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THE STATISTICAL MODEL FOR UNPOLARIZED AND POLARIZED PARTON DISTRIBUTIONS AND FRAGMENTATIONS: A COMPARISON WITH EXPERIMENTS

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Abstract

In the framework of the statistical model for parton distributions and fragmentation functions we present a comparison of the model with a large set of unpolarized and polarized experimental data, the agreement with data supports our approach.

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1 Polarized Parton Distributions

We give a brief review of the parton distributions functions which are described in Refs. [1-6].

1.1 Quarks

The density functions are given by ² :

$$xu^+(x) = \frac{AX_{0u}^+x^b}{\exp[(x - X_{0u}^+)/\bar{x}] + 1} + \frac{\tilde{A}x^{\tilde{b}}}{\exp[\frac{x}{\bar{x}}] + 1} \quad (1)$$

$$xu^-(x) = \frac{AX_{0u}^-x^b}{\exp[(x - X_{0u}^-)/\bar{x}] + 1} + \frac{\tilde{A}x^{\tilde{b}}}{\exp[\frac{x}{\bar{x}}] + 1} \quad (2)$$

$$xd^+(x) = \frac{AX_{0d}^+x^b}{\exp[(x - X_{0d}^+)/\bar{x}] + 1} + \frac{\tilde{A}x^{\tilde{b}}}{\exp[\frac{x}{\bar{x}}] + 1} \quad (3)$$

$$xd^-(x) = \frac{AX_{0d}^-x^b}{\exp[(x - X_{0d}^-)/\bar{x}] + 1} + \frac{\tilde{A}x^{\tilde{b}}}{\exp[\frac{x}{\bar{x}}] + 1} \quad (4)$$

$$A = 1.74938 \quad (5)$$

$$b = 0.40962 \pm 0.00438^{(*)} \quad (6)$$

$$\bar{x} = 0.09907 \pm 0.00110^{(*)} \quad (7)$$

$$X_{0u}^+ = 0.46128 \pm 0.00338^{(*)} \quad (8)$$

$$X_{0u}^- = 0.29766 \pm 0.00303^{(*)} \quad (9)$$

$$X_{0d}^+ = 0.22775 \pm 0.00294^{(*)} \quad (10)$$

$$X_{0d}^- = 0.30174 \pm 0.00239^{(*)} \quad (11)$$

$$\tilde{A} = 0.08318 \pm 0.00157 \quad (12)$$

$$\tilde{b} = -0.25347 \pm 0.00318^{(*)} \quad (13)$$

note:

The temperature \bar{x} is identical for quarks, antiquarks and gluons.

²Values marked with an asterisk are free parameters of the model. The input scale is $Q_0^2 = 4\text{GeV}^2$, and $\Lambda(\overline{MS}) = 300\text{MeV}$. The evolution is performed at NLO.

1.2 Antiquarks

The density functions are given by:

$$x\bar{u}^+(x) = \frac{\bar{A}}{X_{0u}^-} \cdot \frac{x^{\bar{b}}}{\exp[(x + X_{0u}^-)/\bar{x}] + 1} + \frac{\tilde{A}x^{\bar{b}}}{\exp[\frac{x}{\bar{x}}] + 1} \quad (14)$$

$$x\bar{u}^-(x) = \frac{\bar{A}}{X_{0u}^+} \cdot \frac{x^{\bar{b}}}{\exp[(x + X_{0u}^+)/\bar{x}] + 1} + \frac{\tilde{A}x^{\bar{b}}}{\exp[\frac{x}{\bar{x}}] + 1} \quad (15)$$

$$x\bar{d}^+(x) = \frac{\bar{A}}{X_{0d}^-} \cdot \frac{x^{\bar{b}}}{\exp[(x + X_{0d}^-)/\bar{x}] + 1} + \frac{\tilde{A}x^{\bar{b}}}{\exp[\frac{x}{\bar{x}}] + 1} \quad (16)$$

$$x\bar{d}^-(x) = \frac{\bar{A}}{X_{0d}^+} \cdot \frac{x^{\bar{b}}}{\exp[(x + X_{0d}^+)/\bar{x}] + 1} + \frac{\tilde{A}x^{\bar{b}}}{\exp[\frac{x}{\bar{x}}] + 1} \quad (17)$$

$$\bar{A} = 1.90801 \pm 0.12627^{(*)} \quad (18)$$

$$\bar{b} = 2b = 0.81924 \quad (19)$$

$$xs(x) = x\bar{s}(x) = \frac{1}{4}(x\bar{u}(x) + x\bar{d}(x))$$

$x\Delta s(x) = x\Delta\bar{s}(x) = \frac{1}{3}(x\Delta\bar{d}(x) - x\Delta\bar{u}(x))$. This assumption was removed in a new version of the model, see [6].

$$xs^h(x, Q_0^2) = \frac{AX_{0u}^+x^{b_s}}{\exp[(x - X_{0s}^h)/\bar{x}] + 1} \frac{\ln(1 + \exp[kX_{0s}^h/\bar{x}])}{\ln(1 + \exp[kX_{0u}^+/\bar{x}])} + \frac{\tilde{A}_s x^{\bar{b}}}{\exp(x/\bar{x}) + 1}, \quad (20)$$

$$x\bar{s}^h(x, Q_0^2) = \frac{\bar{A}(X_{0d}^+)^{-1}x^{2b_s}}{\exp[(x + X_{0s}^{-h})/\bar{x}] + 1} \frac{\ln(1 + \exp[-kX_{0s}^{-h}/\bar{x}])}{\ln(1 + \exp[-kX_{0d}^+/\bar{x}])} + \frac{\tilde{A}_s x^{\bar{b}}}{\exp(x/\bar{x}) + 1}. \quad (21)$$

$$\begin{aligned} A &= 1.74938, \quad \bar{A} = 1.90801, \quad X_{0u}^+ = 0.46128, \quad X_{0d}^+ = 0.22775, \\ \bar{x} &= 0.09907, \quad \tilde{b} = -0.25347, \quad k = 1.42. \end{aligned} \quad (22)$$

1.3 Gluon

$$xG(x) = \frac{A_G x^{b_G}}{\exp[x/\bar{x}] - 1} \quad (23)$$

$$A_G = 14.27535 \quad (24)$$

$$b_G = 1 + \tilde{b} = 0.74653 \quad (25)$$

$$x\Delta G(x) = 0 \quad \text{at } Q_0^2 = 4\text{GeV}^2 \quad (26)$$

Charm

The charm is set to 0 at $Q_0^2 = 4\text{GeV}^2$

2 Parton Fragmentation Functions

We propose to parametrize the fragmentation functions of the baryons octet with a statistical model as in the case of PDF.

For the quarks $q = u, s, d$ the FF are expressed as

$$D_q^B(x, Q_0^2) = \frac{A_q^B X_q^B x^b}{\exp[(x - X_q^B)/\bar{x}] + 1}, \quad (27)$$

where X_q^B is the potential corresponding to the fragmentation $q \rightarrow B$ and Q_0^2 is an initial scale, given below in Table 1. We will ignore the antiquark FF $D_{\bar{q}}^B$, which are considered to be strongly suppressed. The heavy quark FF $D_Q^B(x, Q_0^2)$ for $Q = c, b, t$, which are expected to be large only in the small x region ($x \leq 0.1$ or so), are parametrized by a diffractive term with a vanishing potential

$$D_Q^B(x, Q_0^2) = \frac{\tilde{A}_Q^B x^{\tilde{b}}}{\exp(x/\bar{x}) + 1}. \quad (28)$$

The initial scale Q_0^2 , which is flavor dependent in this case, is given below in Table 1³. This FF for $Q \rightarrow B$ depends on \tilde{b} and a normalization constant \tilde{A}_B^Q for each baryon B . For the other quarks, we make some reasonable assumptions in order to reduce the number of parameters in addition to b , the universal power of x in Eq. (27). First we have the obvious constraints, namely, $D_u^B = D_d^B$ for $B = p, \Lambda$. Moreover we assume that we need only *four* potentials, two for the proton $X_u^p = X_d^p$ and X_s^p and two for the hyperons $X_u^Y = X_d^Y$ and X_s^Y where $Y = \Lambda, \Sigma^\pm, \Xi^-$. Finally for the gluon to baryon FF $D_g^B(x, Q^2)$, which is hard to determine precisely, we take a Bose-Einstein expression with a vanishing potential

$$D_g^B(x, Q_0^2) = \frac{A_g^B x^{\tilde{b}+1}}{\exp(x/\bar{x}) - 1}. \quad (29)$$

We assume it has the same small x behavior as the heavy quarks and it is the same for all baryons. The normalization constants A_q^B , A_g^B and \tilde{A}_Q^B are determined by fitting the data.

³Due to the fact that the input scale of the t quark is above the highest energy data investigated in this work, it does not contribute to our analysis.

Table 1: Input scales Q_0 and $\Lambda(\overline{MS})$ in GeV unit.

quark	u,d,s	c	b	t
Q_0	0.632	1.4	4.5	175
$\Lambda(\overline{MS})$	0.299	0.246	0.168	0.068

Now, let us report the values of the free parameters we have obtained from the NLO fit:

$$\begin{aligned}
 X_u^p &= 0.648, & X_s^p &= 0.247, & X_u^\Lambda &= 0.296, & X_s^\Lambda &= 0.476 \\
 b &= 0.200, & \tilde{b} &= -0.472, & A_g^B &= 0.051.
 \end{aligned}
 \tag{30}$$

Table 2: Values of the normalization constants of the the octet baryons FF

Baryon	q_1	q_2	$A_{q_1}^B$	$A_{q_2}^B$	A_Q^B
$p(uud)$	$u = d$	s	0.264	1.168	2.943
$\Lambda(uds)$	$u = d$	s	0.428	1.094	0.720
$\Sigma^+(uus)$	u	s	0.033	0.462	0.180
$\Sigma^-(dds)$	d	s	0.030	0.319	0.180
$\Xi^-(dss)$	d	s	0.023	0.082	0.072

3 Parton distributions and fragmentation functions figures

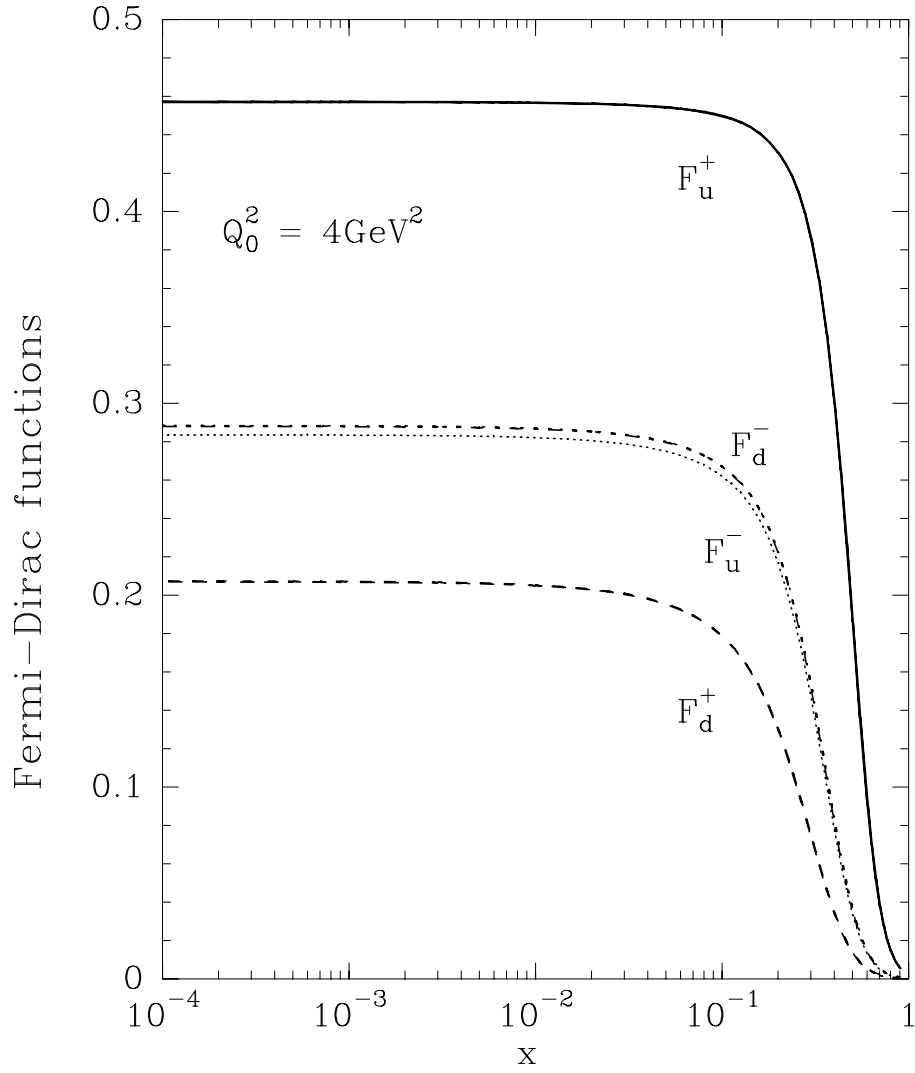


Figure 1: The Fermi-Dirac functions for quarks $F_q^h = X_{0q}^h / (\exp[(x - X_{0q}^h)/\bar{x}] + 1)$ at the input energy scale $Q_0^2 = 4\text{GeV}^2$, as a function of x .

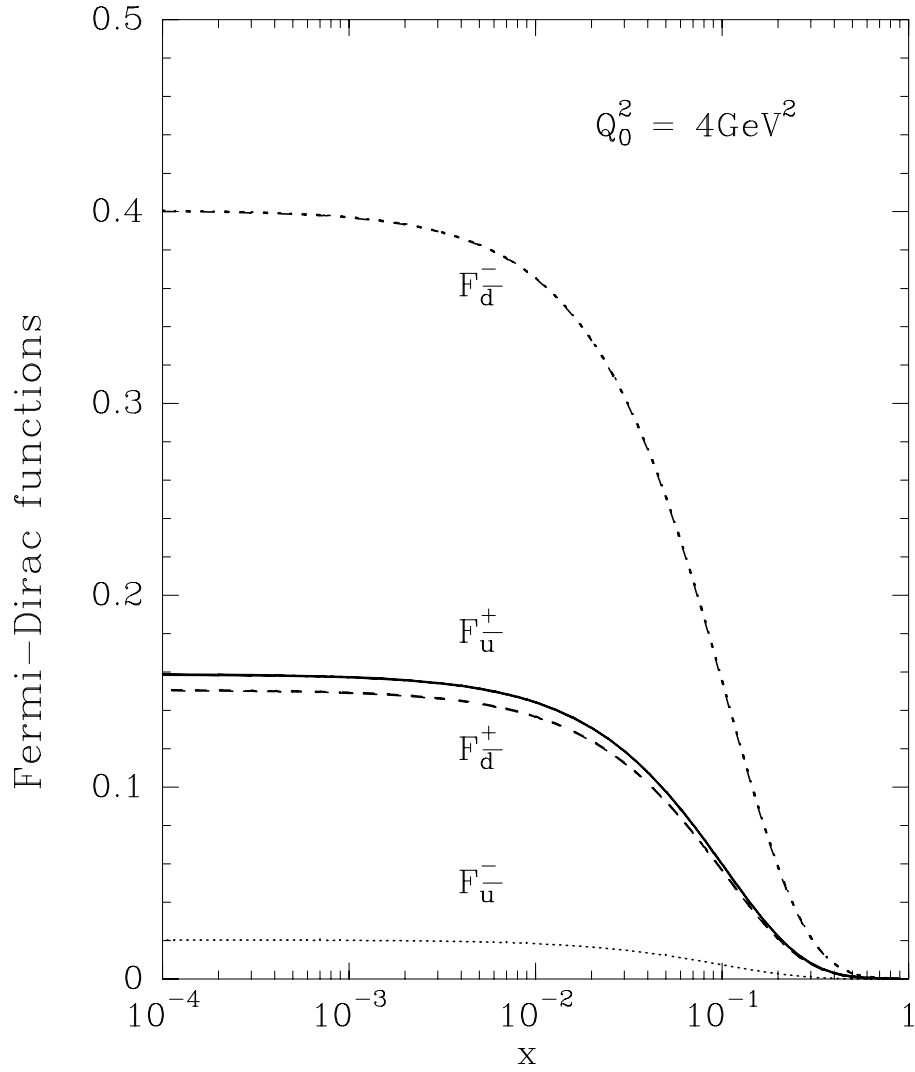


Figure 2: The Fermi-Dirac functions for antiquarks $F_{\bar{q}}^h = 1/X_{0\bar{q}}^h(\exp[(x + X_{0\bar{q}}^h)/\bar{x}] + 1)$ at the input energy scale $Q_0^2 = 4\text{GeV}^2$, as a function of x .

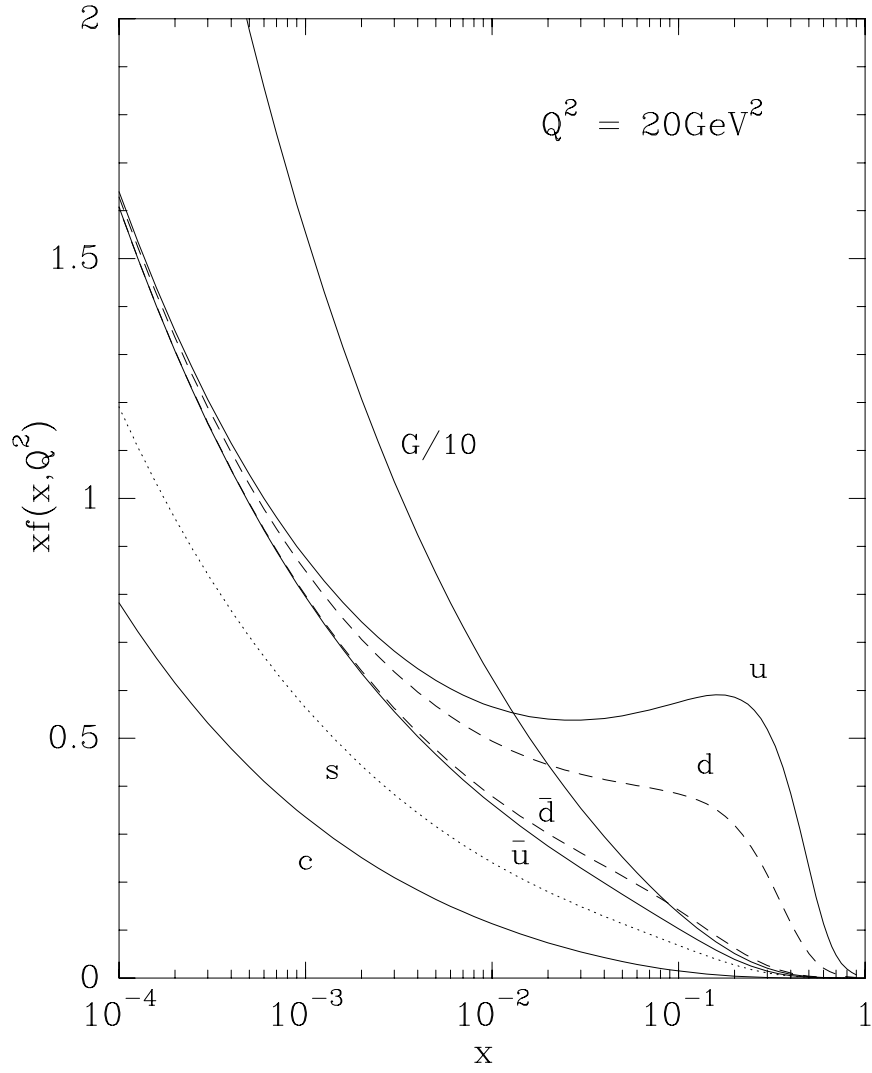


Figure 3: The different unpolarized parton distributions ($f = u, d, \bar{u}, \bar{d}, s, c$ and G) after NLO evolution, at $Q^2 = 20 \text{ GeV}^2$, as a function of x .

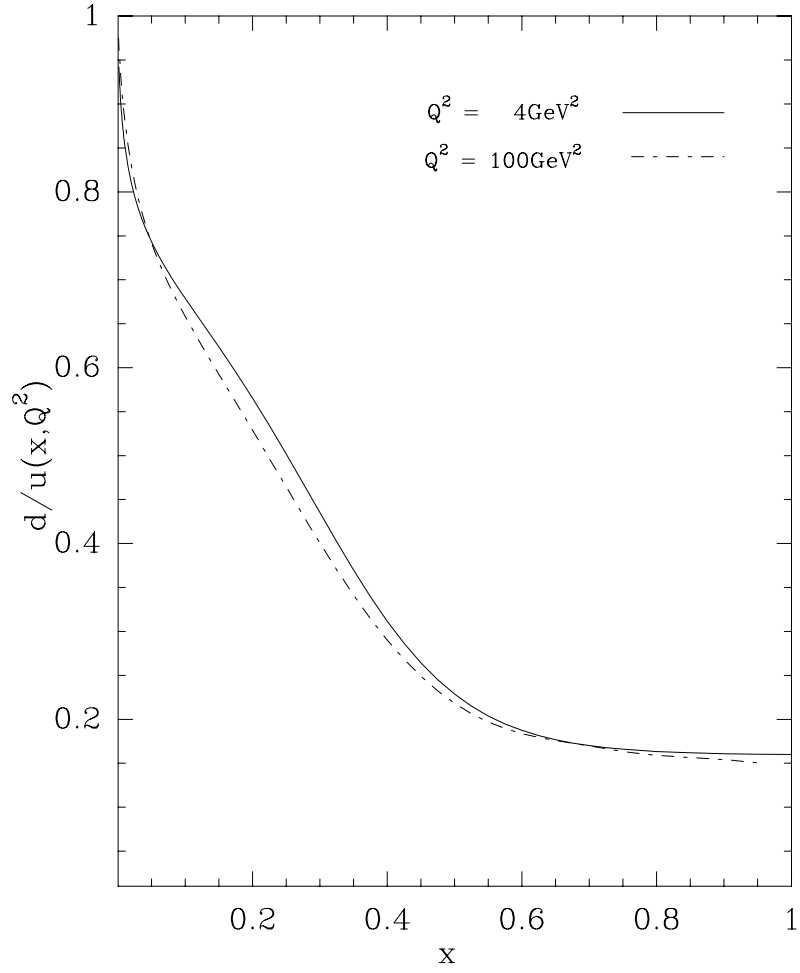


Figure 4: Variation of d/u at large x , for $Q^2 = 4, 100\text{GeV}^2$

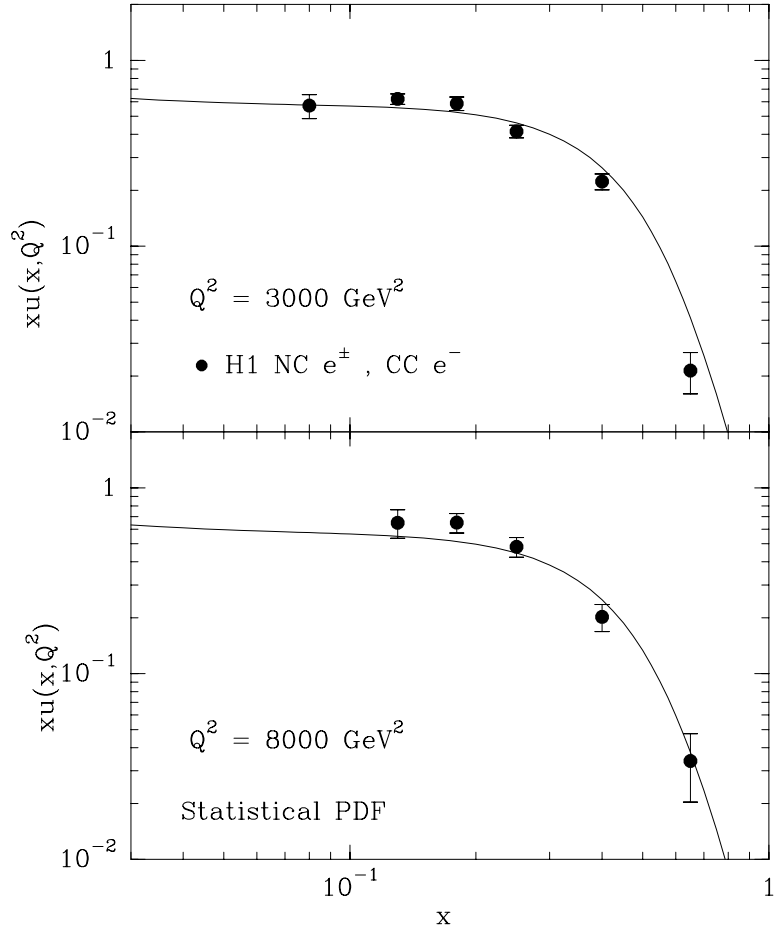


Figure 5: $xu(x, Q^2)$ as function of x for $Q^2 = 3000, 8000 \text{ GeV}^2$, data from H1 collaboration [41, 42].

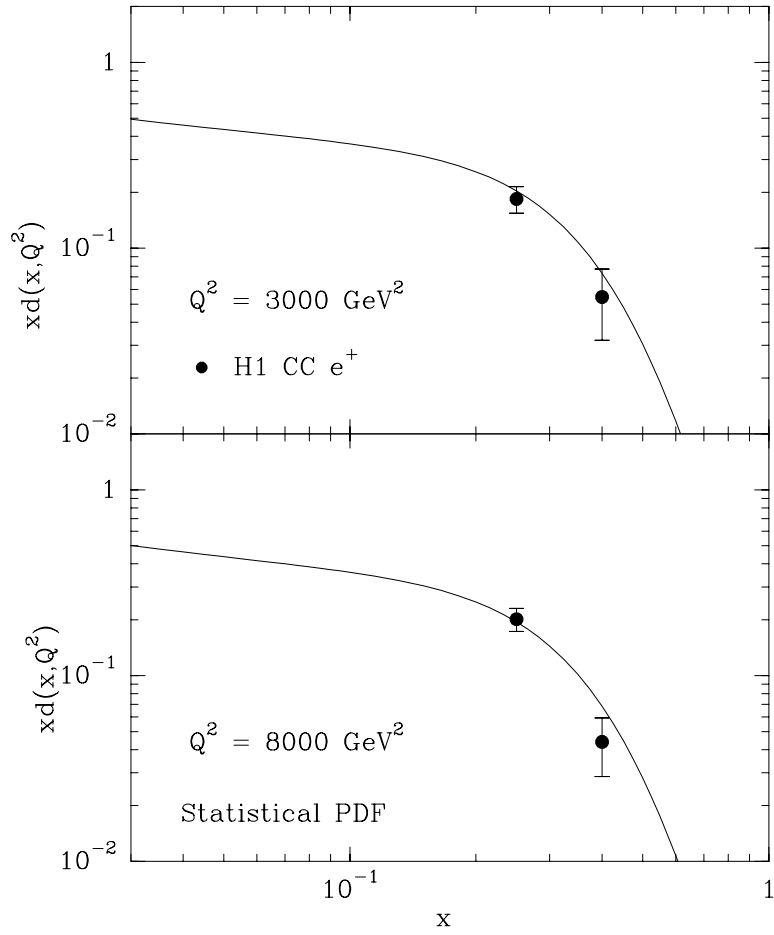


Figure 6: $x d(x, Q^2)$ as function of x for $Q^2 = 3000, 8000 \text{ GeV}^2$, data from H1 collaboration [41, 42].

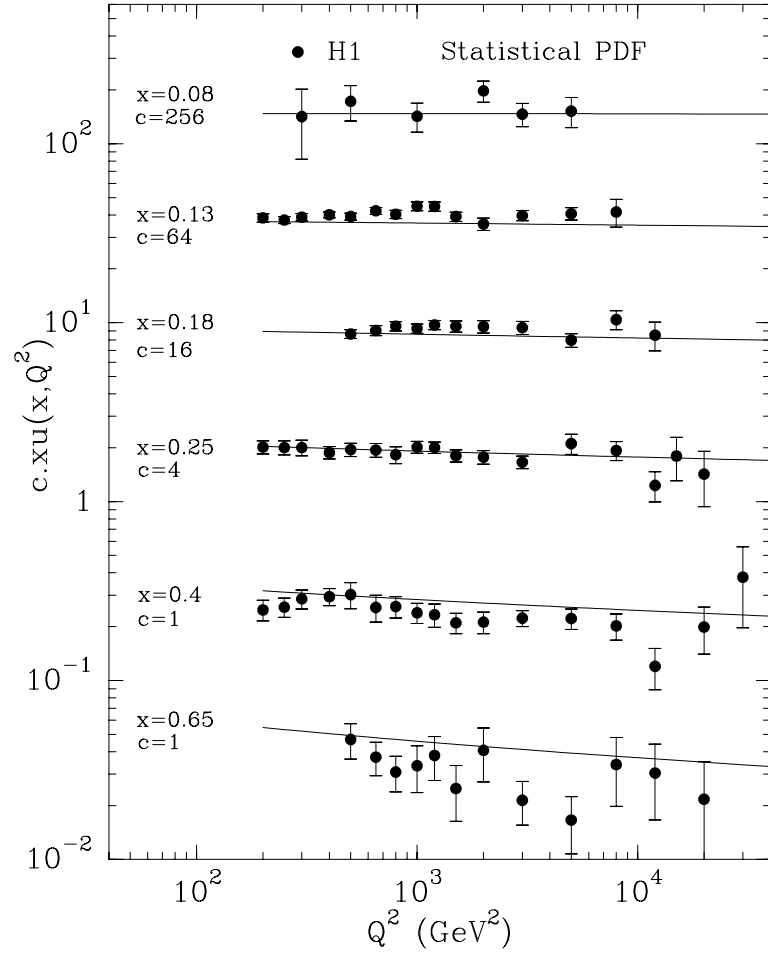


Figure 7: $c \cdot xu(x, Q^2)$ as function of Q^2 for different x bins, data from H1 collaboration [41, 42].

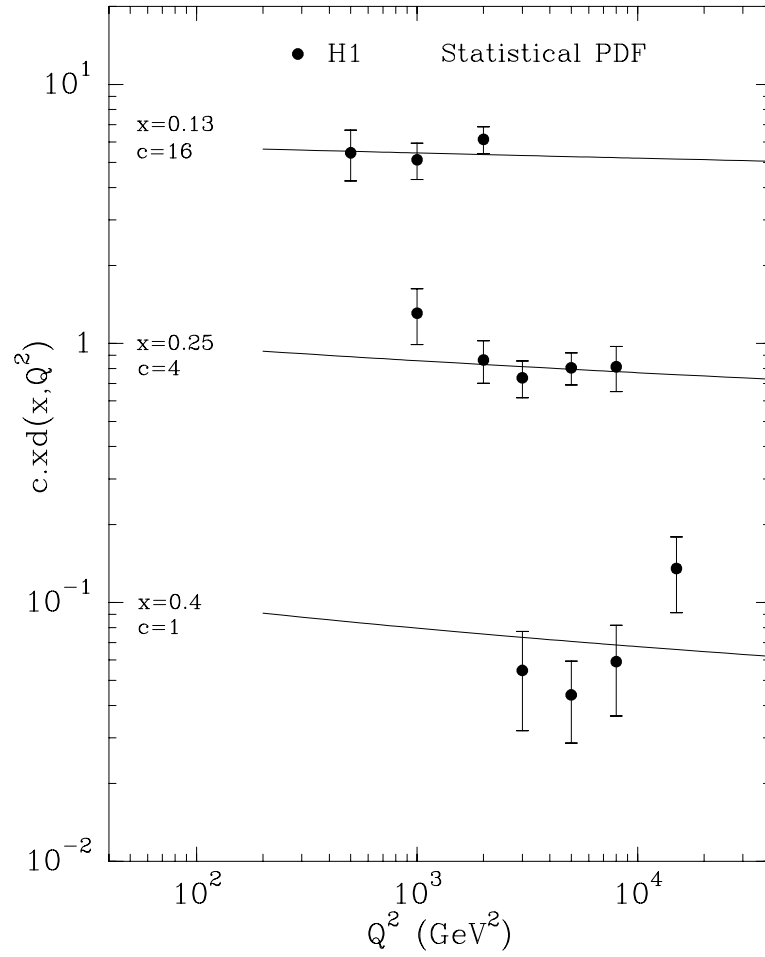


Figure 8: $c \cdot xd(x, Q^2)$ as function of Q^2 for different x bins, data from H1 collaboration [41, 42].

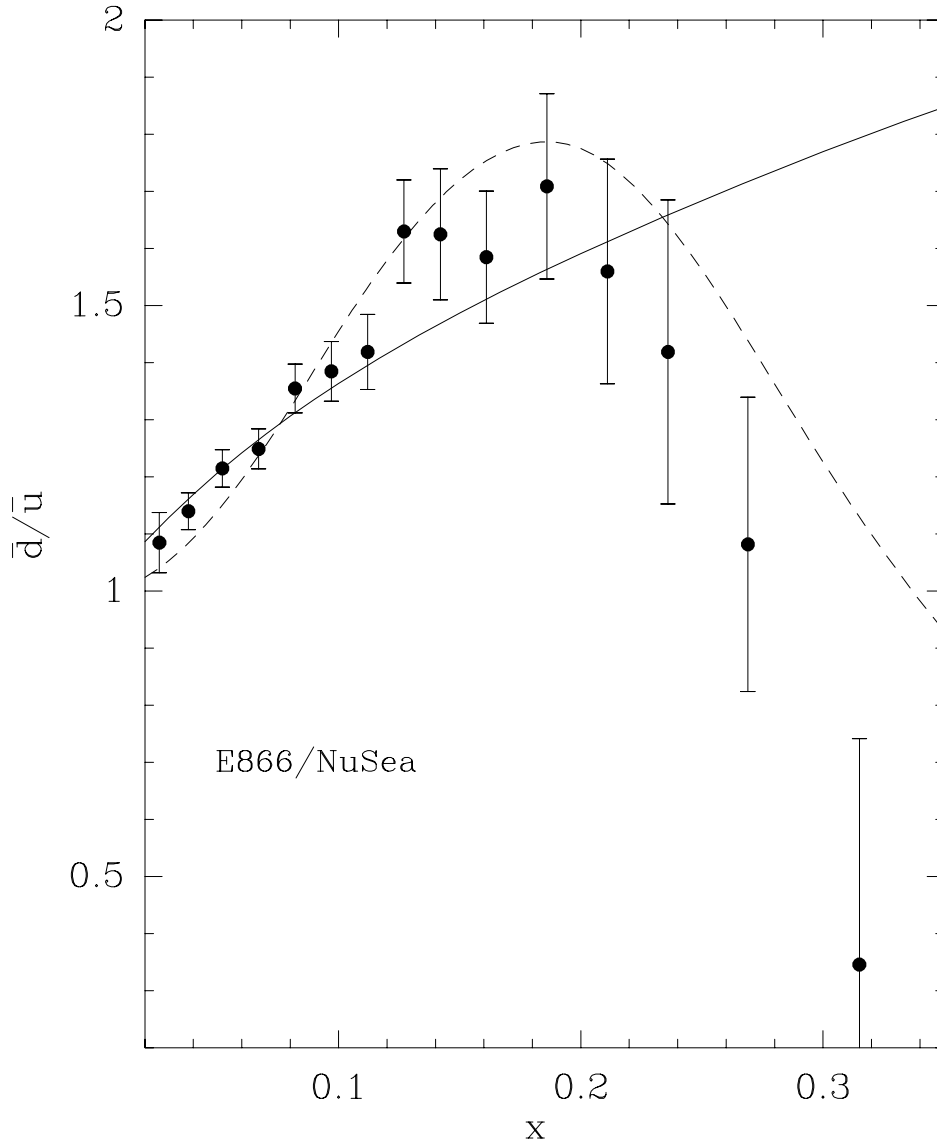


Figure 9: Comparison of the data on $\bar{d}/\bar{u}(x, Q^2)$ from E866/NuSea at $Q^2 = 54\text{GeV}^2$ [25], with the prediction of the statistical model (solid curve) and the set 1 of the parametrization proposed in Ref. [84] (dashed curve).

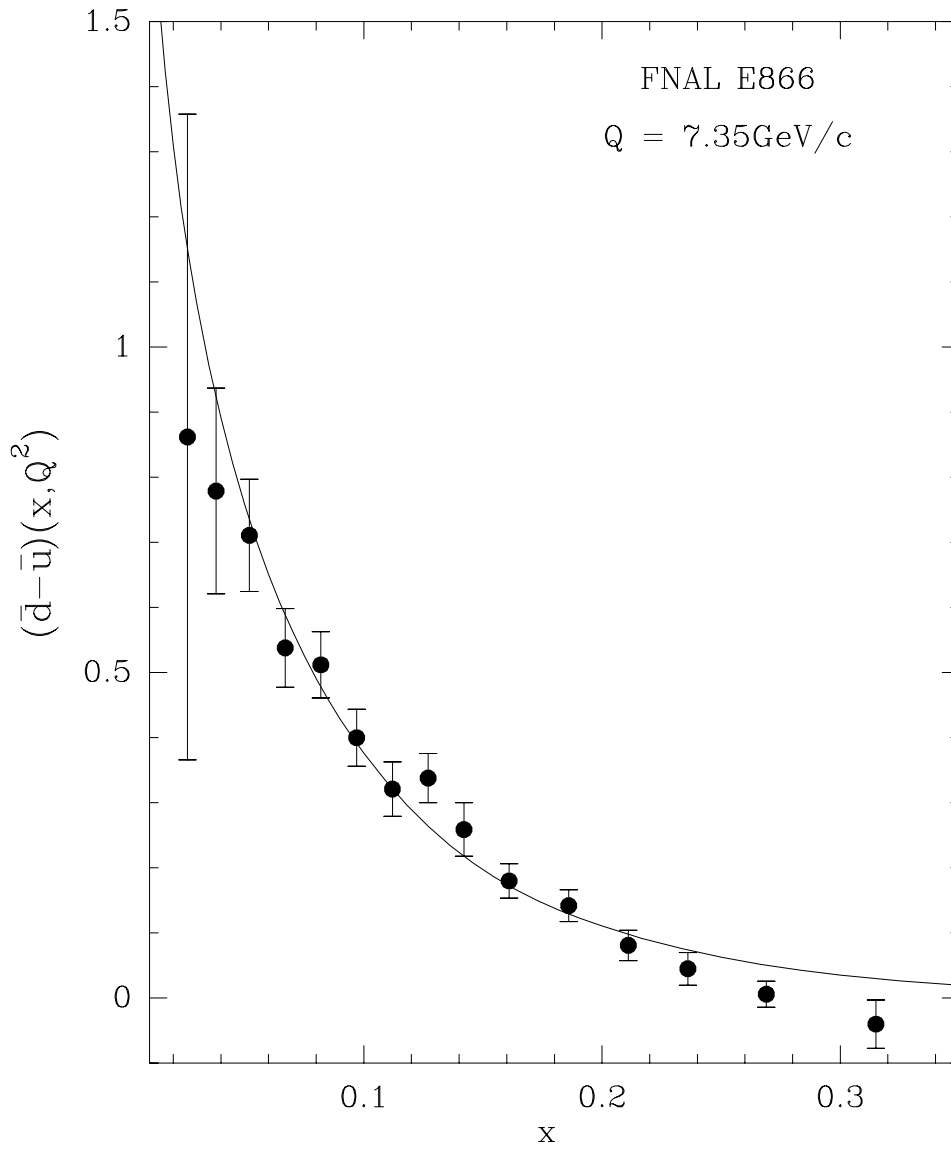


Figure 10: Difference $\bar{d} - \bar{u}$ as a function of x , $Q = 7.35 \text{ GeV}$, experimental results from FNAL-E866.

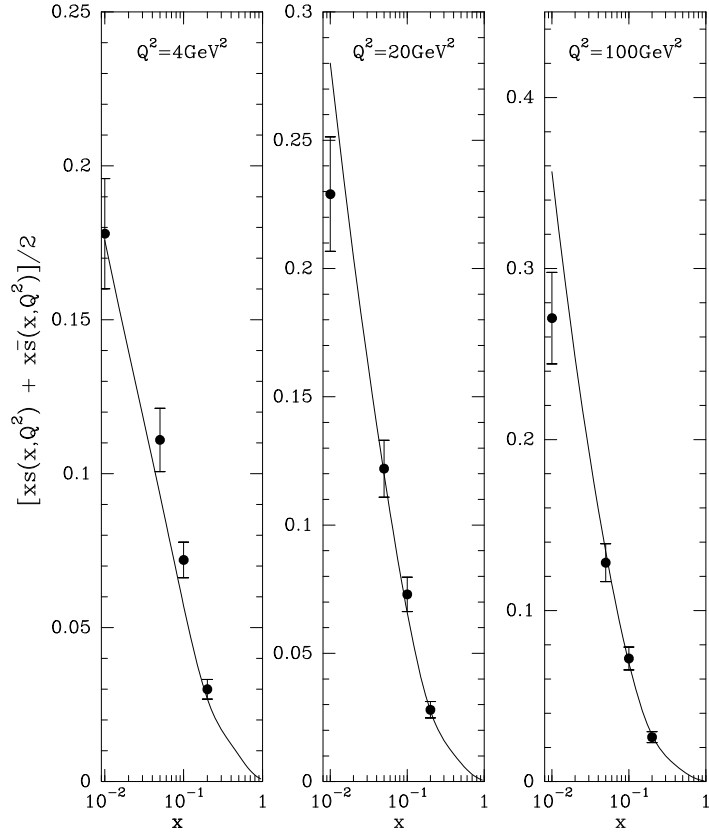


Figure 11: The strange quark distribution $xs(x, Q^2)$ determined at NLO as a function of x for different Q^2 values. Data from CCFR Collaboration [14].

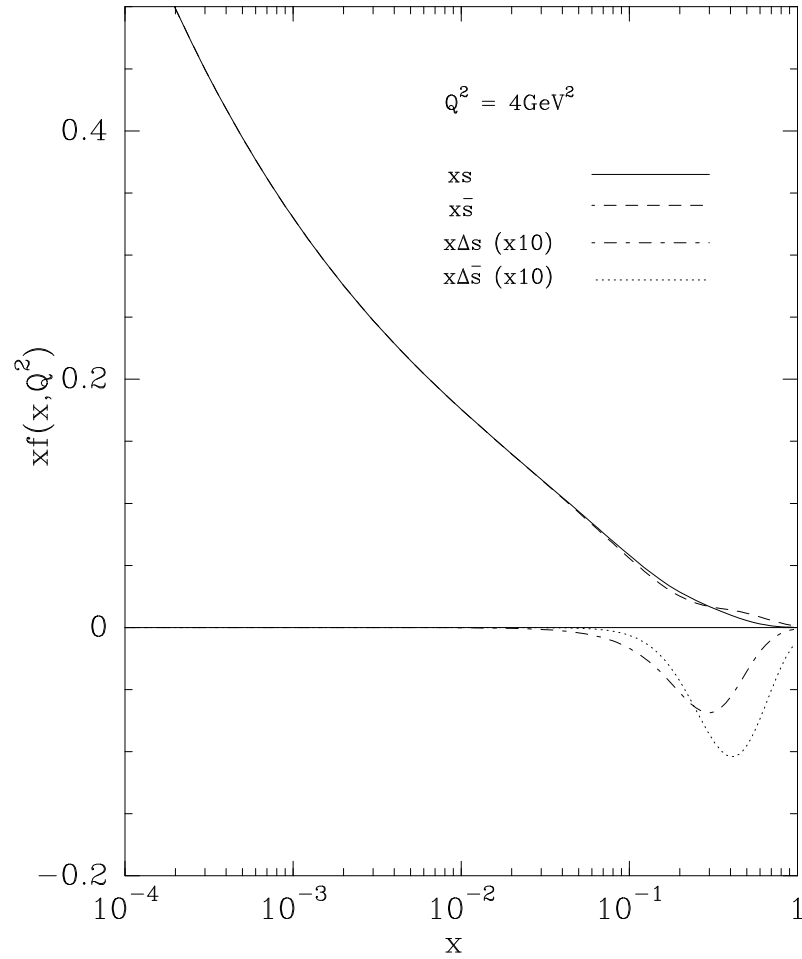


Figure 12: The unpolarized and polarized strange quark and antiquark distributions determined at NLO as a function of x for $Q^2 = 4\text{GeV}^2$.

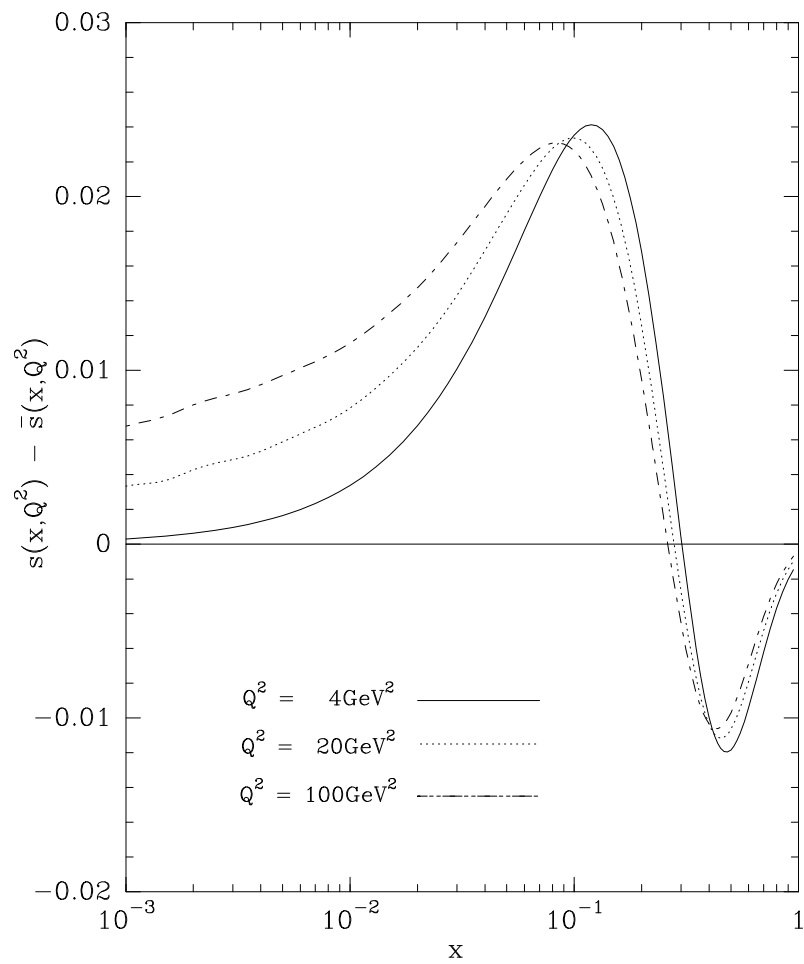


Figure 13: The difference $s - \bar{s}$ quark distributions determined at NLO as a function of x for $Q^2 = 4, 20, 100\text{GeV}^2$.

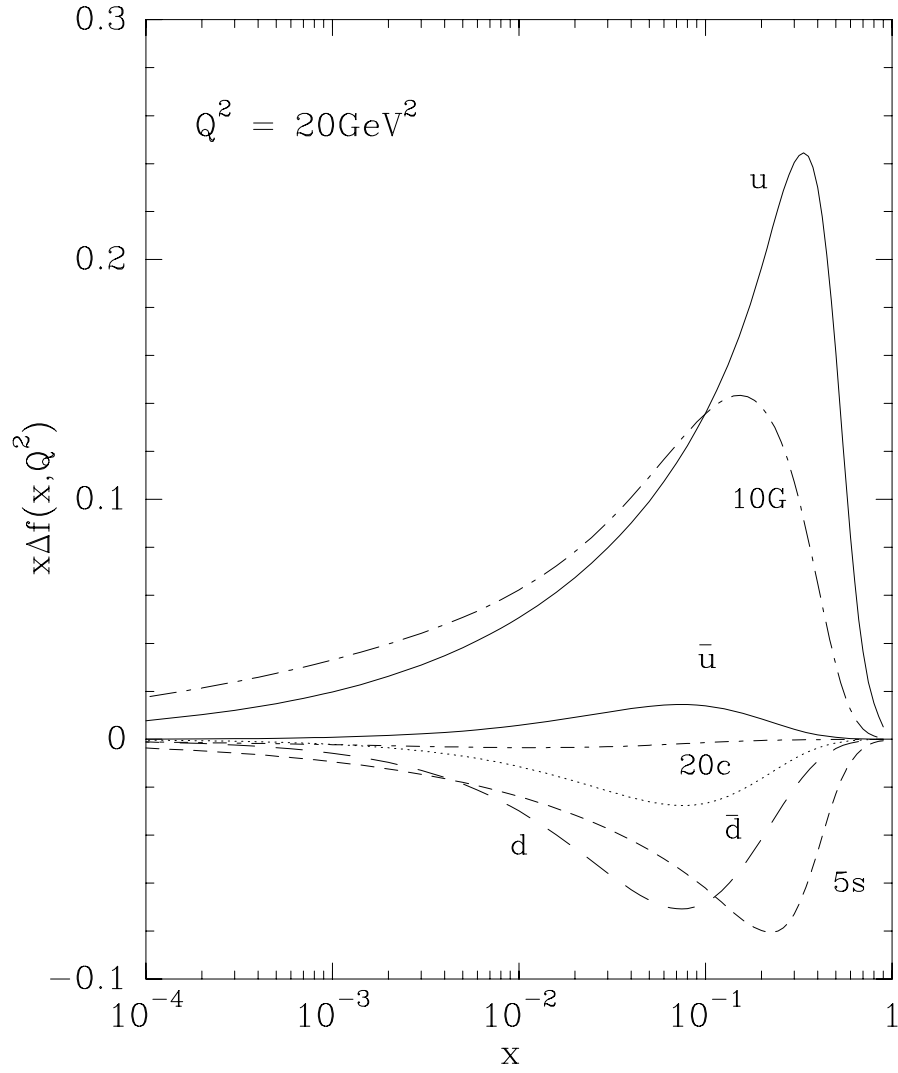


Figure 14: The different polarized parton distributions after NLO evolution, at $Q^2 = 20\text{GeV}^2$, as a function of x .

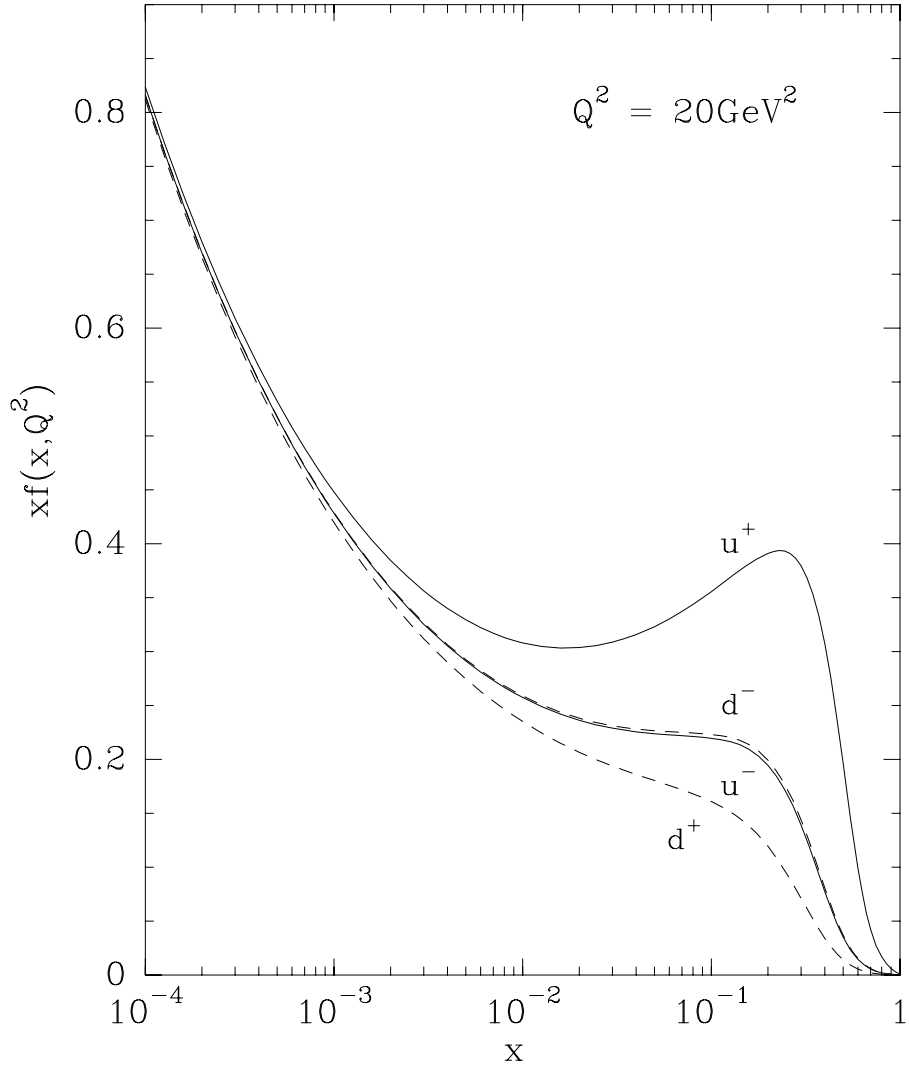


Figure 15: The different helicity components of the light quark distributions after NLO evolution, at $Q^2 = 20\text{GeV}^2$, as a function of x .

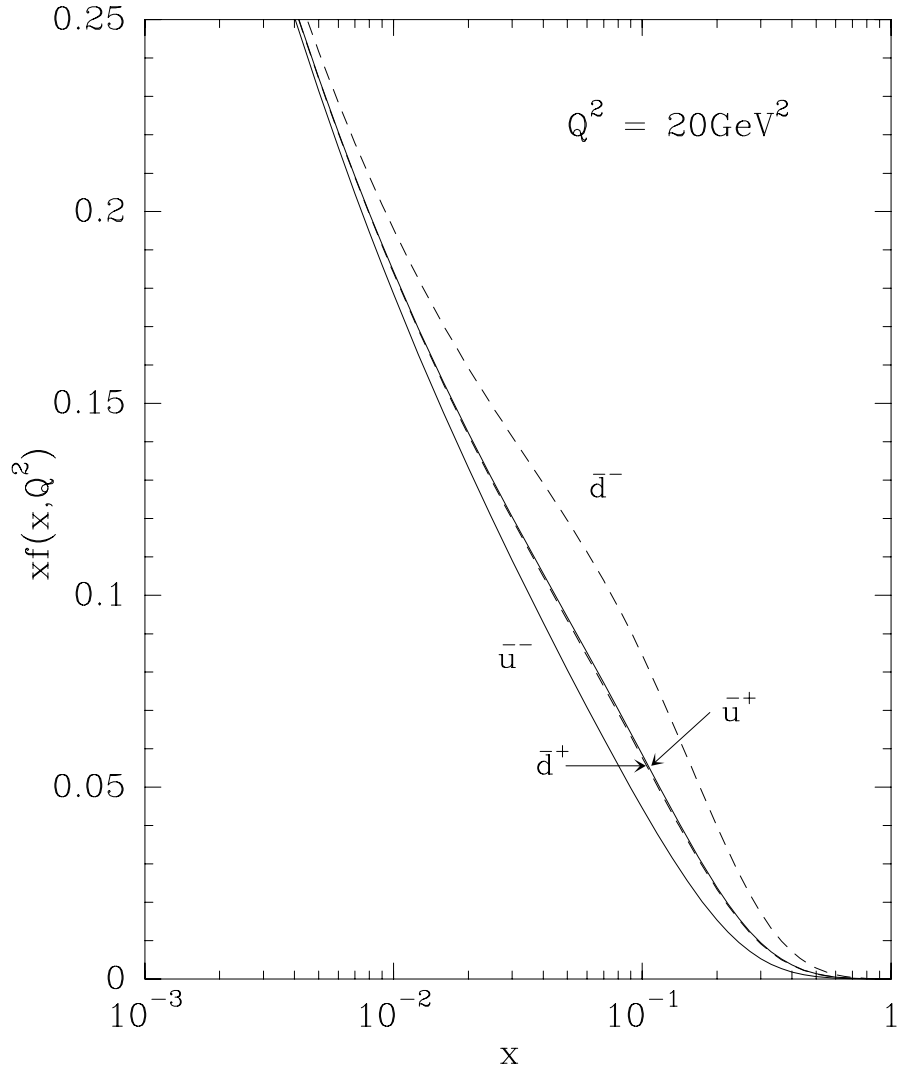


Figure 16: The different helicity components of the light antiquark distributions after NLO evolution, at $Q^2 = 20\text{GeV}^2$, as a function of x .

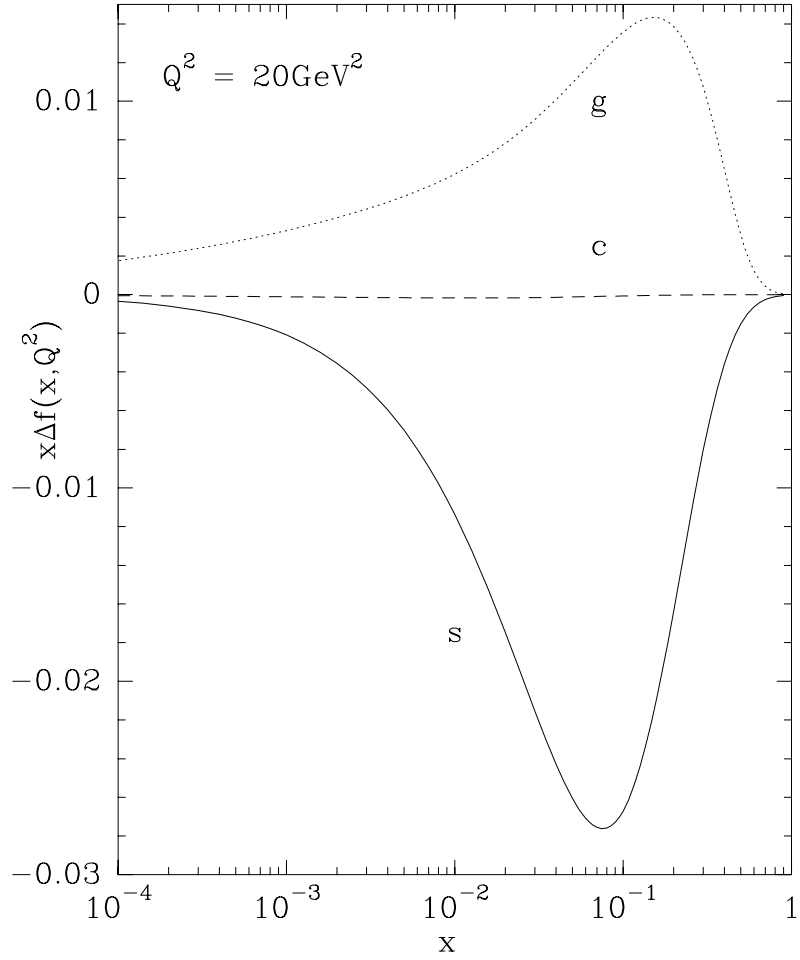


Figure 17: Details of the polarized parton distributions g , s , c , after NLO evolution, at $Q^2 = 20\text{GeV}^2$, as a function of x .

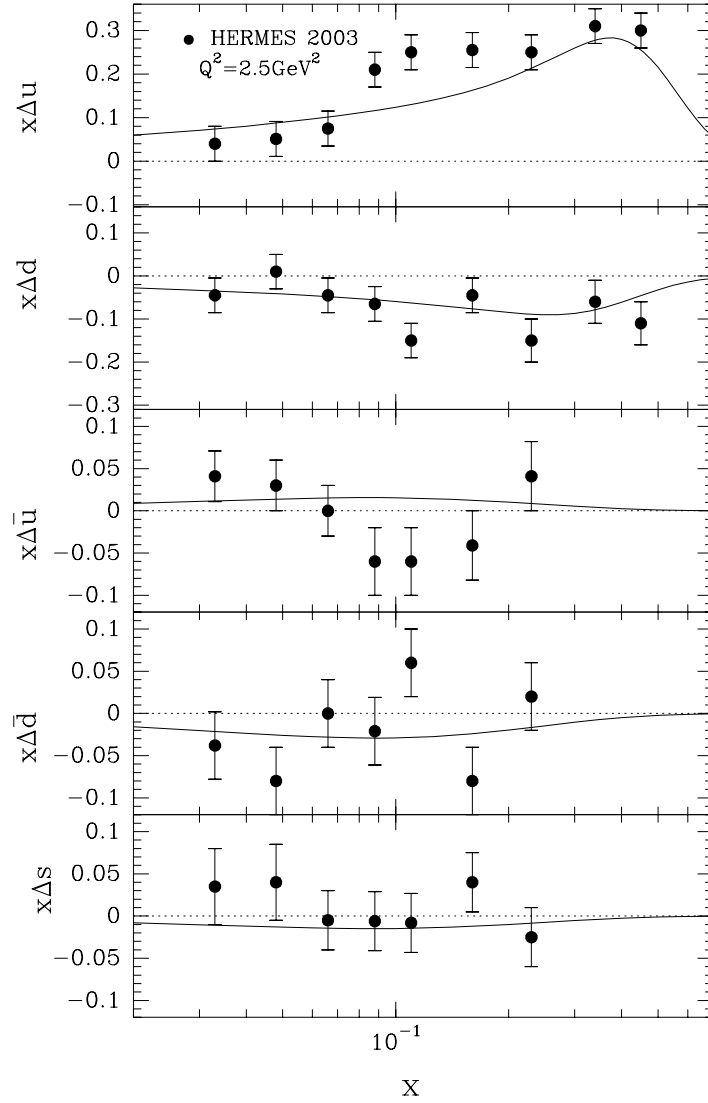


Figure 18: Quark helicity distributions at $\langle Q^2 \rangle = 2.5 \text{ GeV}^2$, as a function of x . Data from HERMES Coll. [46].

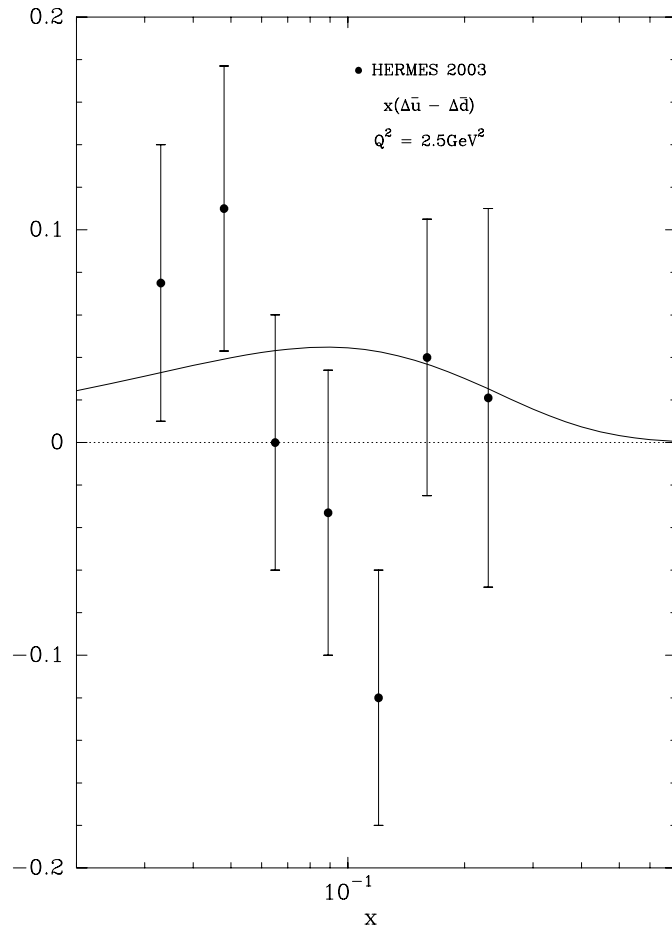


Figure 19: Flavor asymmetry $\Delta\bar{u} - \Delta\bar{d}$ of the light sea quark as a function of x , for $Q^2 = 2.5\text{GeV}^2$. Data from HERMES Coll. [46].

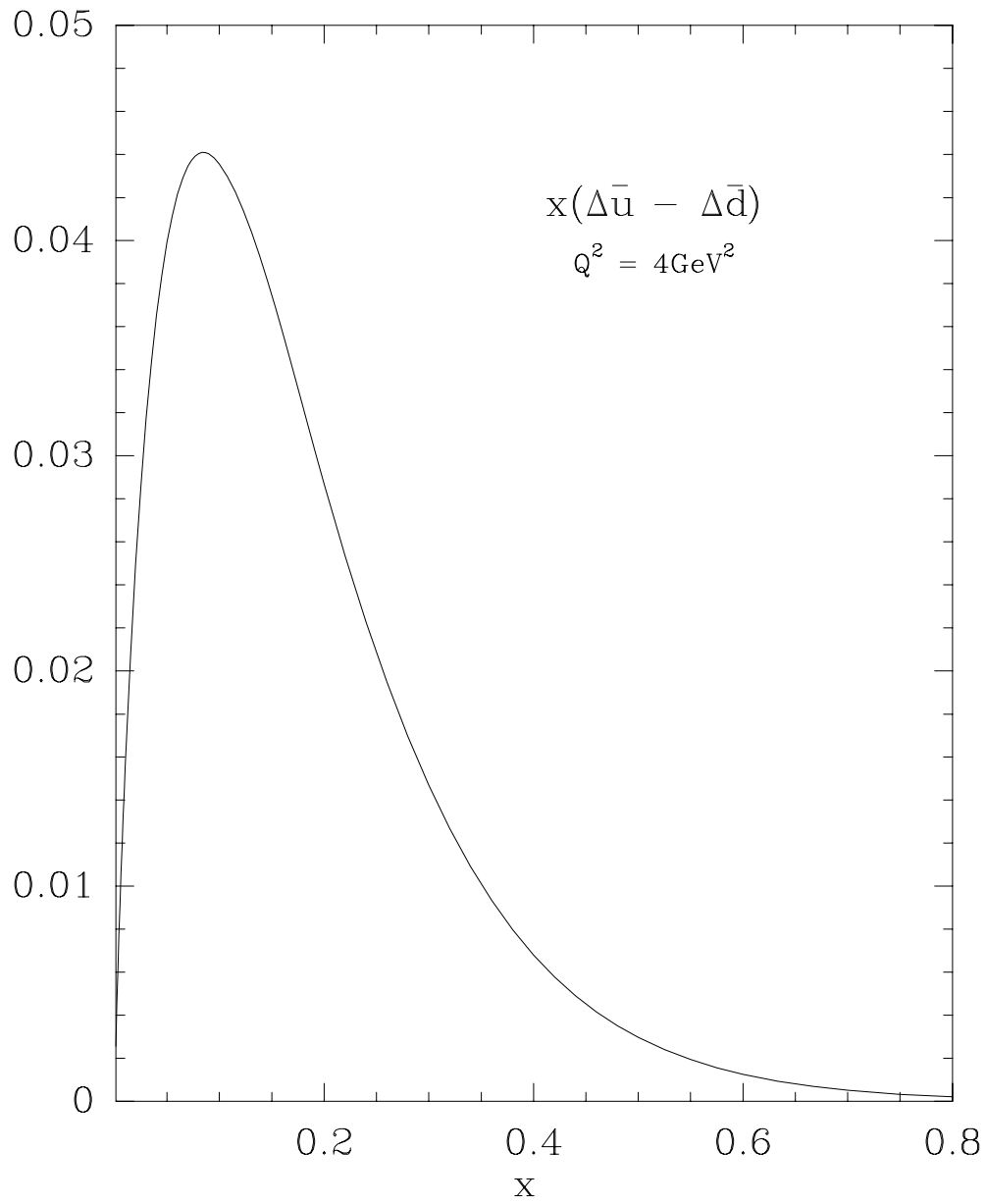


Figure 20: Flavor asymmetry $\Delta\bar{u} - \Delta\bar{d}$ of the light sea quark as a function of x , for $Q^2 = 4\text{GeV}^2$.

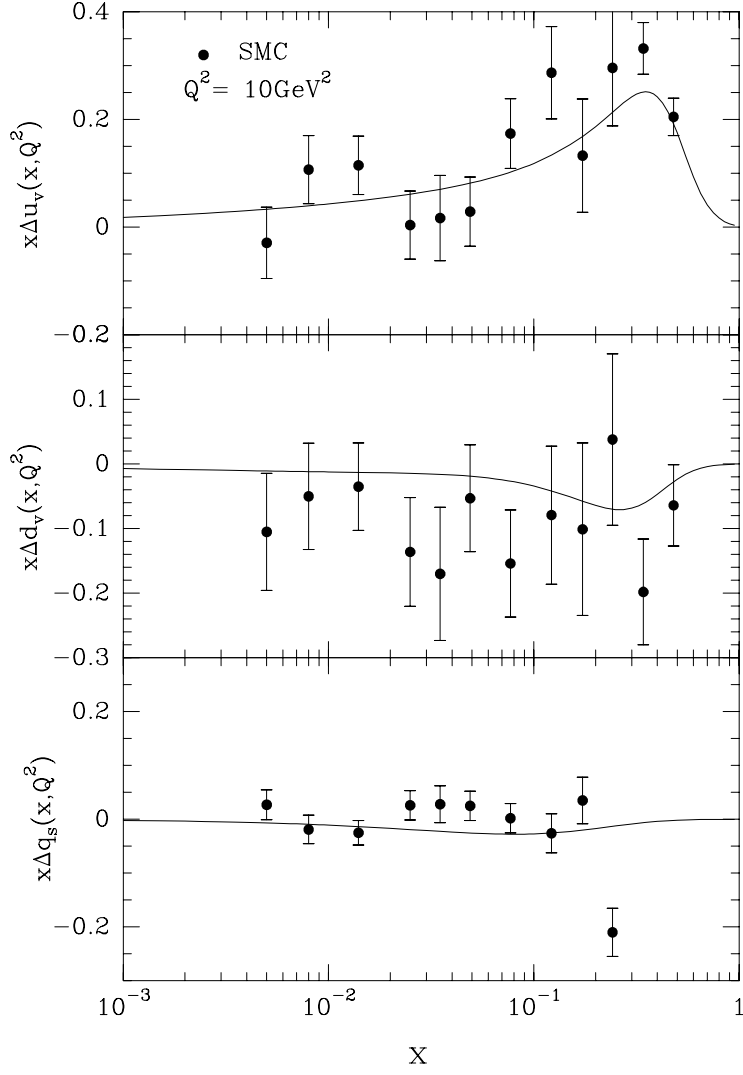


Figure 21: $x\Delta u_v$, $x\Delta d_v$, $x\Delta \bar{q}$ as function of x at fixed $Q^2 = 10 \text{ GeV}^2$, experiment SMC Coll..

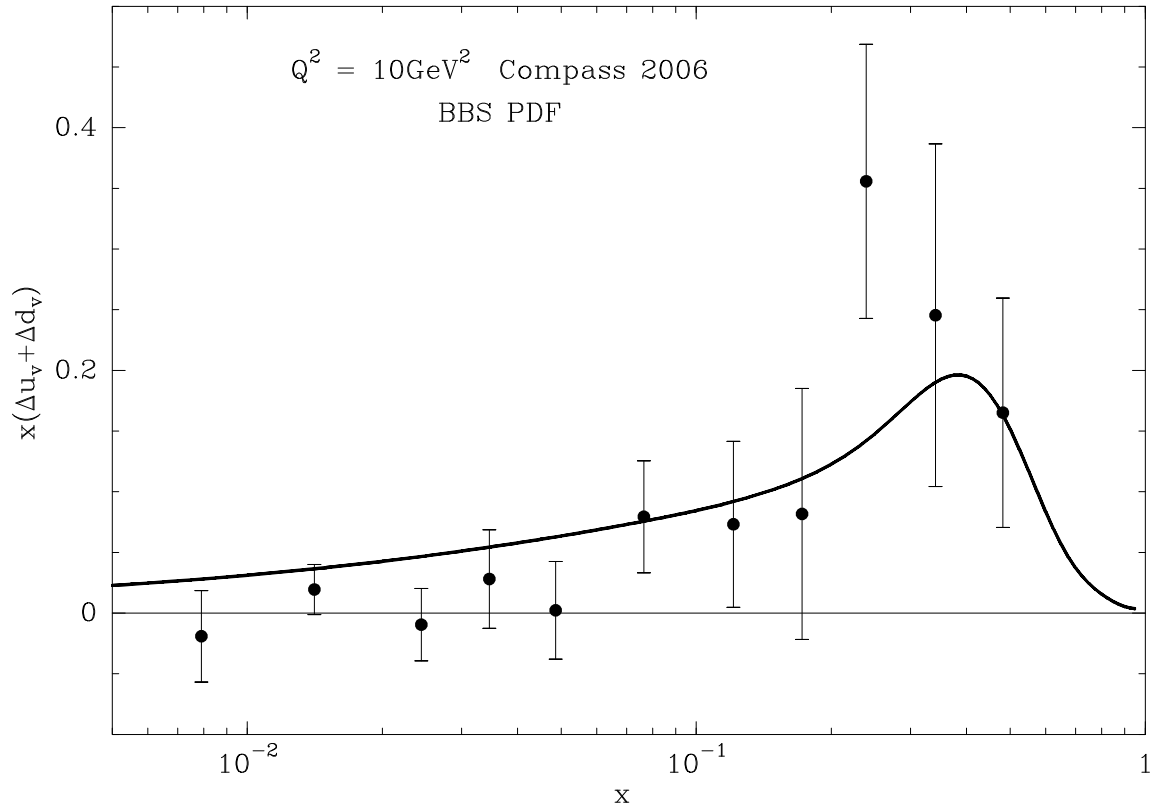


Figure 22: The sum of polarized valence quark distributions determined at NLO as a function of x for $Q^2 = 10 \text{ GeV}^2$, data from Compass Collaboration [109, 110].

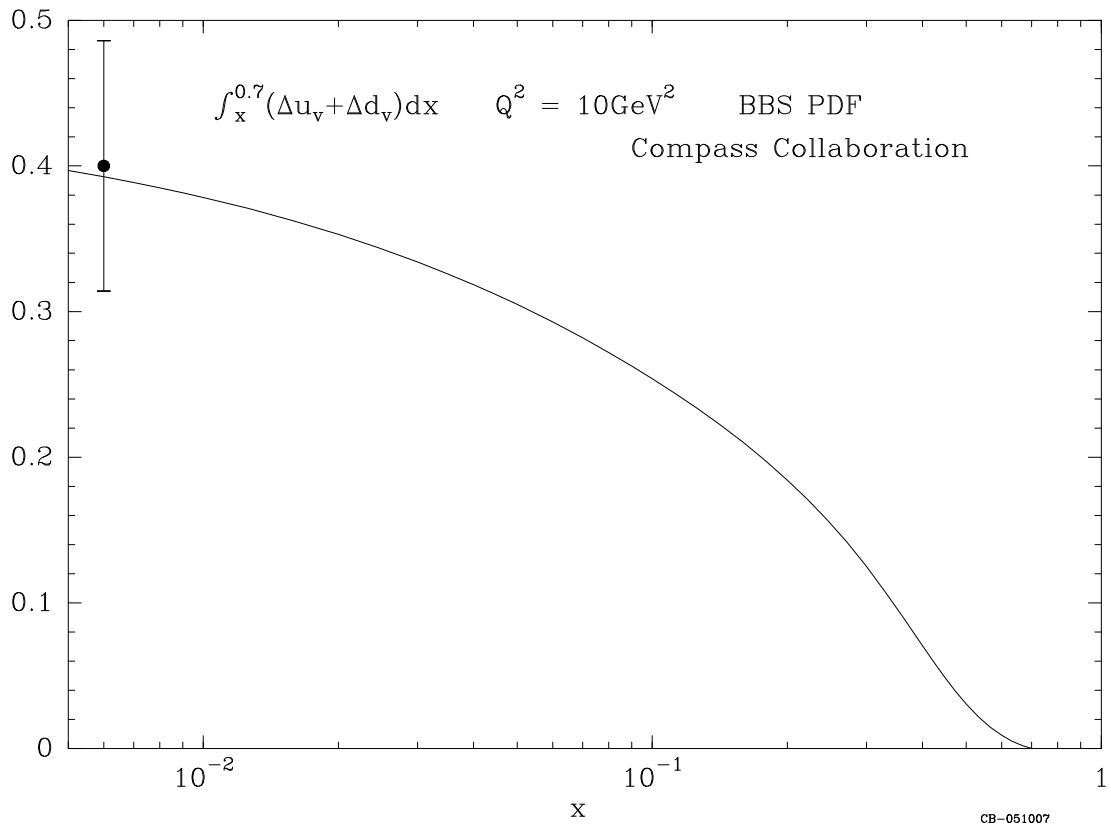


Figure 23: Prediction for the integral $\Delta u_v + \Delta d_v$ determined at NLO as a function of the lower limit x for $Q^2 = 10 \text{ GeV}^2$.

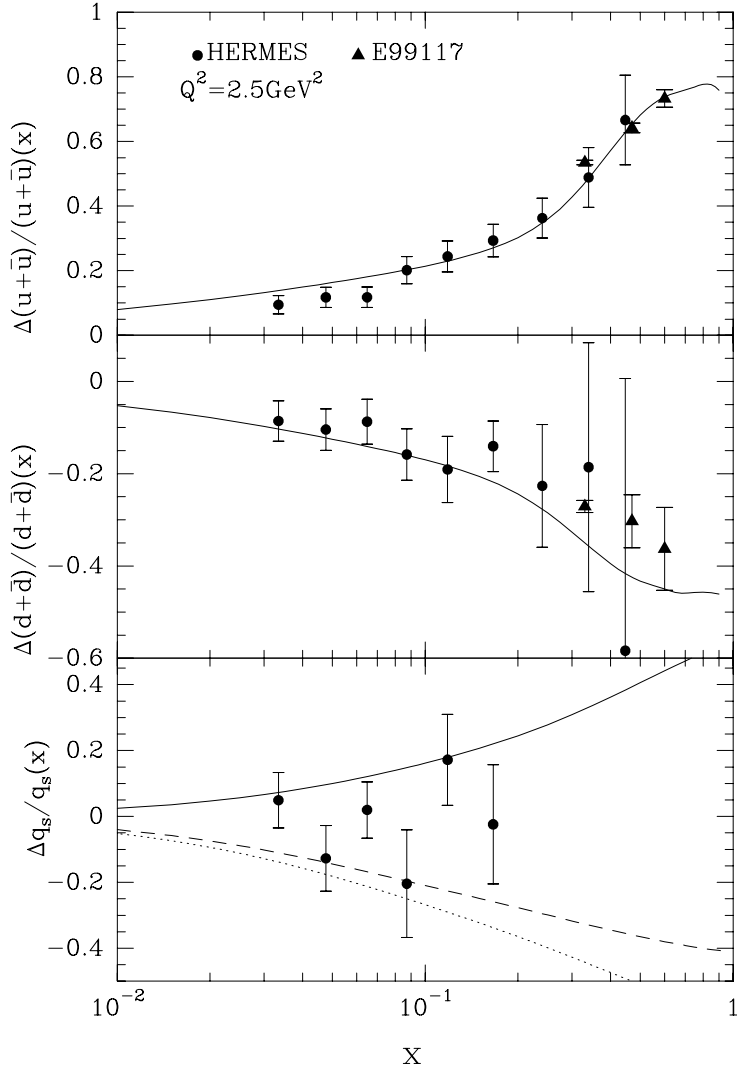


Figure 24: HERMES [44] and E99-117 [54] data on $(\Delta u + \Delta \bar{u})/(u + \bar{u})$, $(\Delta d + \Delta \bar{d})/(d + \bar{d})$, $\Delta q_s/q_s$ as function of x at fixed $Q^2 = 2.5 \text{ GeV}^2$. The curves are our model calculations. For the sea quarks $\Delta \bar{u}/\bar{u}$ (solid curve), $\Delta \bar{d}/\bar{d}$ (dashed curve) and $\Delta s/s$ (dotted curve).

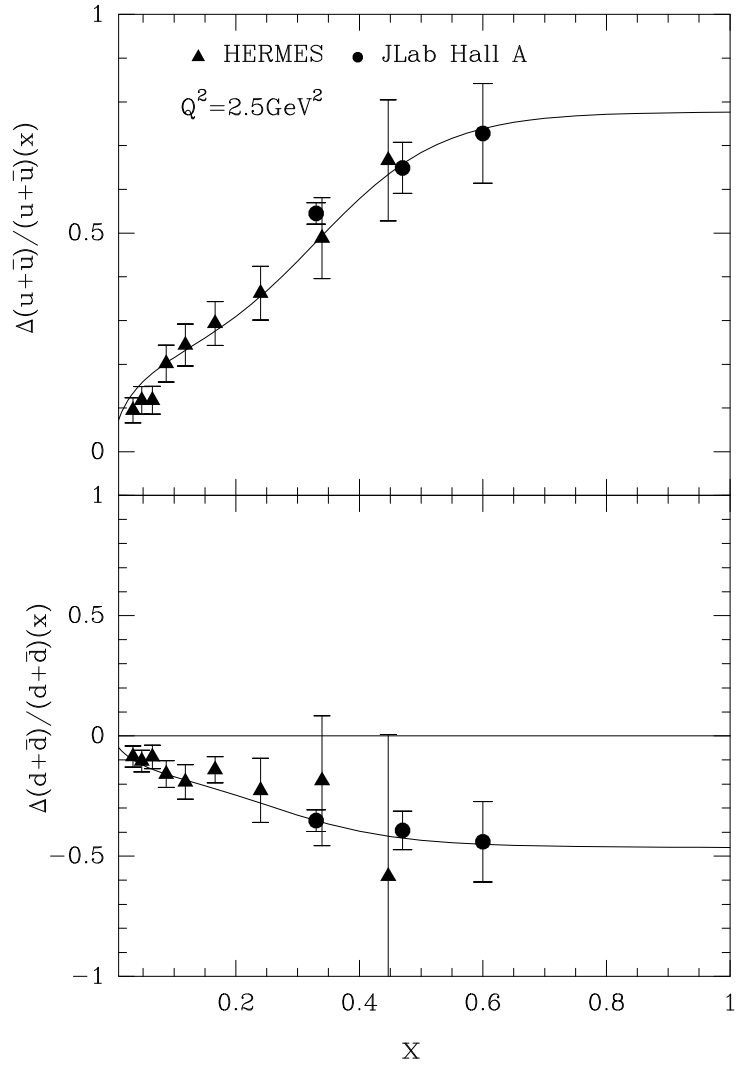


Figure 25: Ratios $(\Delta u + \Delta \bar{u})/(u + \bar{u})$ and $(\Delta d + \Delta \bar{d})/(d + \bar{d})$ as a function of x for $Q^2 = 2.5 \text{ GeV}^2$. Data from Hermes [44] and JLab experiments [45].

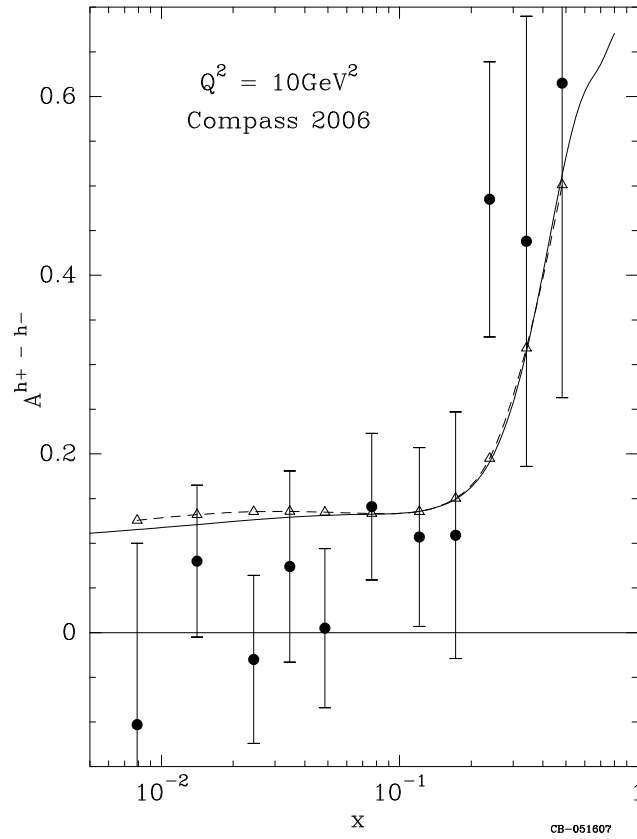


Figure 26: Prediction of BBS PDF for the difference asymmetry $A^{h^+h^-}$ determined at NLO as a function of x for $Q^2 = 10\text{GeV}^2$, data from Compass Collaboration.

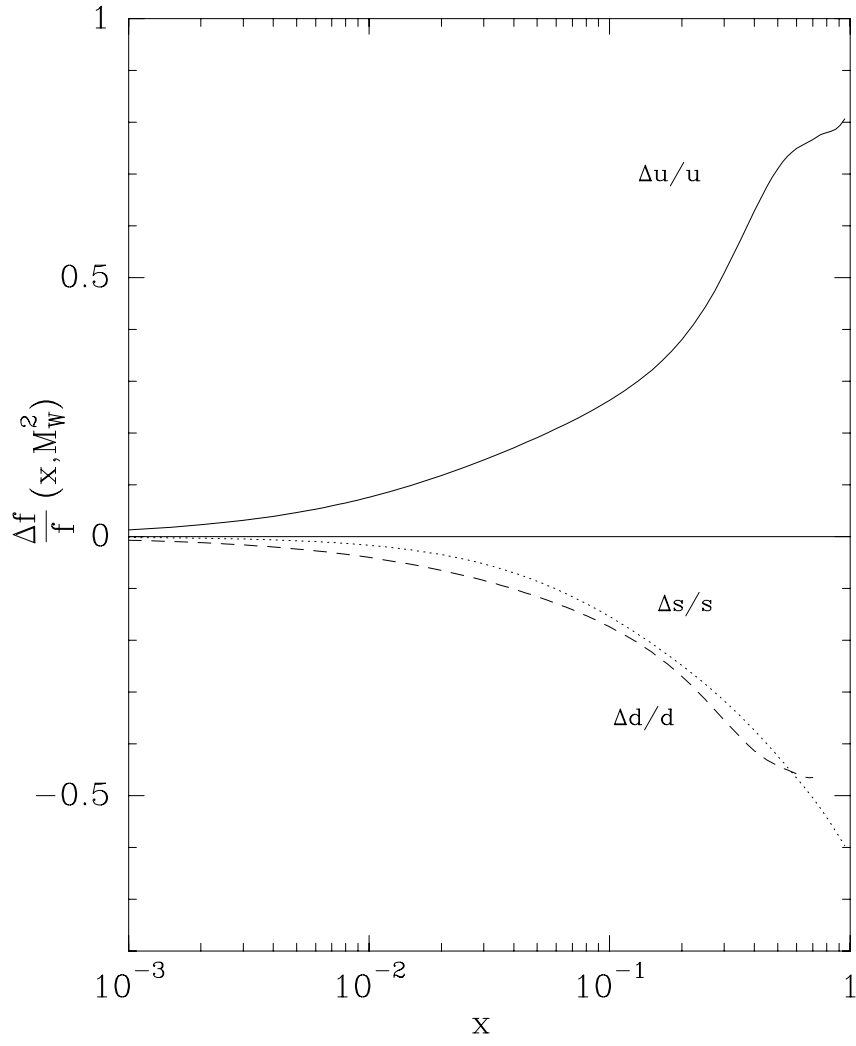


Figure 27: Ratio polarized/unpolarized quark distributions for u , d , s , at $Q^2 = 4\text{GeV}^2$.

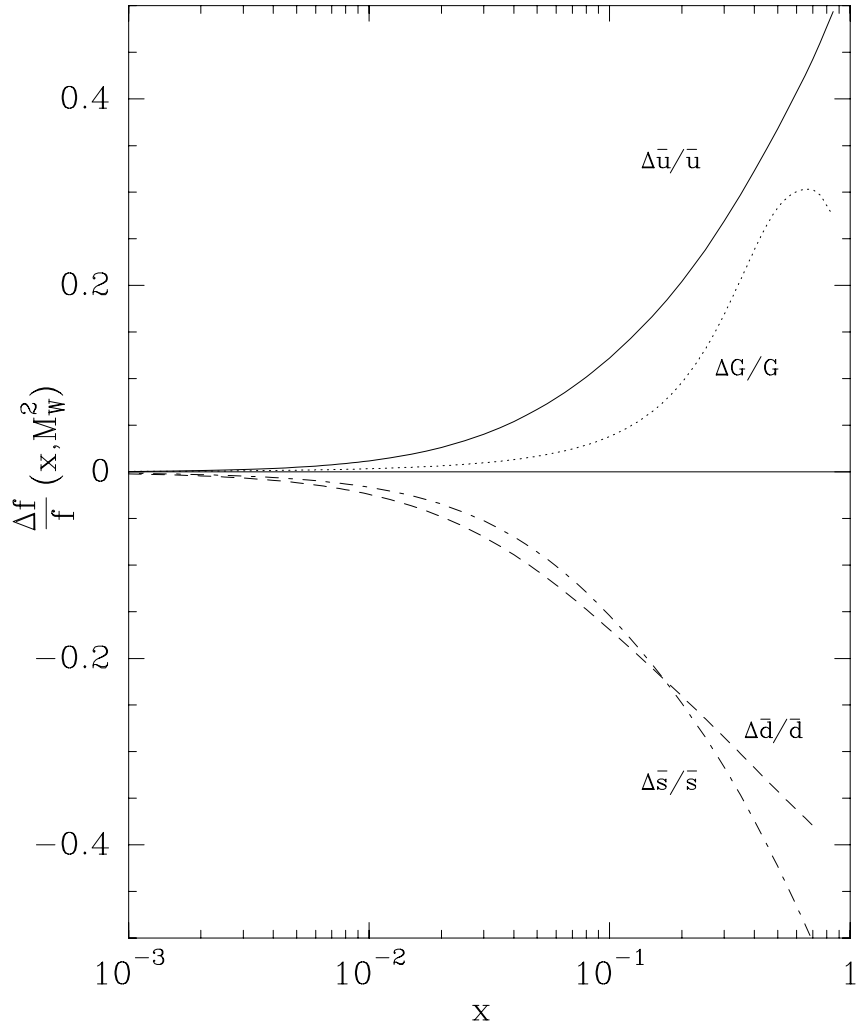


Figure 28: Ratio polarized/unpolarized antiquark distributions for \bar{u} , \bar{d} , \bar{s} and G , at $Q^2 = 4\text{GeV}^2$.

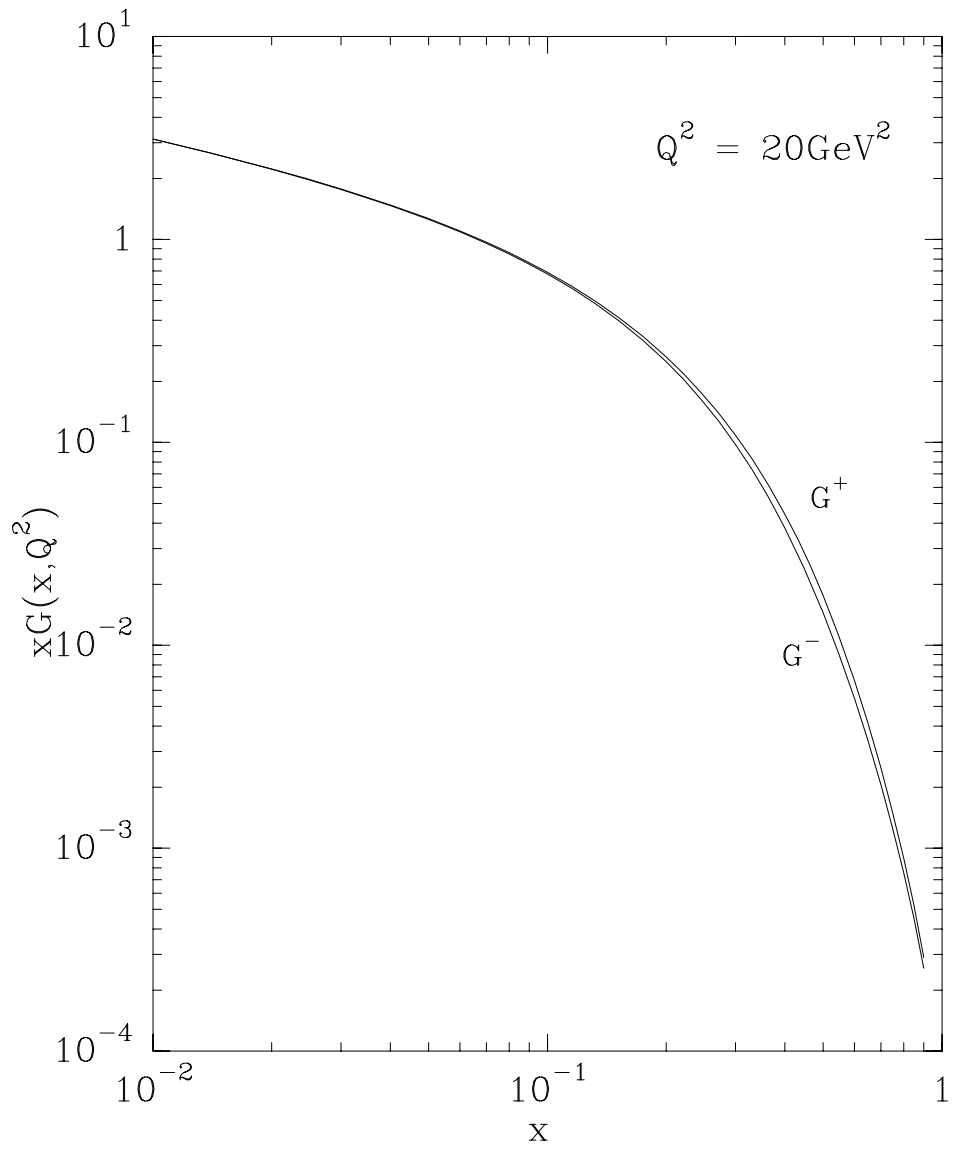


Figure 29: Spin components of gluon density

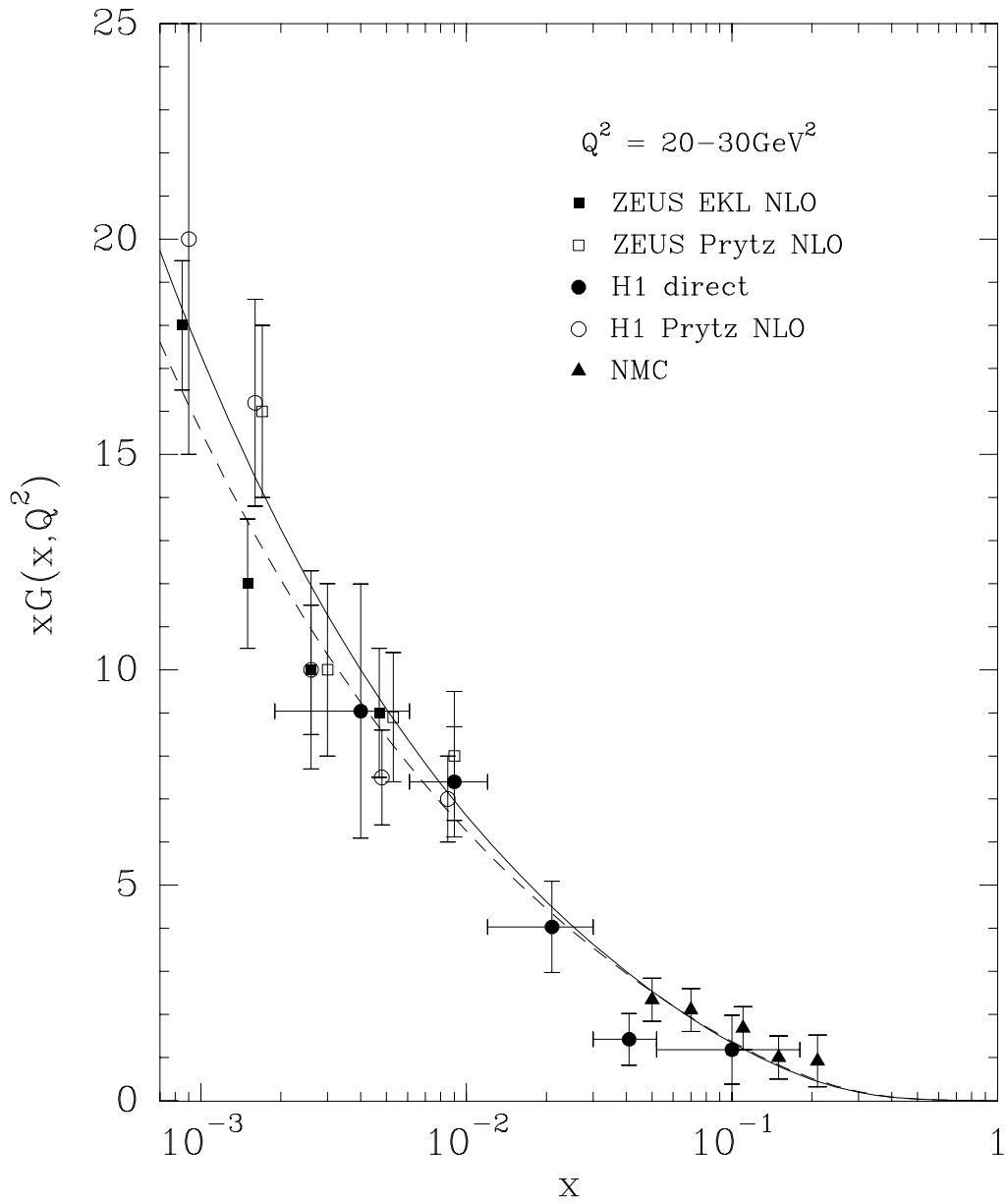


Figure 30: Comparison of $xG(x, Q^2)$ at $Q^2 = 20 - 30\text{GeV}^2$ (dashed-solid) with experimental determination from NMC [57], H1 [39] and ZEUS [91] experiments.

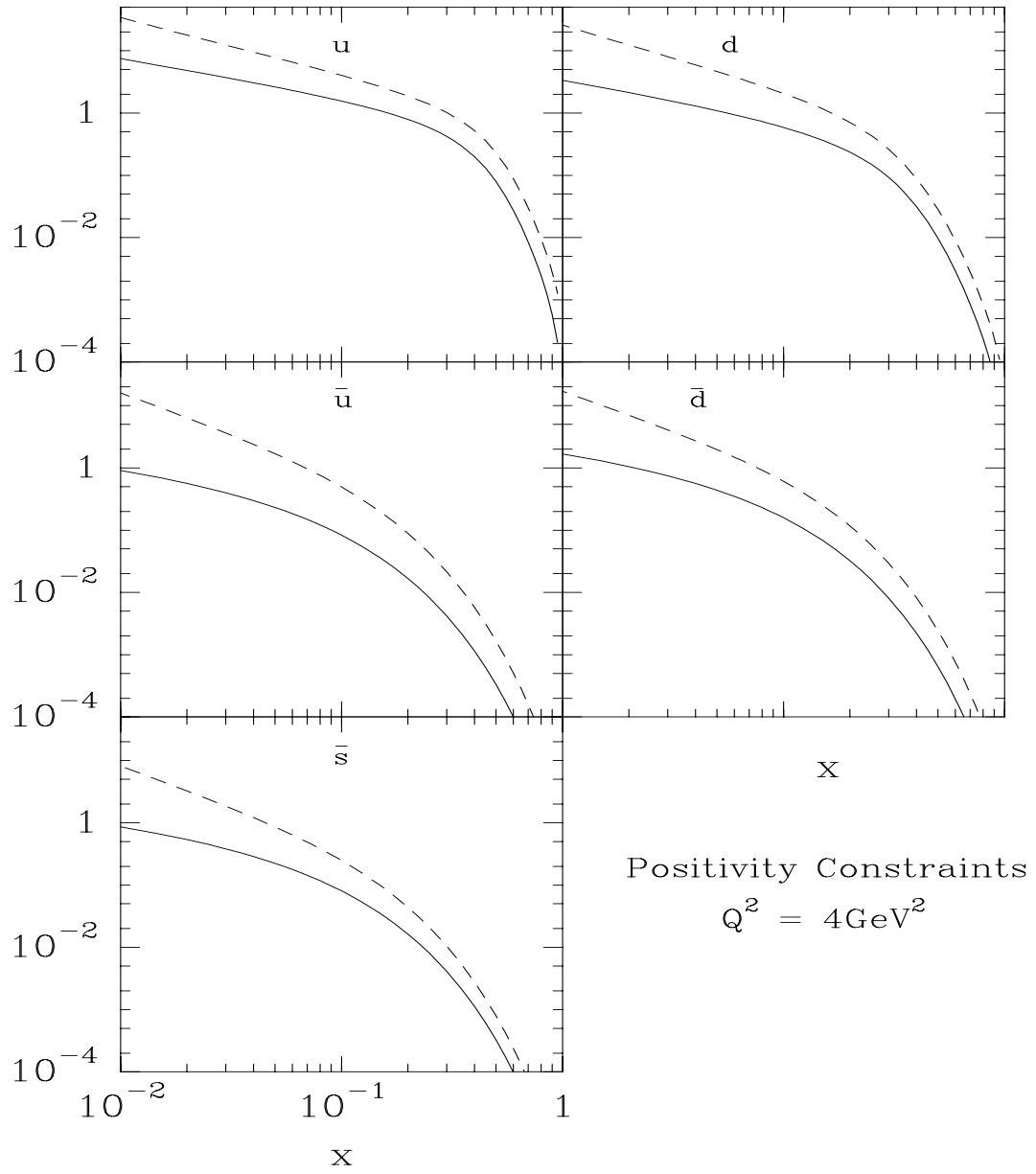


Figure 31: Positivity constraints between polarized and unpolarized distributions according to the inequality of Soffer-Teryaev [98].

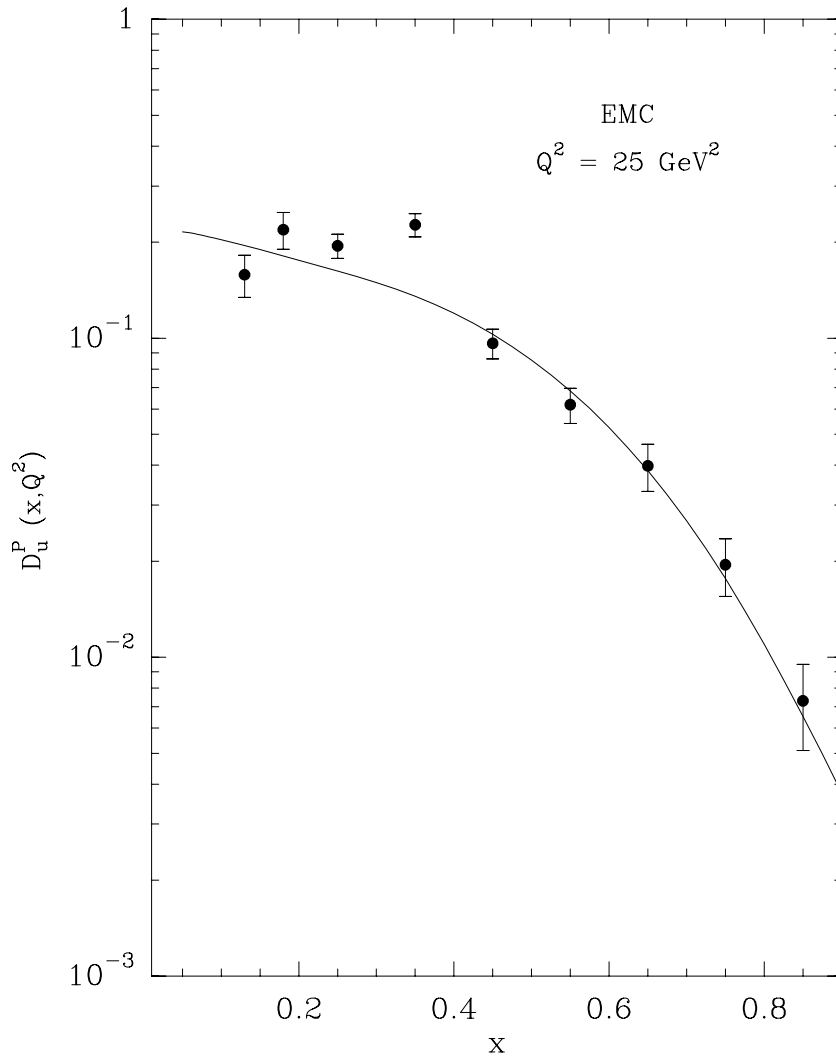


Figure 32: The u quark to proton fragmentation function $D_u^p(x, Q^2)$ as a function of x at $Q^2 = 25 \text{ GeV}^2$. The experimental data are from Ref. [36].

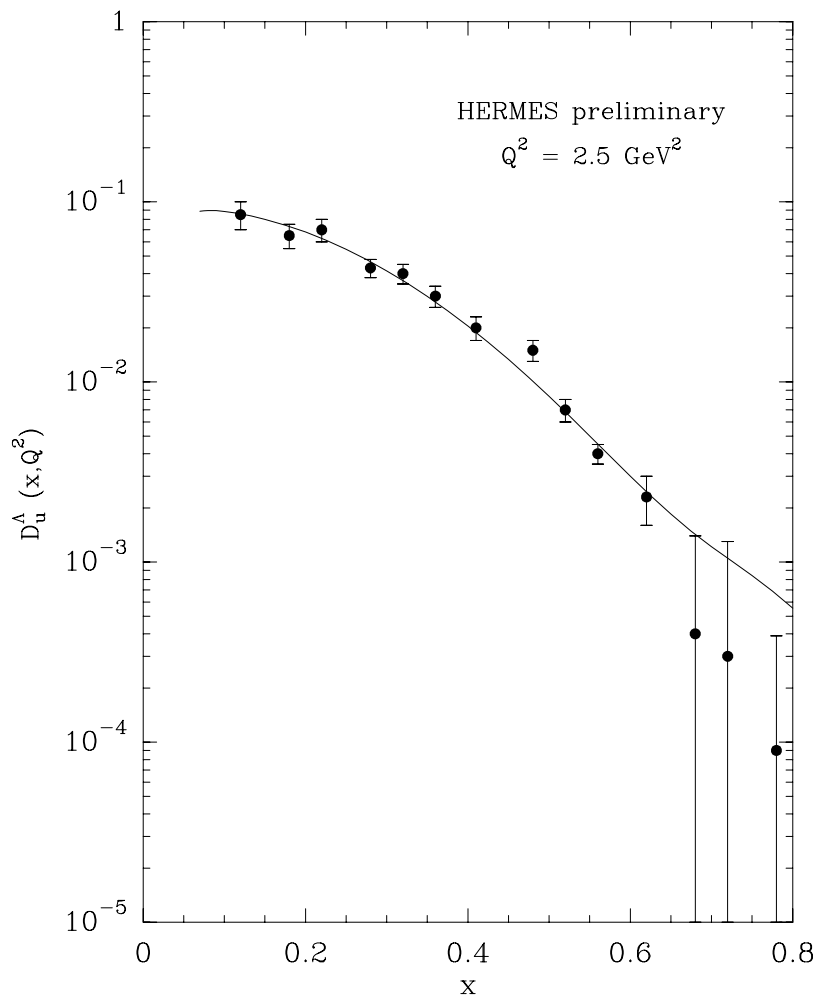


Figure 33: The fragmentation function for u quark to Λ , $D_u^\Lambda(x, Q^2)$, as a function of x at $Q^2 = 2.5 \text{ GeV}^2$. The experimental data are from Ref. [43].

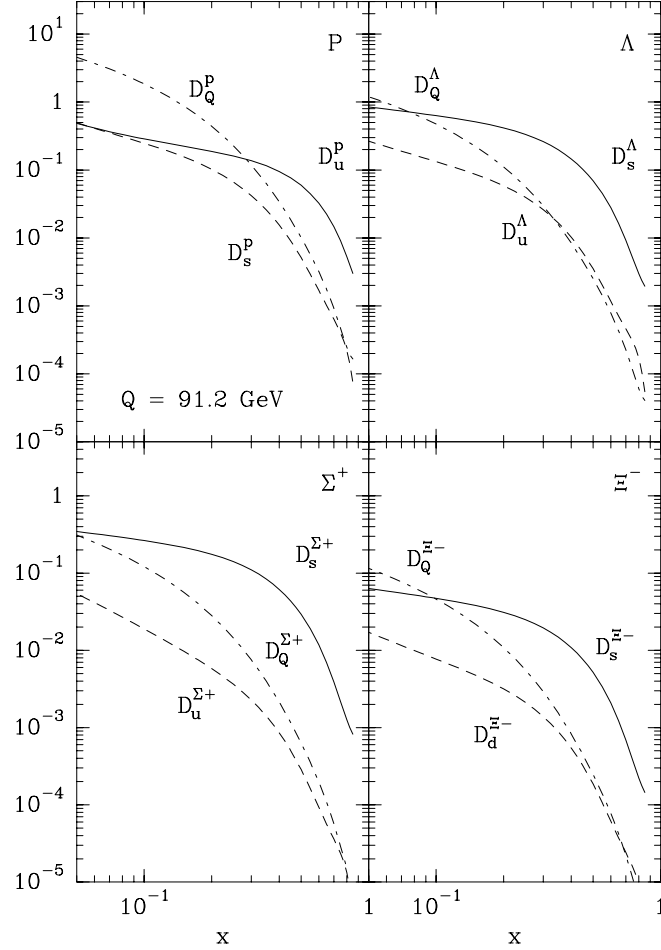


Figure 34: The quark to octet baryons fragmentation functions $D_q^B(x, Q^2)$ and $D_Q^B(x, Q^2)$ ($B = p, \Lambda, \Sigma^\pm, \Xi^\pm$, $q = u, d, s$ and $Q = c, b, t$), as a function of x at $Q = 91.2\text{GeV}$. Note that we used different vertical scales in the upper and lower parts of the figure.

4 Unpolarized experiments

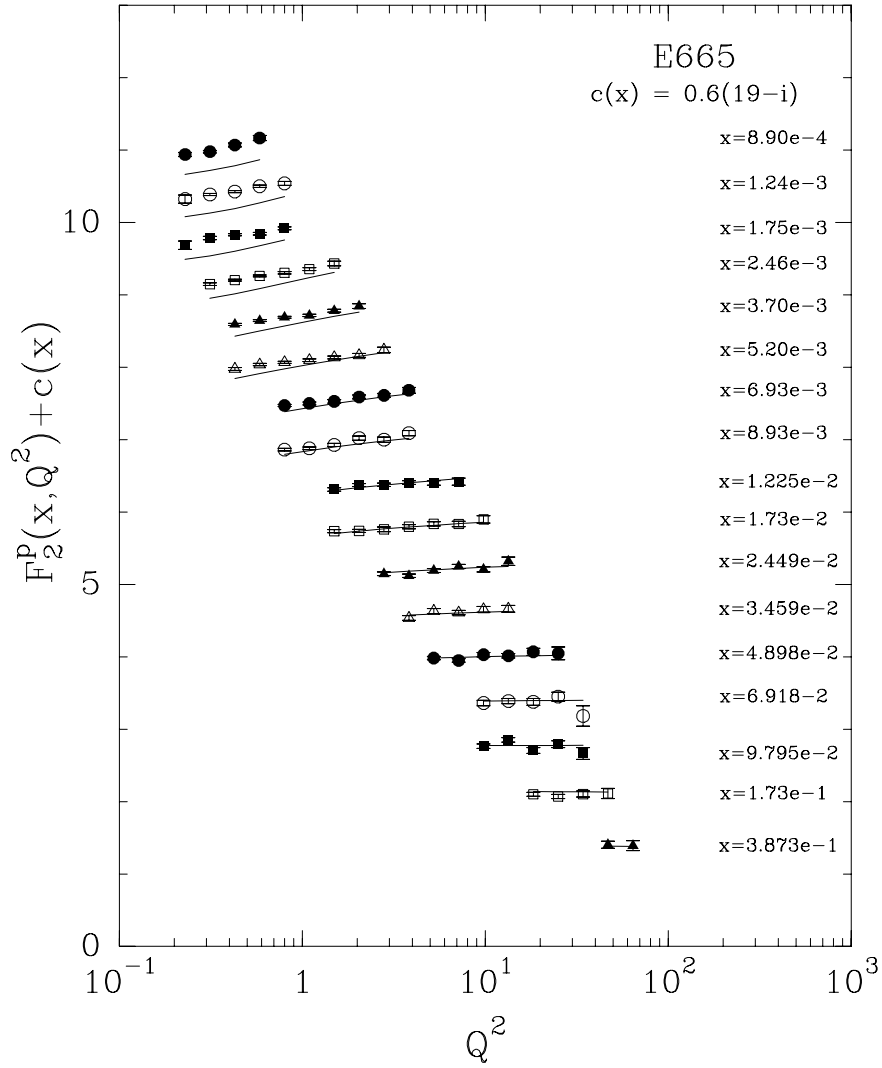


Figure 35: $F_2^p(x, Q^2)$ as function of Q^2 for fixed x , E665 data [23]. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 8.9 \cdot 10^{-4}$.

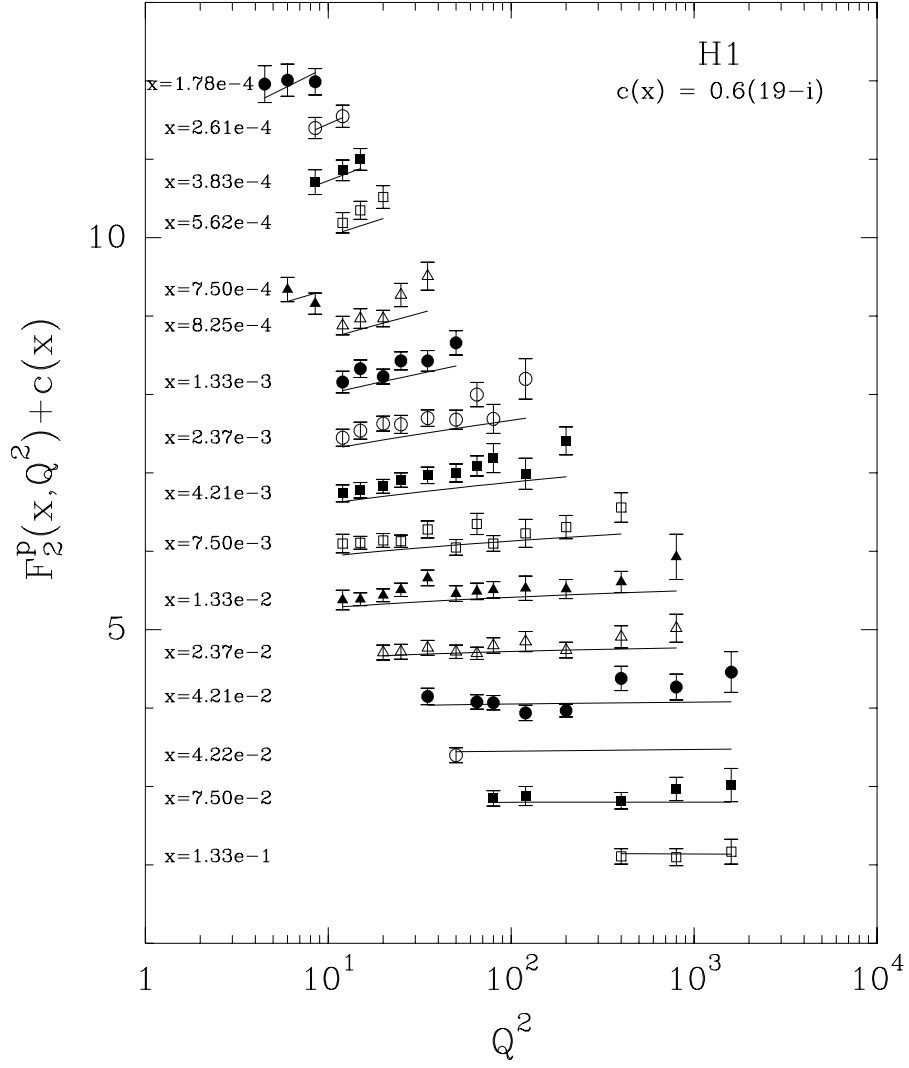


Figure 36: $F_2^p(x, Q^2)$ as function of Q^2 for fixed x , H1 data [37, 38]. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 1.78 \cdot 10^{-4}$.

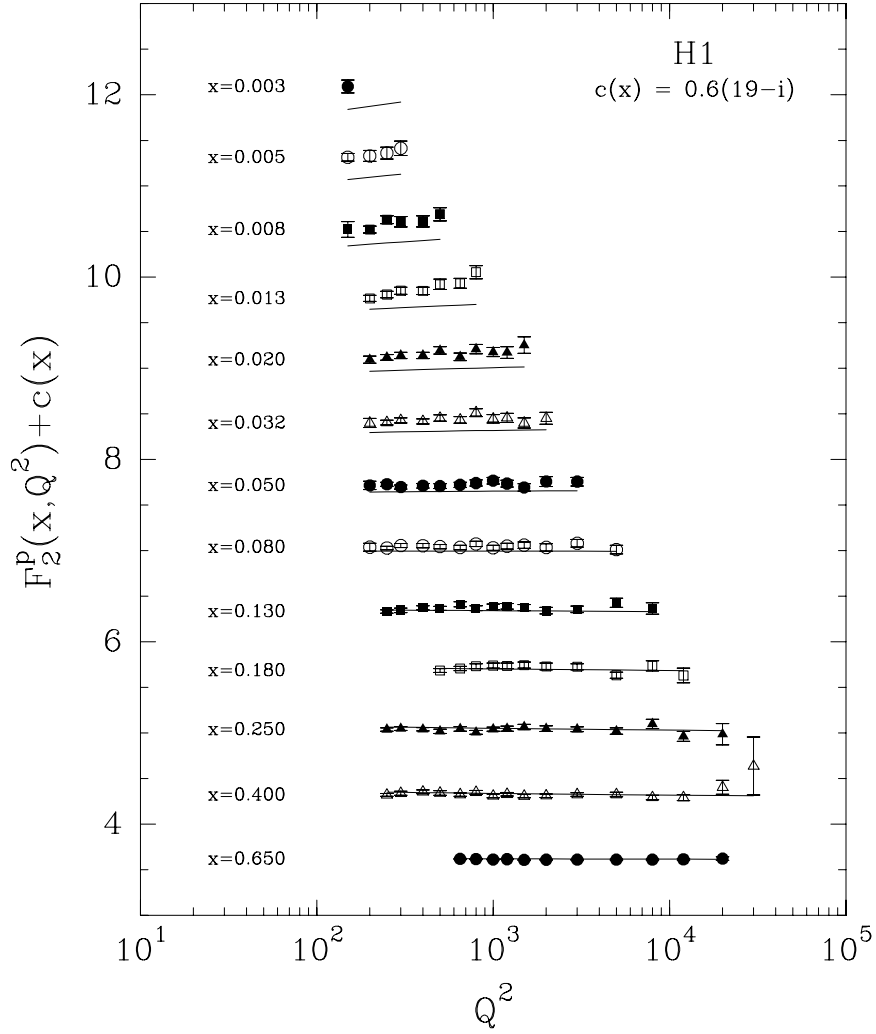


Figure 37: $F_2^p(x, Q^2)$ as function of Q^2 for fixed x , H1 Coll. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 0.003$.

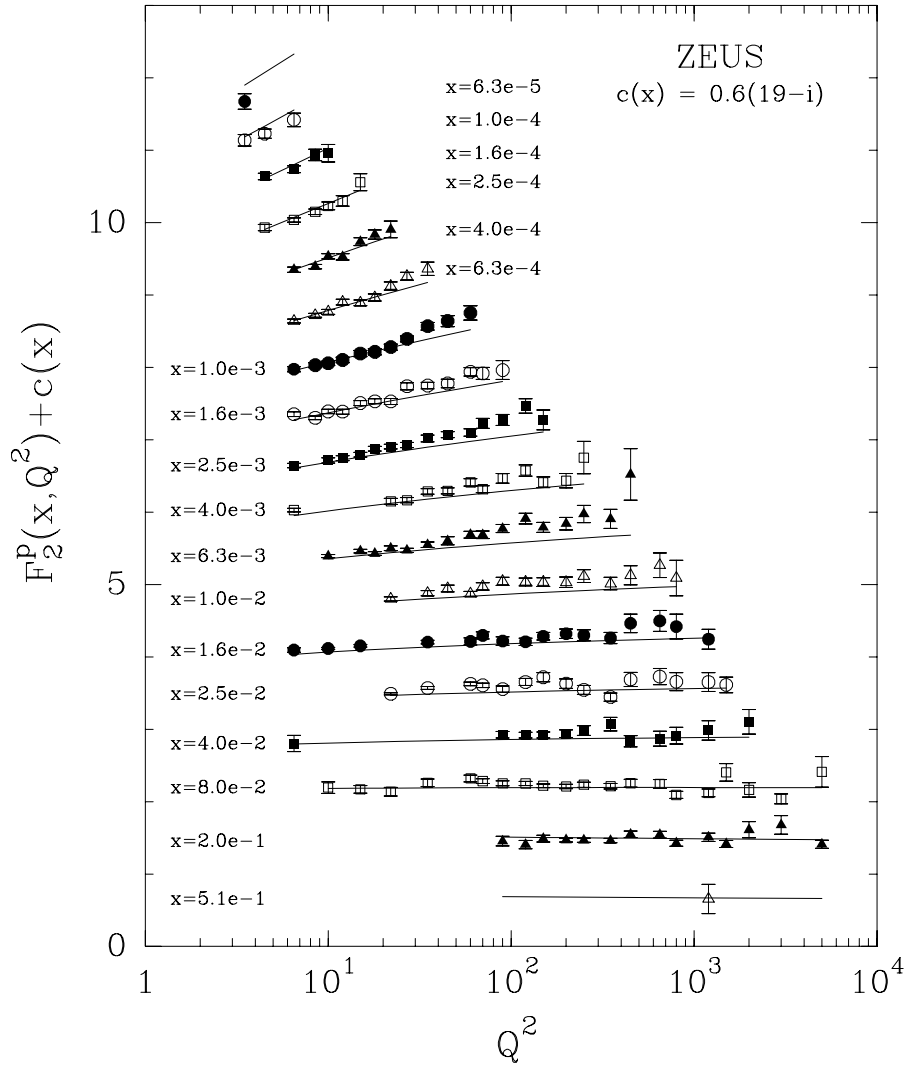


Figure 38: $F_2^p(x, Q^2)$ as function of Q^2 for fixed x , ZEUS data [92, 93]. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 6.3 \cdot 10^{-5}$.

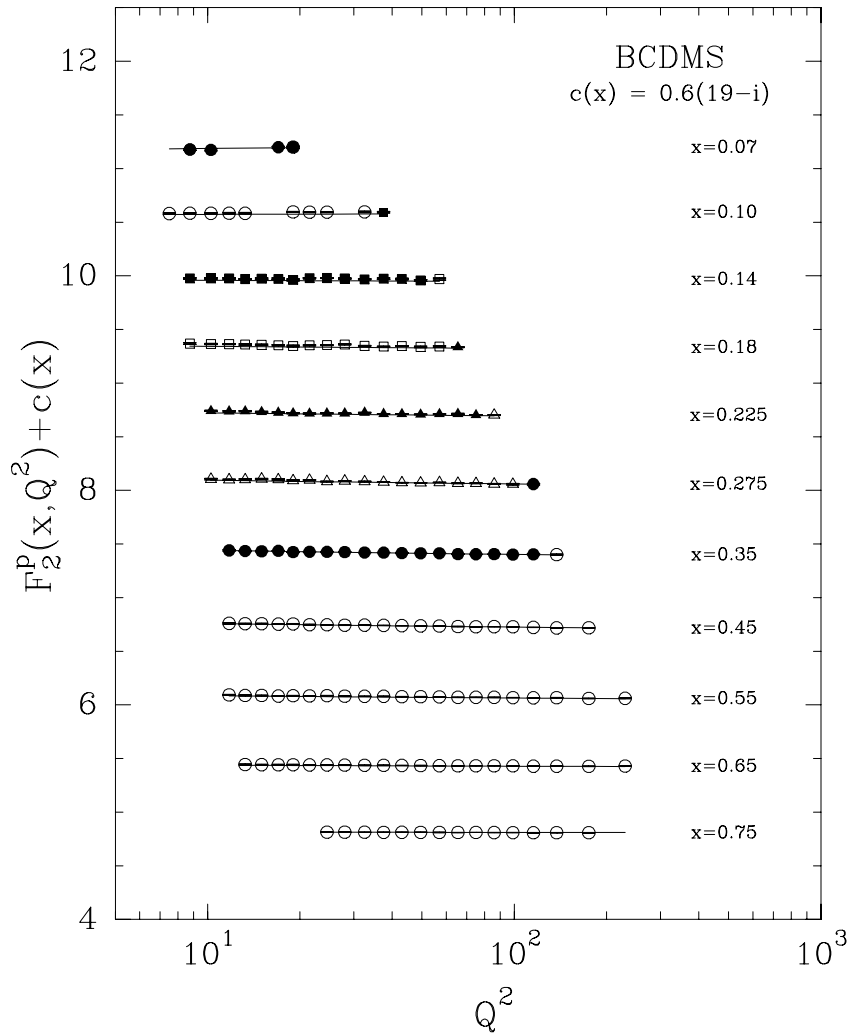


Figure 39: $F_2^p(x, Q^2)$ as function of Q^2 for fixed x , BCDMS Coll. [11, 12]. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 0.07$

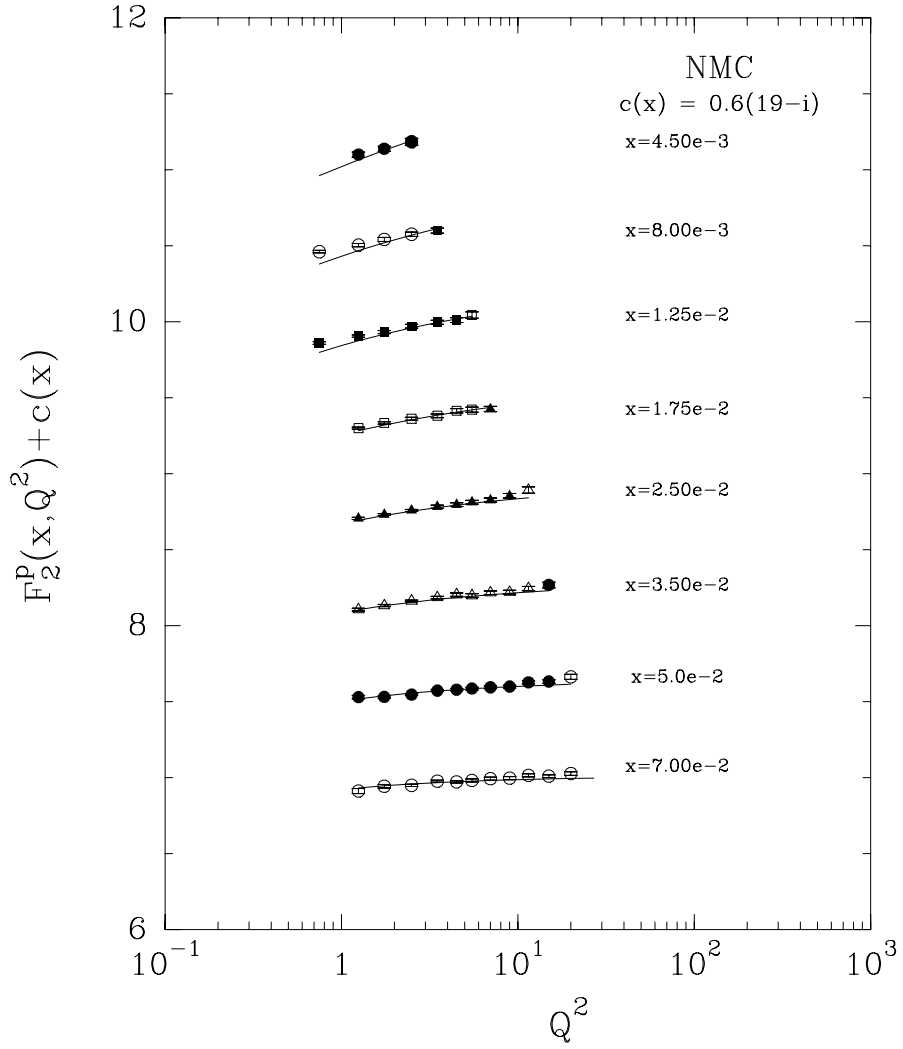


Figure 40: $F_2^p(x, Q^2)$ as function of Q^2 for fixed x , NMC Coll. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 4.5 \cdot 10^{-3}$.

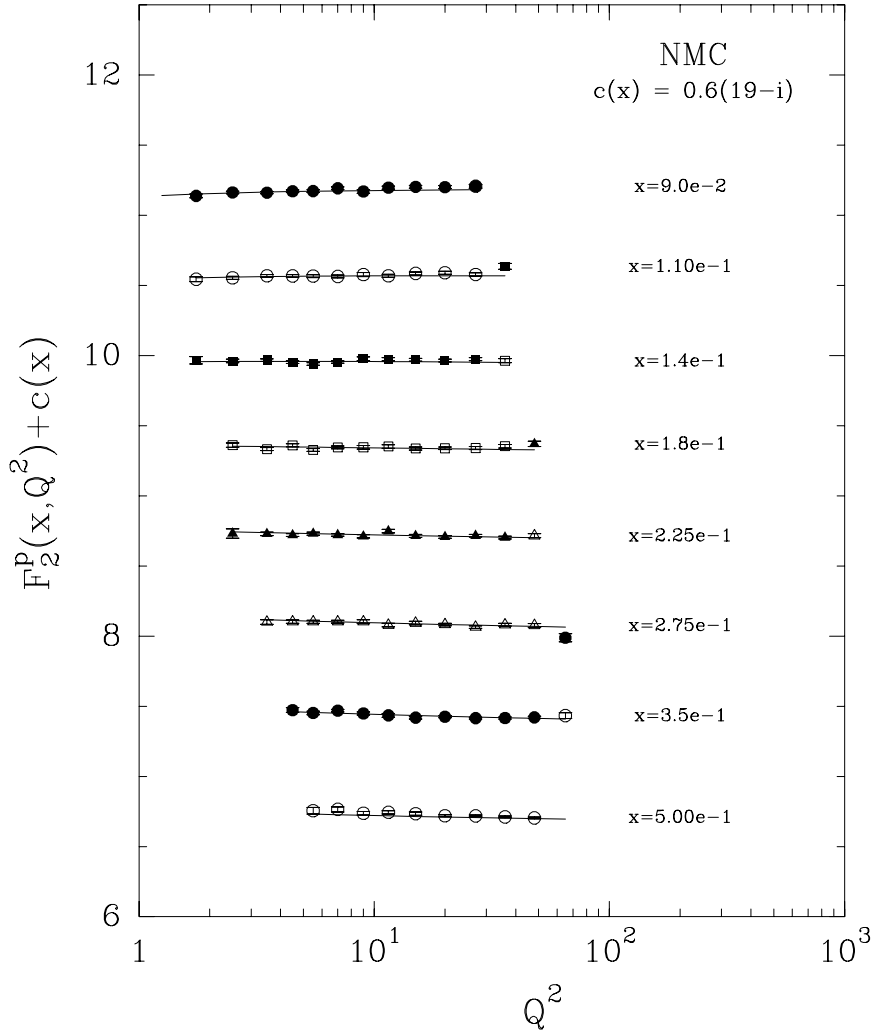


Figure 41: $F_2^p(x, Q^2)$ as function of Q^2 for fixed x , NMC Coll. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 9 \cdot 10^{-2}$.

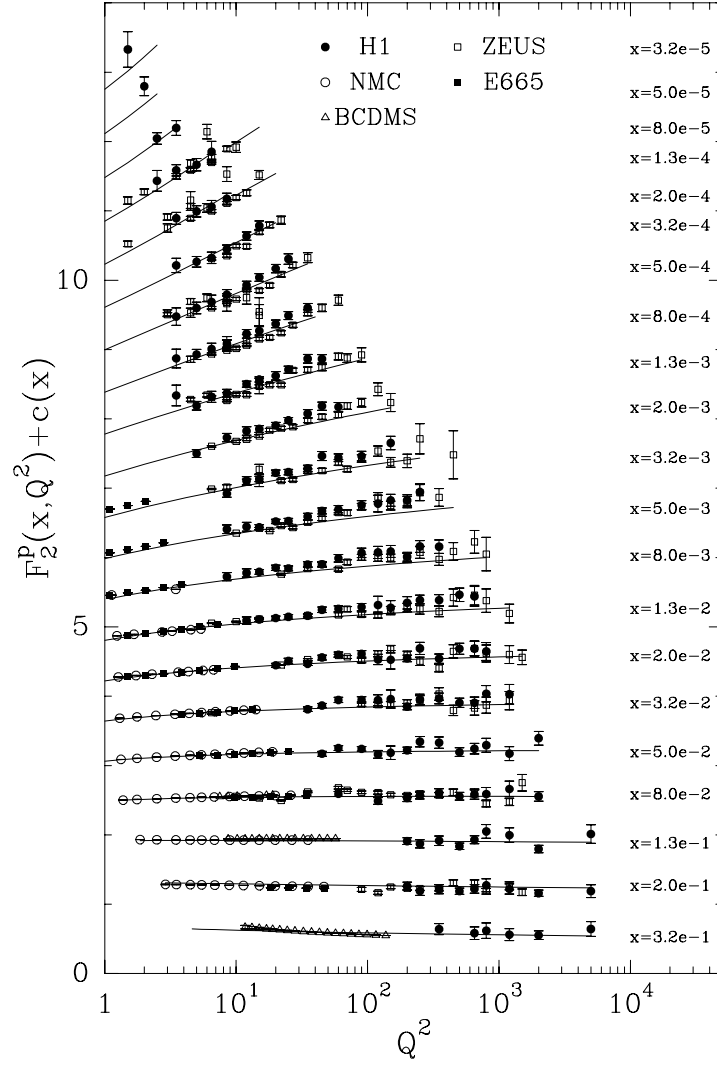


Figure 42: $F_2^p(x, Q^2)$ as function of Q^2 for fixed x , $c(x) = 0.6(i_x - 0.4)$, $i_x = 1 \rightarrow x = 0.32$, rebinned data H1, ZEUS, E665, NMC, BCDMS. (Presentation of data, courtesy of R. Voss).

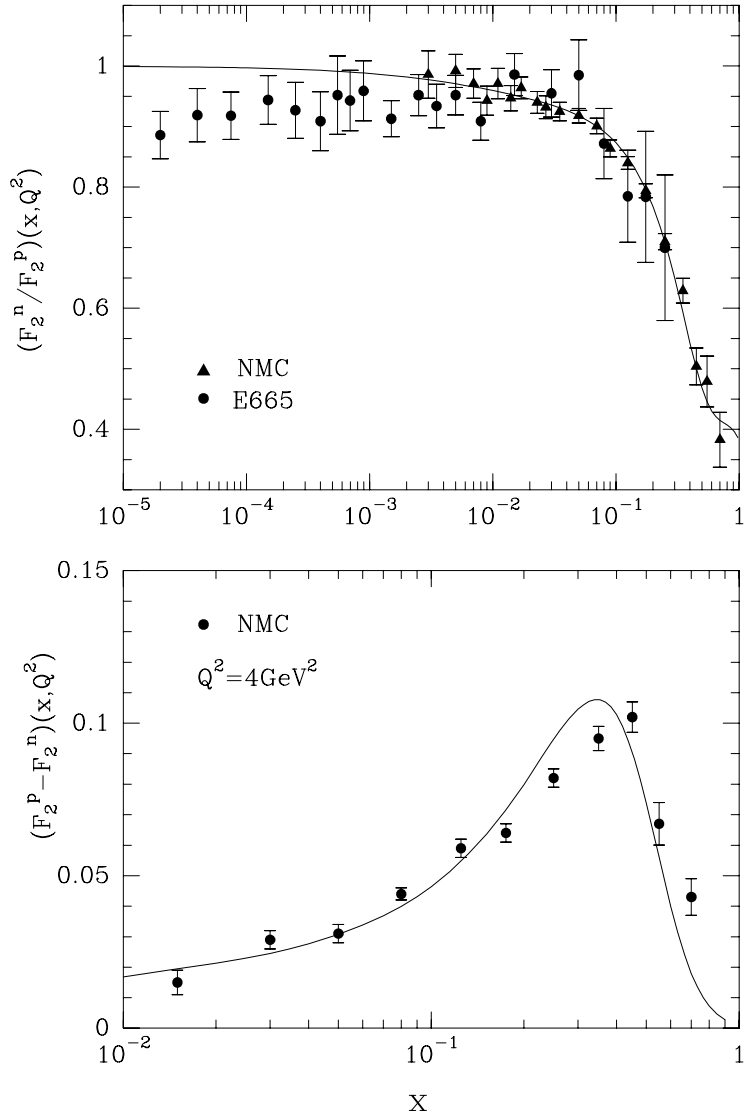


Figure 43: Ratio F_2^n/F_2^p as a function of x for different Q^2 values, data are from NMC and E665 Coll. Difference $F_2^p - F_2^n$ as a function of x for $Q^2 = 4\text{GeV}^2$, data are from NMC Coll.. The curves are shown for $Q^2 = 4\text{GeV}^2$.

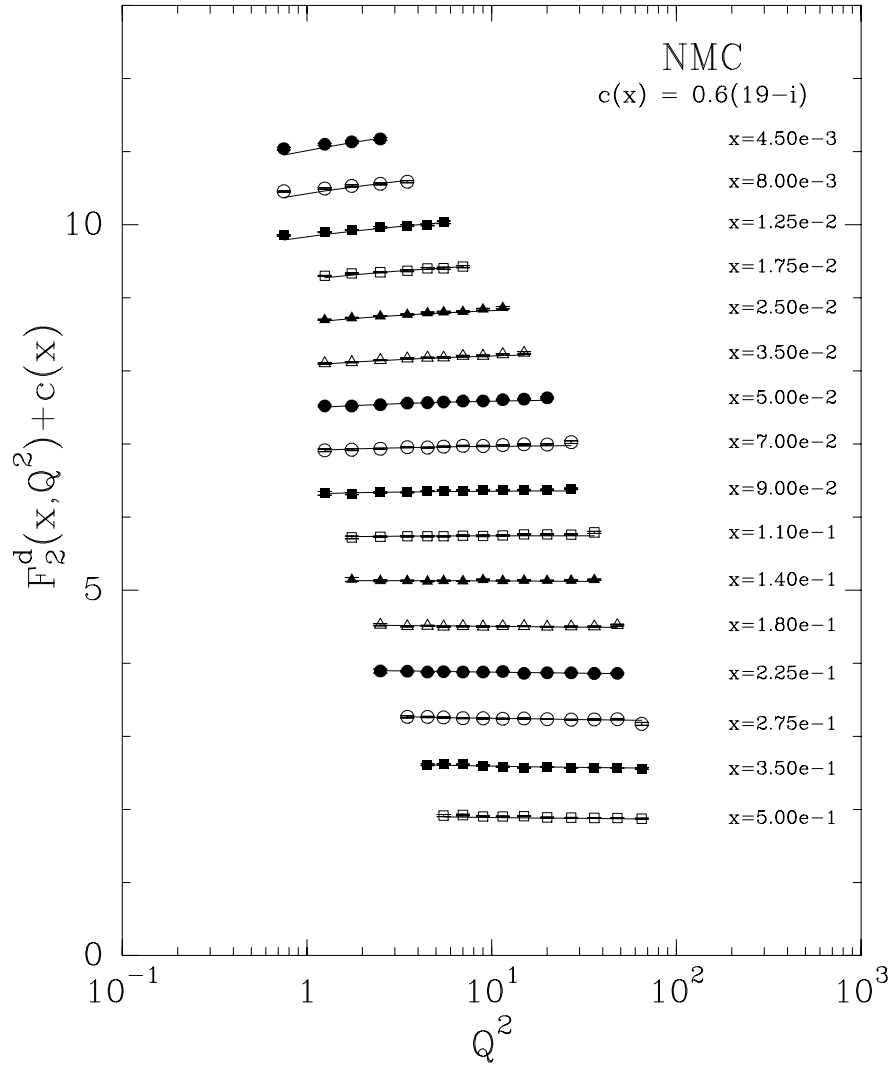


Figure 44: $F_2^d(x, Q^2)$ as function of Q^2 for fixed x , NMC data [58]. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 4.5 \cdot 10^{-3}$.

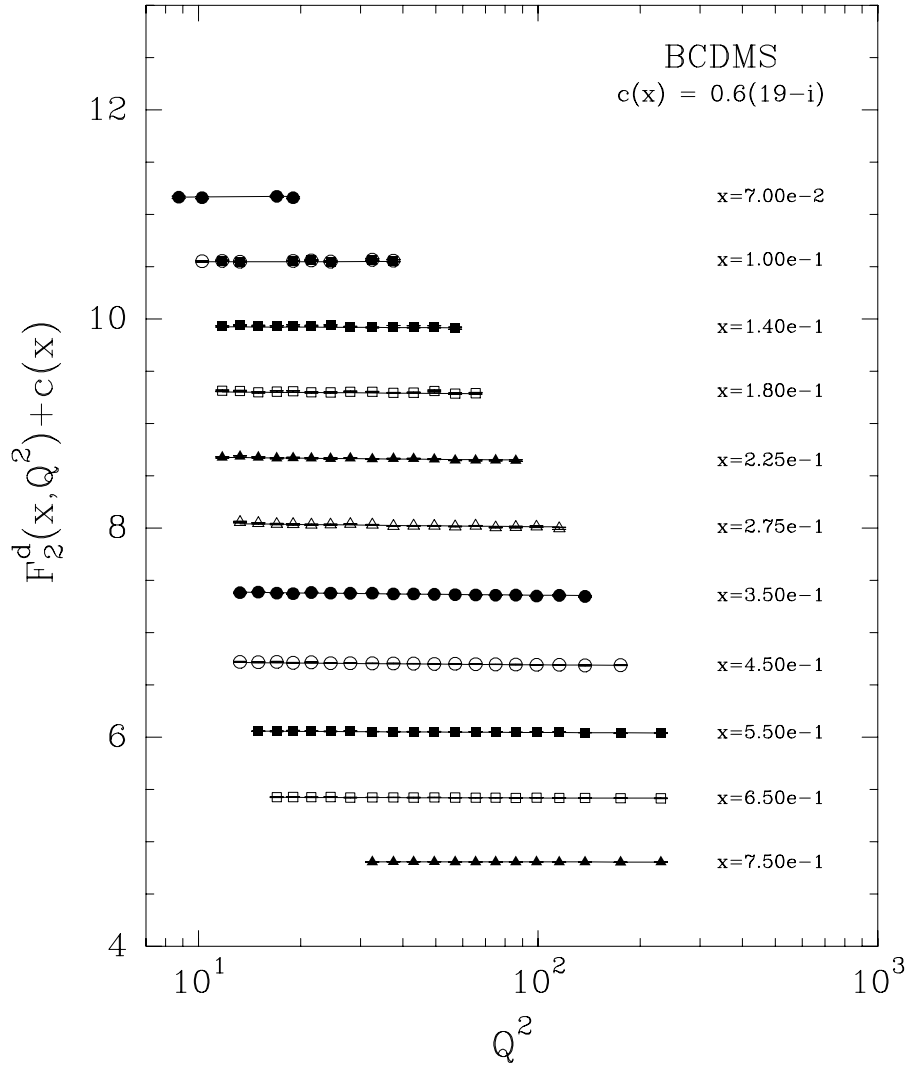


Figure 45: $F_2^d(x, Q^2)$ as function of Q^2 for fixed x , BCDMS data [12]. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 7 \cdot 10^{-2}$.

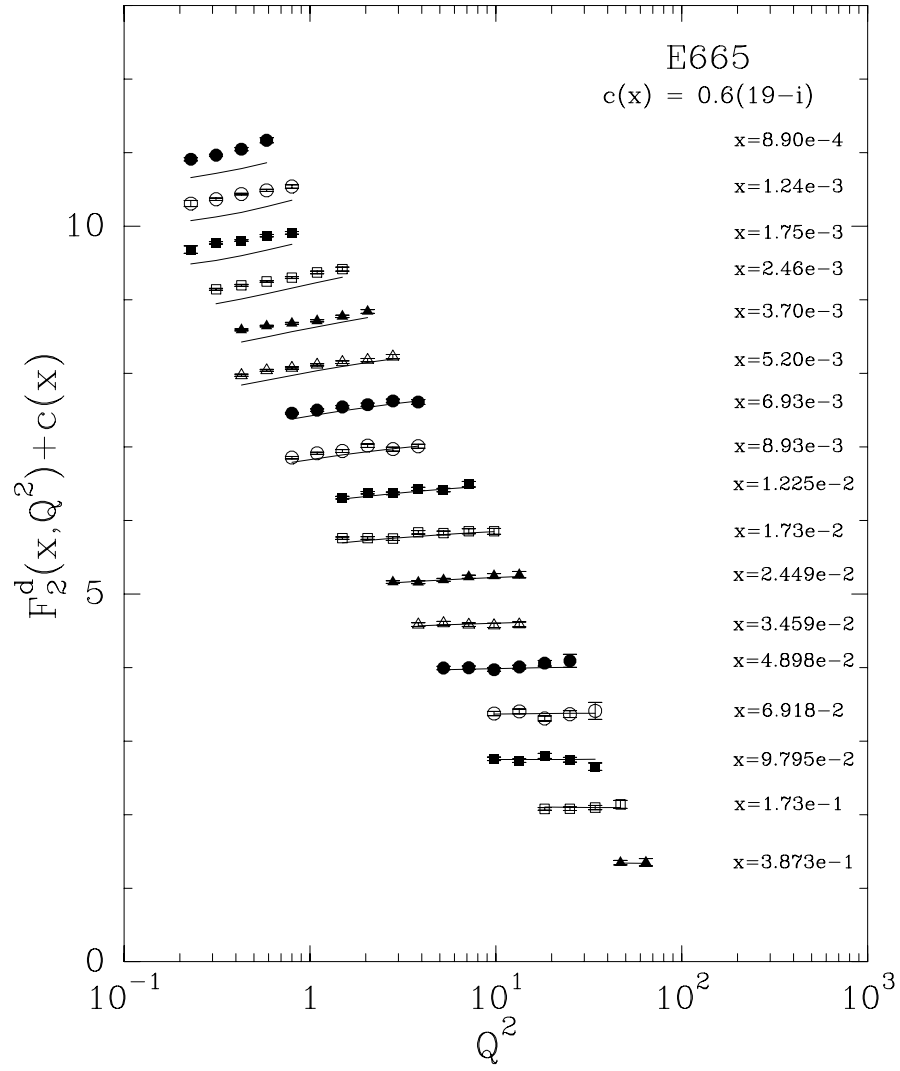


Figure 46: $F_2^d(x, Q^2)$ as function of Q^2 for fixed x , E665 data [23]. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 8.9 \cdot 10^{-4}$.

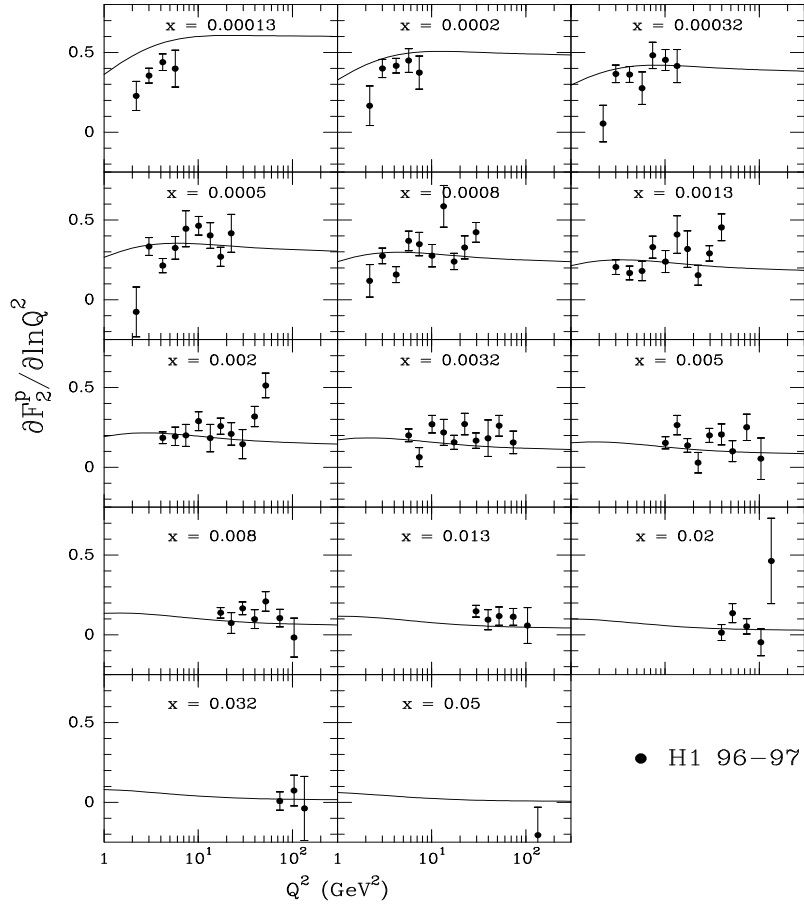


Figure 47: Prediction of the partial derivative $\partial F_2^p(x, Q^2)/\partial \ln(Q^2)$ for fixed x as a function of Q^2 . Data from H1 Collaboration [111].

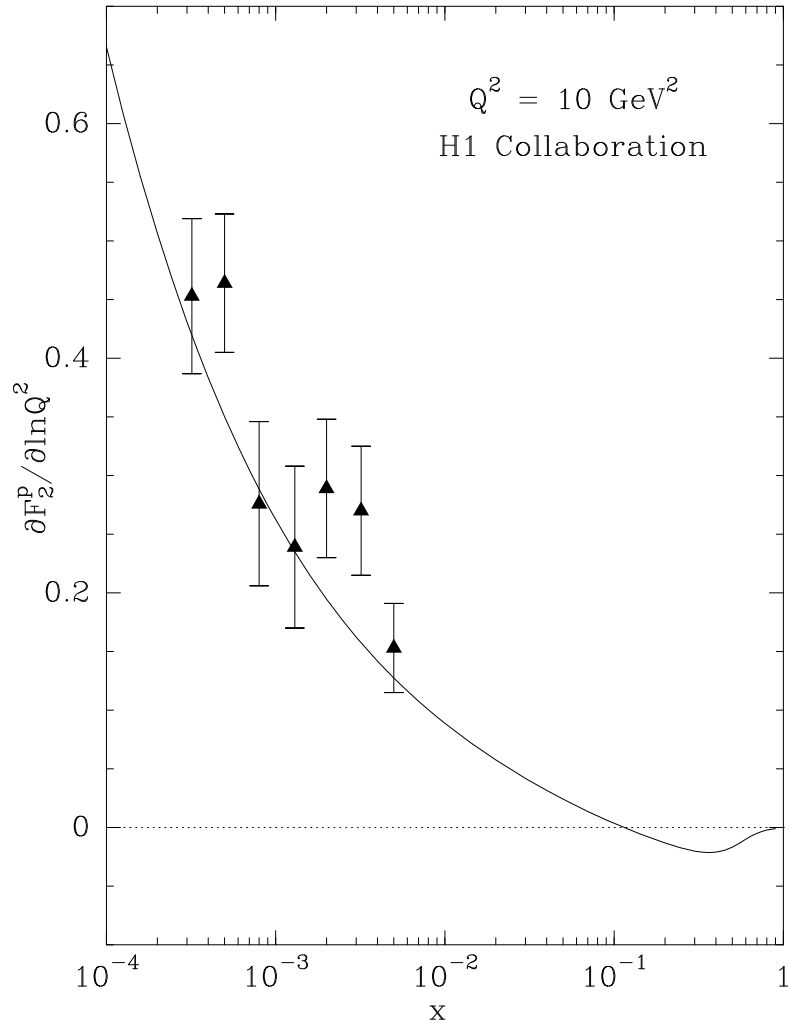


Figure 48: Prediction of the partial derivative $\partial F_2^p(x, Q^2)/\partial \ln(Q^2)$ for $Q^2 = 10\text{GeV}^2$ as a function of x . Data from H1 Collaboration [111].

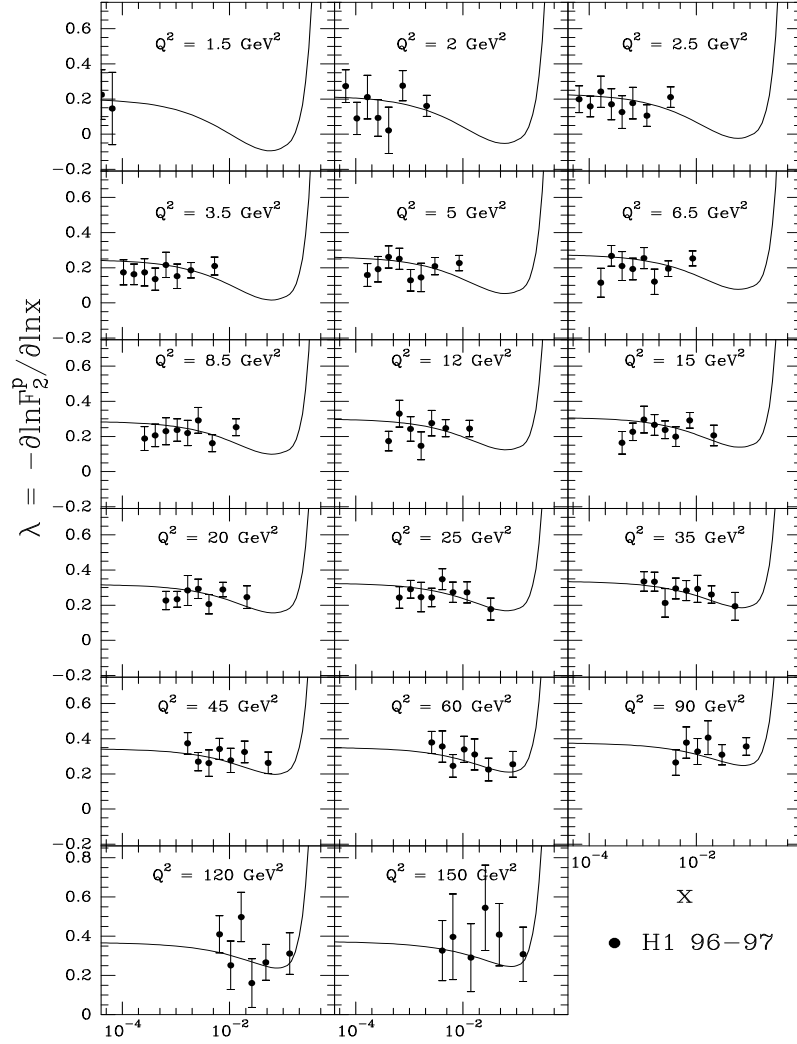


Figure 49: Prediction of the partial derivative $-\partial \ln F_2^p(x, Q^2)/\partial \ln(x)$ for fixed Q^2 as a function of x . Data from H1 Collaboration [112].

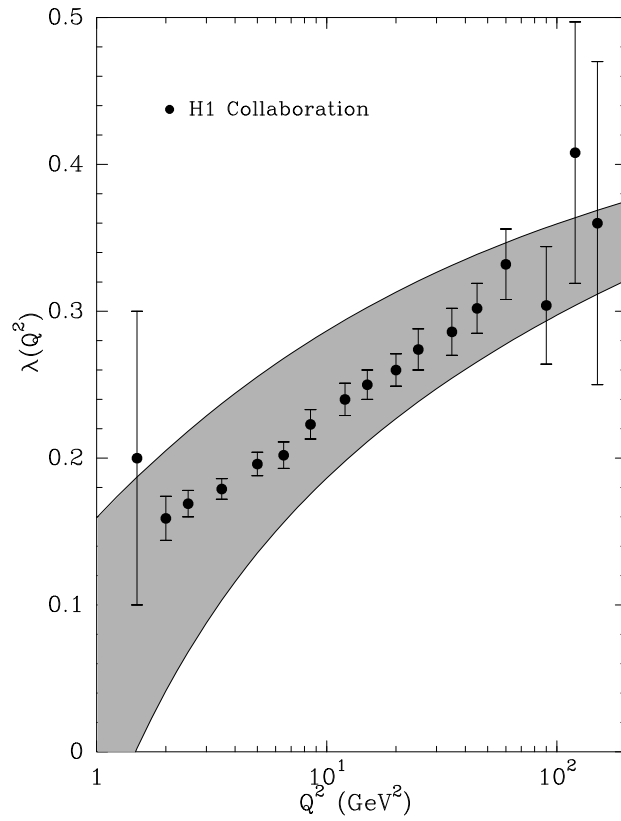


Figure 50: F_2^p partial derivative $\lambda(x, Q^2)$ as a function of Q^2 , the shaded surface represents the allowed domain for $10^{-4} \leq x \leq 10^{-2}$, predicted by the statistical model. Data from H1 Collaboration [112].

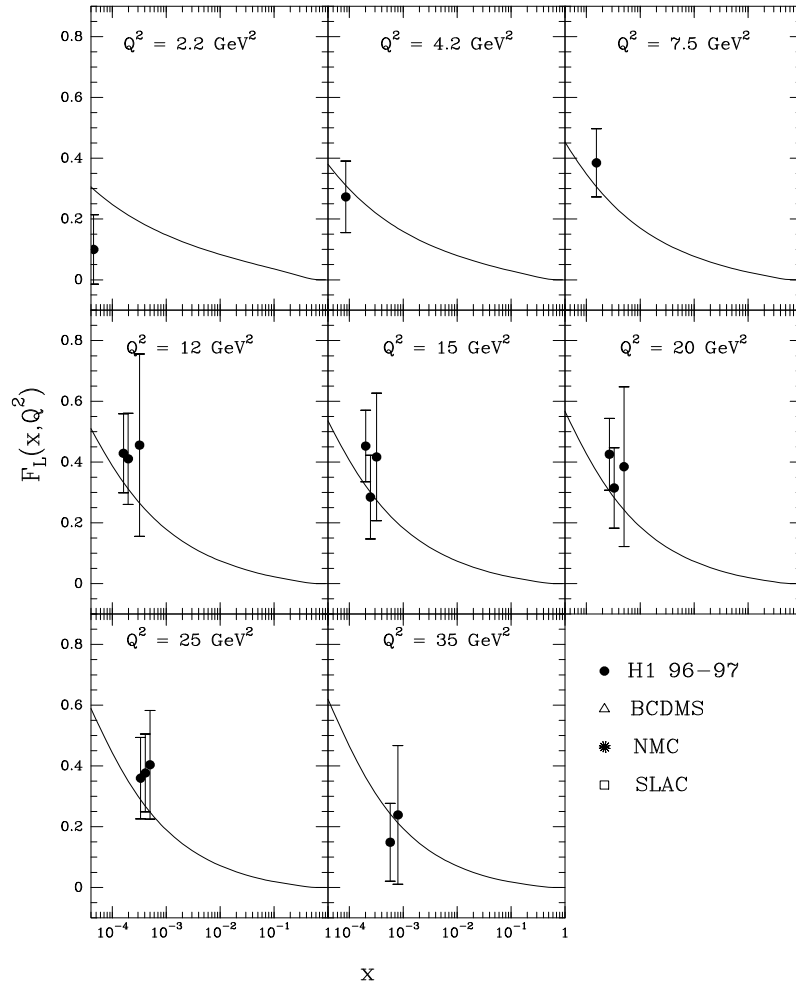


Figure 51: Prediction of the structure function F_L for different Q^2 as a function of x . Data from H1 Collaboration [111].

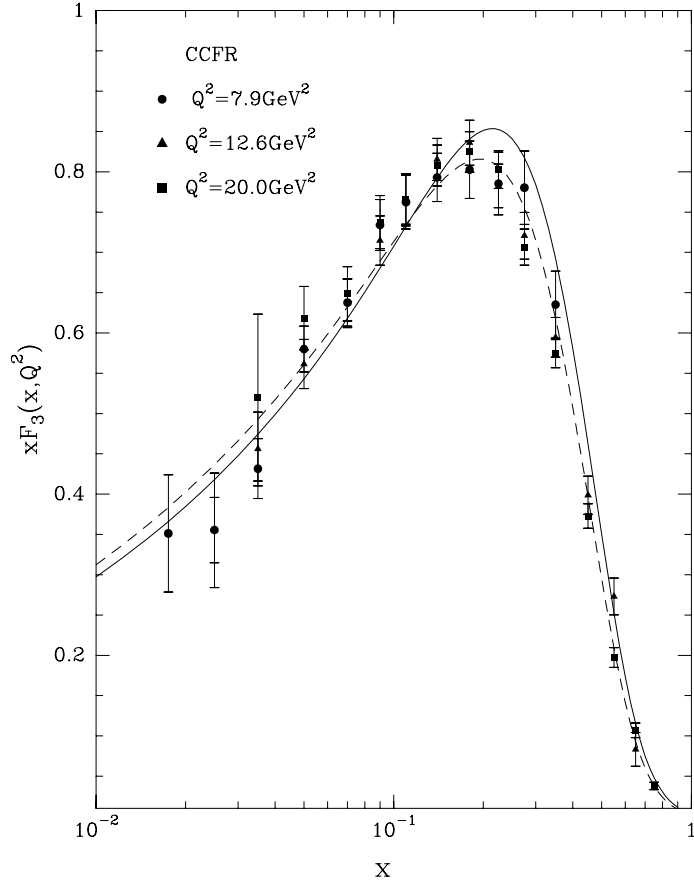


Figure 52: $xF_3^{\nu N}(x, Q^2)$ as function of x for low Q^2 values, CCFR Coll. The curves are for $Q^2 = 4, 12.6\text{GeV}^2$, solid, dashed respectively.

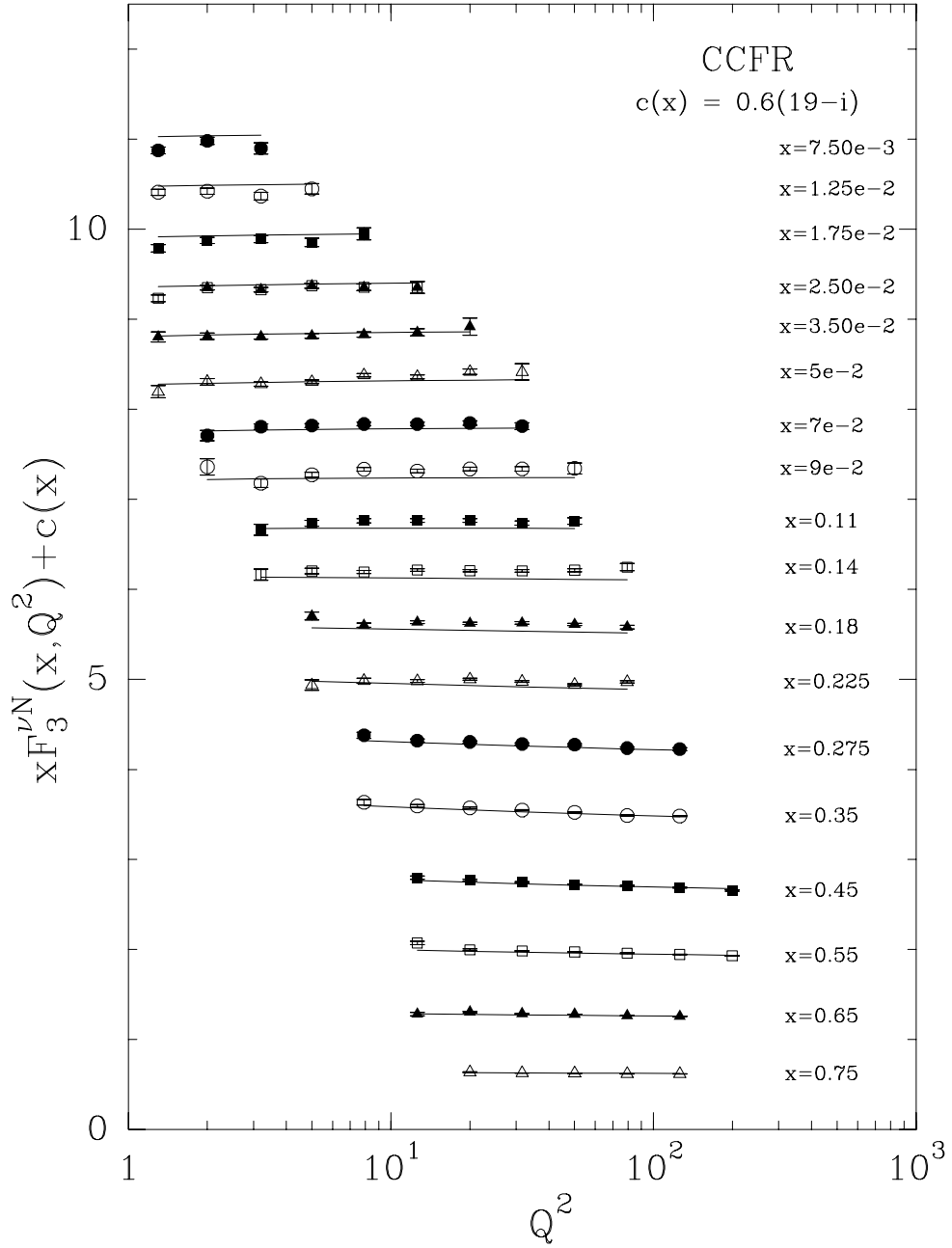


Figure 53: $xF_3^{\nu N}(x, Q^2)$ as function of Q^2 for fixed x , CCFR data [13]. The function $c(x_i) = 0.6(19 - i)$, $i = 1$ corresponds to $x = 7.5 \cdot 10^{-3}$.

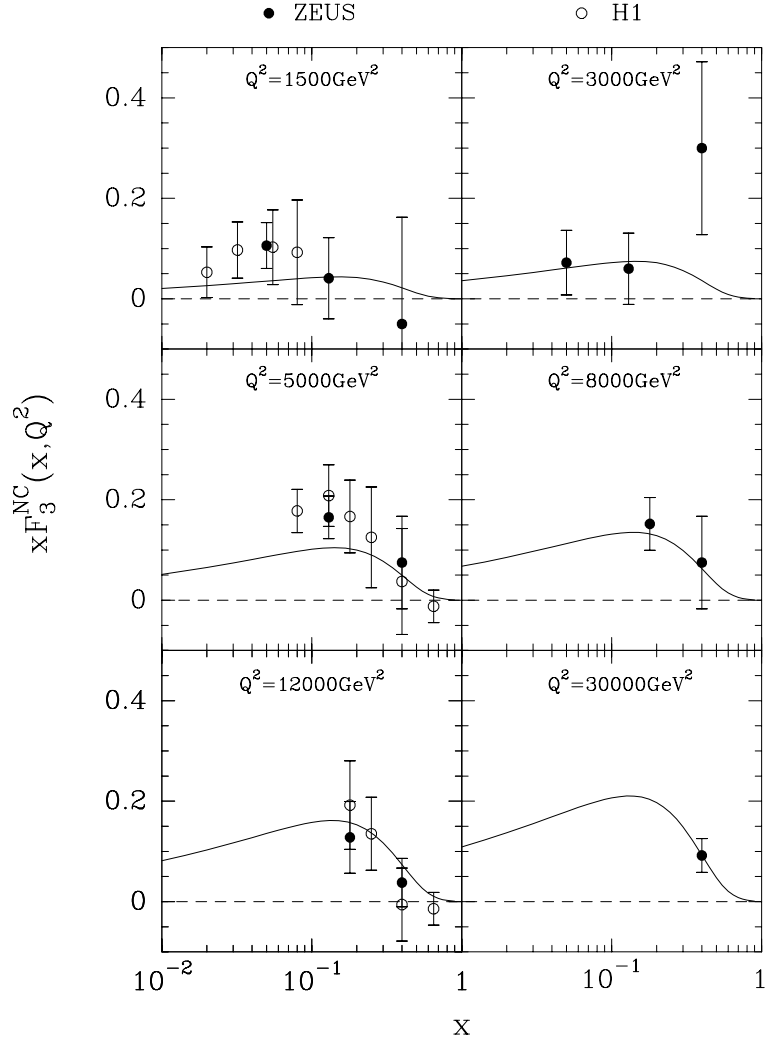


Figure 54: The structure function $x F_3^{NC}$ as a function of x , for different Q^2 . Data from ZEUS Coll. [95], H1 Coll. [40].

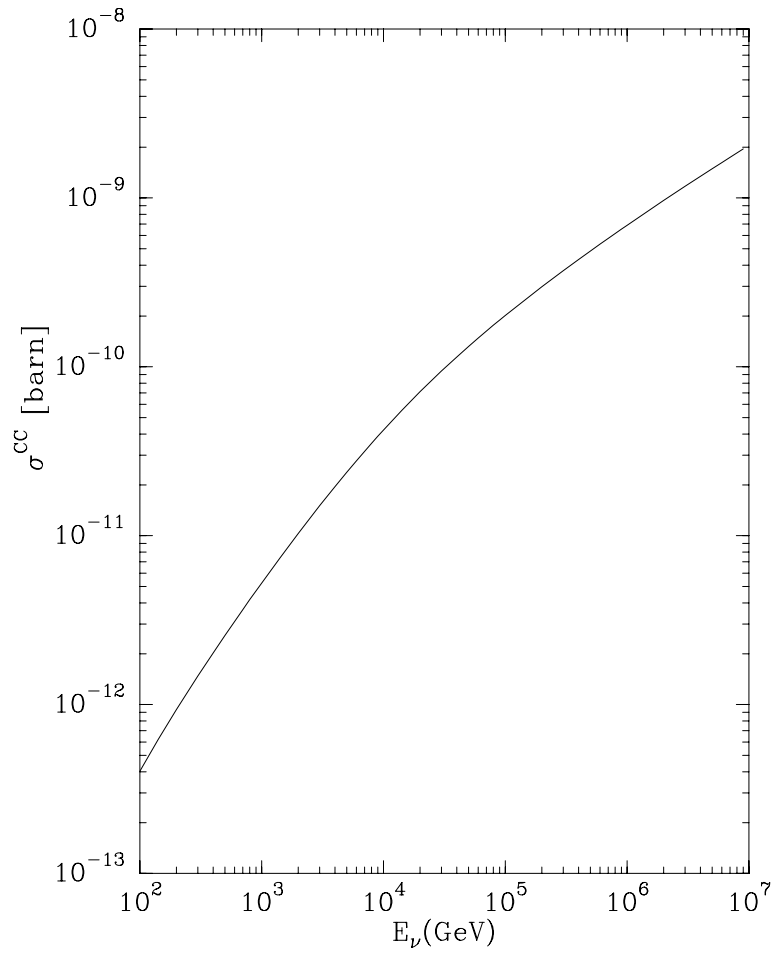


Figure 55: Charged-current total cross section νN for an isoscalar nucleon as a function of the neutrino energy.

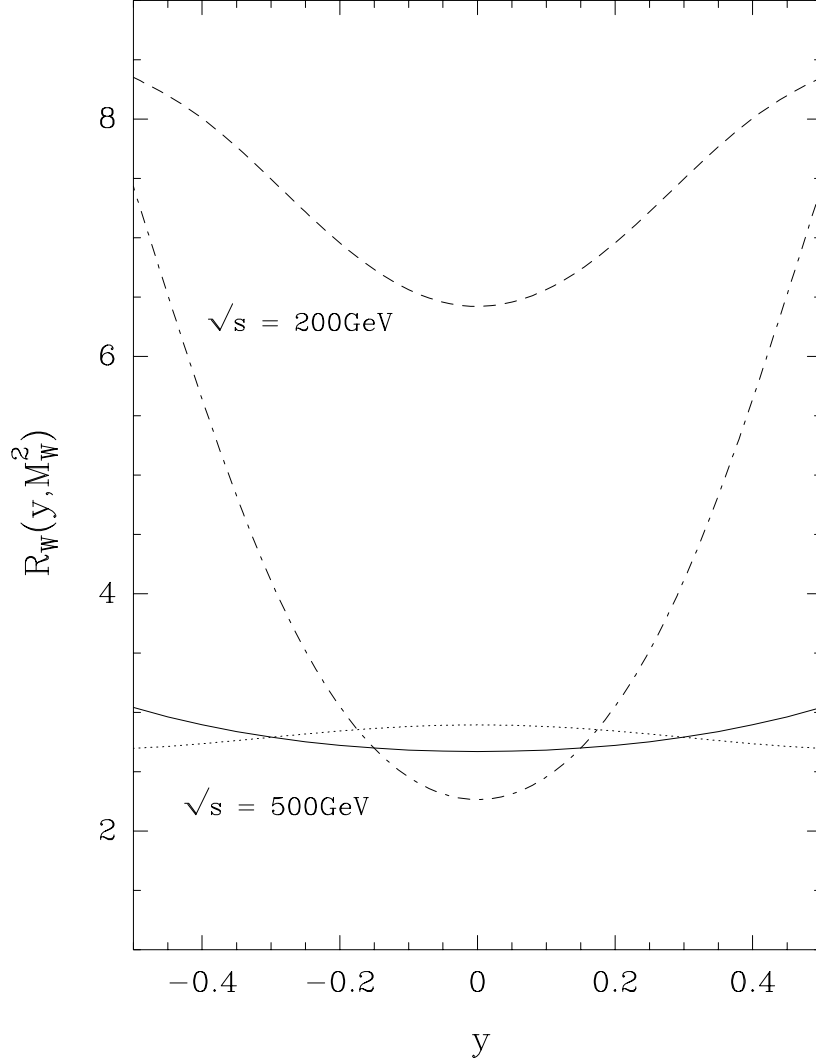


Figure 56: Theoretical calculations for the ratio $R_W(y) = (d\sigma^{W^+}/dy) / (d\sigma^{W^-}/dy)$ for pp versus the W rapidity, at two RHIC-BNL energies. Solid curve ($\sqrt{s} = 500\text{GeV}$) and dashed curve ($\sqrt{s} = 200\text{GeV}$) are the statistical model predictions. Dotted curve ($\sqrt{s} = 500\text{GeV}$) and dashed-dotted curve ($\sqrt{s} = 200\text{GeV}$) are the predictions obtained using the $\bar{d}(x)/\bar{u}(x)$ ratio from Ref. [84].

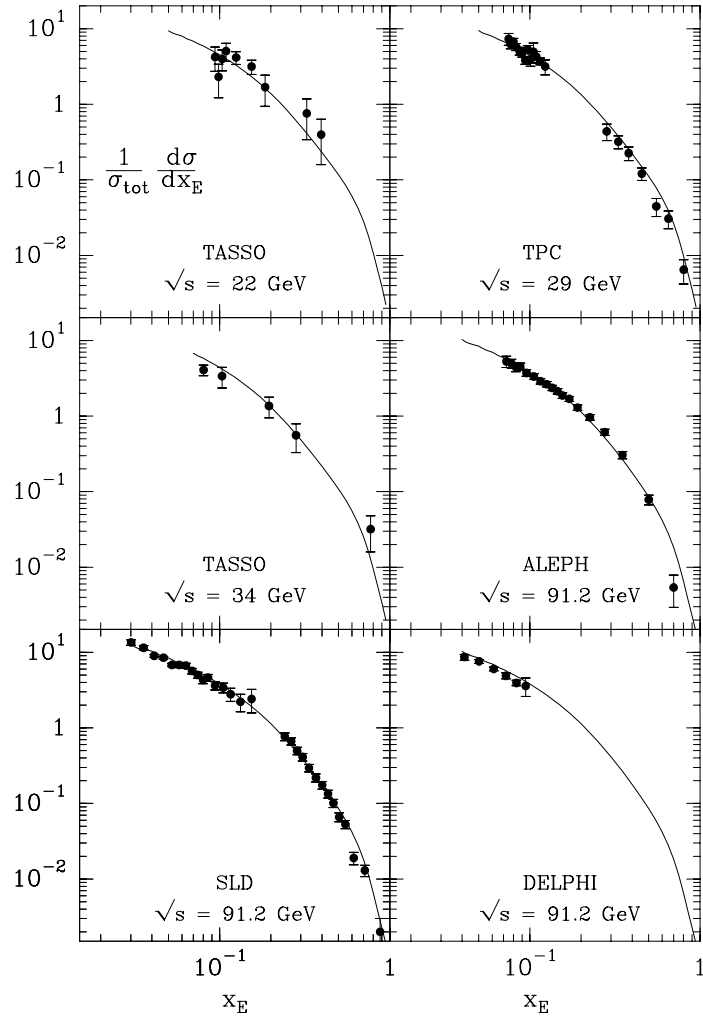


Figure 57: Cross sections for proton production in e^+e^- annihilation at several energies as function of x_E . The experimental data are from Refs. [8, 20, 79, 86, 90, 88].

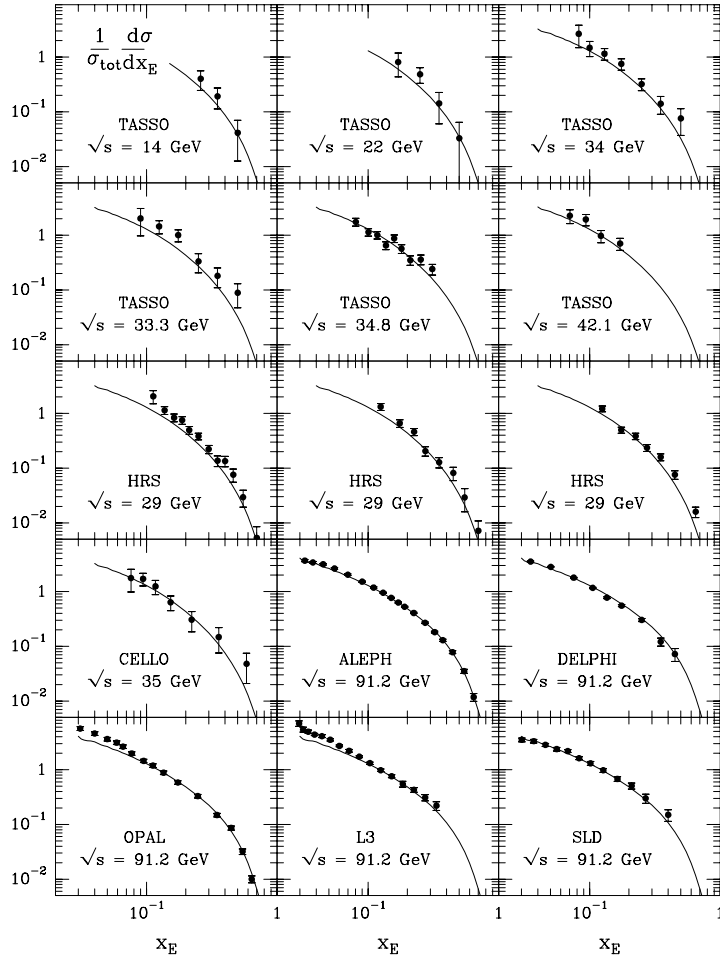


Figure 58: Cross sections for Λ production in e^+e^- annihilation at several energies, as function of x_E . The experimental data are from Refs. [15, 9, 21, 61, 55, 79, 85, 87, 89, 50, 51, 52].

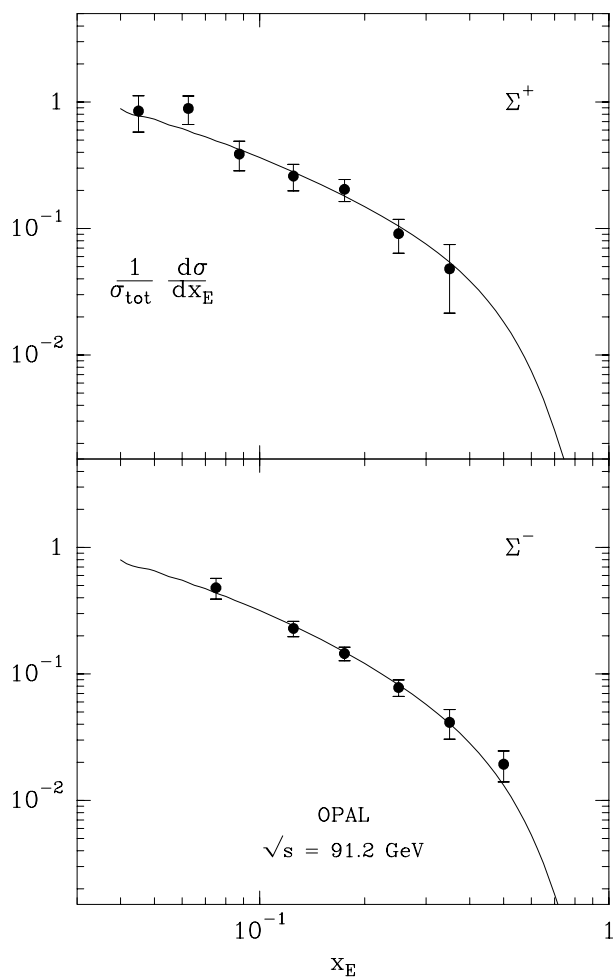


Figure 59: Cross sections for Σ^\pm production in e^+e^- annihilation at the Z-pole as function of x_E . The experimental data are from Ref. [61].

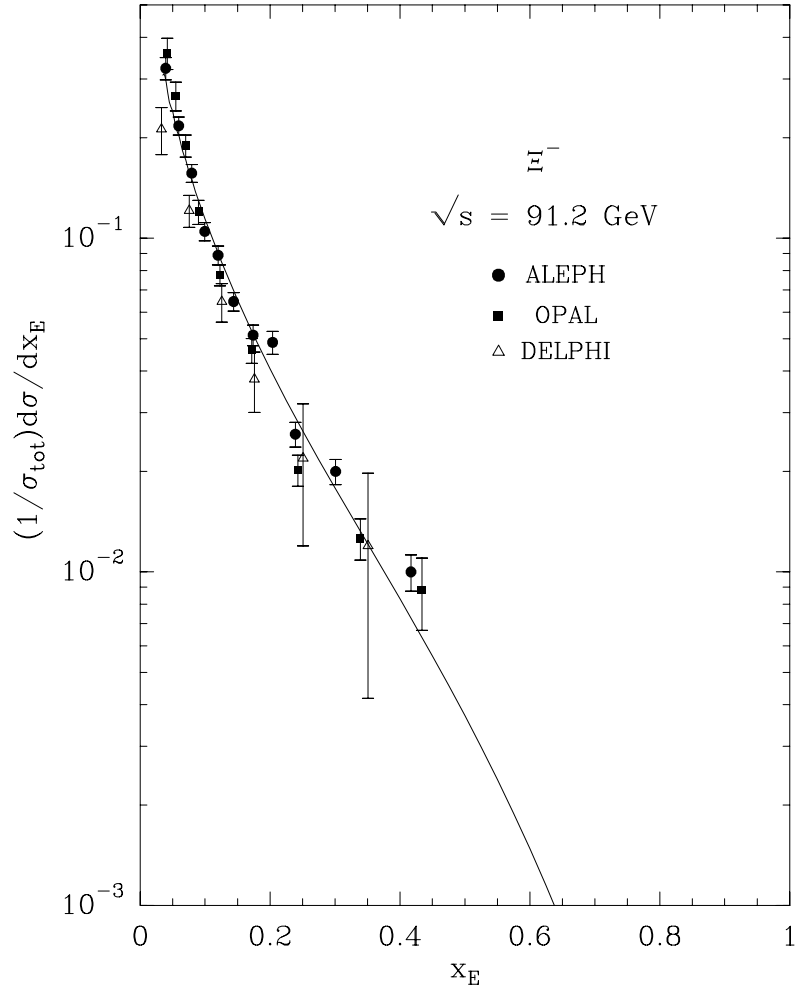


Figure 60: Cross sections for Ξ^- production in e^+e^- annihilation at the Z-pole as function of x_E . The experimental data are from Refs. [9, 61, 22].

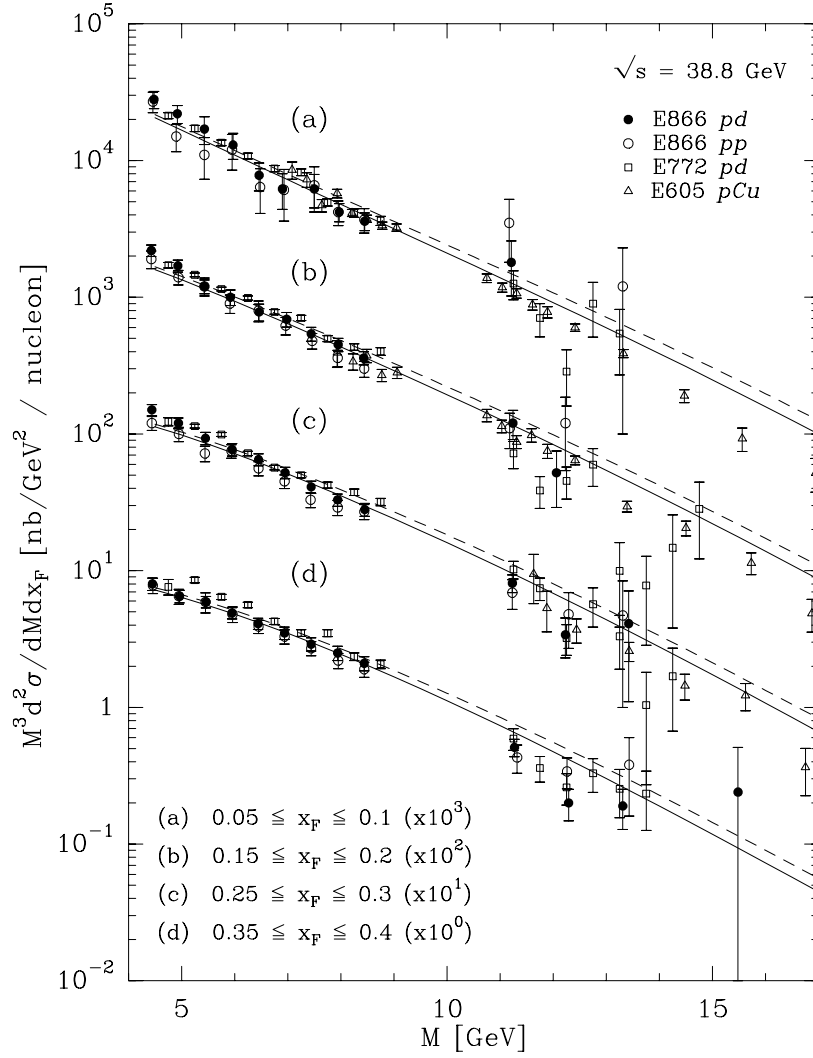


Figure 61: Drell-Yan cross sections per nucleon at $\sqrt{s} = 38.8 \text{ GeV}$ for *pp*, *pd*, and *pCu* as a function of M for selected x_F bins. Experimental data are from Refs. [26, 27, 28].

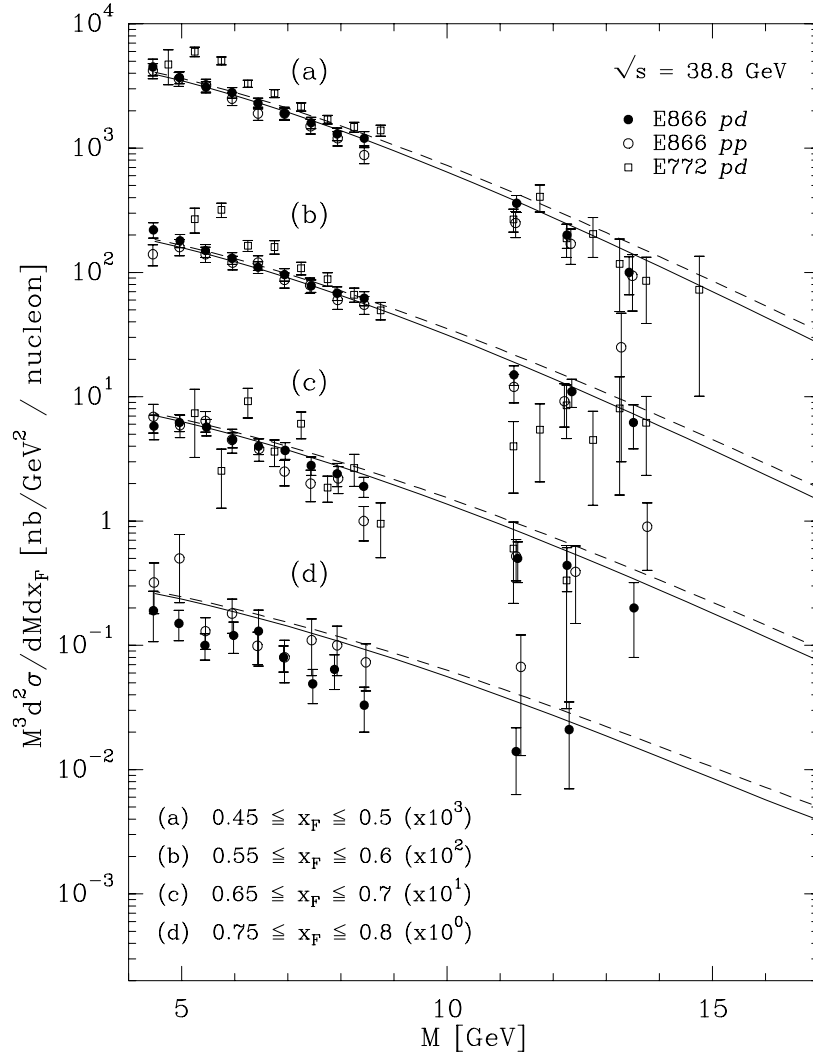


Figure 62: Drell-Yan cross sections per nucleon at $\sqrt{s} = 38.8 \text{ GeV}$ for *pp* and *pd* as a function of M for selected x_F bins. Experimental data are from Refs. [26, 27].

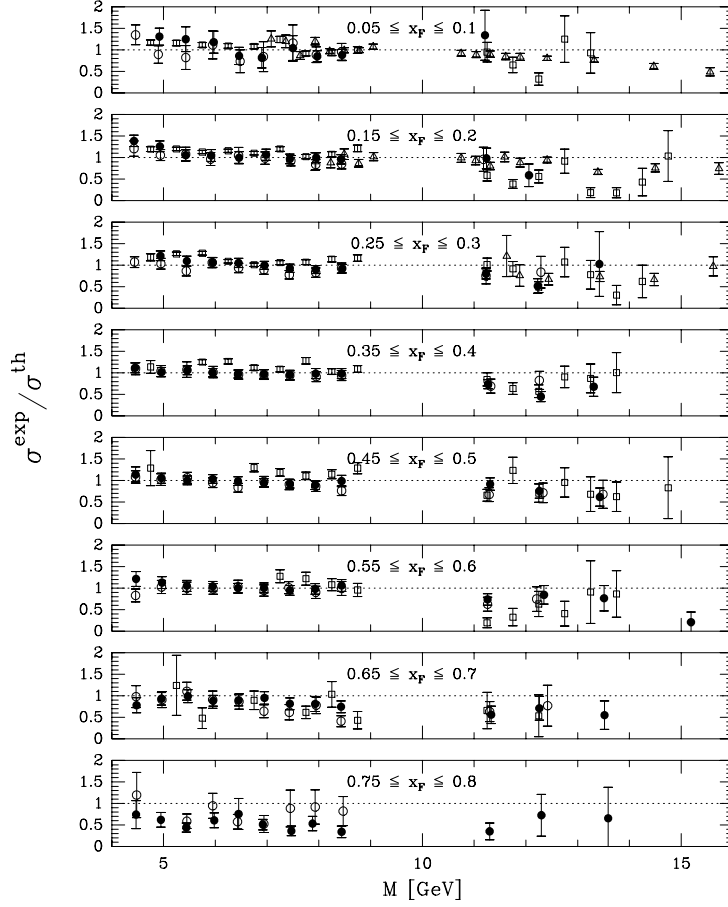


Figure 63: Drell-Yan cross sections ratios experiment vs theory at $\sqrt{s} = 38.8\text{GeV}$ for pp , pd , and pCu as a function of M for selected x_F bins. Experimental data are from Refs. [26, 27, 28].

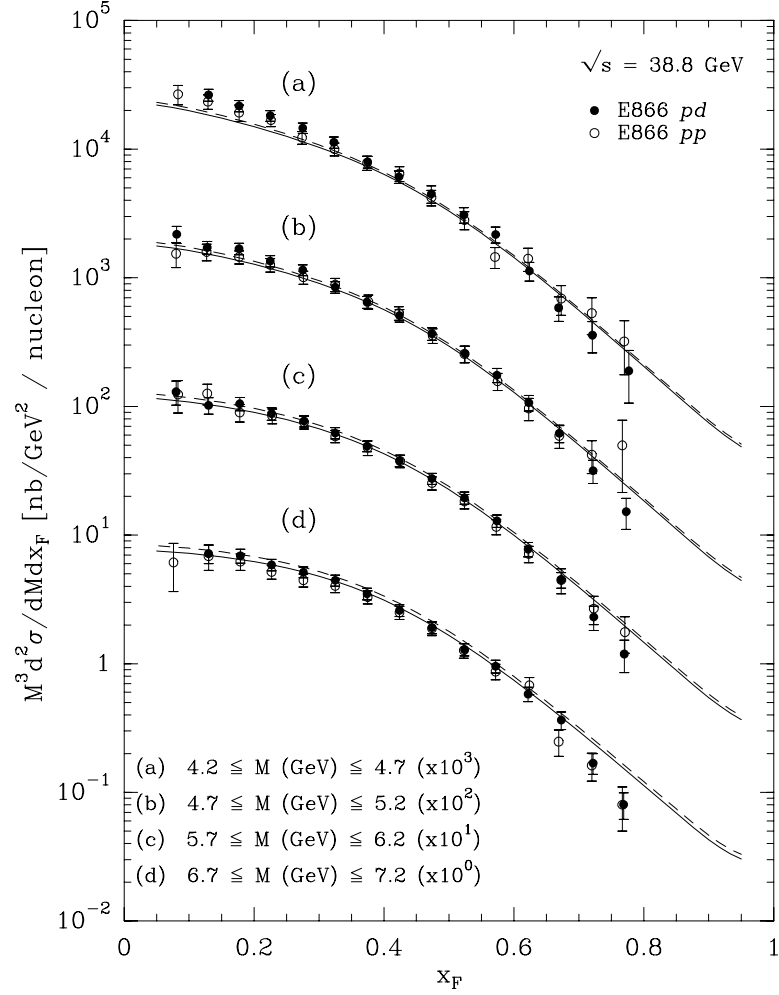


Figure 64: Drell-Yan cross sections per nucleon at $\sqrt{s} = 38.8\text{GeV}$ for *pp* and *pd* as a function of x_F for selected M bins. Experimental data are from Ref. [26].

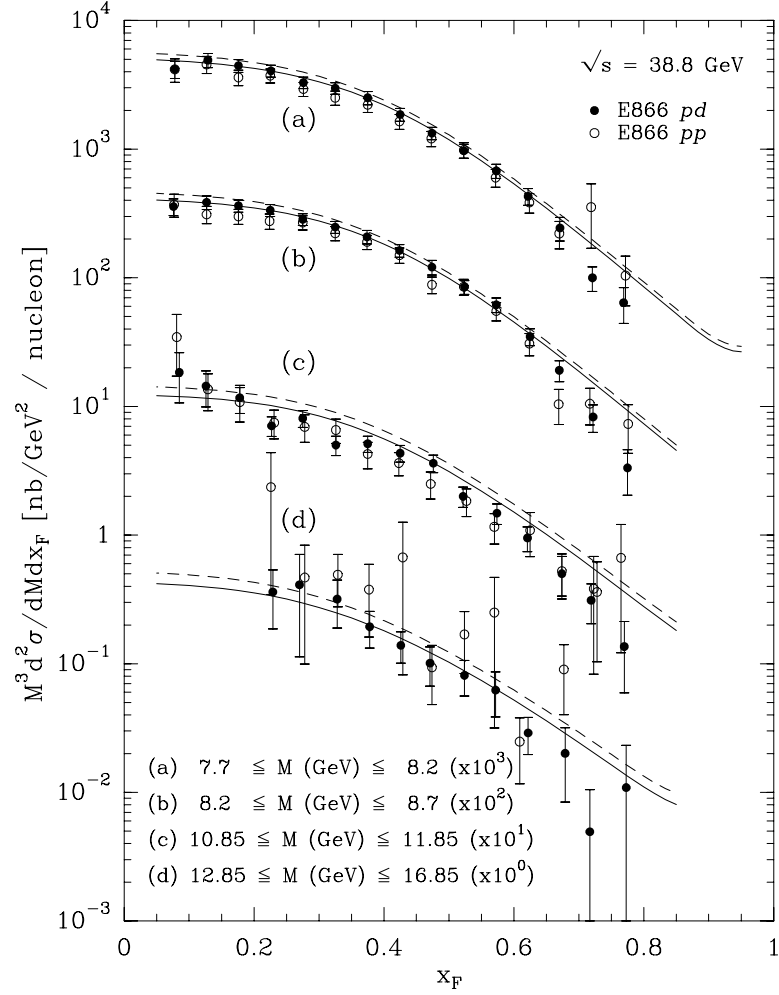


Figure 65: Drell-Yan cross sections per nucleon at $\sqrt{s} = 38.8 \text{ GeV}$ for *pp* and *pd* as a function of x_F for selected M bins. Experimental data are from Ref. [26].

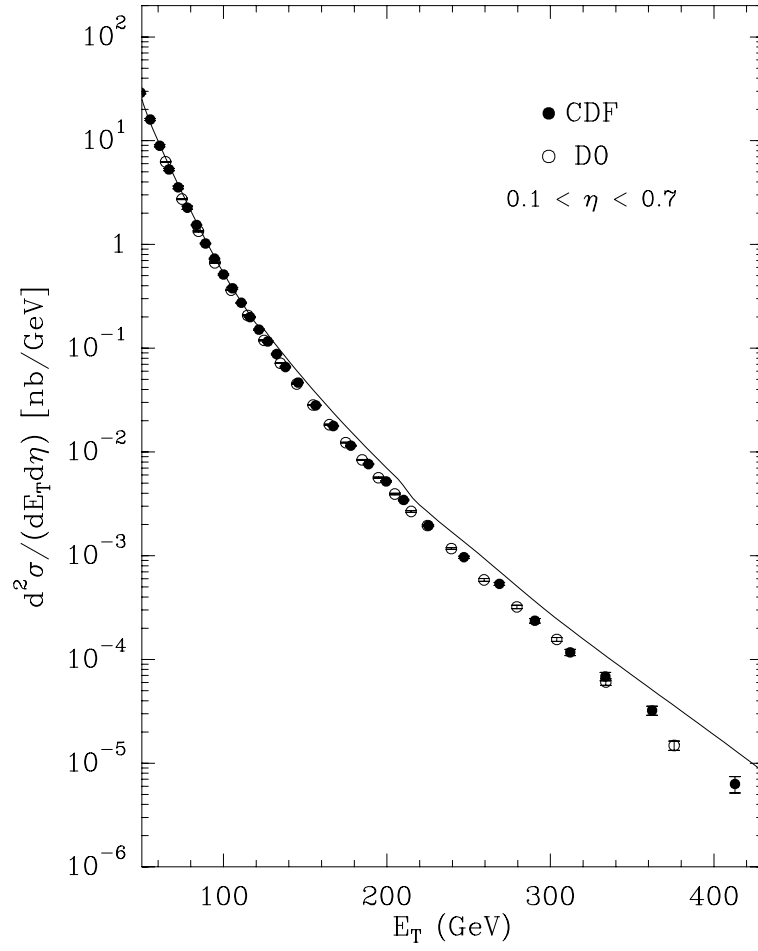


Figure 66: Cross section for single jet production in $\bar{p}p$ at $\sqrt{s} = 1.8\text{TeV}$ as a function of E_T . Data from CDF [17] and D0 [18] collaborations.

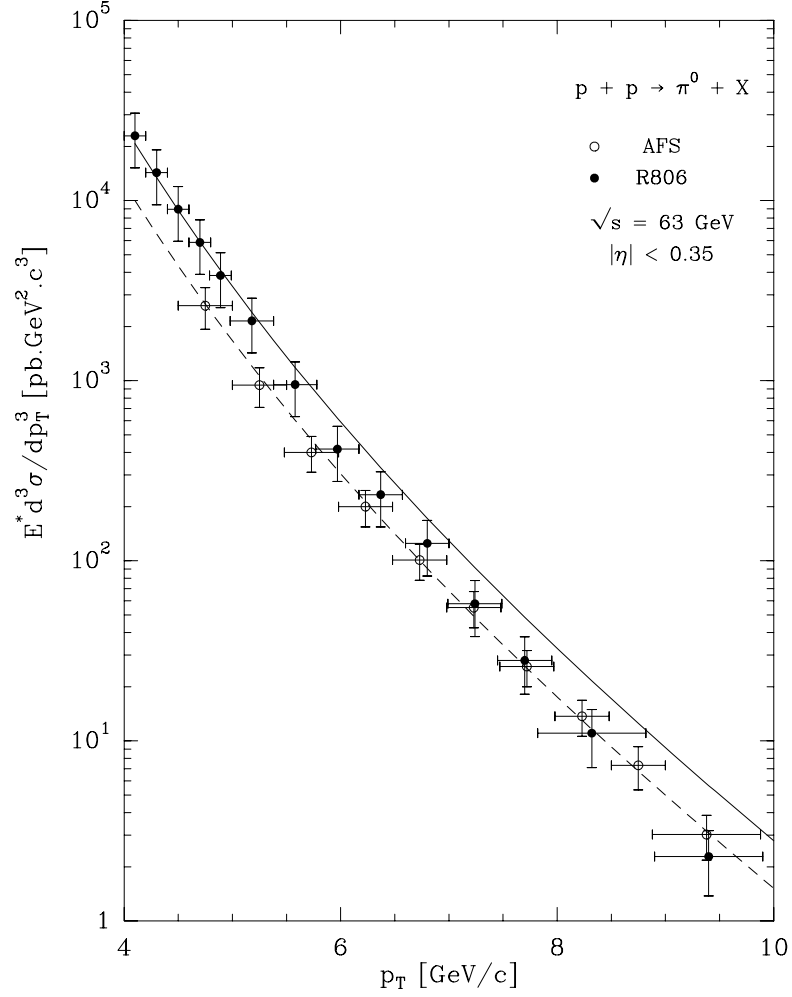


Figure 67: Inclusive π^0 production in pp reaction at $\sqrt{s} = 63\text{GeV}$ as a function of p_T . Data from AFS [7] and R806 [63] Collaborations. Solid curve scale $\mu = p_T/2$, dashed $\mu = p_T$, fragmentation functions from KKP [100].

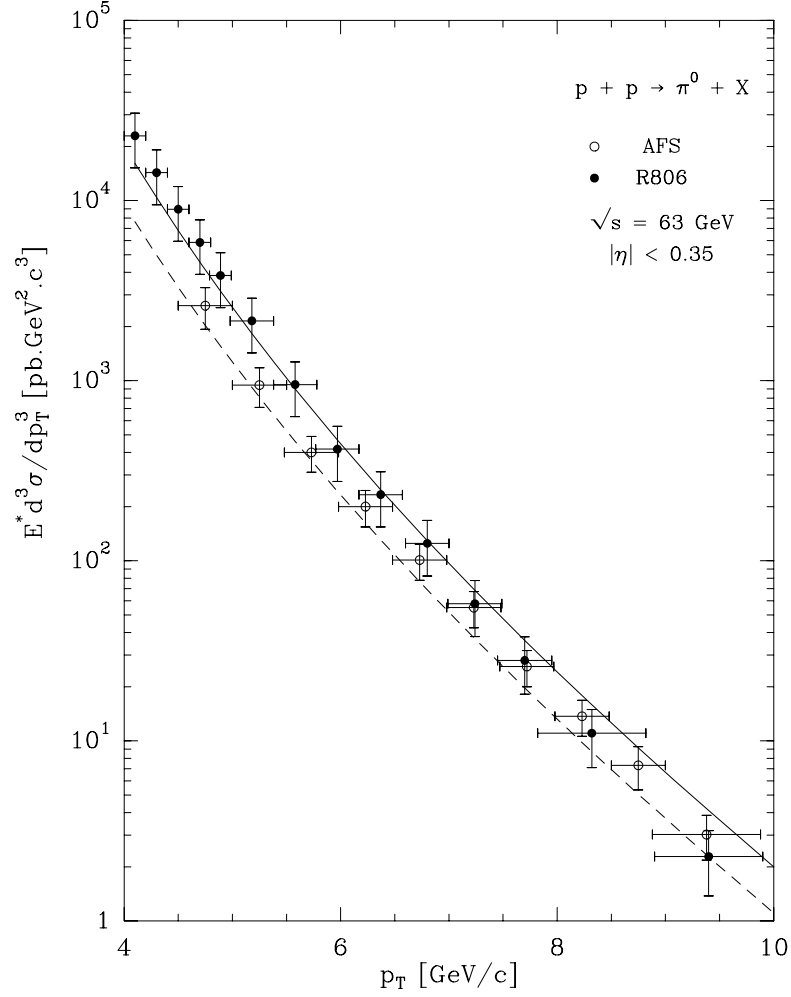


Figure 68: Inclusive π^0 production in pp reaction at $\sqrt{s} = 63\text{GeV}$ as a function of p_T . Data from AFS [7] and R806 [63] Collaborations. Solid curve scale $\mu = p_T/2$, dashed $\mu = p_T$, fragmentation functions BKP [101].

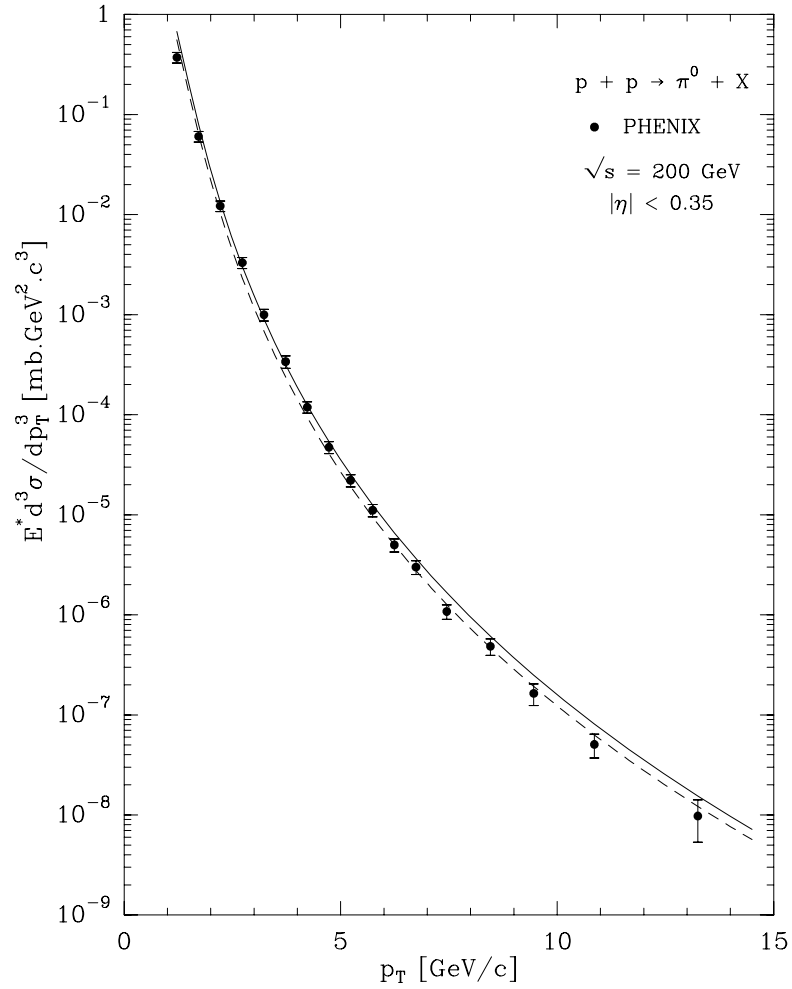


Figure 69: Inclusive π^0 production in pp reaction at $\sqrt{s} = 200\text{GeV}$ as a function of p_T , scale $\mu = p_T$. Data from Phenix Collaboration [62]. Solid curve fragmentation functions from KKP [100], dashed curve BKP [101].

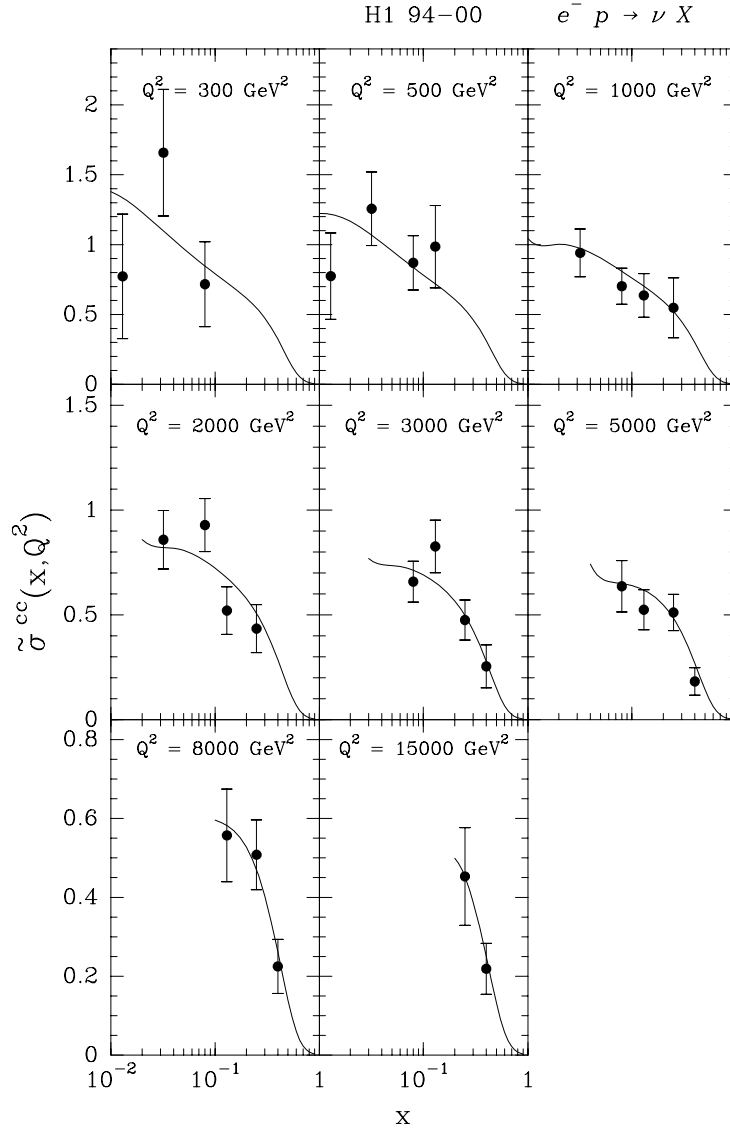


Figure 70: The reduced charged current cross section, $\tilde{\sigma}$, in e^-p reaction as a function of x , for different fixed values of Q^2 . Data from H1 Coll. [40].

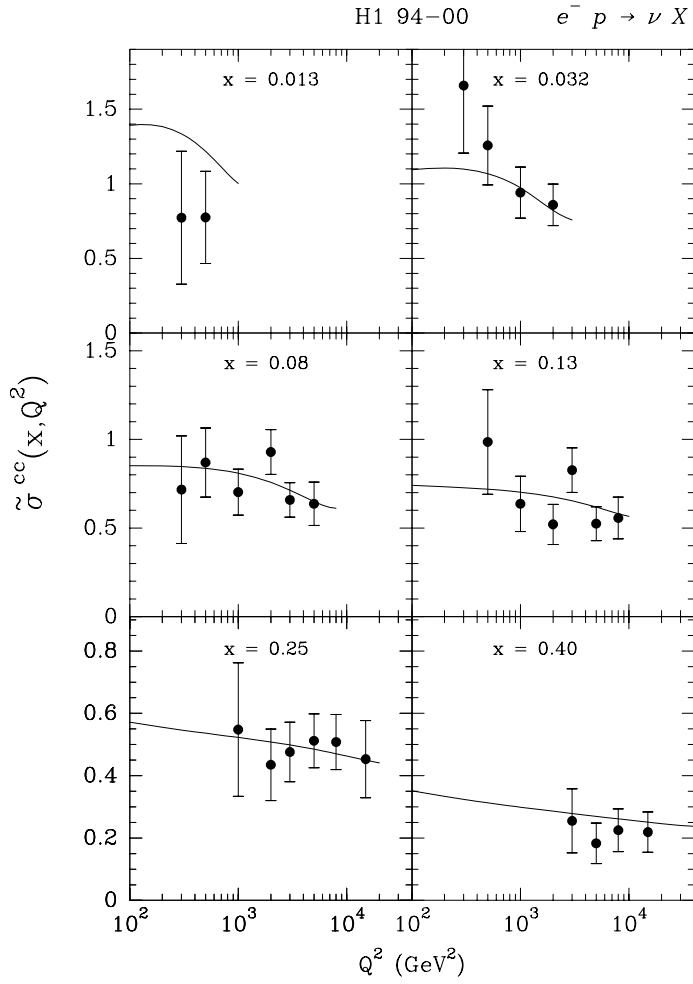


Figure 71: The reduced charged current cross section, $\tilde{\sigma}$, in e^-p reaction as a function of Q^2 , for different fixed values of x . Data from H1 Coll. [40].

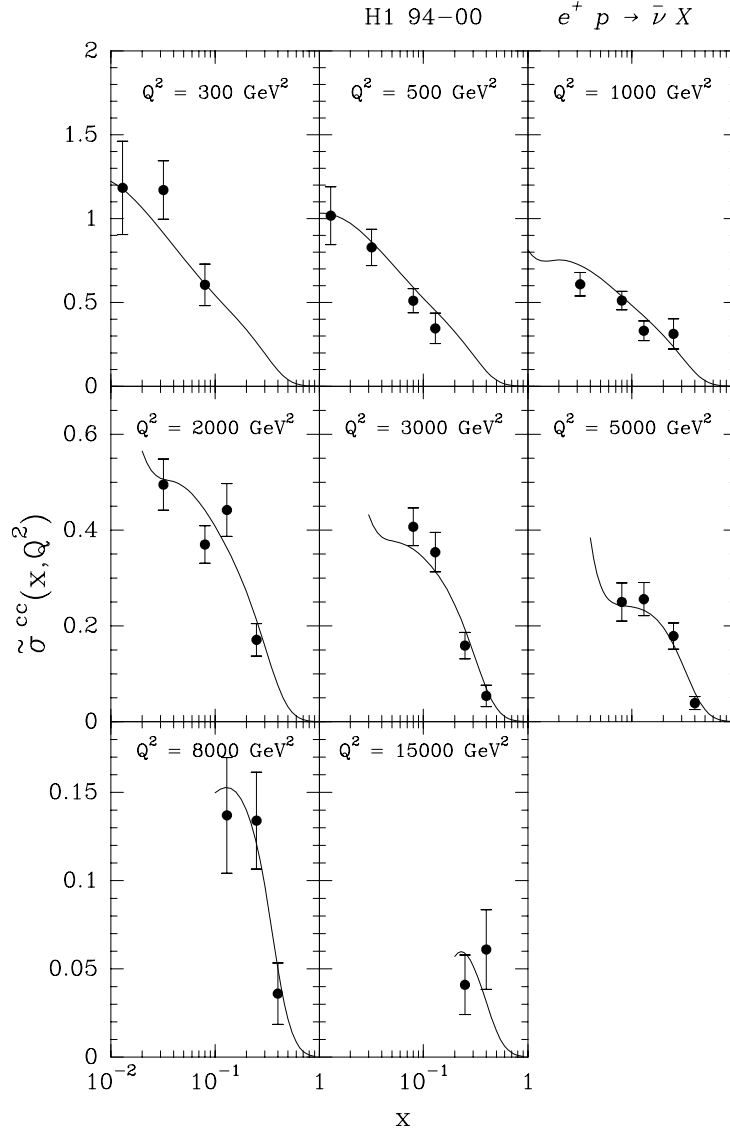


Figure 72: The reduced charged current cross section, $\tilde{\sigma}$, in e^+p reaction as a function of x , for different fixed values of Q^2 . Data from H1 Coll. [41].

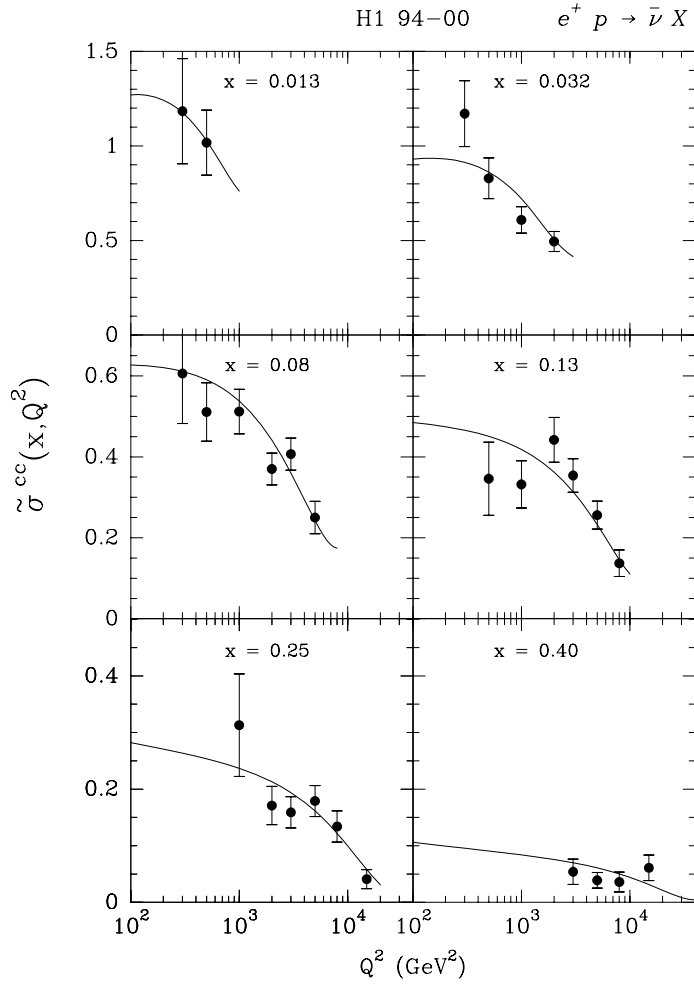


Figure 73: The reduced charged current cross section, $\tilde{\sigma}$, in e^+p reaction as a function of Q^2 , for different fixed values of x . Data from H1 Coll. [41].

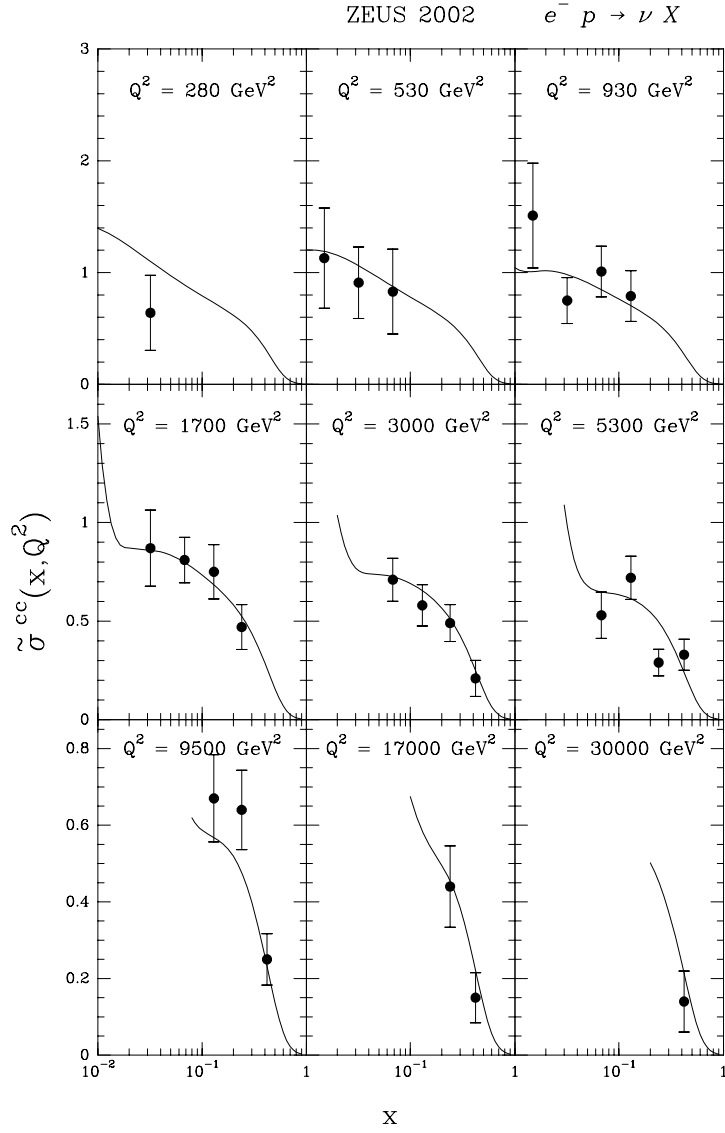


Figure 74: The reduced charged current cross section, $\tilde{\sigma}$, in e^-p reaction as a function of x , for different fixed values of Q^2 . Data from ZEUS Coll. [96].

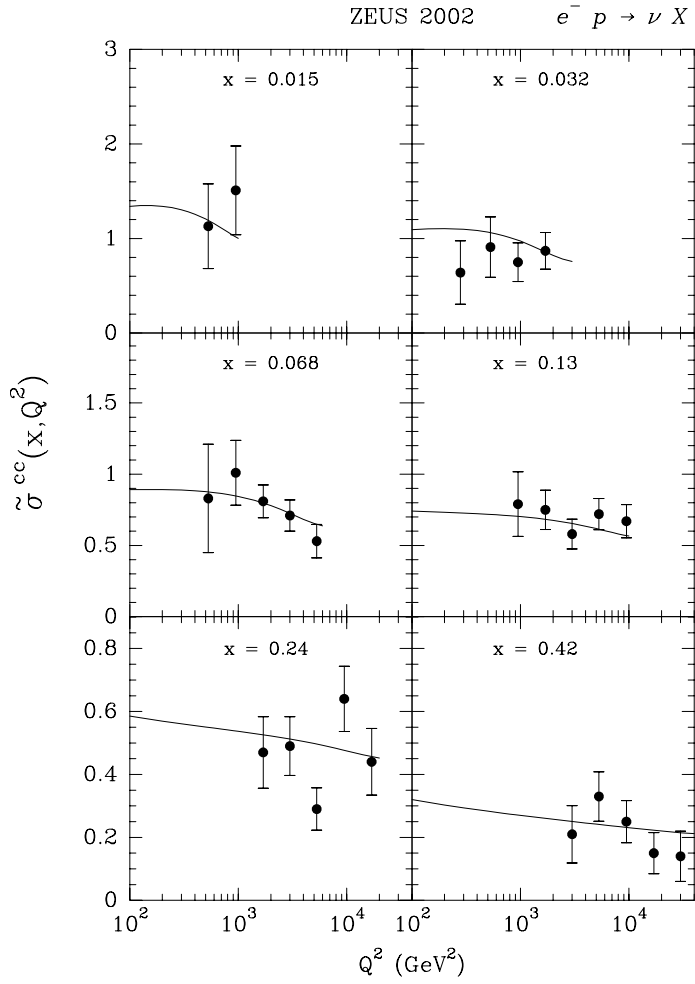


Figure 75: The reduced charged current cross section, $\tilde{\sigma}$, in e^-p reaction as a function of Q^2 , for different fixed values of x . Data from ZEUS Coll. [96].

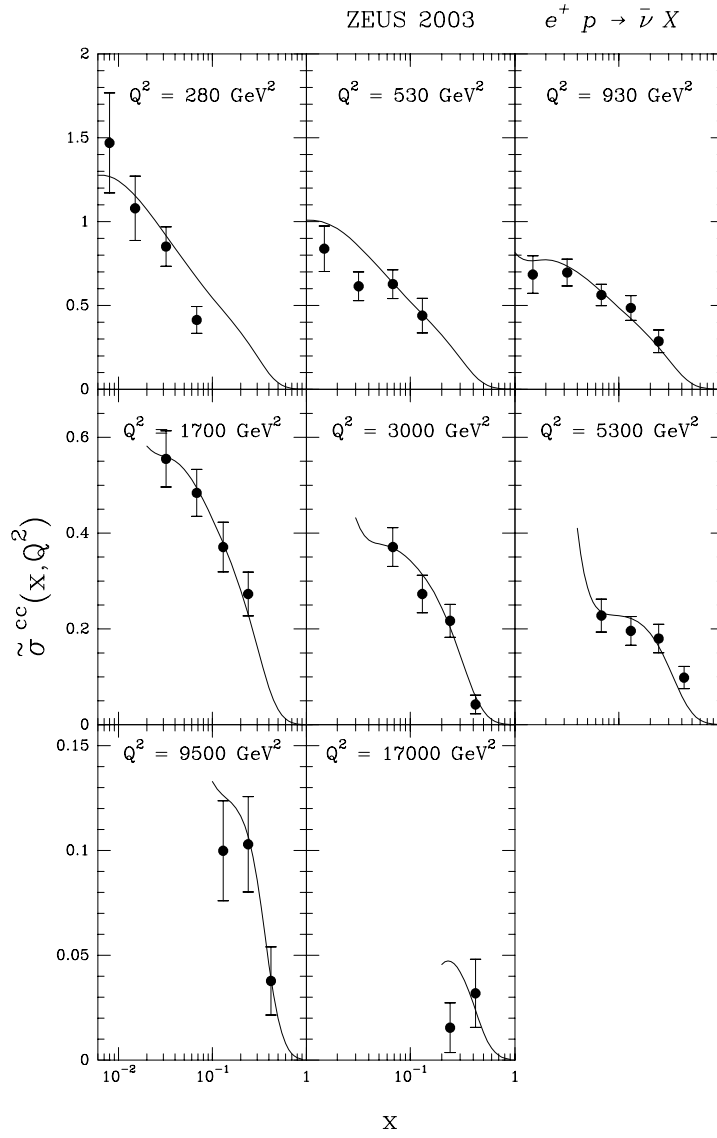


Figure 76: The reduced charged current cross section, $\tilde{\sigma}$, in e^+p reaction as a function of x , for different fixed values of Q^2 . Data from ZEUS Coll. [97].

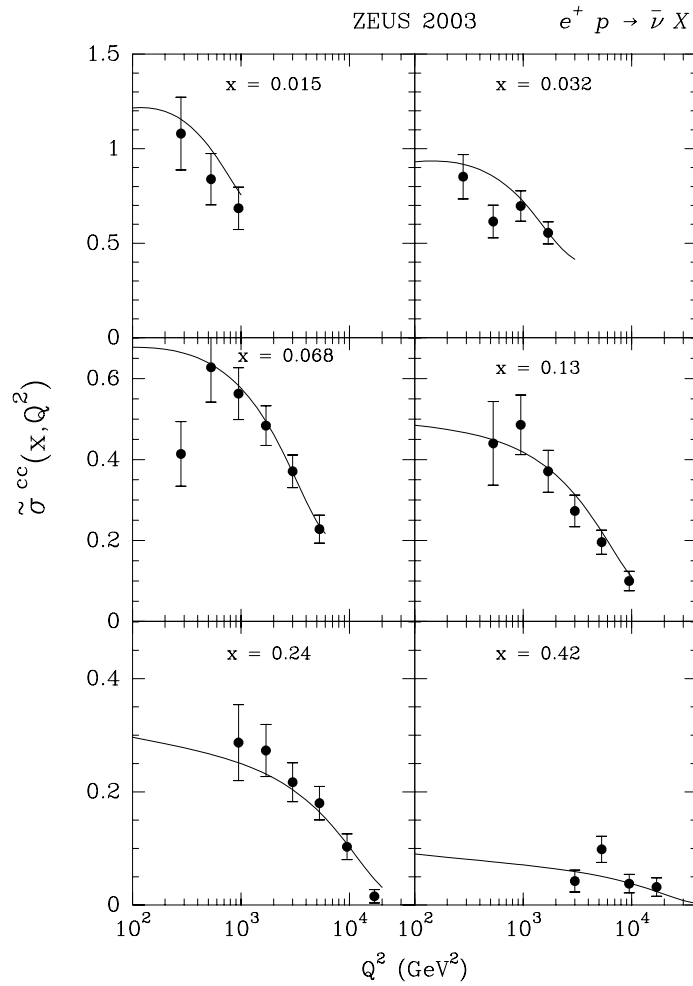


Figure 77: The reduced charged current cross section, $\tilde{\sigma}$, in e^+p reaction as a function of Q^2 , for different fixed values of x . Data from ZEUS Coll. [97].

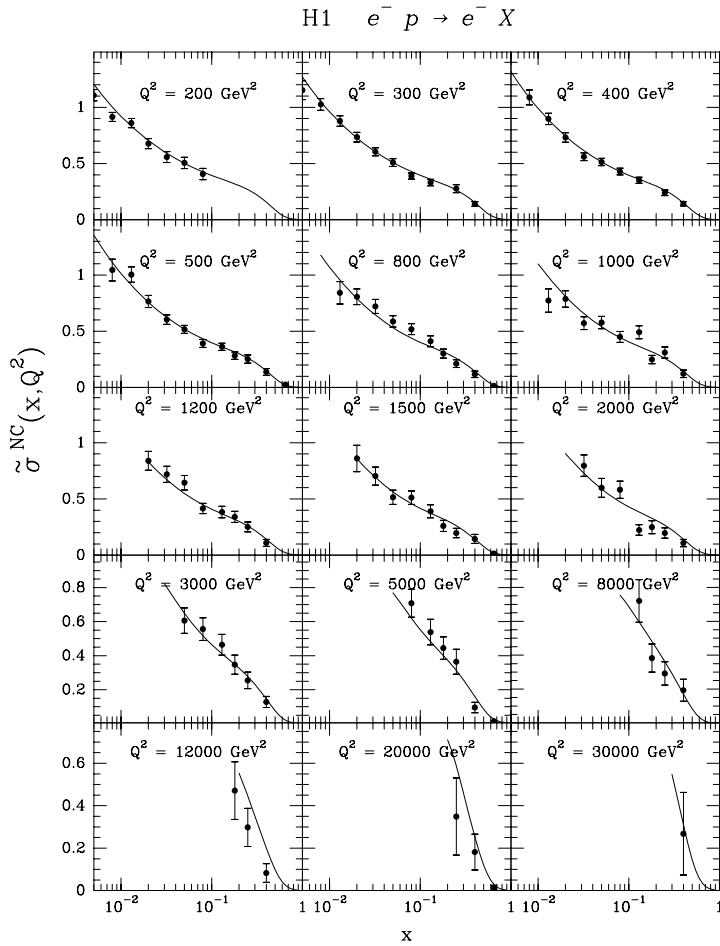


Figure 78: The reduced neutral current cross section $\tilde{\sigma}$, in $e^- p$ reaction as a function of x , for different fixed values of Q^2 and $\sqrt{s} = 320\text{GeV}$. Data from H1 Coll [40]

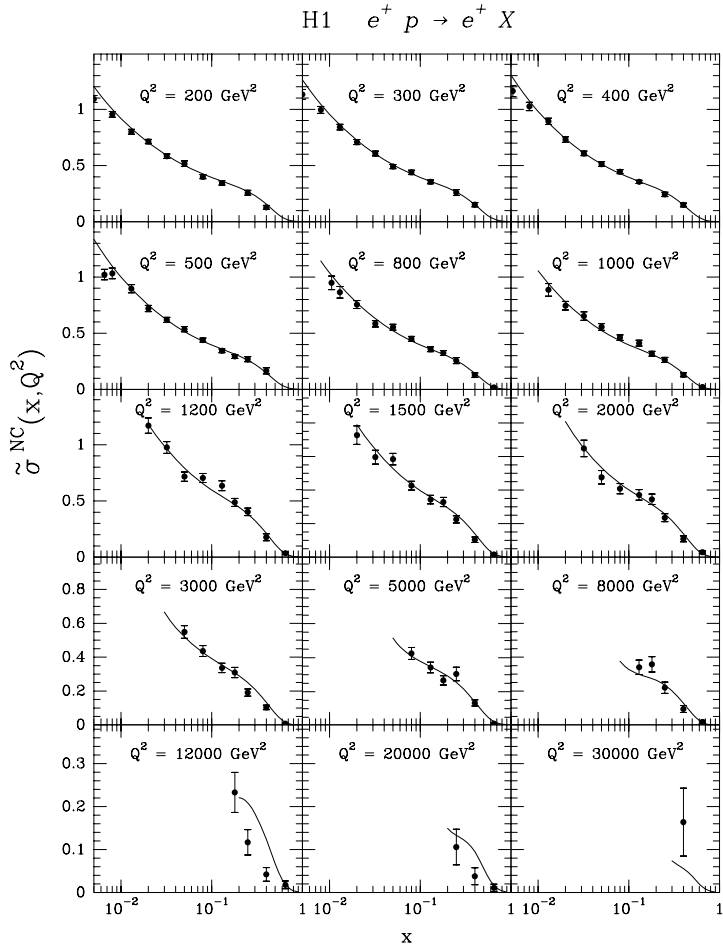


Figure 79: The reduced neutral current cross section $\tilde{\sigma}$, in e^+p reaction as a function of x , for different fixed values of Q^2 and $\sqrt{s} = 319\text{GeV}$. Data from H1 Coll [40]

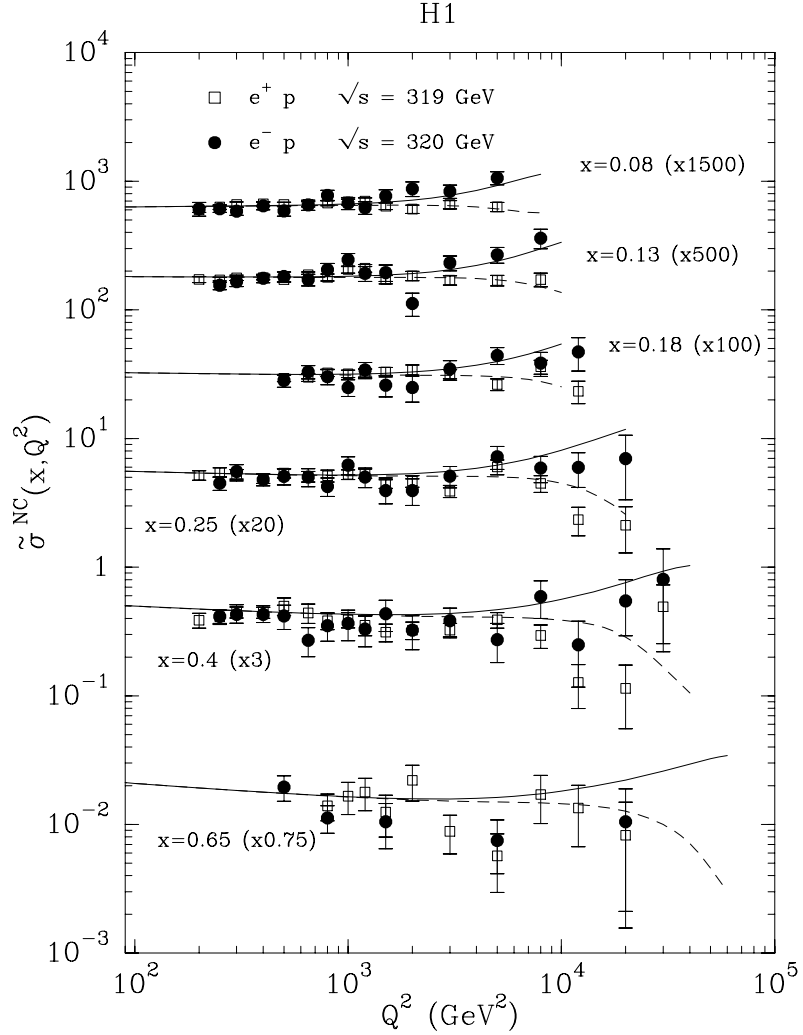


Figure 80: The reduced neutral current cross section $\tilde{\sigma}$, in $e^\pm p$ reaction as a function of Q^2 , for different fixed values of x . Solid line $e^- p$, dashed line $e^+ p$. Data from H1 Coll [40]

ZEUS $e^- p \rightarrow e^- X$

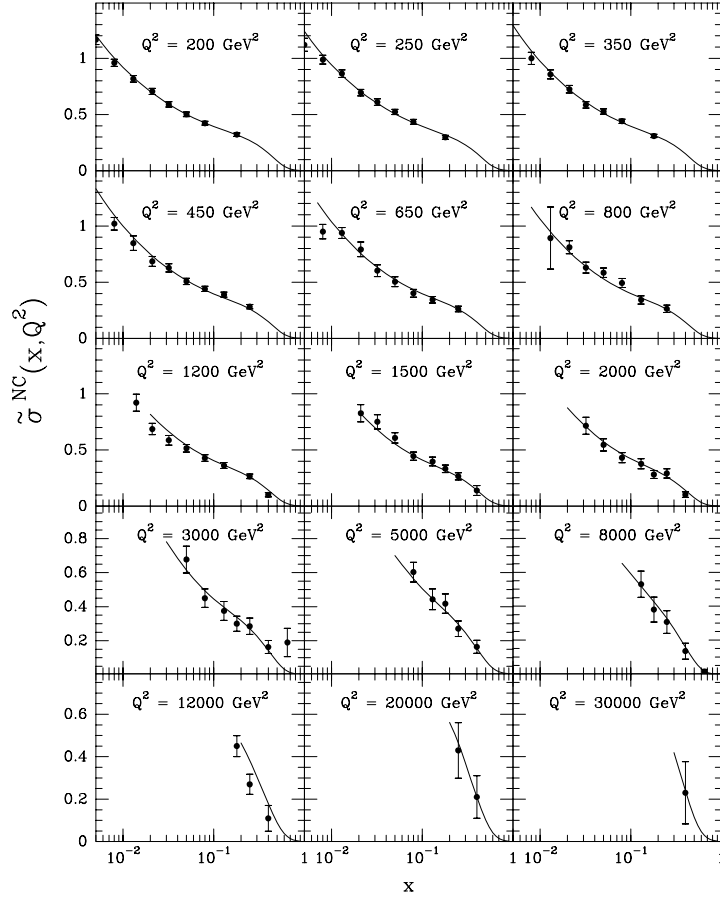


Figure 81: The reduced neutral current cross section $\tilde{\sigma}$, in $e^- p$ reaction as a function of x , for different fixed values of Q^2 and $\sqrt{s} = 318\text{GeV}$. Data from Zeus Coll [97]

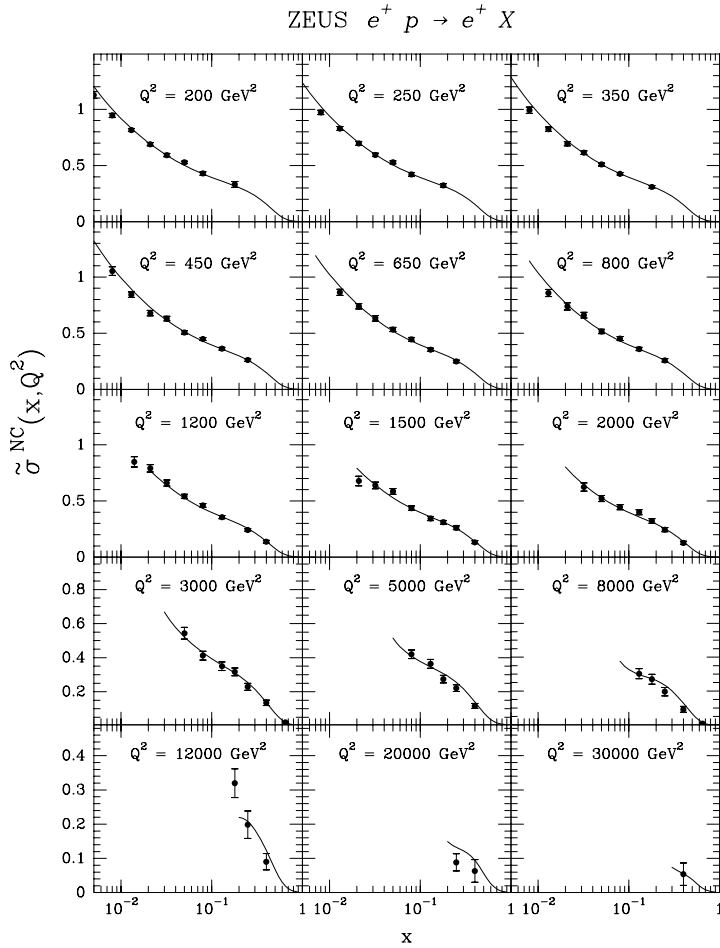


Figure 82: The reduced neutral current cross section $\tilde{\sigma}$, in e^+p reaction as a function of x , for different fixed values of Q^2 and $\sqrt{s} = 318\text{GeV}$. Data from Zeus Coll [97]

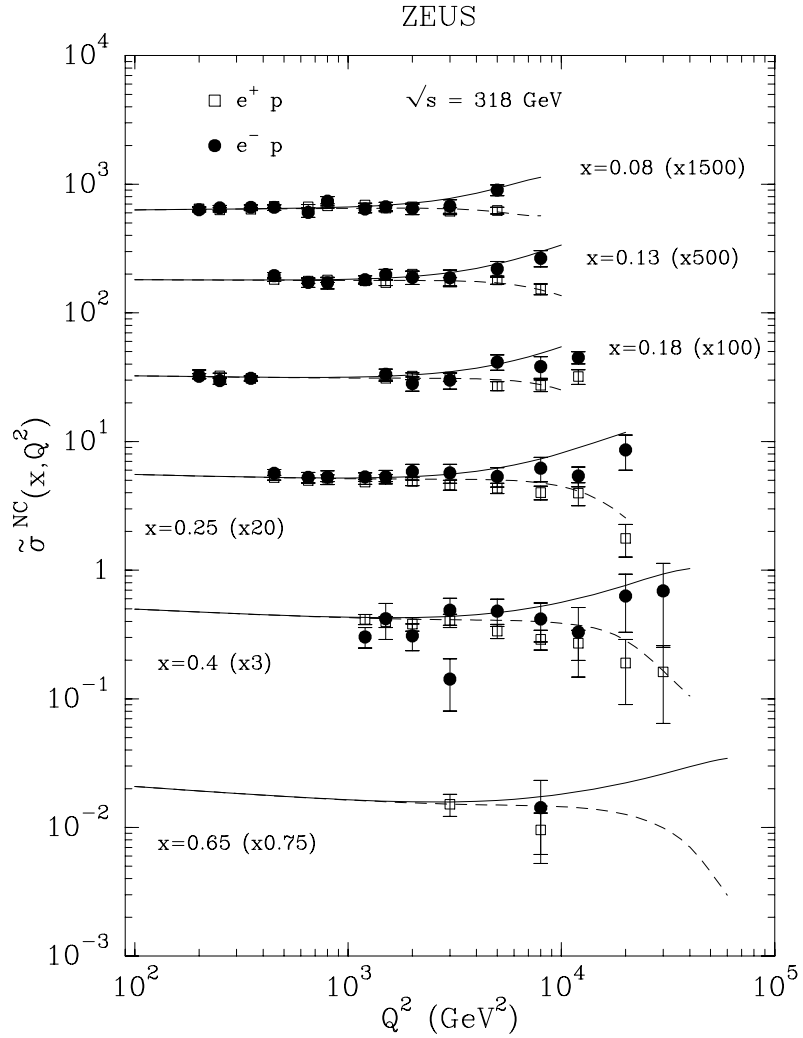


Figure 83: The reduced neutral current cross section $\tilde{\sigma}$, in $e^\pm p$ reaction as a function of Q^2 , for different fixed values of x . Solid line e^-p , dashed line e^+p . Data from Zeus Coll [97]

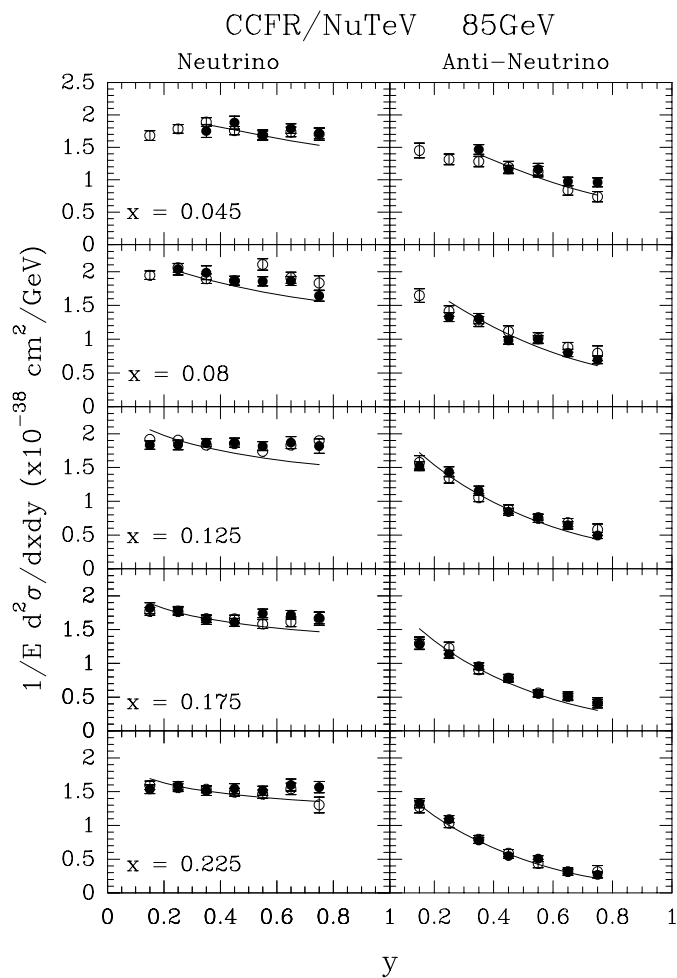


Figure 84: Differential cross section νN proton for $E_\nu = 85\text{GeV}$ as a function of y for different x bins. Data from CCFR [29] and NuTeV collaboration [31, 30].

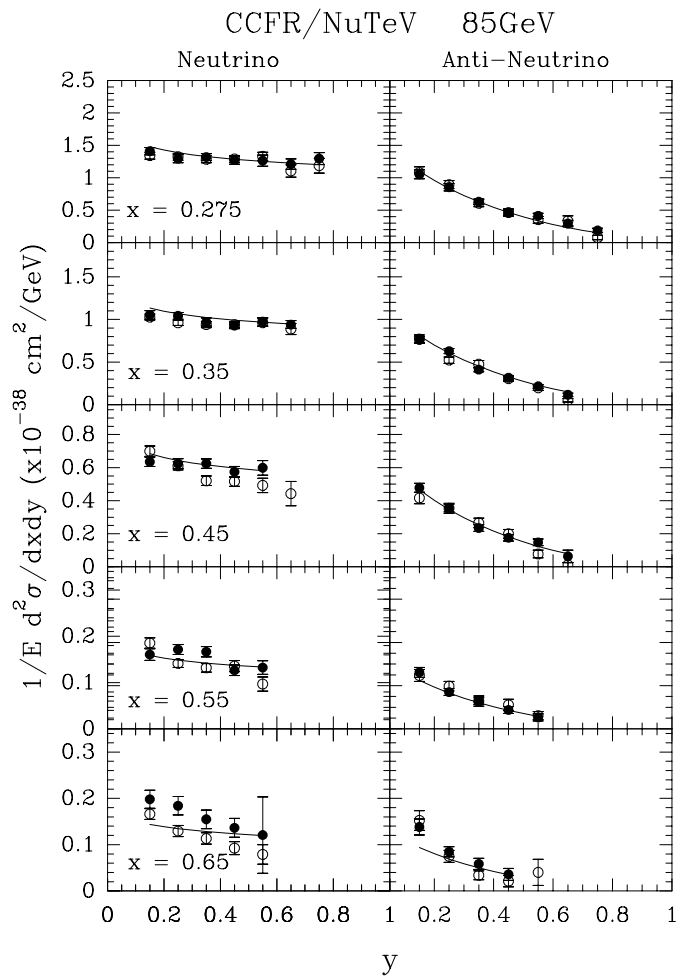


Figure 85: Differential cross section νN proton for $E_\nu = 85\text{GeV}$ as a function of y for different x bins. Data from CCFR [29] and NuTeV collaboration [31, 30].

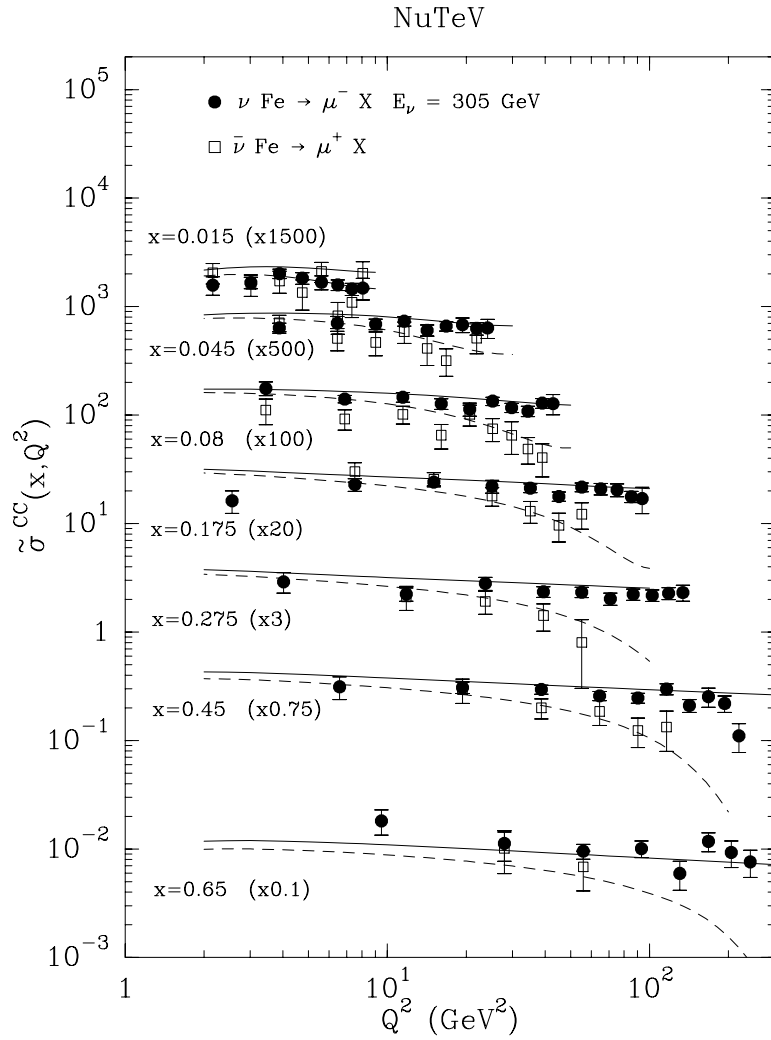


Figure 86: The reduced charged current cross section νN , for different x bins as a function of Q^2 . The data points are obtained from the differential cross section [31, 30], they are not a direct measurement

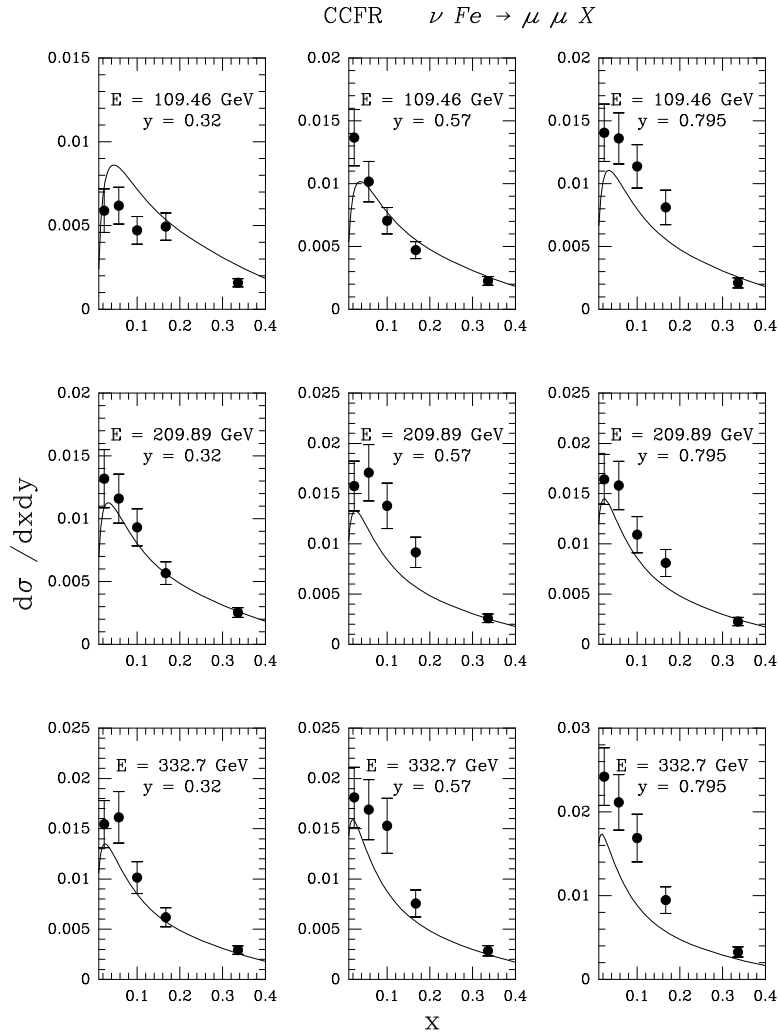


Figure 87: Comparison of the CCFR ν data [103] to the result of the fit for $d\sigma/dxdy$, in units of charged-current σ , for various kinematic ranges in energy, x and y .

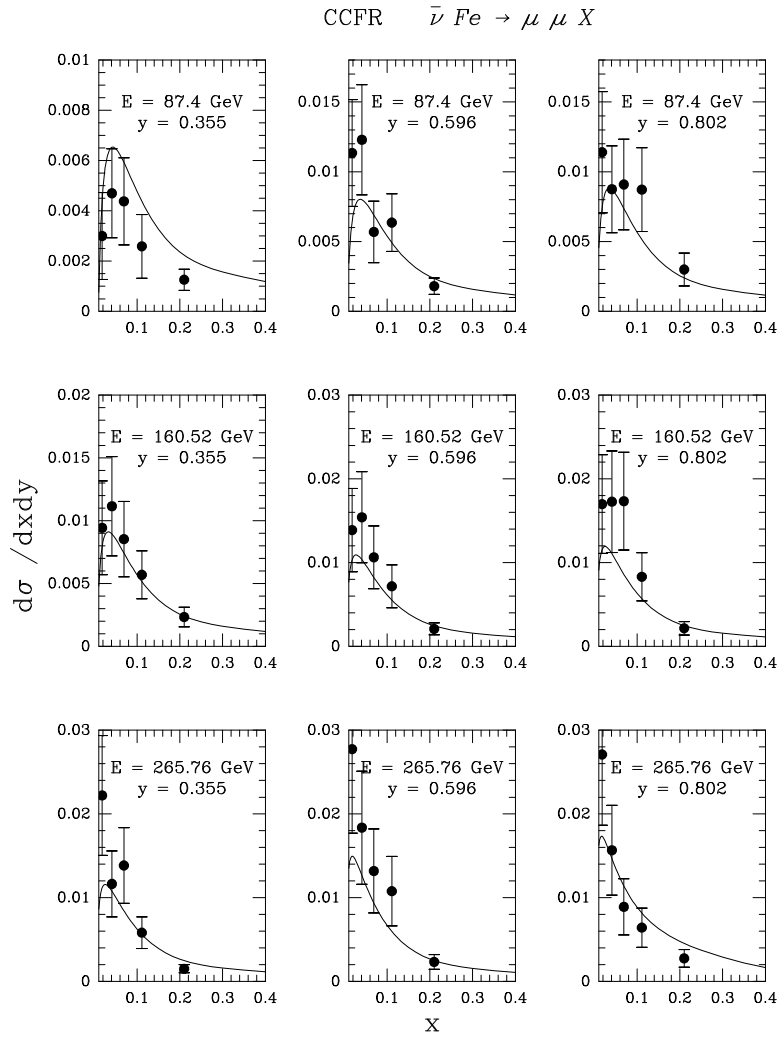


Figure 88: Comparison of the CCFR $\bar{\nu}$ data [103] to the result of the fit for $d\sigma/dx dy$ in units of charged-current σ , for various kinematic ranges in energy, x and y .

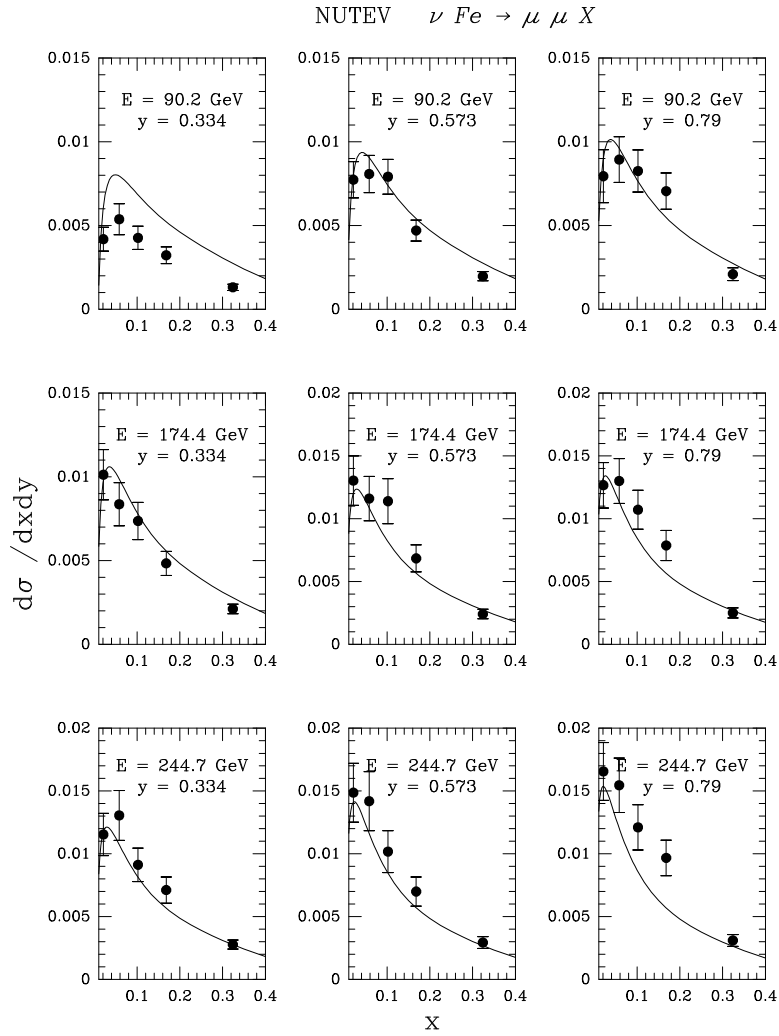


Figure 89: Comparison of the NuTeV ν data [103] to the result of the fit for $d\sigma/dxdy$, in units of charged-current σ , for various kinematic ranges in energy, x and y .

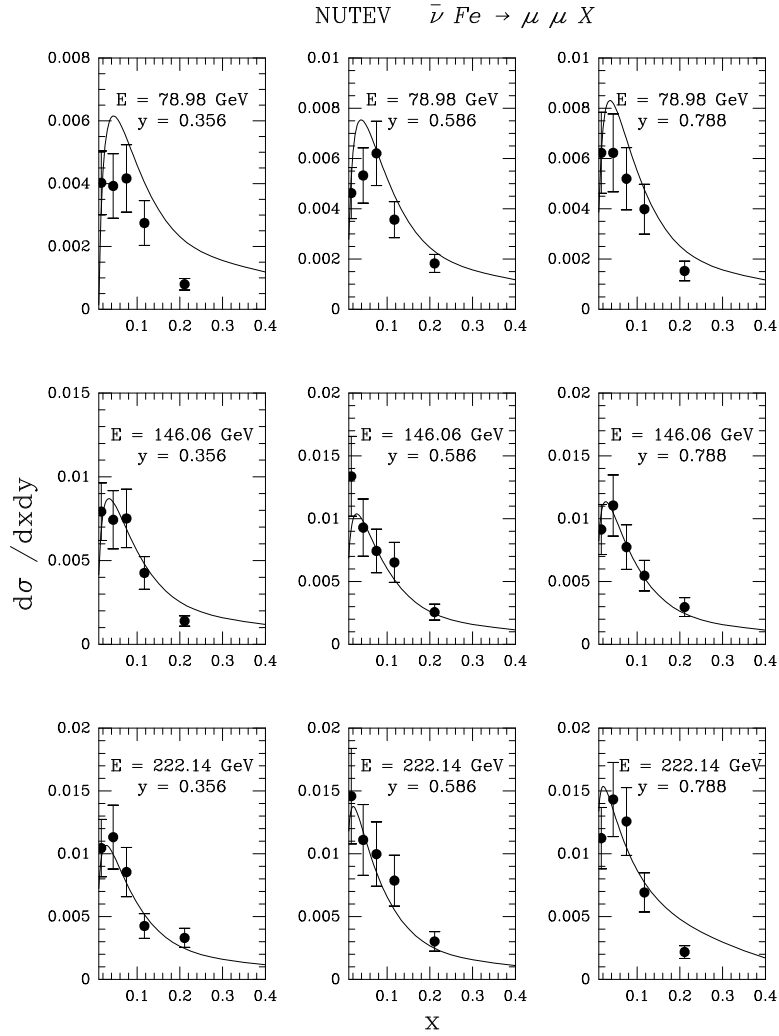


Figure 90: Comparison of the NuTeV $\bar{\nu}$ data [103] to the result of the fit for $d\sigma/dx dy$, in units of charged-current σ , for various kinematic ranges in energy, x and y .

5 Polarized experiments

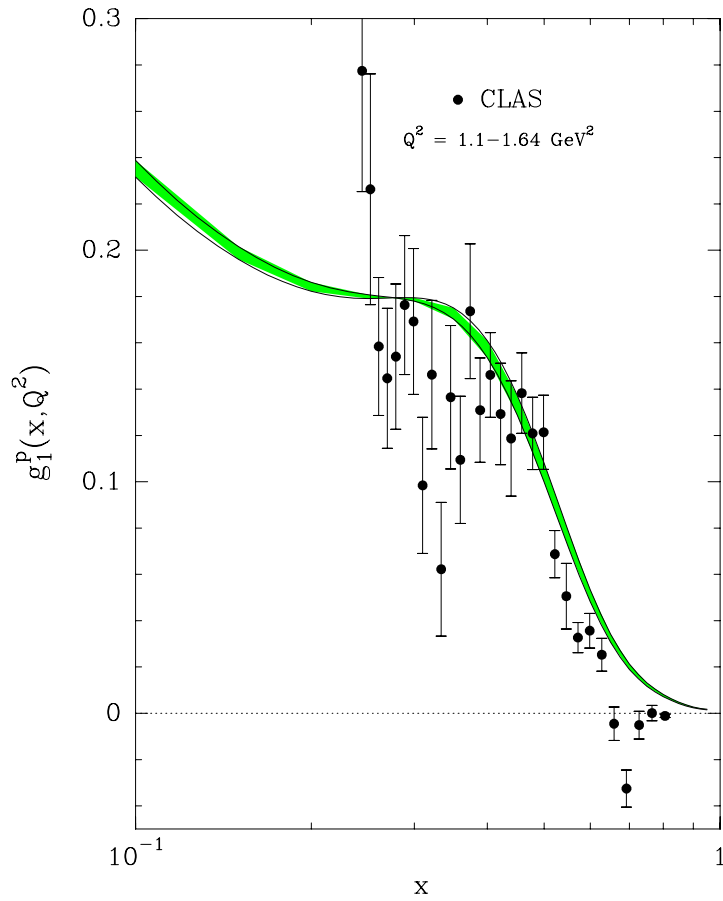


Figure 91: $g_1^p(x, Q^2)$ as function of x at for a range $1.1 \leq Q^2 \leq 1.64 \text{ GeV}^2$, CLAS Coll [16]. The two curves represent the extreme Q^2 values.

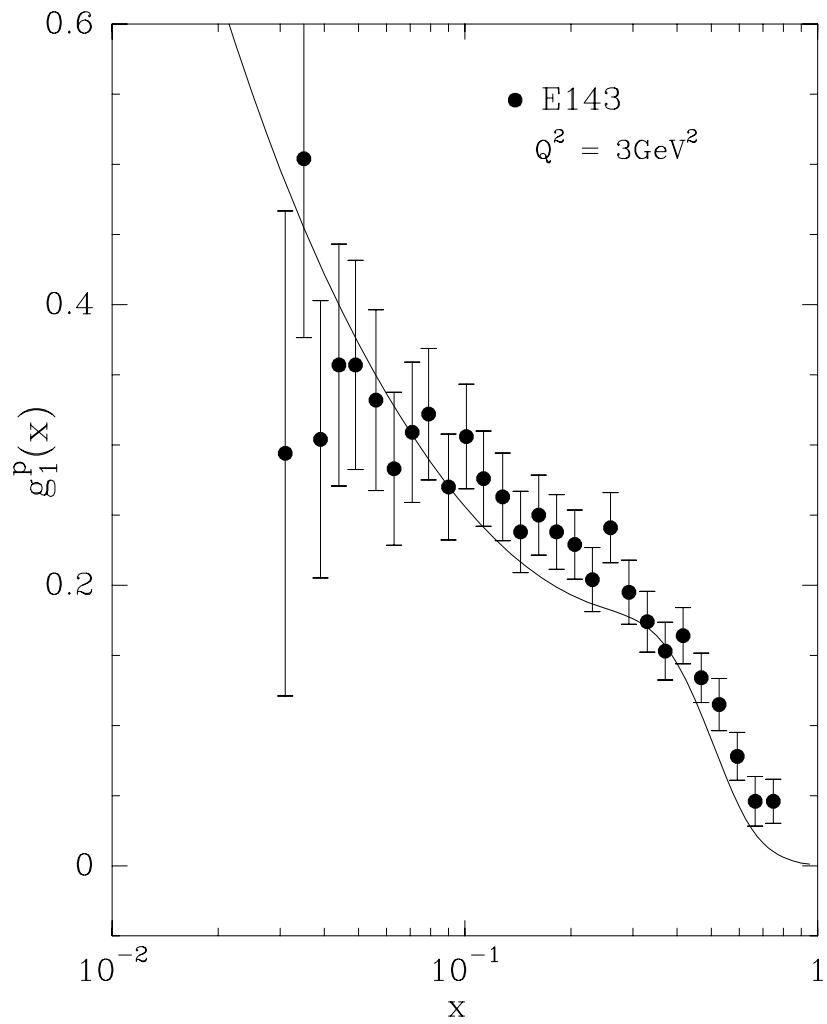


Figure 92: $g_1^p(x, Q^2)$ as function of x at fixed $Q^2 = 3\text{GeV}^2$, E143 Coll.

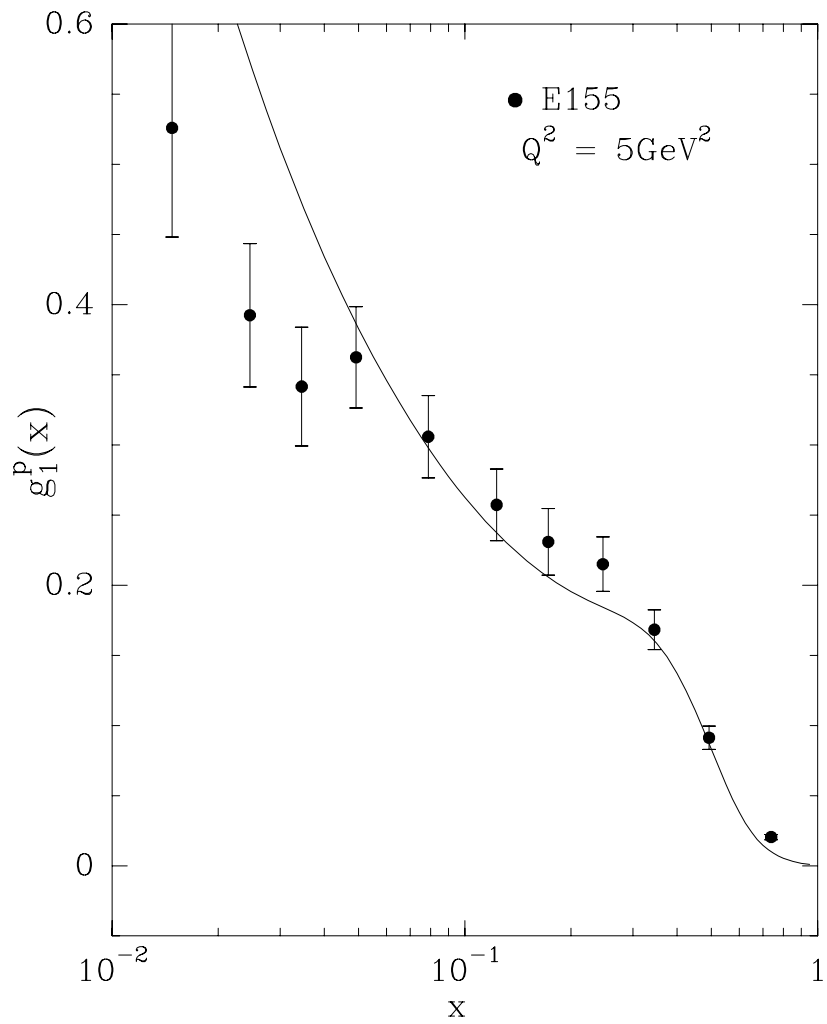


Figure 93: $g_1^p(x, Q^2)$ as function of x at fixed $Q^2 = 5\text{GeV}^2$, E155 Coll.

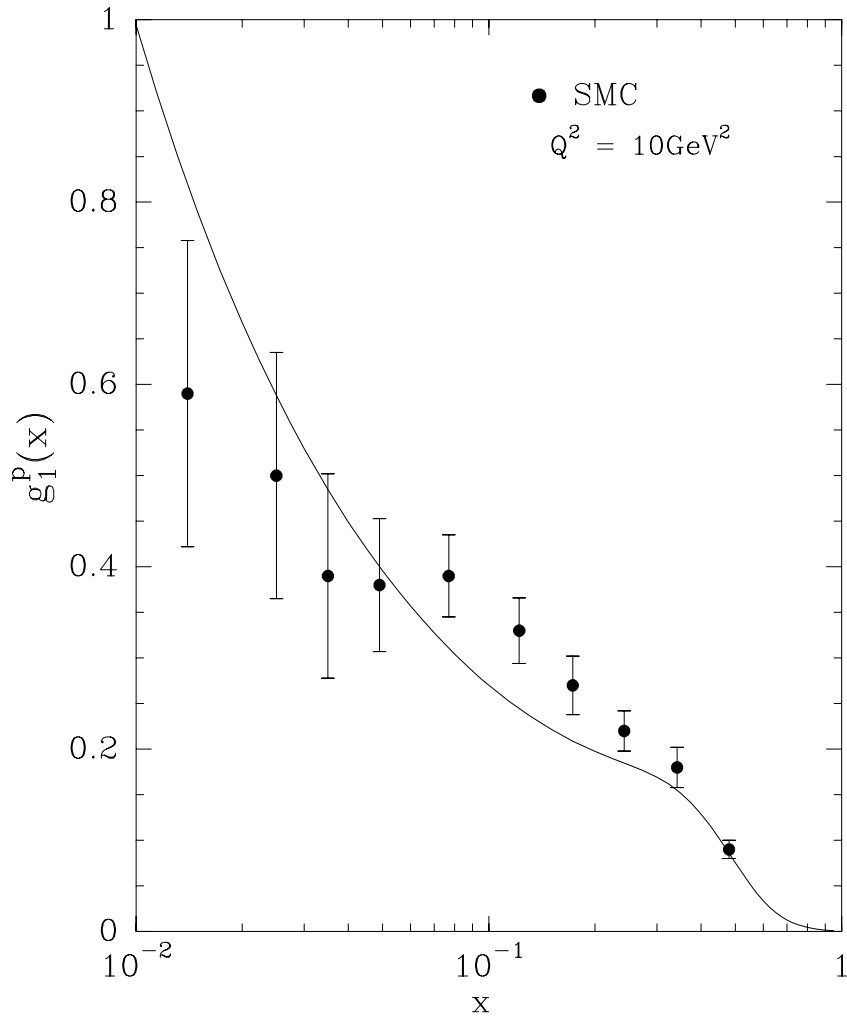


Figure 94: $g_1^p(x, Q^2)$ as function of x at fixed $Q^2 = 10\text{GeV}^2$, evolved SMC data.

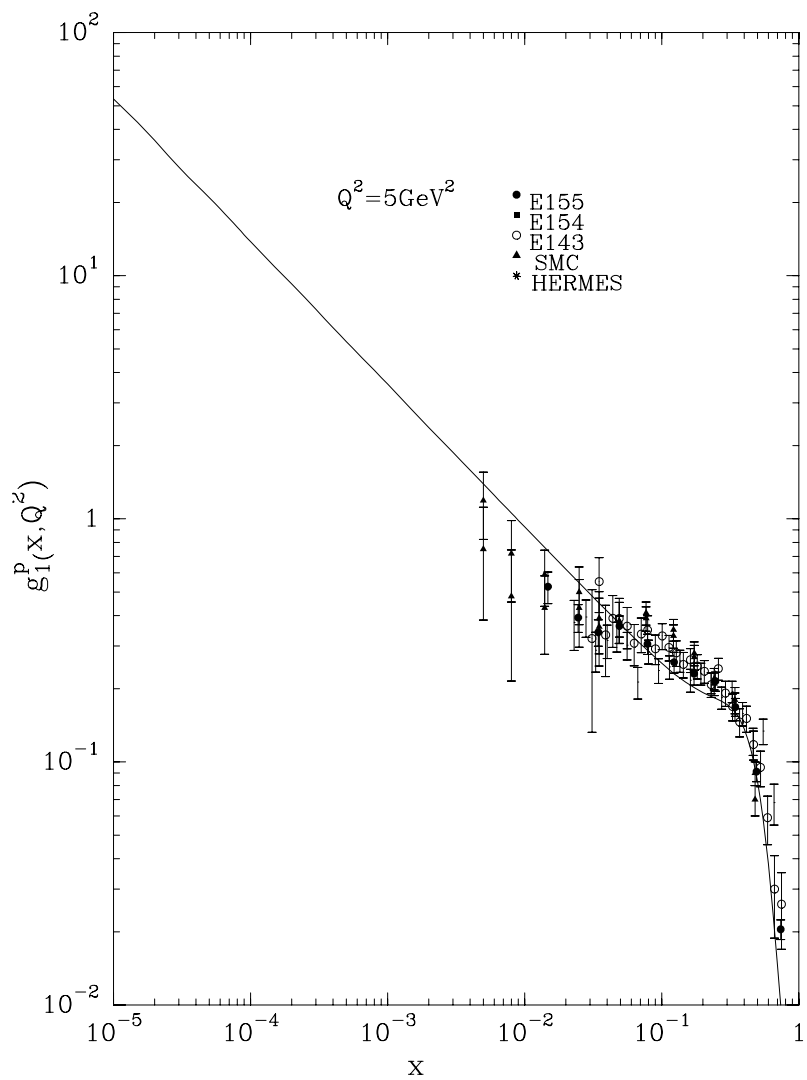


Figure 95: Behavior of $g_1^p(x, Q^2)$ at low x and fixed $Q^2 = 5\text{GeV}^2$,

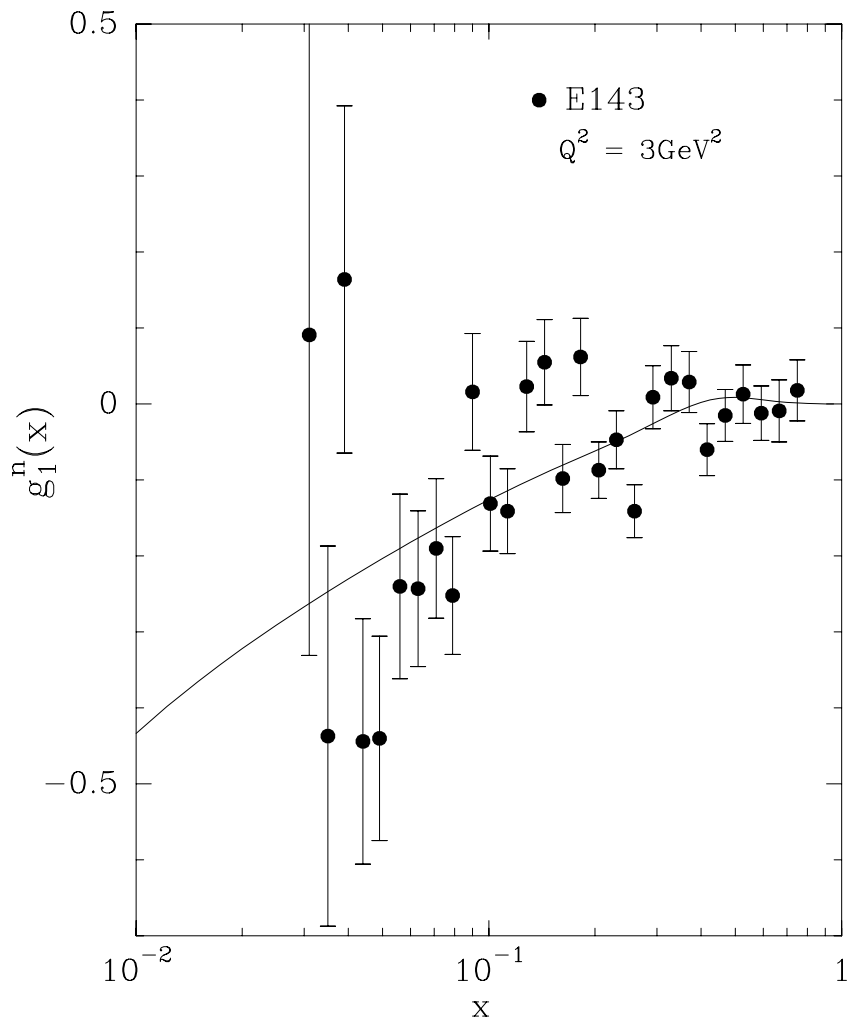


Figure 96: $g_1^n(x, Q^2)$ as function of x at fixed $Q^2 = 3\text{GeV}^2$, E143 Coll.

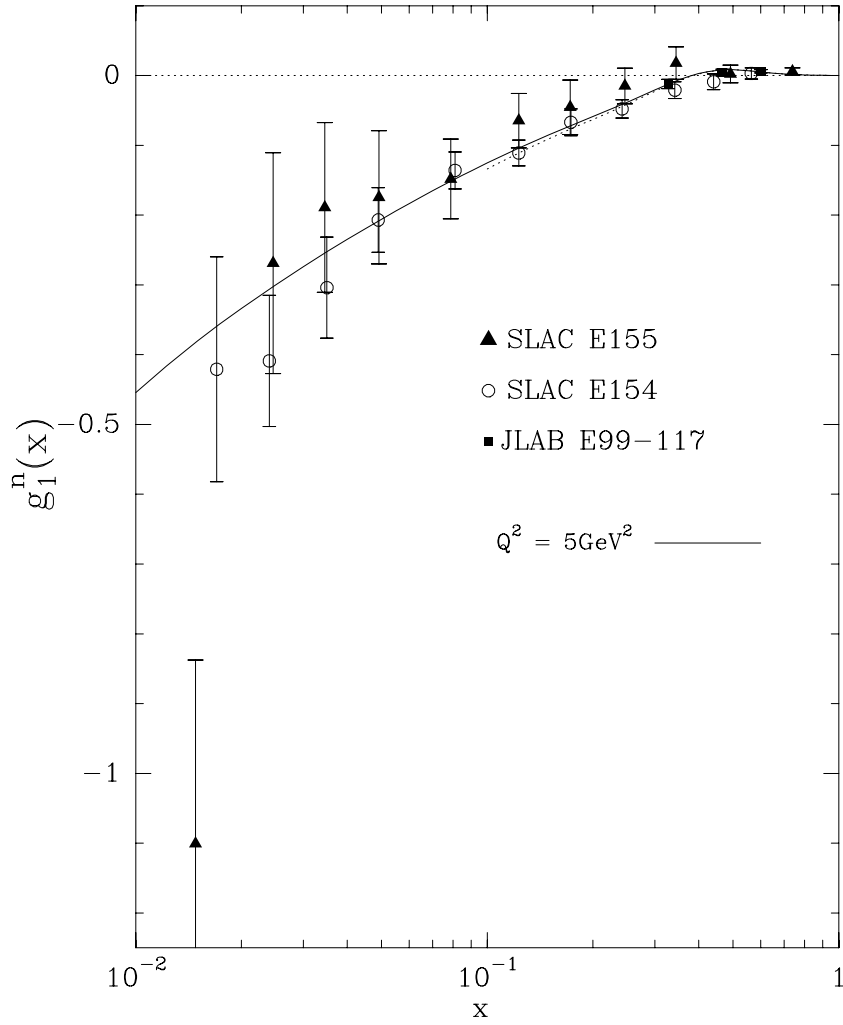


Figure 97: $g_1^n(x, Q^2)$ as function of x at fixed $Q^2 = 5\text{GeV}^2$, E154, E155, JLab Coll..

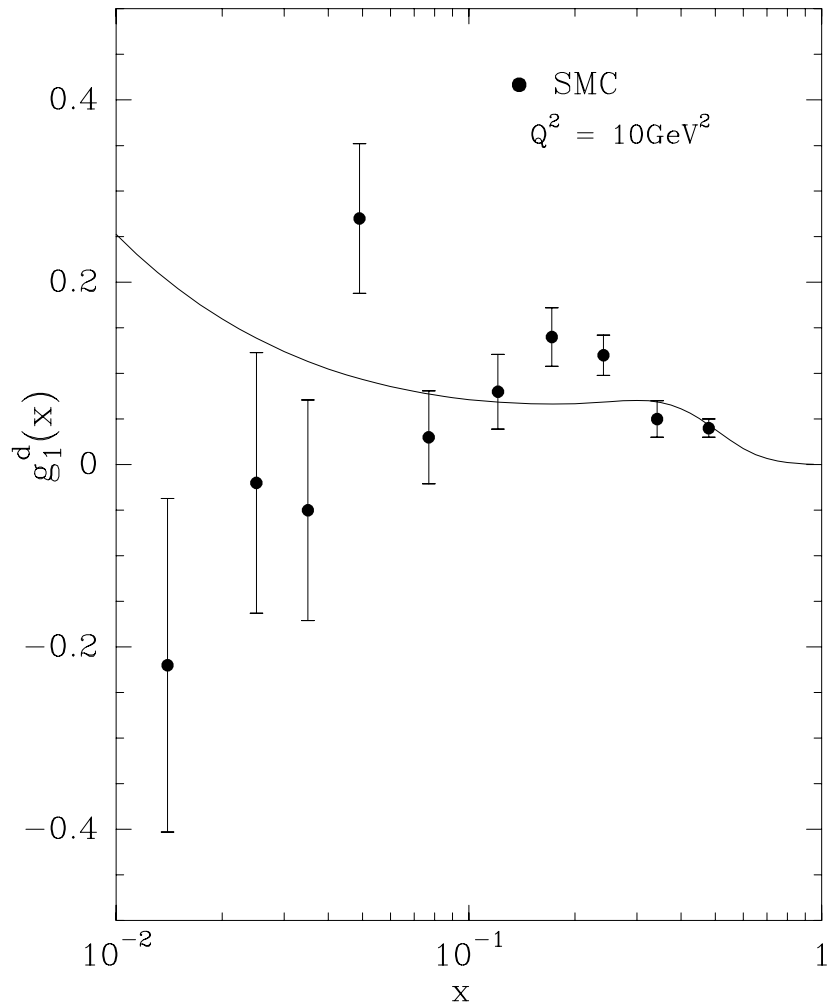


Figure 98: $g_1^d(x, Q^2)$ as function of x at fixed $Q^2 = 10\text{GeV}^2$, evolved SMC data.

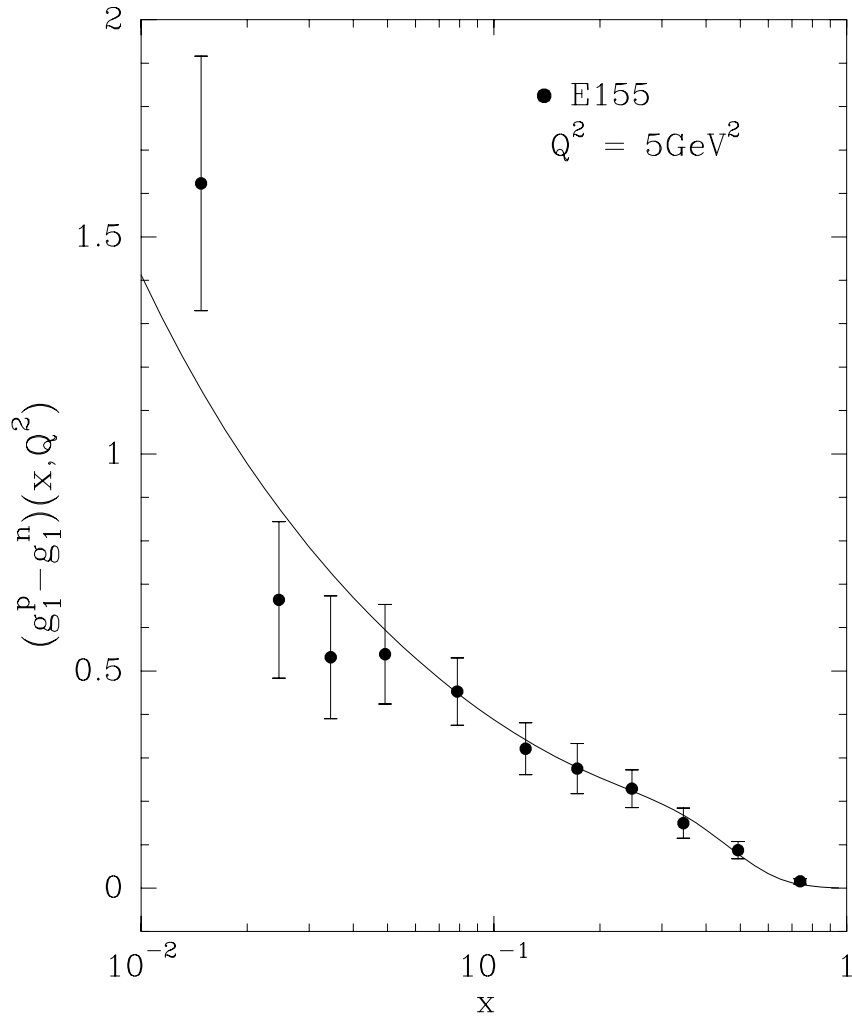


Figure 99: $g_1^p(x, Q^2) - g_1^n(x, Q^2)$ as function of x at fixed $Q^2 = 5\text{GeV}^2$, E155 Coll..

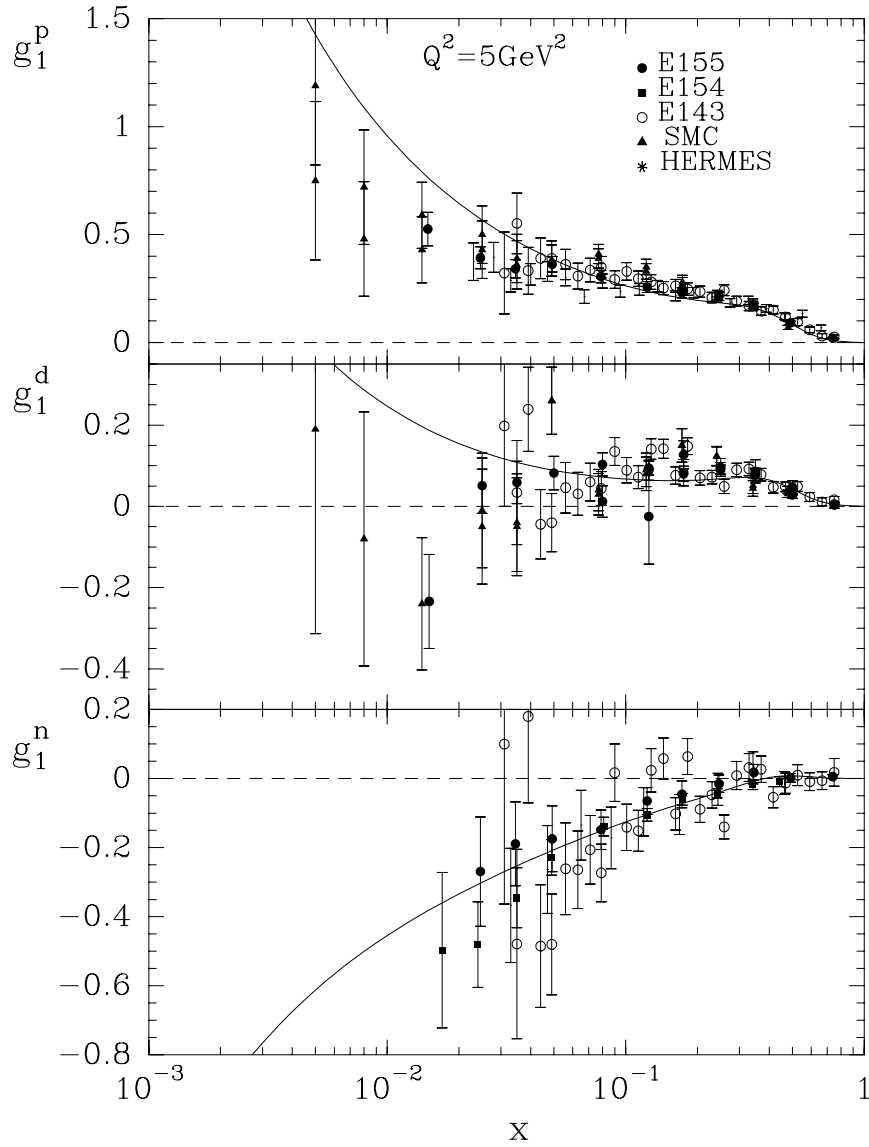


Figure 100: $g_1^{p,d,n}(x, Q^2)$ as function of x for different Q^2 values, from E155, E154, E143, SMC, HERMES experiments. The curves correspond to our model predictions at $Q^2 = 5\text{GeV}^2$.

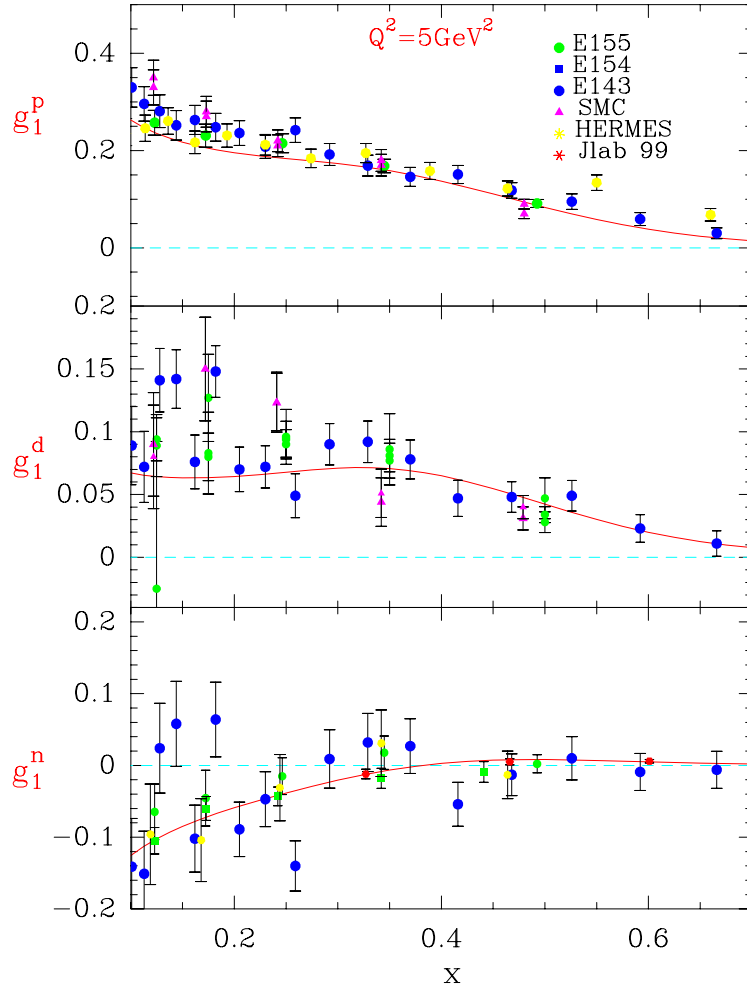


Figure 101: $g_1^{p,d,n}(x, Q^2)$ at large x values for different Q^2 values, from E155, E154, E143, SMC, HERMES, Jlab experiments. The curves correspond to our model predictions at $Q^2 = 5\text{GeV}^2$.

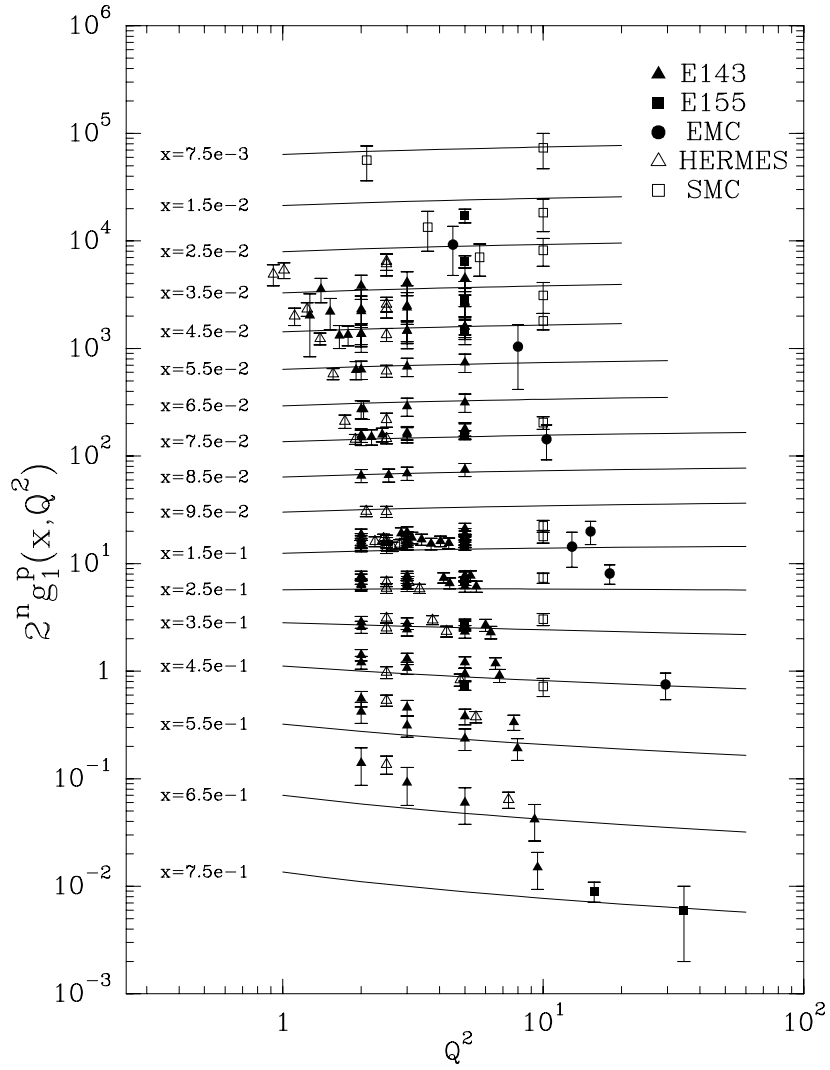


Figure 102: $2^n g_1^p(x, Q^2)$ as function of Q^2 for different x values. $n = 0$ corresponds to $x = 0.75$ and $n = 16$ to $x = 7.5 \cdot 10^{-3}$. Experimental data are rebinned to the nearest x values.

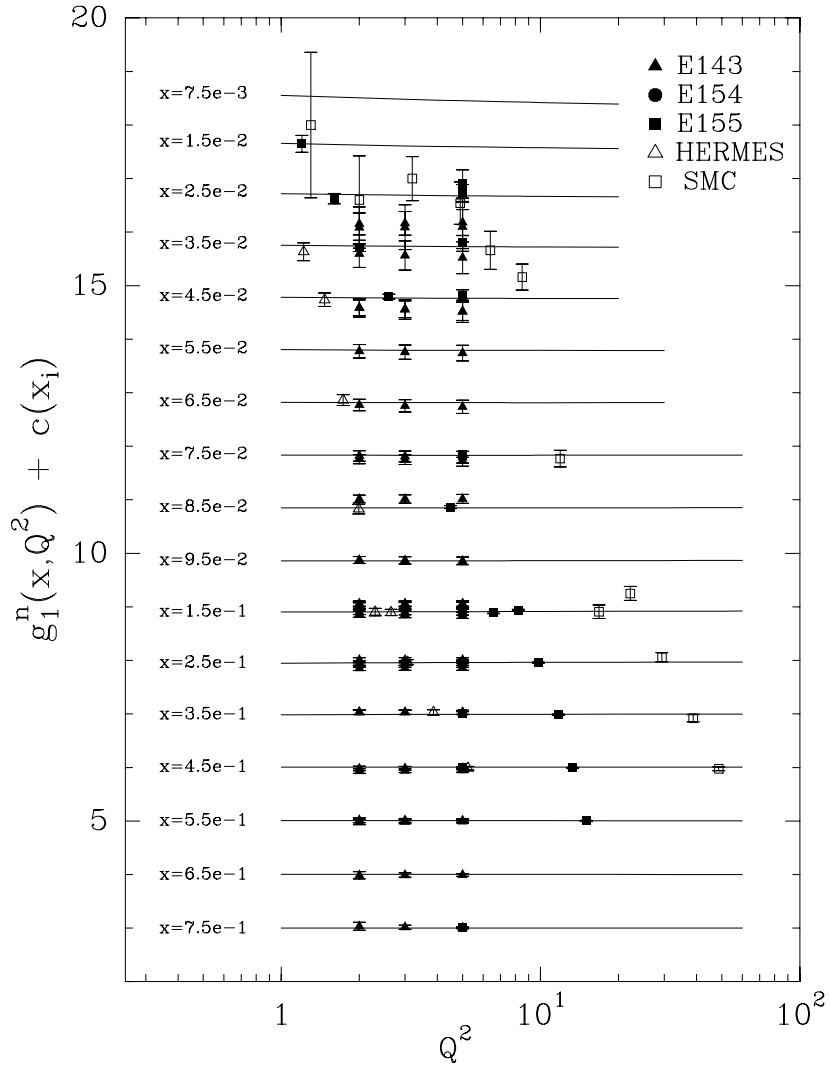


Figure 103: $g_1^n(x, Q^2)$ as function of Q^2 for different x values. The function $c(x_i) = 19 - i$, $i = 0$ corresponds to $x = 7.5 \cdot 10^{-3}$. Experimental data are rebinned to the nearest x values.

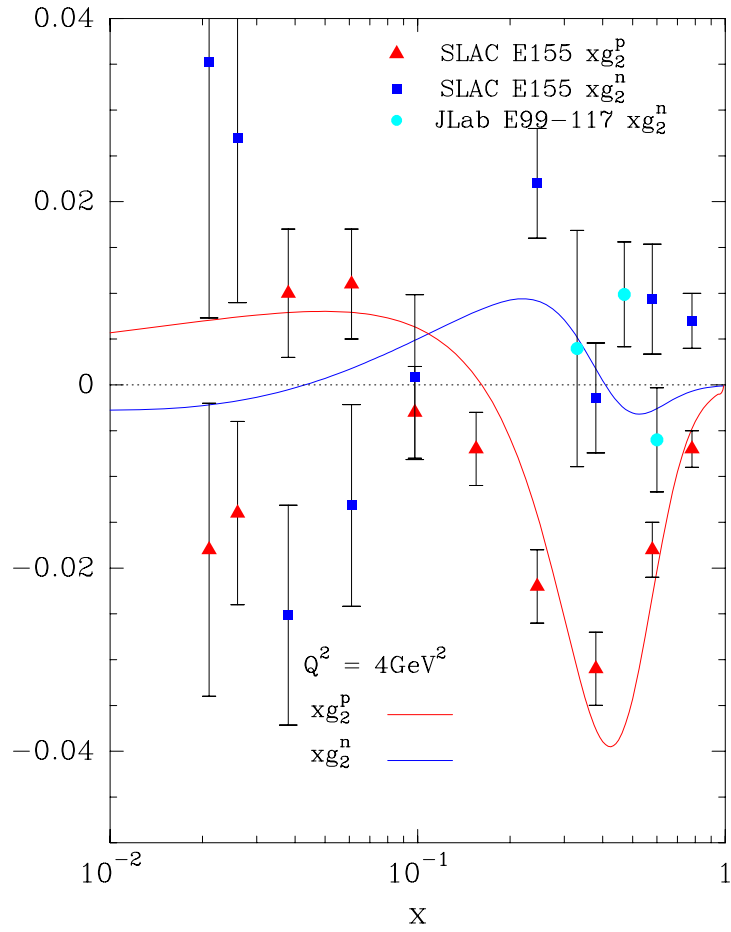


Figure 104: xg_2 for proton and neutron as a function of x , for $Q^2 = 4\text{GeV}^2$. Data from SLAC E155 [77], JLab E99-117 [54].

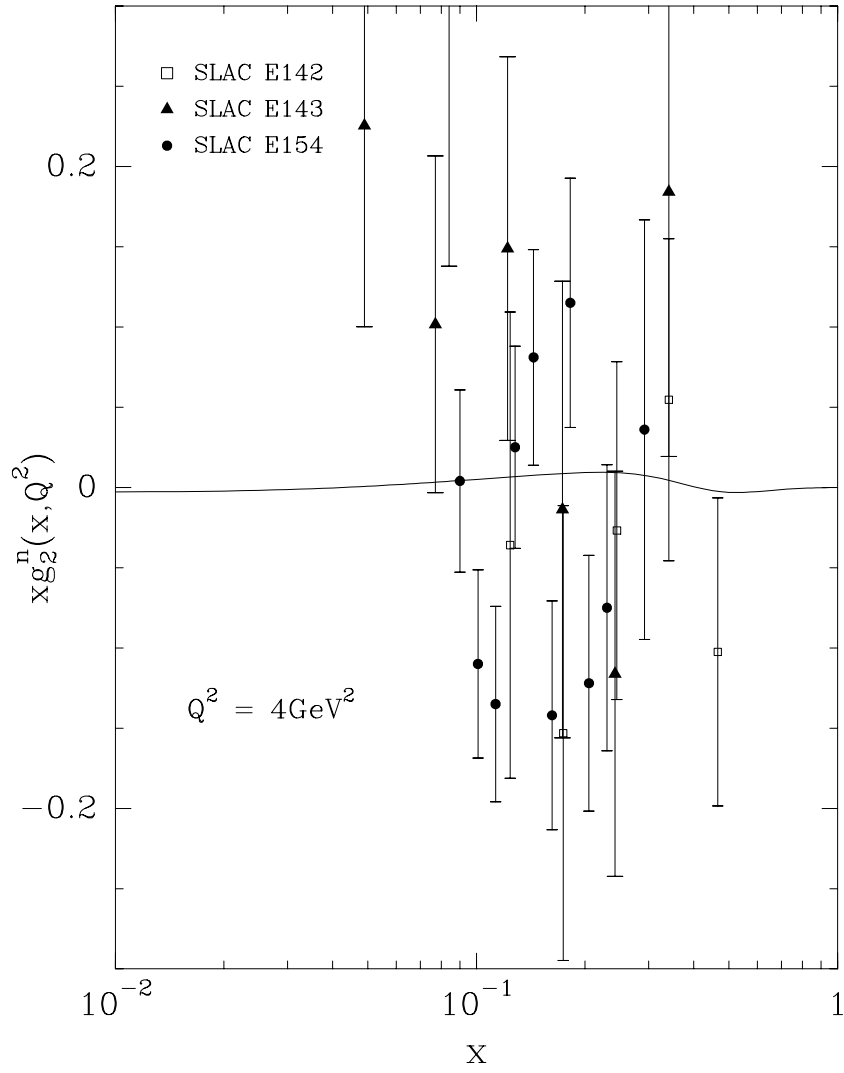


Figure 105: xg_2 for neutron as a function of x , for $Q^2 = 4\text{GeV}^2$. Data from E142, E143, E154 [66]-[72].

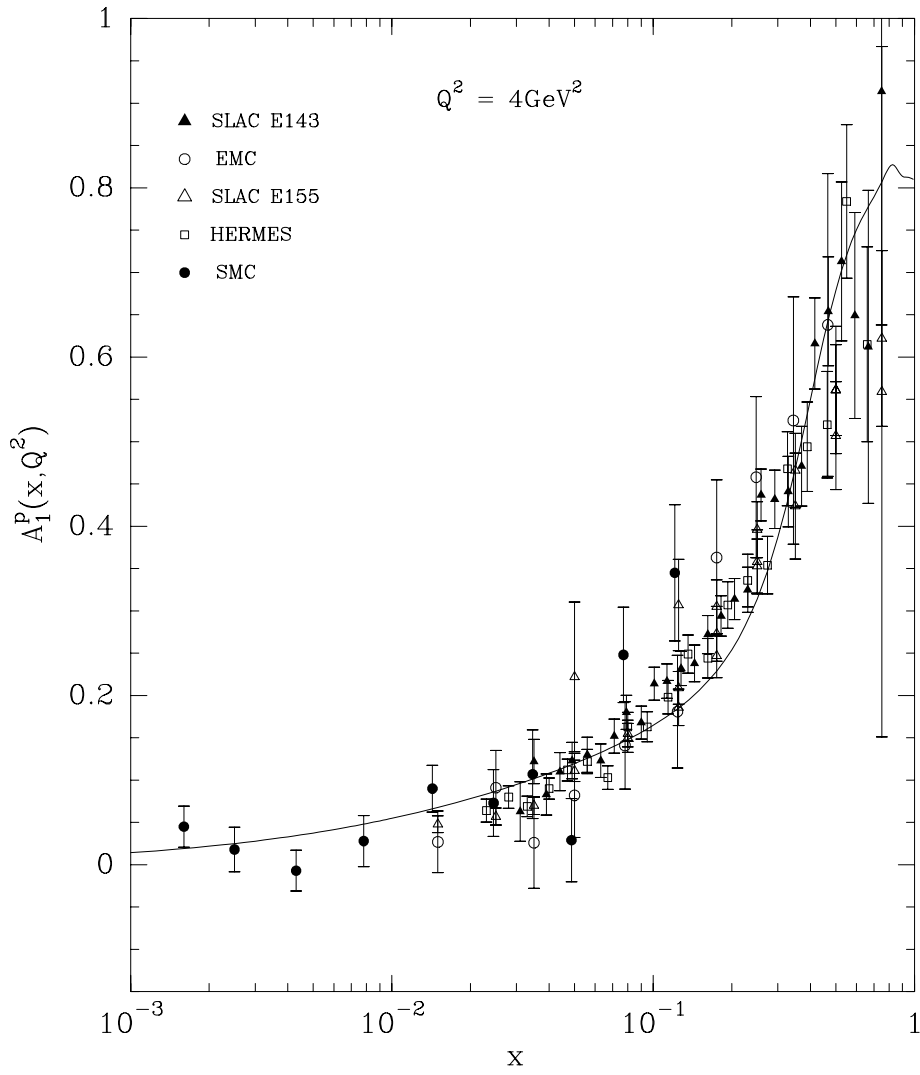


Figure 106: A_1^p as a function of x , for $Q^2 = 4\text{GeV}^2$. Data from E143[70], EMC[35], E155[76], HERMES[48], SMC[81].

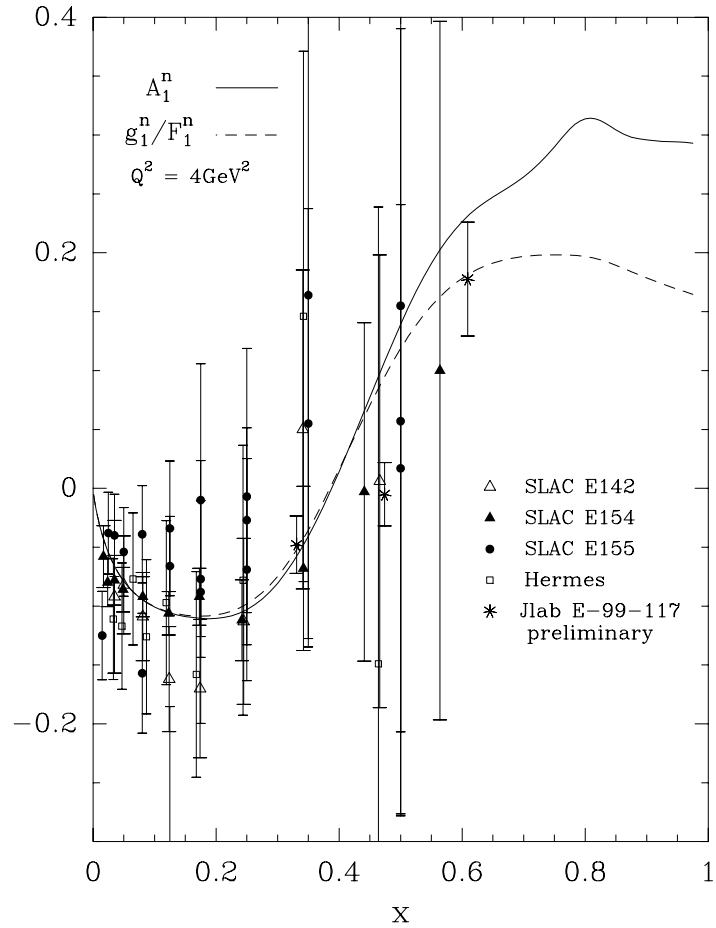


Figure 107: A_1^n as a function of x , for $Q^2 = 4\text{GeV}^2$ solid curve, g_1^n/F_1^n dashed curve. Data from E142[66], E155[76], E154[74], HERMES[49], Jlab E-99-117[53].

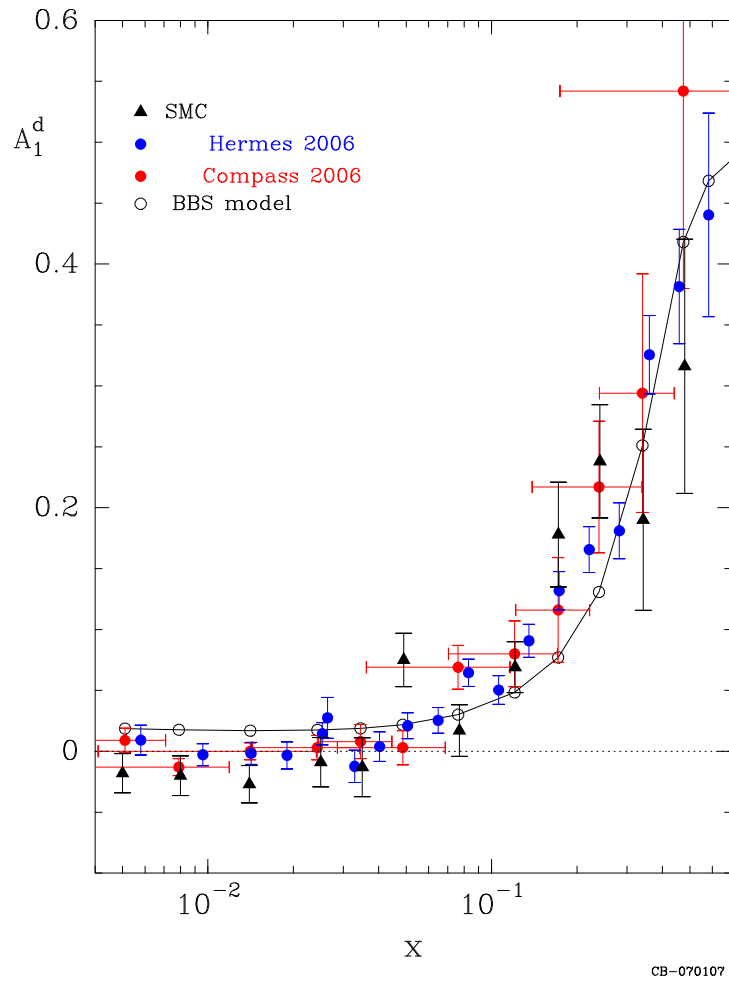


Figure 108: The longitudinal spin asymmetry A_1^d as a function of x . Data from Compass, Hermes, SMC Collaborations [113, 114, 115].

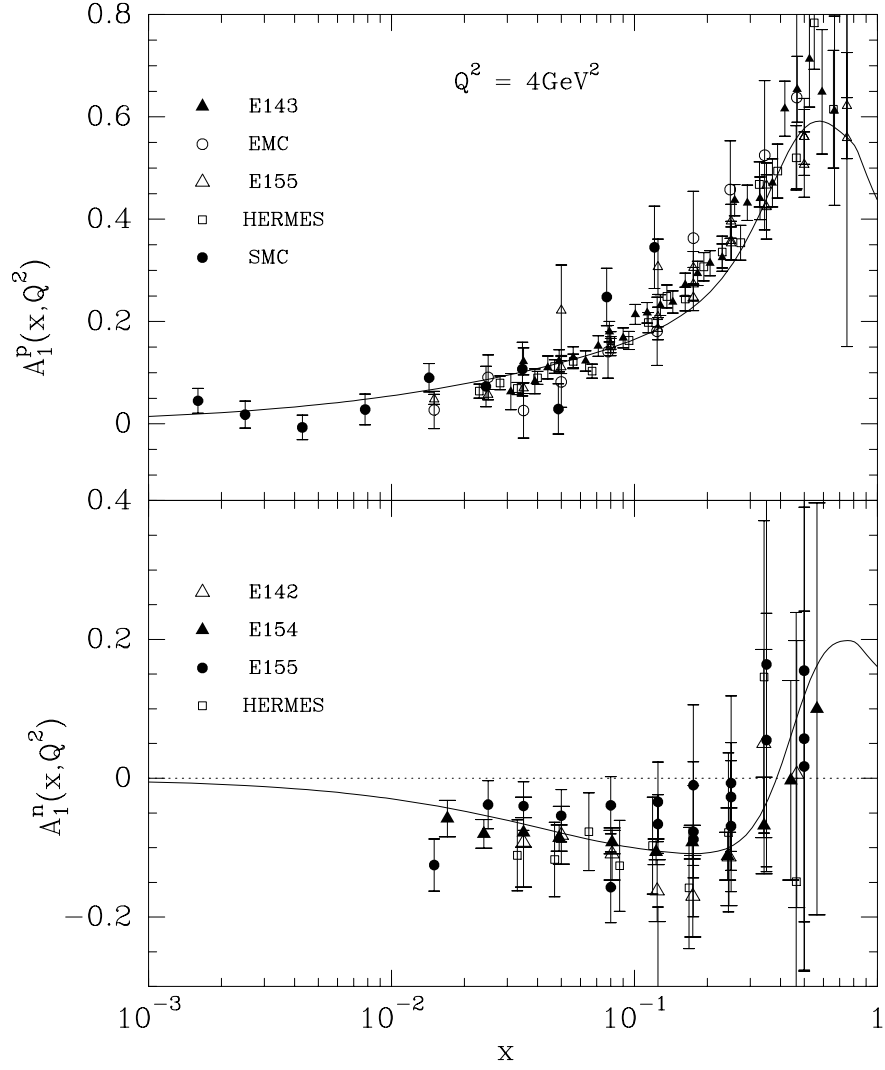


Figure 109: Compilation of the asymmetries A_1^p and A_1^n from E155, E154, E142, E143, EMC, SMC and HERMES experiments [33]-[69]. The curves correspond to our model predictions at $Q^2 = 4\text{GeV}^2$.

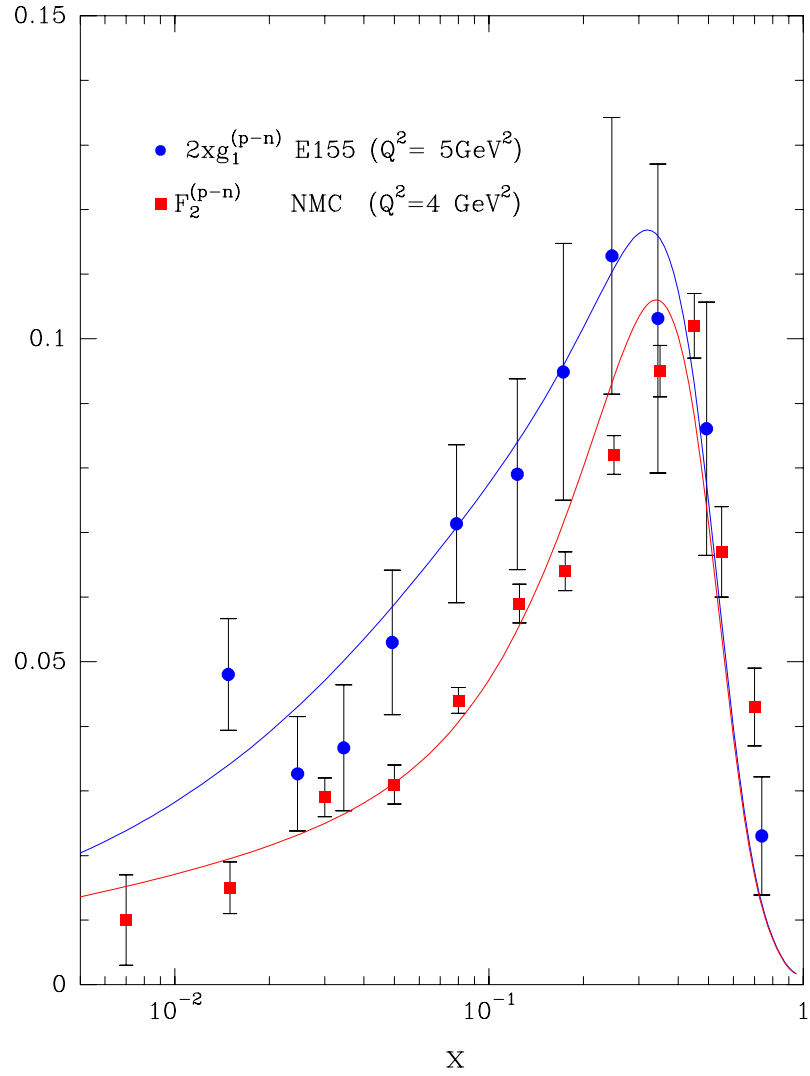


Figure 110: The quantities $2x(g_1^p - g_1^n)$ and $F_2^p - F_2^n$ as function of x at fixed $Q^2 = 4 - 5 \text{ GeV}^2$, calculated from E155, NMC Coll. Curves are model predictions.

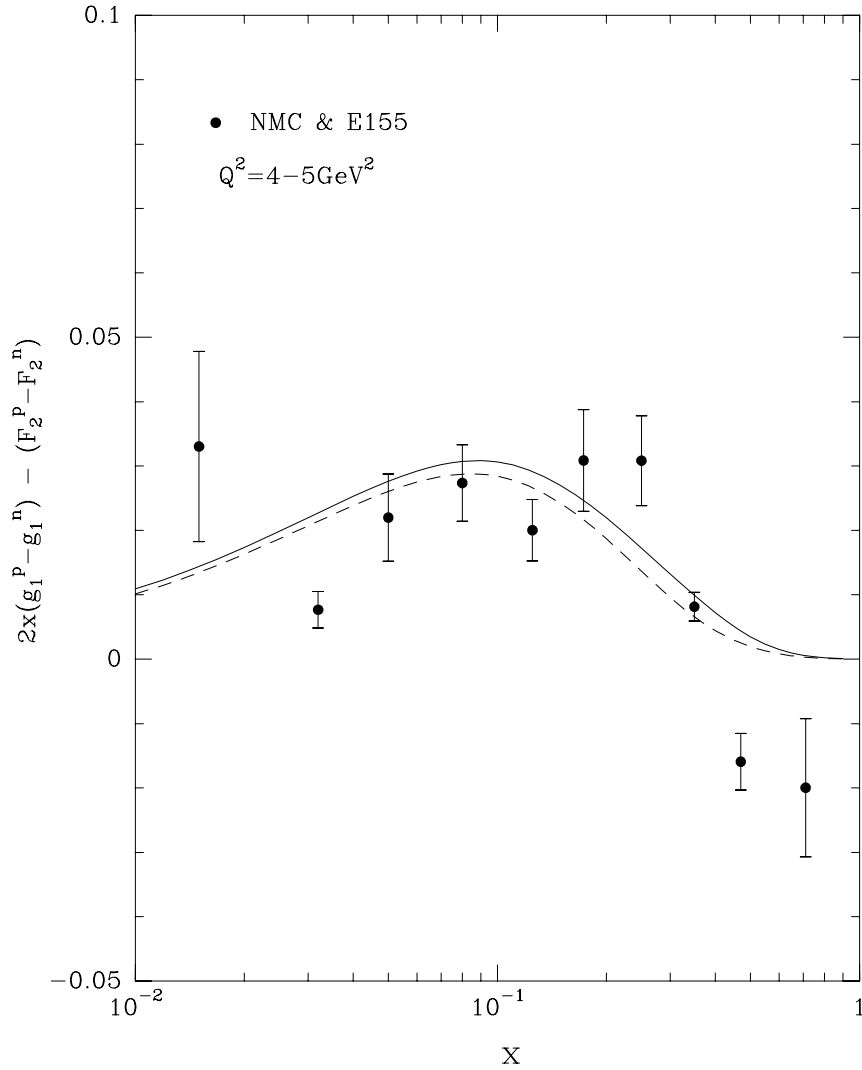


Figure 111: The quantity $2x(g_1^p - g_1^n) - (F_2^p - F_2^n)$ as function of x at fixed $Q^2 = 4 - 5 \text{ GeV}^2$, calculated from E155, NMC Coll. Comparison with the difference $d^- - u^-$ as a function of x , $Q^2 = 4 \text{ GeV}^2$. $2/3(d^- - u^- + \bar{d}^- - \bar{u}^-)$, solid curve, $2/3(\bar{d}^- - \bar{u}^-)$, dashed curve.

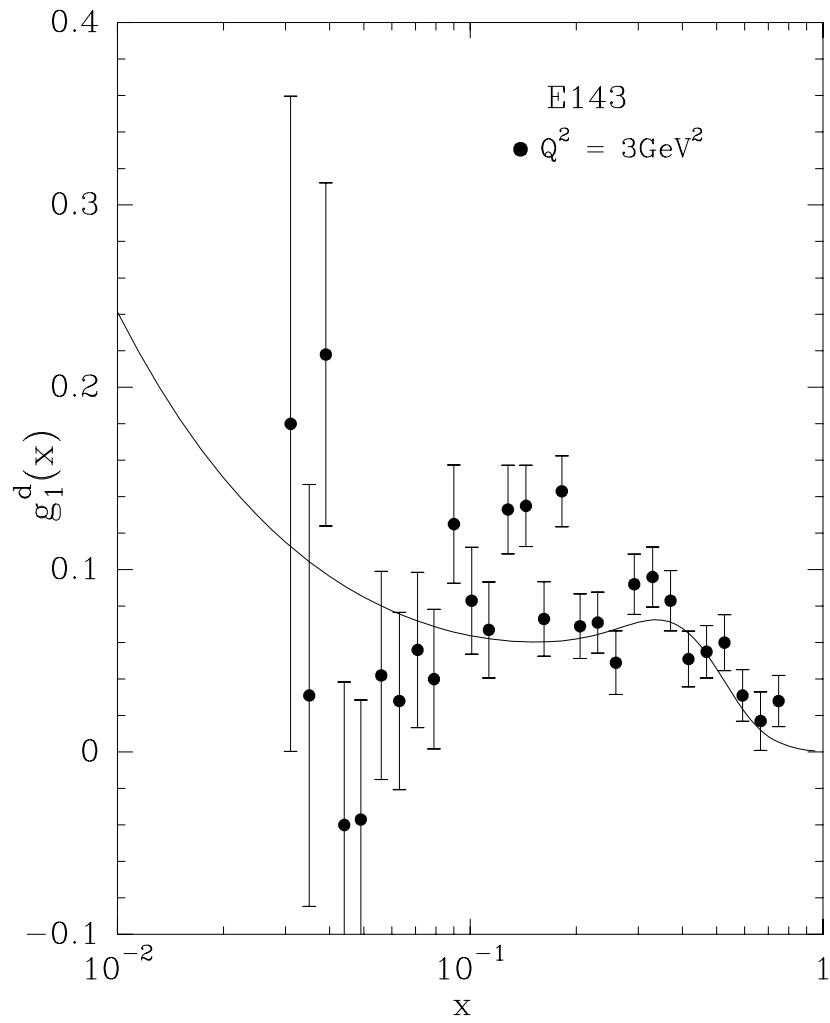


Figure 112: $g_1^d(x, Q^2)$ as function of x at fixed $Q^2 = 3\text{GeV}^2$, E143 Coll.

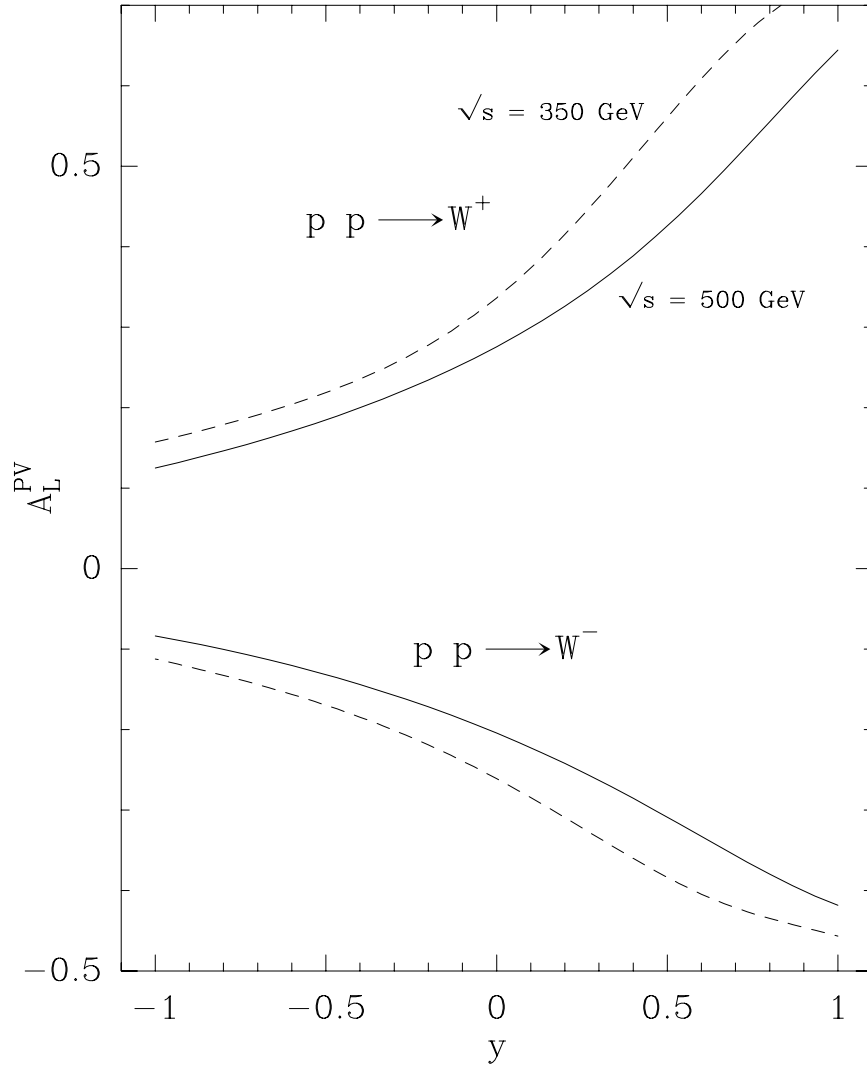


Figure 113: The parity violating asymmetry A_L^{PV} for $pp \rightarrow W^\pm$ production versus the rapidity y at $\sqrt{s} = 350, 500$ GeV (dashed, solid).

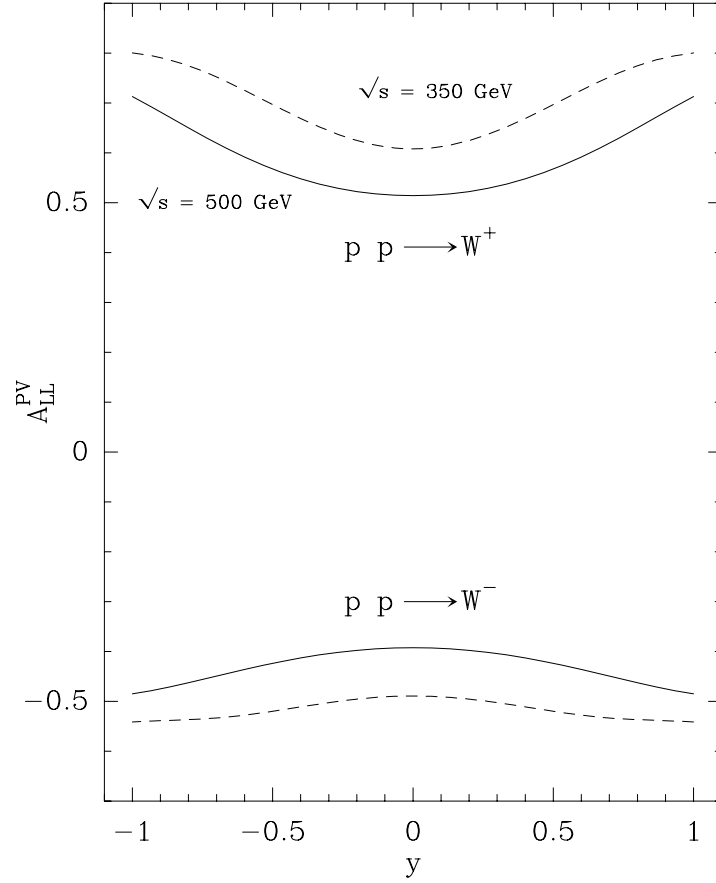


Figure 114: The parity violating asymmetry A_{LL}^{PV} versus the rapidity y for $pp \rightarrow W^\pm$ production at $\sqrt{s} = 350, 500$ GeV (dashed, solid).

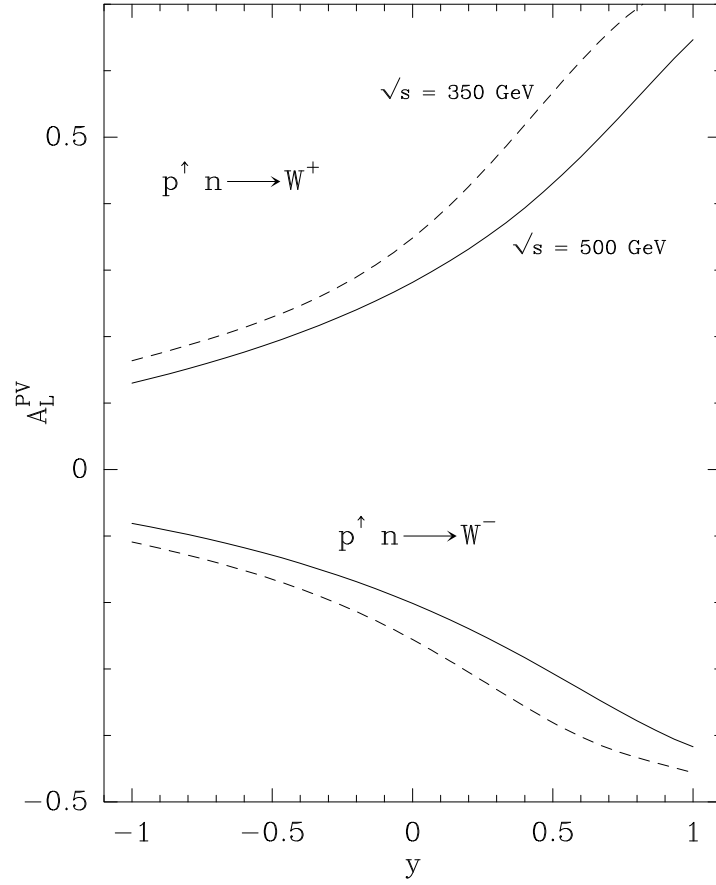


Figure 115: The parity violating asymmetry A_L^{PV} with polarized proton for $p^\uparrow n \rightarrow W^\pm$ production versus the rapidity y at $\sqrt{s} = 350, 500$ GeV (dashed, solid).

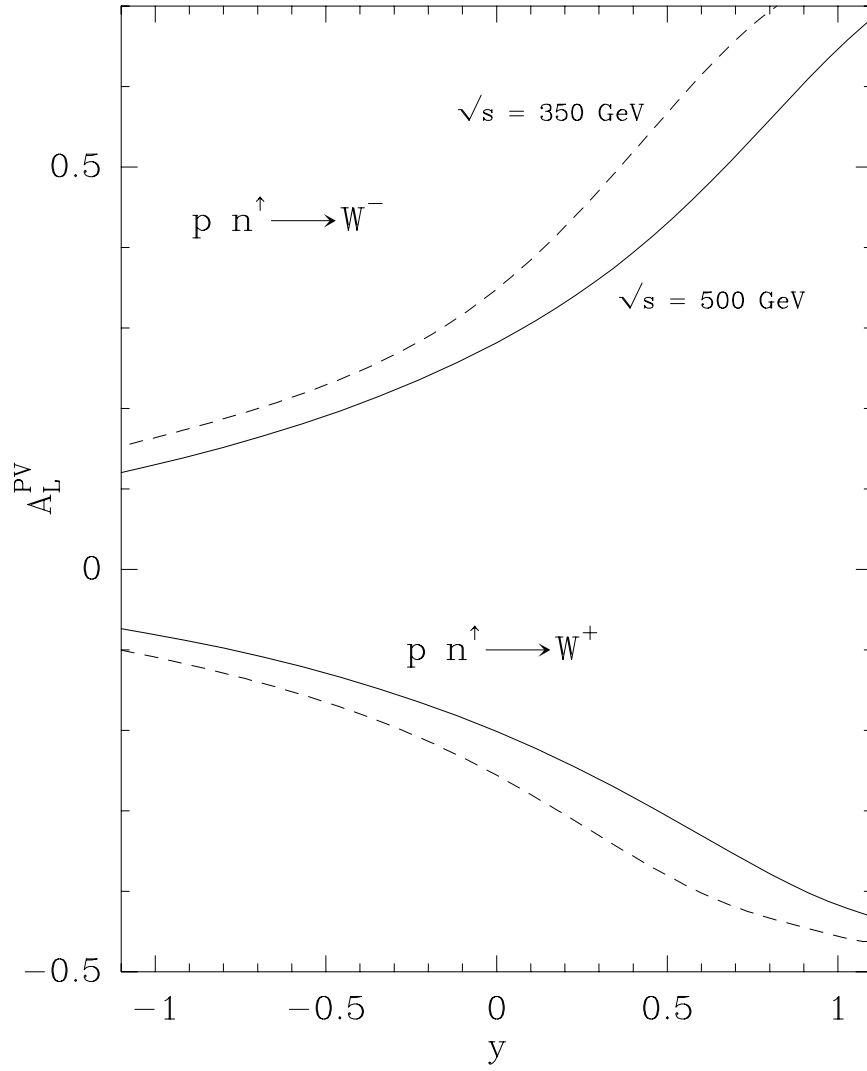


Figure 116: Parity violating asymmetry A_L^{PV} with a polarized neutron for $pn^\uparrow \rightarrow W^\pm$ production versus the rapidity y at $\sqrt{s} = 350, 500$ GeV (dashed, solid) .

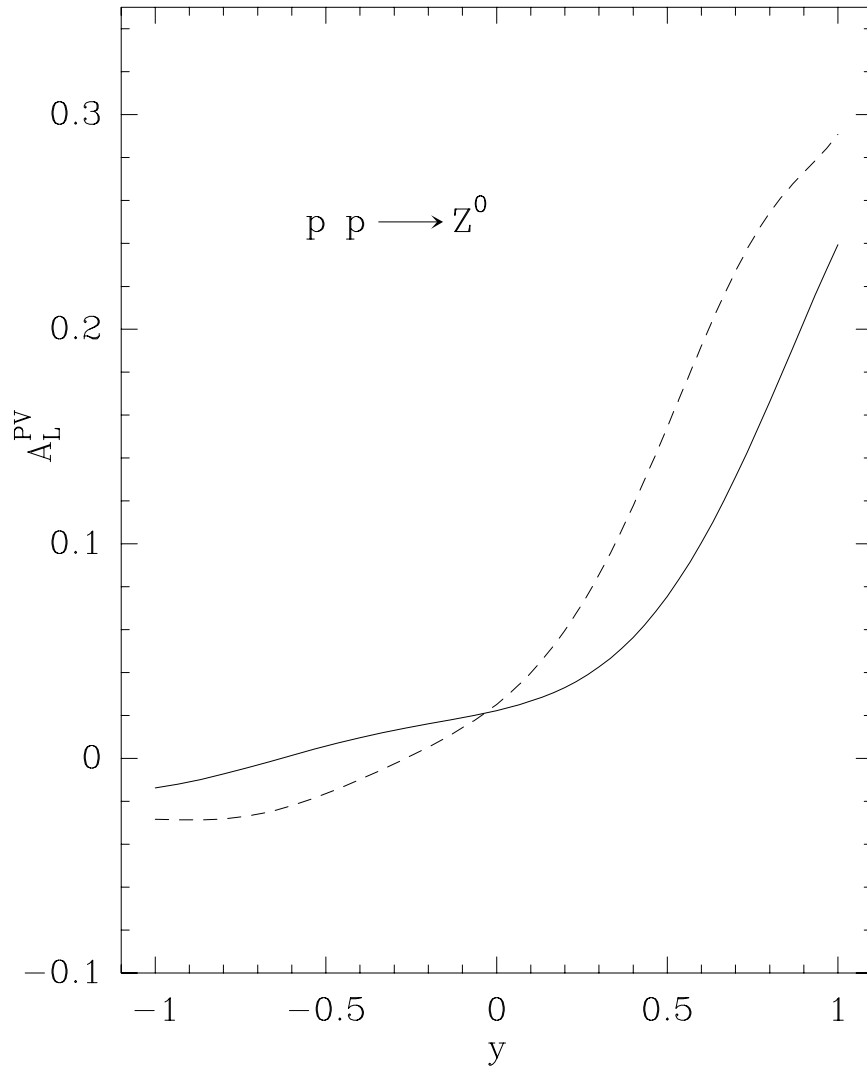


Figure 117: The parity violating asymmetry A_L^{PV} for $pp \rightarrow Z^0$ production versus the rapidity y at $\sqrt{s} = 350, 500\text{GeV}$ (dashed, solid).

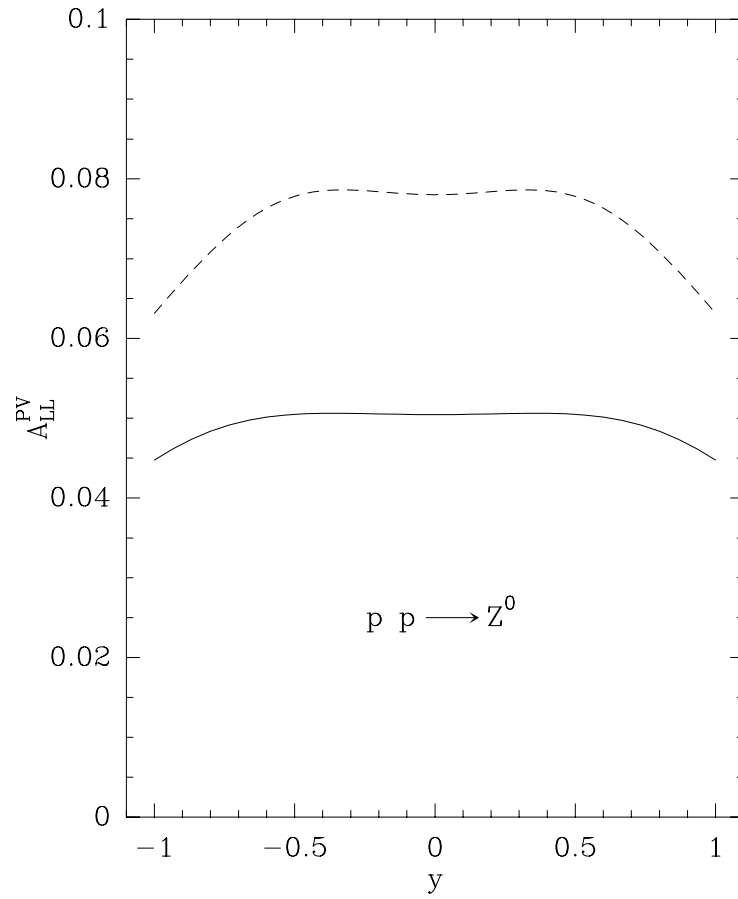


Figure 118: The parity violating asymmetry A_{LL}^{PV} versus the rapidity y for Z^0 production at $\sqrt{s} = 350, 500$ GeV (dashed, solid).

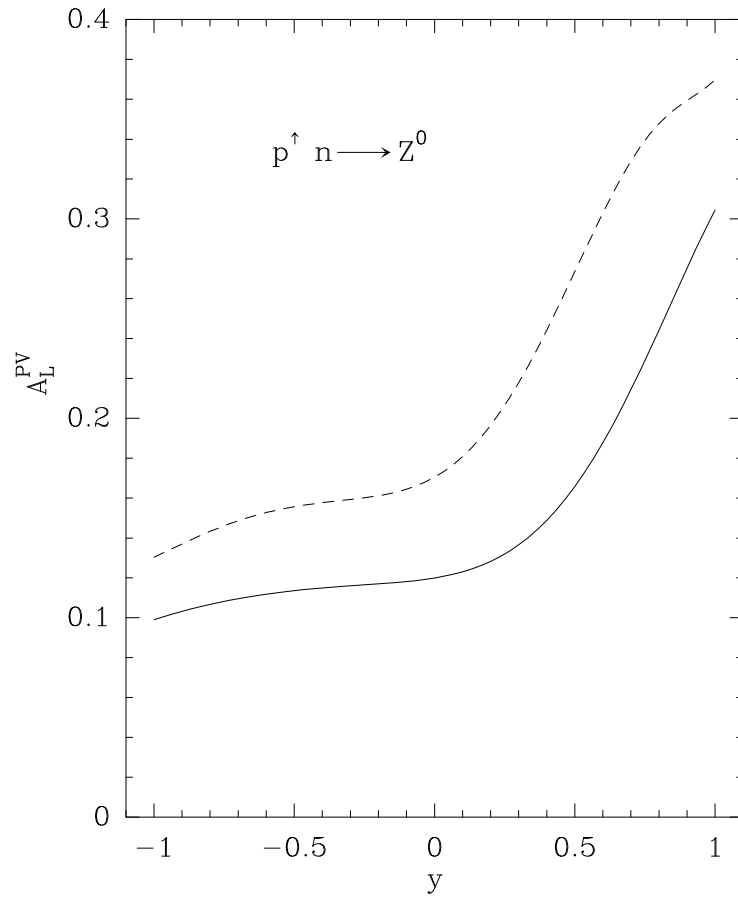


Figure 119: The parity violating asymmetry A_L^{PV} for $p^\uparrow n \rightarrow Z^0$ production versus the rapidity y at $\sqrt{s} = 350, 500\text{GeV}$ (dashed, solid).

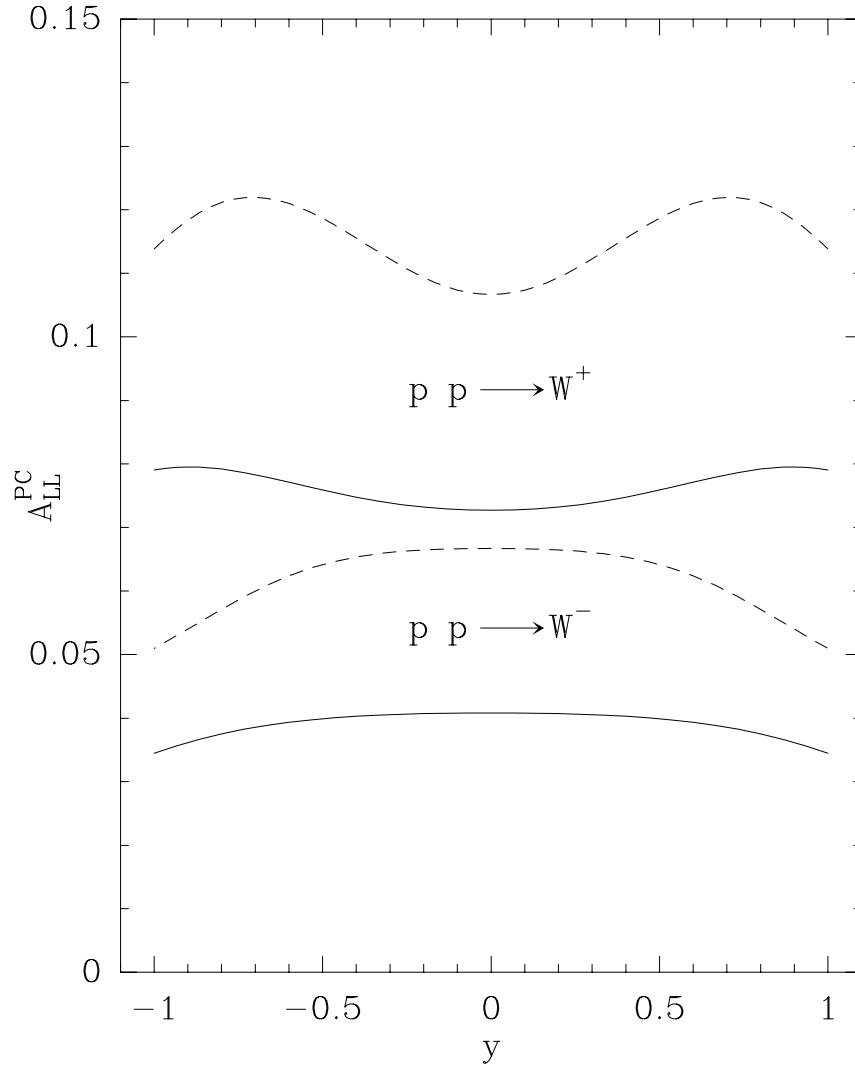


Figure 120: Parity conserving double helicity asymmetry A_{LL}^{PC} for $pp \rightarrow W^\pm$ production versus the rapidity y at $\sqrt{s} = 350, 500$ GeV (dashed, solid) .

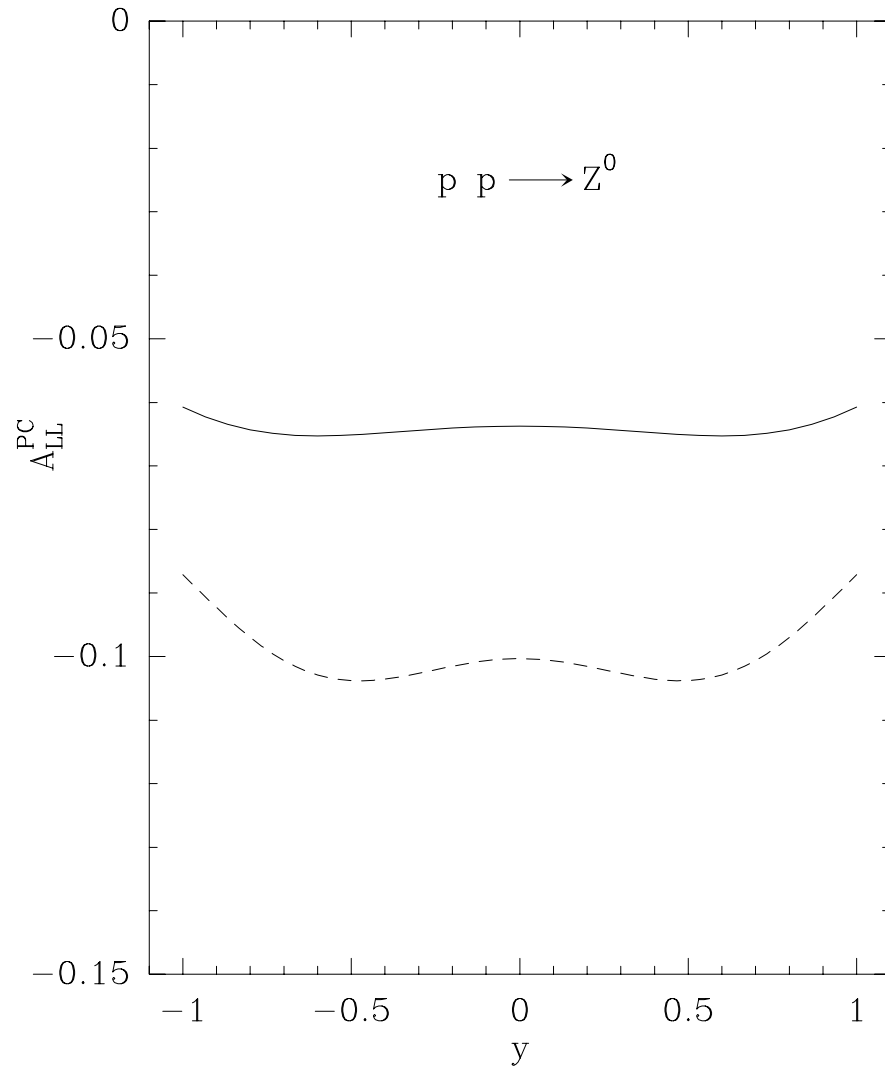


Figure 121: Parity conserving double helicity asymmetry A_{LL}^{PC} for $pp \rightarrow Z^0$ production versus the rapidity y at $\sqrt{s} = 350, 500\text{GeV}$ (dashed, solid) .

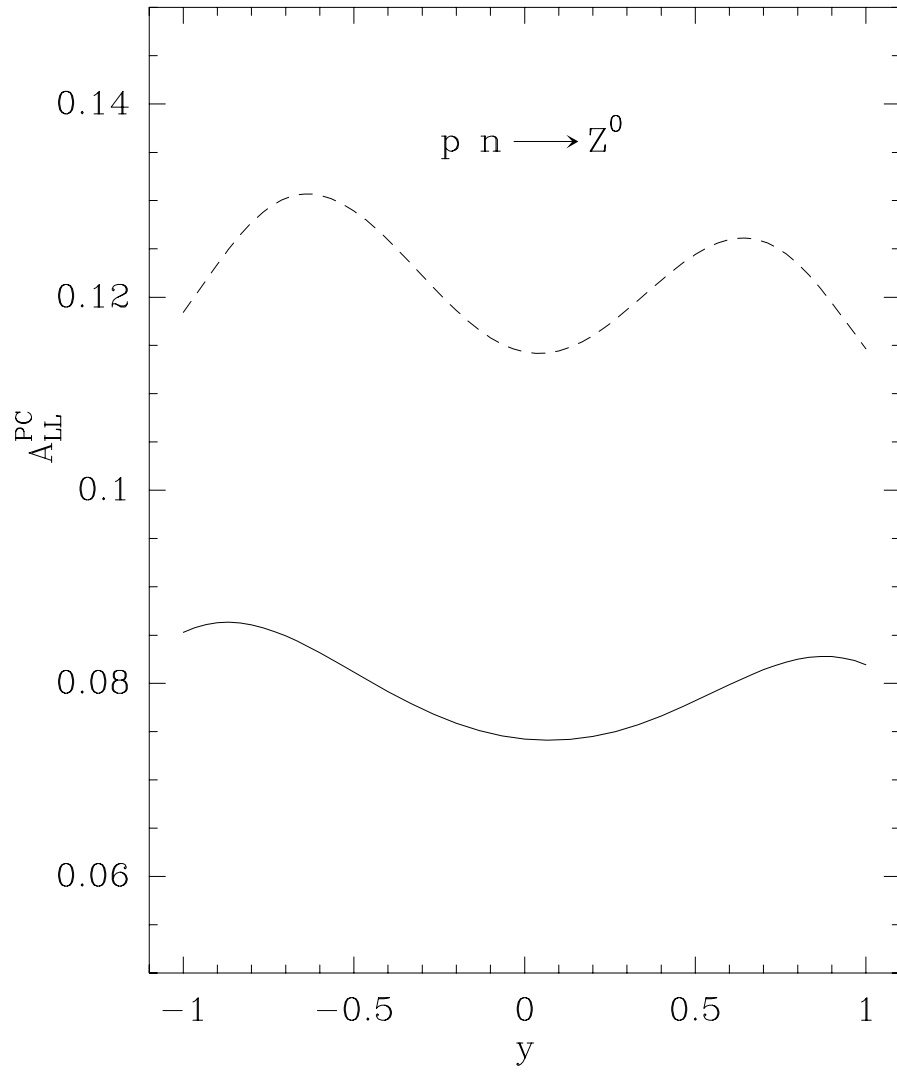


Figure 122: Parity conserving double helicity asymmetry A_{LL}^{PC} for $pn \rightarrow Z^0$ production versus the rapidity y at $\sqrt{s} = 350, 500\text{GeV}$ (dashed, solid) .

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