Q^2-Dependence of the Spin Structure Functions of the Proton and the Deuteron

The data obtained in the Stanford Linear Accelerator Center (SLAC) experiment E155 cover a large range in Q^2, improving the available experimental data on the Q^2-dependence of the spin structure functions. We present the latest results of our analysis.

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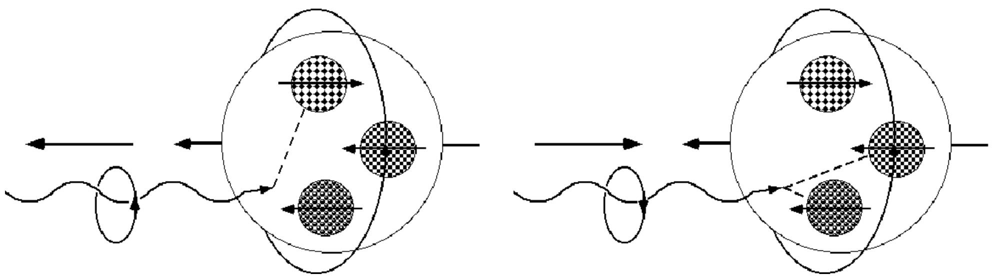
Summary

Introduction

Phenomenological Study of Q^2-Dependence of Virtual Photon Asymmetry $A_1(x_{Bjorken}, Q^2)$

Helicity and Spin of Virtual Photon--Nucleon Interaction



parallel *anti-parallel*

$$A_1(x_{Bj}, Q^2) = \left(g_1(x_{Bj}, Q^2) - \gamma^2 g_2(x_{Bj}, Q^2)\right) \Big/ F_1(x_{Bj}, Q^2)$$

$$g_2^{WW}\left(x_{Bj}, Q^2\right) = -g_1\left(x_{Bj}, Q^2\right) + \int_{x_{Bj}}^{1} \frac{g_1\left(y, Q^2\right)}{y}\, dy$$

Motivation

Calculation of E155 Radiative Corrections
Requires Model of $A_1(x_{Bjorken}, Q^2)$ as Input

$\Rightarrow$ New Model (Fit), incl. E155 Data

g_1 and F_1 have Well-Established
Q^2-Dependence, but Prior to E155, no
Conclusive Answer if A_1 is Q^2-Dependent

$$A_1 \approx \frac{g_1(x_{Bj}, Q^2)}{F_1(x_{Bj}, Q^2)}$$

Procedure

Calculation of Radiative Corrections Based on
Recipe of *T. V. Kuchto* and *N. M. Shumeiko*
Nucl. Phys. B219(1983) 412-436

Use A_1 Model and g_2^{ww} (Derived from A_1)

A_1 Model is Fit to Data via Iterative Process

Model Fine-Tuned with Direct Fit to Raw Asymmetries

Best Fit Requires Largest Data Set, Kinematic Coverage

⇒ Use All Available Data and Maximize Data Set:

Simultaneous Fits to A_1^p, A_1^n & A_1^d Data Using
Parameterization of A_1^p and A_1^n and

$$g_1^d = \frac{1}{2}\left(1 - \frac{3}{2}\omega_D\right)\left(g_1^p + g_1^n\right)$$

(ω_D = D-State Probability)

Procedure

Form of General Parameterization of A_1^p and A_1^n:

$$A_1 = x^{\alpha}\left(a + bx + cx^2\right)\left(1 + d \cdot \mathrm{f}\left(Q^2\right)\right)$$

Forms of f(Q^2) Examined:

$^1/_{Q^2}$, $^1/_{Q}$, $\log Q^2$, None,

Others, Combinations

Data Set

(only points with $Q^2 > 1.0$ GeV^2, not in Resonance Region)

Proton (N=268)

E155, E143, E130, E80, Hermes, SMC, EMC

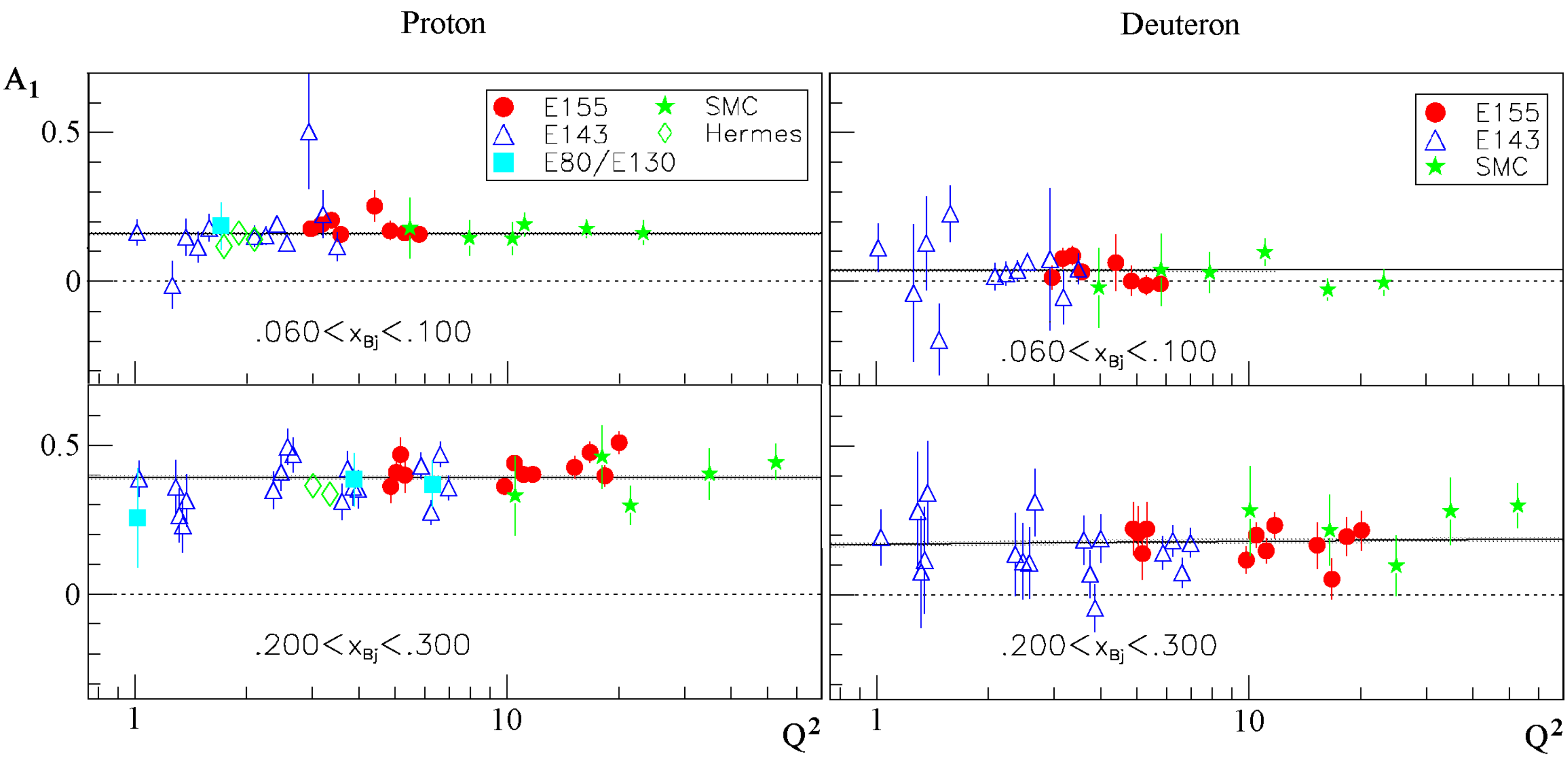
Deuteron (N=224)

E155, E143, SMC

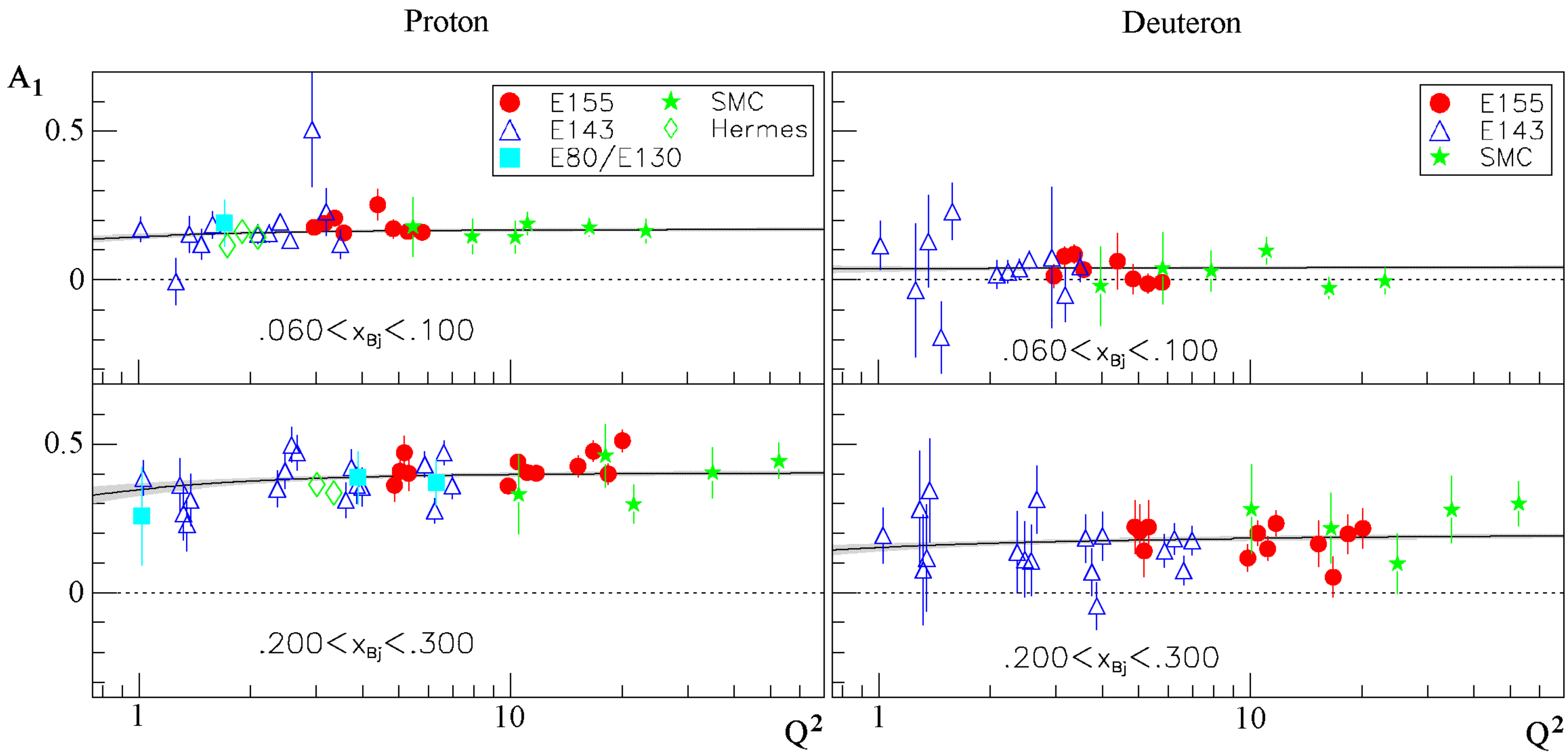
Neutron (N=35)

E154, E142, Hermes

A_1 vs. Q^2 — No Q^2-Dependent Term

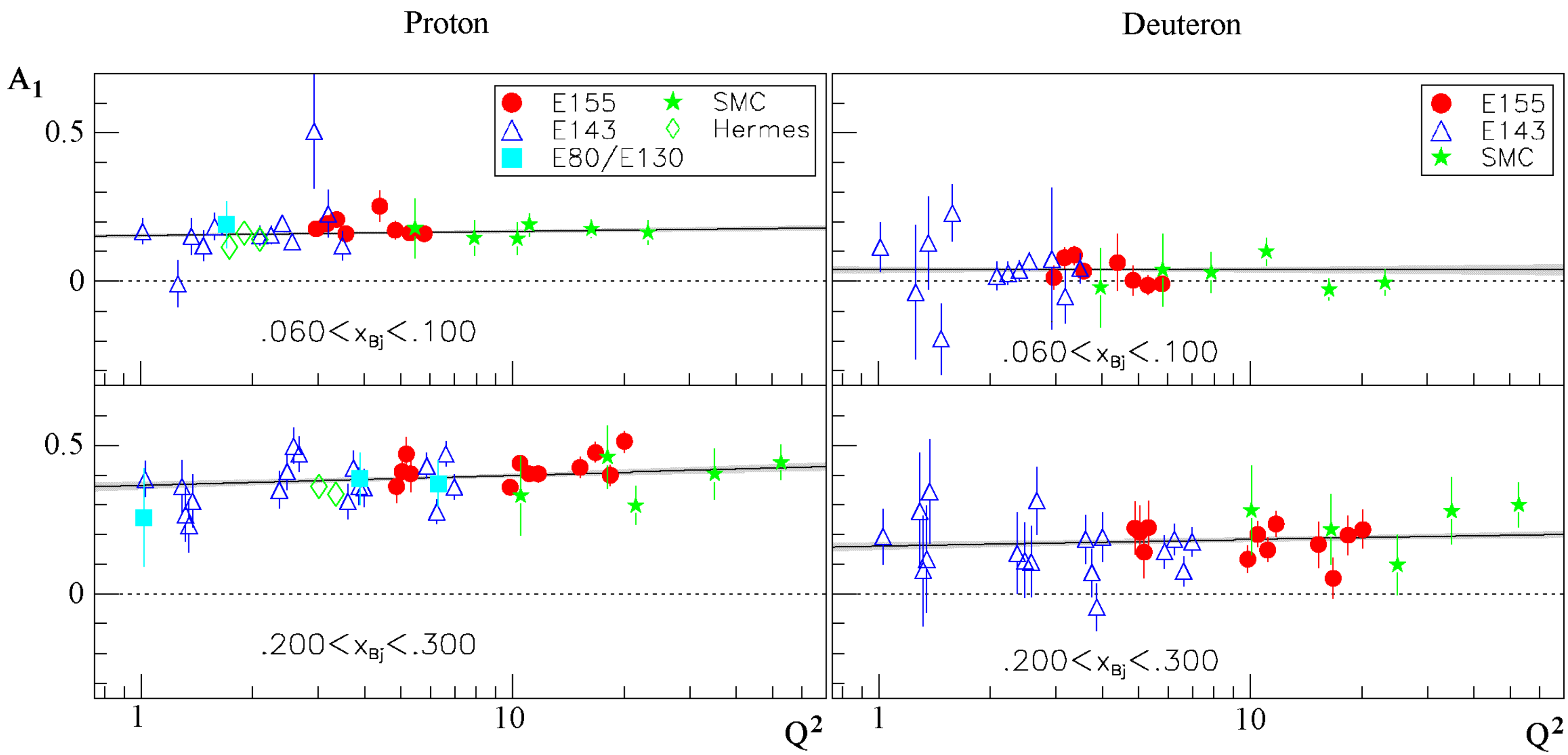


A_1 vs. Q^2 — $^1/_{Q^2}$



Proton
Deuteron
A1
0.5
0
E155
E143
E80/E130
SMC
Hermes
.060<xBj<.100
.200<xBj<.300
1
10
Q2

A_1 vs. Q^2 — log Q^2



Results

χ^2 of Fits

	A_1^p	A_1^d
N	*268*	*224*
None	273.5	256.3
$^1/_{Q^2}$	266.9	256.8
log Q^2	266.1	256.7

Change to A_1^p Due to $1+d\cdot f(Q^2)$

Q^2	**1**	**10**	**100**
$^1/_{Q^2}$	-14%	-1%	0
log Q^2	0	9%	18%

Summary

For $Q^2 > 1$ GeV^2 and Based on Currently
Available Data, $1/Q^2$ Form Improves χ^2 of Fit to
A_1^p by ~2.5σ, Compared to No Q^2 Term

Below $Q^2 = 1$ GeV^2, Strong Q^2 Dependence, as Expected

No Significant Q^2 Dependence of A_1^d Evident

Newly Obtained Global Fit to World A_1 Data
with Overall χ^2 of 539.0 for 527 Data Points
Provides Good Model for RC Calculation