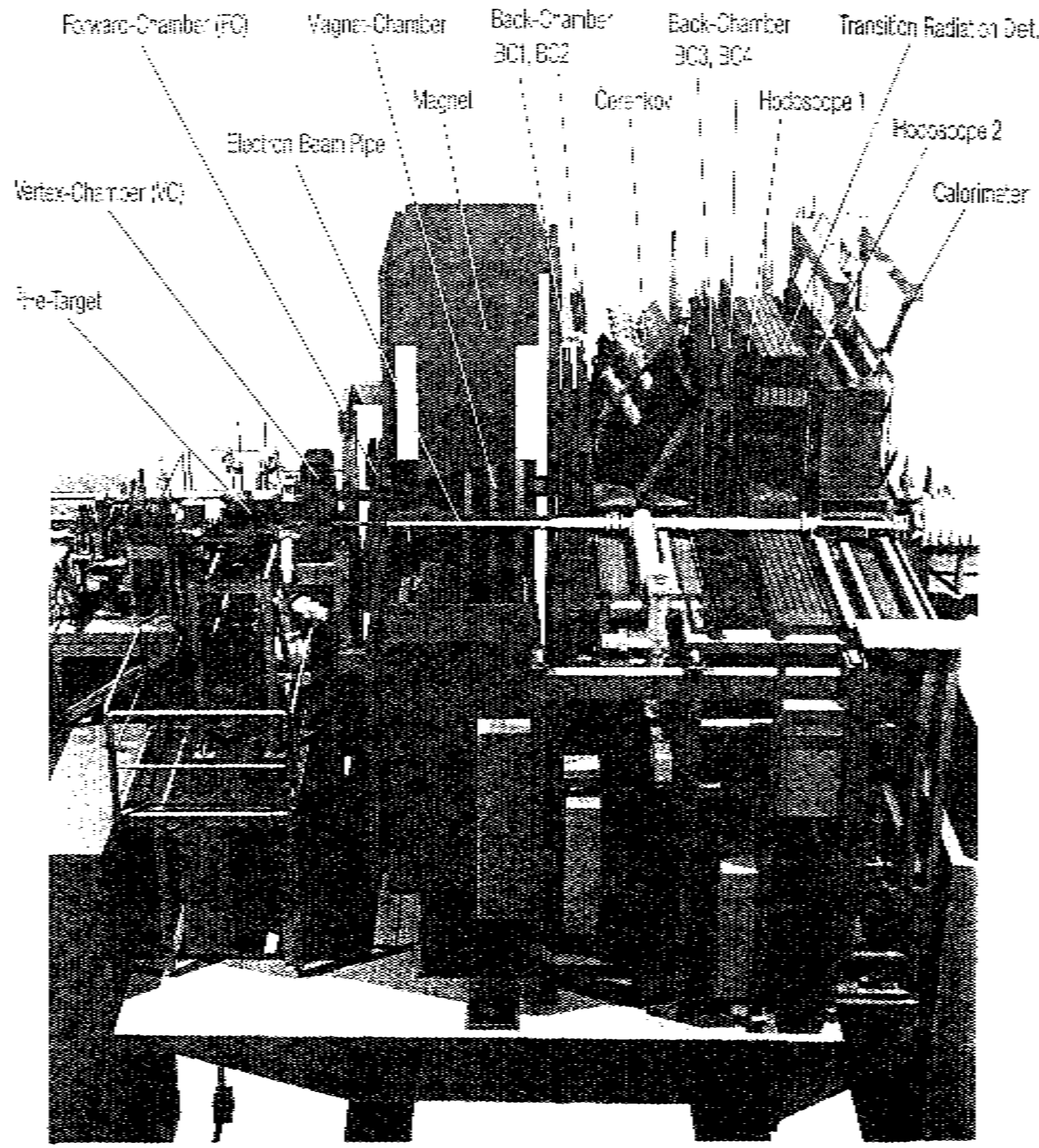


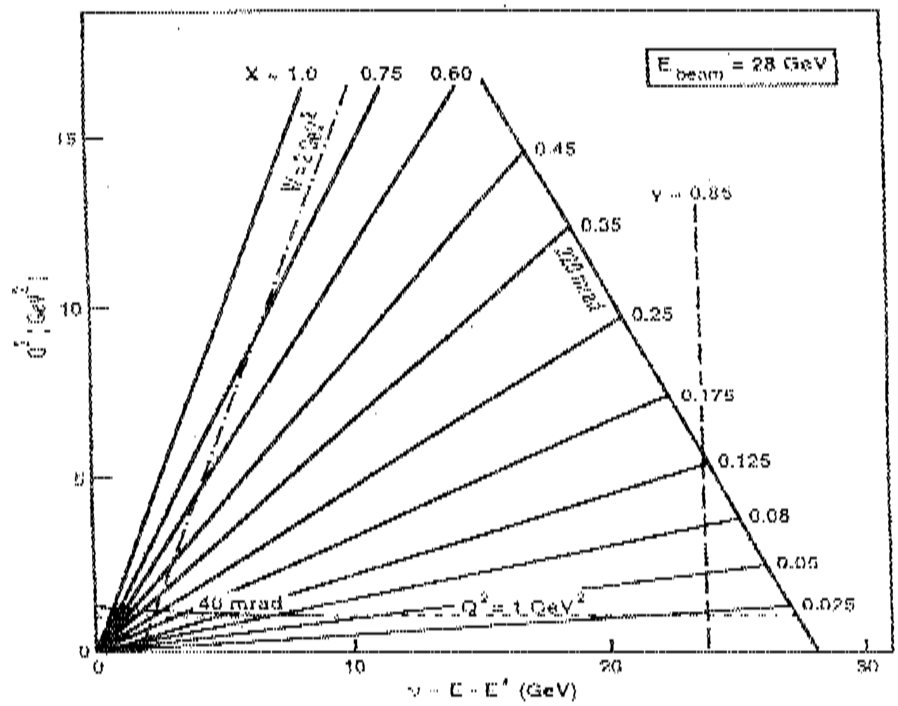
Internal Target Technique



Target Consists of Pure Polarized Atoms

- No Dilution
- No Windows
- Small External Radiative Corrections
- Fast Polarization Reversal
- Low Magnetic Fields


Forward-Chamber (FC)
Magnet-Chamber
Back-Chamber
BC1, BC2
Back-Chamber
BC3, BC4
Transition Radiation Det.
Magnet
Čerenkov
Hodoscope 1
Hodoscope 2
Electron Beam Pipe
Vertex-Chamber (VC)
Calorimeter
Pre-Target



$$0.02 < x < 0.8$$

$$1 < Q^2 < 12\ (\mathrm{GeV}/c)^2$$

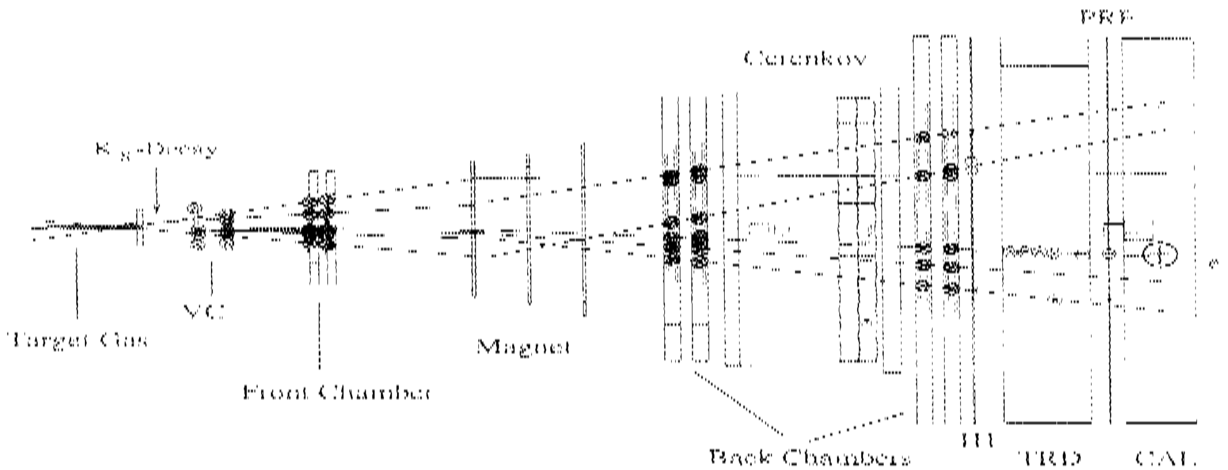
$$\frac{\triangle p}{p} \sim 1.75\%$$

$$\frac{\triangle x}{x} \sim 5.2\%$$

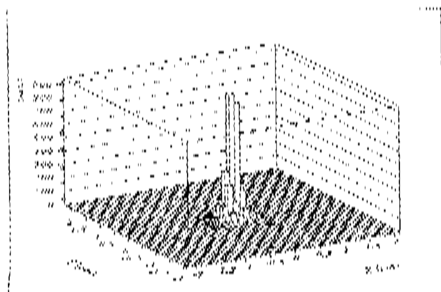
$$\frac{\triangle Q^2}{Q^2} \sim 2.9\%$$

Event Reconstruction

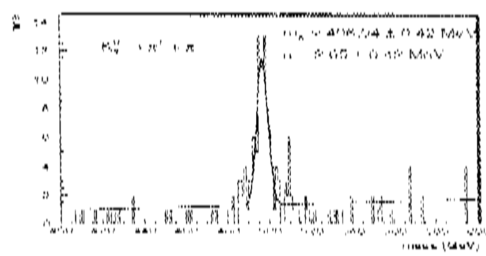
(DIS event with K_s in hadronic final state):



transverse vertex distribution:



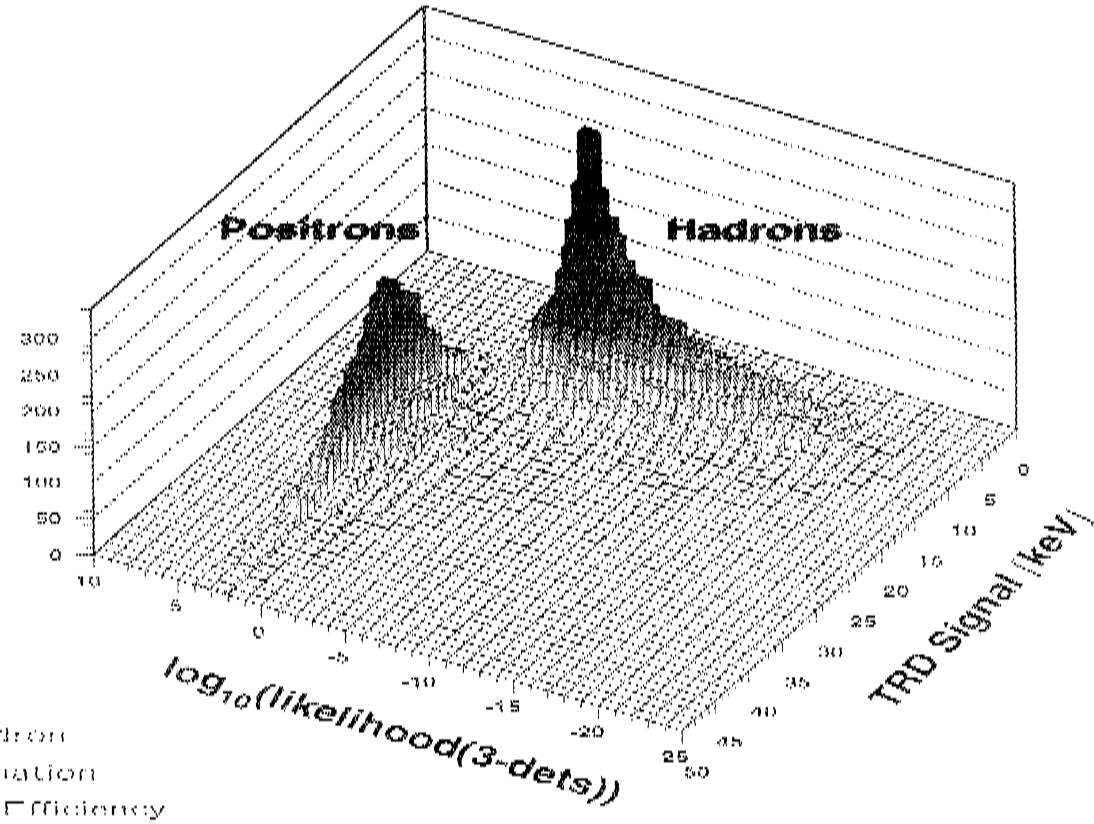
K_s mass peak:



Particle Identification

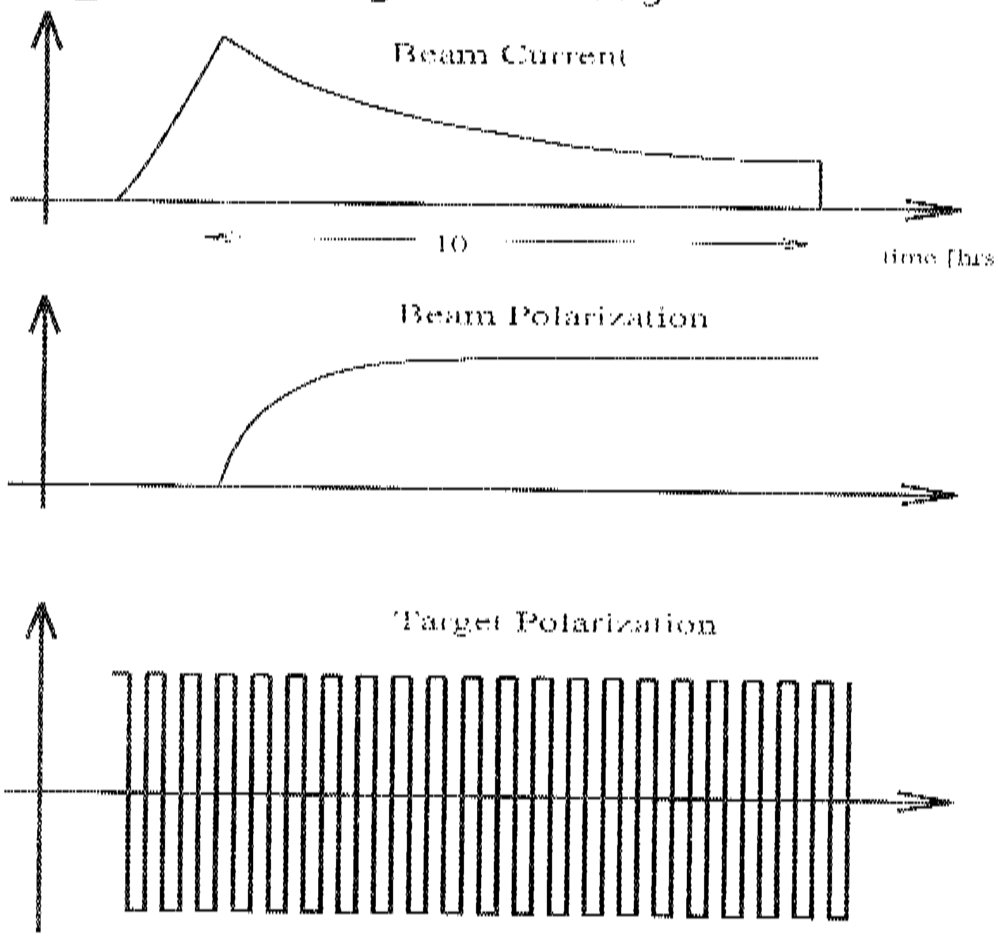
Combination of

- Čerenkov / Preshower Detector / Calorimeter
- TRD



<1% Hadron
Contamination
95% e^{+} Efficiency

Forming the Asymmetry



Target Density : constant

Forming $g_1^n(x)$ and Γ_1^n

$$A_1^n = \frac{A_1^{^3He} - \frac{2F_2^p}{2F_2^p + F_2^n} P_p^{^3He} A_1^p}{\frac{F_2^n}{2F_2^p + F_2^n} P_n^{^3He}}$$

$F_2^n(x) = 2F_2^d(x) - F_2^p(x)$

$F_2(x)$ from NMC fit to NMC, SLAC, and BCDMS Data
[P. Amaudruz *et al*, Phys. Lett. B295, 159 (1992).]

$A_1^p(x)$ Parameterized SLAC/SMC Data

$$g_1^n = A_1^n \cdot \frac{F_2^n(1 + Q^2/\nu^2)}{2x(1 + R)}$$

$R(x)$ SLAC Parameterization R1990
[L.W. Whitlow *et al*, Phys. Lett. B282, 475 (1992).]

Assume $A_2^n(x) = 0$

Radiative Corrections

Akushevich and Shumeiko Prescription

[I.V. Akushevich and N.M. Shumeiko, Journal of Physics G20, 513 (1994); I.V. Akushevich and N.M. Shumeiko, Physics of Atomic Nuclei, 58, 1919 (1995).]

Extrapolations

High x:

Take $g_1^n(x)$ Proportional to $(1 - x)^3$

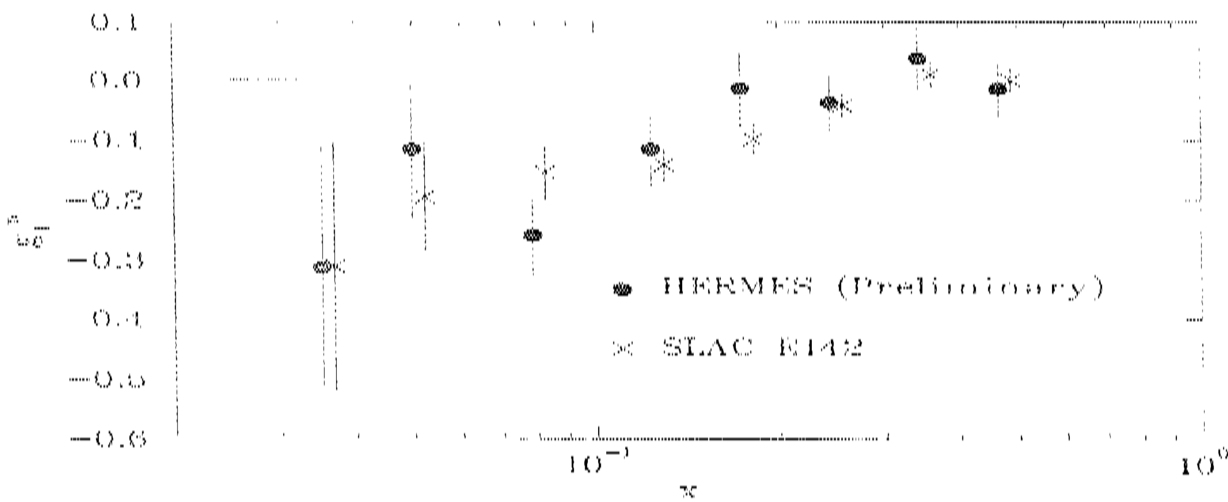
Low x:

- Take $g_1^n(x) = Cx^{-\alpha}$
- Take $g_1^n(x) = C\log(1/x)$

$\longrightarrow$ Both Give Similar Results

First HERMES Results

Spin Structure Function $g_1^n(x)$ of the Neutron

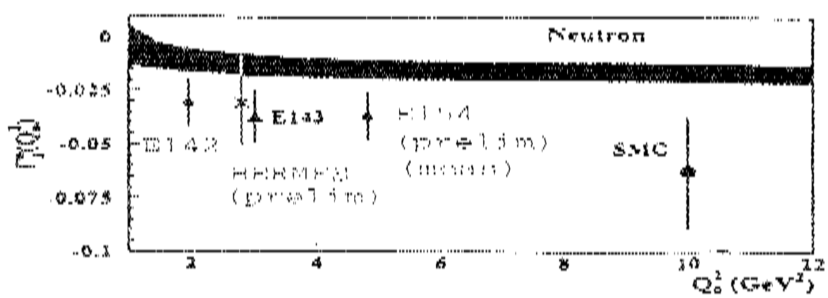


Ellis-Jaffe Sum Rule (PRELIMINARY):

$$\int_0^1 g_1^n(x)\,dx = \quad 0.032 \pm 0.013 \pm 0.017$$

Comparison of Γ_1^n

Experiment	$< q^2 >$	Γ_1^n
E142	2	-0.031 ± 0.011
E143	3	$-0.037 \pm 0.008 \pm 0.011$
E154 (prelim,meas)	5	$-0.037 \pm 0.004 \pm 0.010$
SMC	10	$-0.063 \pm 0.024 \pm 0.013$
HERMES (Preliminary)	3	$-0.032 \pm 0.013 \pm 0.017$



HERMES Semi-Inclusive Physics

- Identify Quark by Tagging Leading Hadron

Flavor Decomposition of Valence Spin

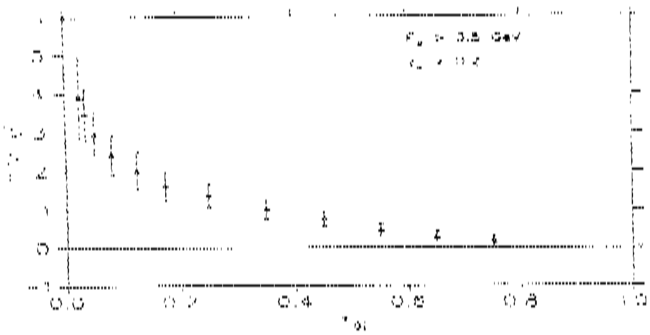
- Pion Charge Difference Asymmetries

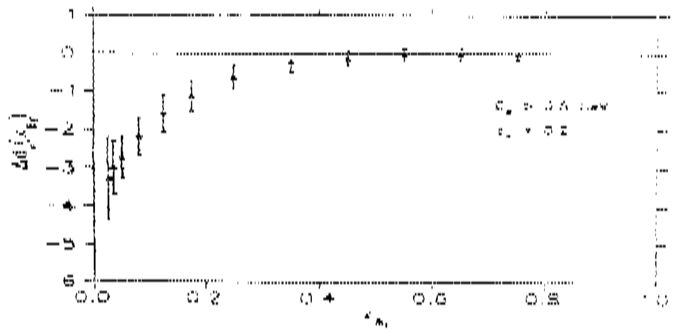
$$A^{p}_{\pi}(x) = \frac{4\Delta u_v(x) - \Delta d_v(x)}{4u_v(x) - d_v(x)} \qquad A^{^3He}_{\pi}(x) = \frac{4\Delta d_v(x) - \Delta u_v(x)}{u_v(x) + 2d_v(x)}$$

→ Extract Spin Dependent Valence Distributions

- Insight into Ellis-Jaffe Sum Rule

HERMES Proposed:





- 6×10^6 DIS e^+ on ^{3}He (1995)
- 1.2×10^6 DIS e^+ on H (1996)

HERMES 1995 Hadron Yields

Data Taken: August November 1995

Particle	approx. yield
π^0	100k
π^+	330k
π^-	220k
K^+	$\sim$ 5k
K^-	$\sim$ 6k
K_s^0	1.3k
ρ^0	6k
p	$\sim$ 16k
$\bar{p}$	$\sim$ 1,500
Λ	$\sim$ 1,000
J/Ψ	$\sim$ 60 100?
$D^0, \bar{D}^0$	$\sim$ few hundred?

PRELIMINARY

Conclusion:

- 1995 Data Taking Period Very Successful
  - High Luminosity and Polarization
  - Low Backgrounds
  - Preliminary Measurement of $g_1^n(x)$
  - Semi-Inclusive Analysis in Progress
- 1996 Data Taking with $\vec{H}$ Target Underway
  - Improved Detectors (tracking/trigger)
  - Longitudinal Beam Polarimeter
  - $\longrightarrow$ $g_1^p(x)$ and Ellis Jaffe Sum Rule for Proton
  - $\longrightarrow$ Bjørken Sum Rule
  - $\longrightarrow$ Flavor Decomposition of Spin Contributions