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A Global Analysis of Recent Experimental Results: How Well Determined are the Parton Distribution Functions? *

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A GLOBAL ANALYSIS OF RECENT EXPERIMENTAL RESULTS: HOW WELL DETERMINED ARE THE PARTON DISTRIBUTION FUNCTIONS?

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ABSTRACT

Following is a brief summary of the results of an analysis of experimental data performed to extract the parton distribution functions. In contrast to other global analyses, this study investigated how the fit results depend on:

1. Experimental Systematic Errors
2. Kinematic Cuts on the Analyzed Data
3. Choice of Initial Functional Forms,

with a prime goal being a close look at the range of low-x behavior allowed by data. This is crucial for predictions for the SSC/LHC, HERA, and even at Tevatron Collider energies. Since all details can be found in the just released Fermilab preprint Parton Distributions from a Global QCD Analysis of Deep Inelastic Scattering and Lepton-Pair Production by J.G.M. and Wu-Ki Tung (Fermilab-Pub-90/74 and IIT-Pub-90/11), this summary will be only a brief outline of major results.

NOTE: Due to a formatting problem in the preparation of the tables of the Fermilab/IIT Preprint, a negative sign was inadvertently dropped in some of the coefficients of the t-quark distributions in several tables. All other quark parametrizations are correct. The corrected parametrization of the t-quark distributions can be found in the tables of this summary.

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There are several widely used sets of parton distribution functions currently available. The following table briefly summarizes the characteristics of these other global analyses:

COMPARISON OF EXISTING PDF'S: METHODS USED

	Dk-Ow[1]	EHLQ[2]	MRS[3]	DFLM[4]
Experimental Factors				
Systematic Errors	NO	NO	NO/(YES HMRS)	YES
Correlated Errors	NO	NO	NO	YES
EMC Effect	NO	NO	YES	NO
Vary Kinematic Cuts	NO	NO	NO	NO
Theoretical Factors				
Study of small-x behavior	NO	NO	YES	NO
N-L-O QCD	NO	NO	MS-bar	DIS
Study of Functional Form	NO	NO	NO	NO
Experimental Data Used				
Latest ν Data	NO	NO	YES	YES
Latest μ Data	NO	NO	YES	NO

The objective of the present analysis has been to contain or cover ALL points listed in the above table.

I) INPUT:

The only currently available neutrino scattering results with point-to-point systematic errors, which we demand for inclusion in our fit, is CDHSW[6] and we have used their measured values of F_2 and xF_3. The CCFRR collaboration will soon release their measurements of F_2 and xF_3 based on the largest sample of neutrino events to date. We will refit the parton distributions when this data becomes available.

For muon scattering we have taken the results from the two most recent and largest experiments EMC[6] and BCDMS[7]. From both experiments we have taken their measurements of F_2 off H_2 and D_2 targets.

Drell-Yan scattering is represented by the two FNAL experiments; E288[8] and E605[9] .

II) Kinematic Cuts:

Until we have a better understanding of how non-perturbative (**higher twist**) effects contribute to measured values, we try to avoid the kinematic region which they could dominate. It is, however, still not entirely clear exactly what this region is. Our procedure to try to fix this region involves performing the analysis with Q^2 cuts of 20, 15, 10, 5, and 2 GeV^2 and noting the stability of the fit. We determined the cut to be;

$$Q^2 > 10\ GeV^2 \text{ and } W > 4\ GeV.$$

Within the data sets mentioned as input above, there are 776 measured points in this kinematic range.

Results of a combined SLAC-BCDMS analysis presented[10] at this workshop indicate that as long as $x < 0.4$, one can go down to very low values of Q^2 without having to account for higher twist in the fit. We will include these new twist-4 results in our subsequent analyses.

III) DATA POINT MEASUREMENT ERRORS:

It is clearly **INCORRECT** to neglect systematic errors in a global analysis of recent high statistics experiments! As the following two figures show, the systematic errors are at least as large as, if not larger than, the statistical errors.

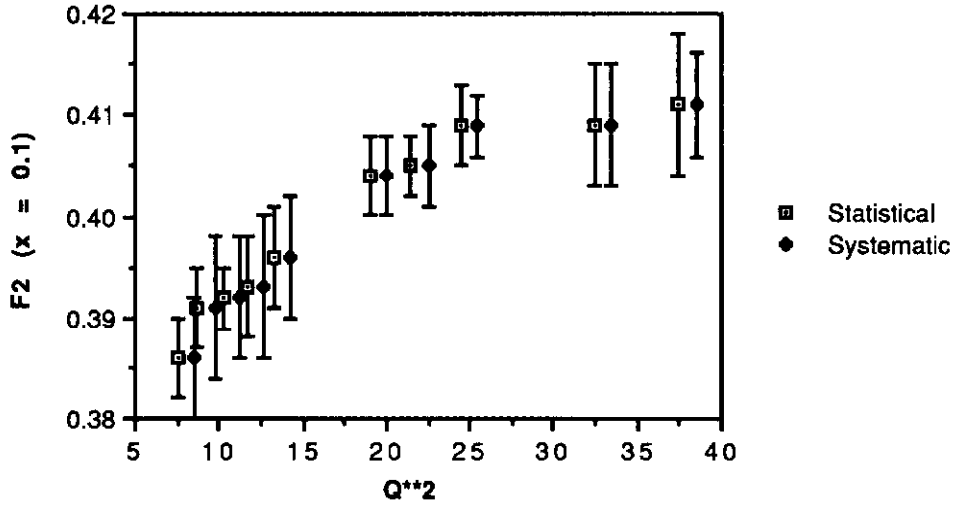

Fig a

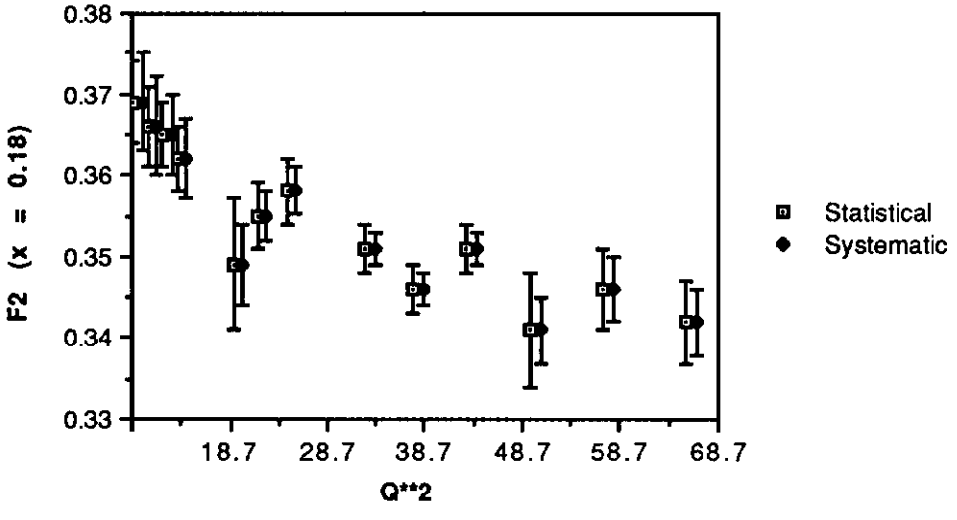

Fig b

Measurements of F_2 by the BCD collaboration demonstrating the relative size of the statistical and systematic errors at x= 0.1 (Fig a) and x = 0.18 (Fig. b).

There are several ways of incorporating both systematic and statistical errors in the overall fit which can be summarized as follows;

1. The statistically rigorous method would be to define an overall extra "loop" in the fit and perturb the central measured value by each of the quoted systematic errors of a given measured point (eg. 4 in the case of BCDMS data) in turn. This perturbed value is then used in the statistical fit.

2. Redefine the "statistical" error as:

$$D^2_{"st"} = d^2_{st} + d^2_{sy_{unco}}$$

and define

$$D^2_{"syst"} = \sum_i^{algebraic} d^2_{dy_{cor}}$$

Then, in this representation:

$$\chi^2 = c^2 + \sum_i^{npts} (T_i - M_i - cD_{"syst"})^2 \; / \; D^2_{"stat"}$$

3. Combine statistical and point-to-point systematic errors in quadrature (much less CPU-thirsty than method 1 and 8 fewer parameters than method 2).

Due to limited CPU availability for the fits we have chosen to use method 3. We are currently studying the influence of this choice on the fit results and will comment more fully on this in our to-be-published long paper.

IV) FUNCTIONAL FORM:

We fit to:

$$F^a(x,Q) = e^{A_0^a} \, x^{A_1^a} \, (1-x)^{A_2^a} \, \ln^{A_3^a} (1 + \frac{1}{x})$$

which, with the ln term, is particularly well suited to investigate small-x extrapolations.

V) PROCEDURE:

We fit only those variables which are sensitive to the data being examined eg. only flavor-blind valence quark distributions fit to xF_3. In addition to the shape parameters we have floating relative normalizations between data sets. With the use of sum rules, the maximum number of parameters in the fit is 11 shape parameters, 4 relative normalizations and λ.

Various combinations of data sets were used to investigate the consistency of fits and data. The various groupings are referred to as;

E-fit -- CDHSW + D-Y + EMC (472 points)
B-fit -- CDHSW + D-Y + BCDMS (647 points)
S-fit -- CDHSW + D-Y + EMC + BCDMS (776 points).

VI) RESULTS:

χ^2

The B-fit yields the best result with χ^2/d.o.f. = 0.8 (recall that errors are the quadratic sum of systematic + statistical), see Figs. 1-3. The results of the E-fit are about 10% worse while the χ^2/d.o.f. for the S-fit is about 20% higher than the B-fit, see Figs. 4-7.

If, when combining BCDMS and EMC results, one takes the following points into consideration;

1. include systematic errors,
2. an overall relative normalization brings the data sets in-line at small x where errors are small, and
3. reasonable Q^2-cut,

the results for the combined fit are not unacceptable. However the χ^2 for the EMC data set is still high compared to all others in the combined fit.

λ (2,4)

E-fit, 130-150 MeV
B-fit, 190-225 MeV
S-fit, 175-225 MeV

Valence Quarks

NO surprises.

Sea Quarks

The fits are NOT sensitive to composition of the sea. We provide fit results for a symmetric sea and a reduced s-quark sea.

Gluon

D.I.S. data alone tends to favor a relatively hard gluon (A_2 = 3.5 - 4.5). However, D.I.S. is not particularly sensitive to the gluon. Upon adding D-Y results, the fit favors a softer gluon distribution (A_2 = 6.5 - 7.5).

We do NOT determine the gluon distribution from direct-photon production since the current results are limited both in accuracy and x range, and there are still open questions on the correct interpretation in N-L-O QCD.

If we fix the value of A_2 for the gluon to be 4.0, this causes an increase in χ^2/d.o.f. for both the xF_3 and D-Y data sets of $\approx$ 40%!

Systematic Errors

If we do NOT include systematic errors in the fit, the χ^2/d.o.f. increases to 2.5(!), λ drops by 20 %, and the valence quarks at x=0.5, 0.3 are reduced by 40%, and 20% respectively. The sea and gluon also become somewhat softer.

Q^2 cut

If we vary the Q^2 cut from 20 to 5 GeV^2, we find that the value of λ (20 : 10 : 5 GeV^2) = 240 : 210 : 195 MeV. We find no other significant differences

VII) PARAMETRIZATION OF PARTON DISTRIBUTION FUNCTIONS:

The A_n coefficients exhibit well-behaved Q-dependence (see Fig. 9) so that we can parametrize them as:

$$A_i = C_0^i + C_1^i\, T(Q) + C_2^i\, T^2(Q), \quad i = 0,3$$

$$T(Q) = \ln \frac{\ln(Q^2 / \Lambda^2)}{\ln(Q_0^2 / \Lambda^2)}$$

This parametrization accurately describes the fit results for the kinematic range:

$$10^{-5} < x < 1.0$$

$$4.0 < \mathbf{Q} < 10^4 \text{ GeV}$$

Furthermore, the PDF's are always positive definite and are smoothly varying in both x and Q even outside of the original range. The C_i needed to determine the shape parameters (A_i) for ALL of the parton distribution functions are given in Table 1 and the Appendices. **NOTE that the t-quark parametrization in these tables has been corrected for the missing minus signs.**

VIII) IMPORTANCE OF RE-NORMALIZATION SCHEME (MS-BAR VS DIS)

There are several renormalization schemes used in next-to-leading order QCD formulations the most common being the MS-bar and DIS schemes. Depending on which scheme has been used to calculate the hard scattering cross section, the corresponding parton distribution functions must be employed. In general, the gluon distribution will be much softer when expressed in the DIS scheme as compared to the MS-bar scheme. We provide the parton distribution functions in BOTH schemes in the tables. To help visualize the scheme dependent difference in the parton distribution functions, Fig 8. displays xg(x) and xu(x) at $Q^2 = 10$ GeV^2 in both schemes.

IX) RANGE OF ALLOWED LOW-X BEHAVIOR:

Our chosen form is ideal for exploring the range of small-x behavior allowed by present data and, thus, emphasize our severe **lack** of knowledge in this region. In Fig. 10 we plot the structure function F_2 and the gluon distribution at $Q^2 = 10$ GeV^2 and 10000 GeV^2 while Fig. 11 shows the ratio of predictions for three typical values of Q^2. It is obvious that the parton densities and, therefore, the physical cross sections derived from them, can differ by factors of 3 at the highest Q^2 and by an order of magnitude at more moderate Q^2.

X) WHAT DO WE NEED TO FURTHER RESTRICT THE PDF'S?

Based on our experience in fitting the available experimental data (see our more detailed publication[11] for details), the following input would significantly help restrict the parametrization of the parton distribution functions:

1. Statistically and systematically accurate measurements of $\mathbf{F_2}$ with $x < 10^{-3}$ at reasonable Q.

2. Measurements of **Drell-Yan** cross section with small mass lepton pairs at high s (i.e. Q = 20 GeV at Tevatron) see Fig. 13.

3. Measurement of **direct photon** production over an **extended x range** and resolution of questions regarding the theoretical interpretation of the results. The direct photon results should then be part of the fit, NOT an artificially imposed constraint on the gluon distribution.

4. Measurement of **W/Z ratio at high y**, see Fig. 12.

5. Measurement of the integrated and differential production **cross sections of B-pairs** over a wide kinematic range (as proposed by, for example, BCD).

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Tables

Table Ia - Fit S - DIS scheme									
$\Lambda(2,4) = 0.212GeV$						$Q_0^2 = 4GeV^2$			
	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
A_0									
C_0	1.34	1.62	1.88	-0.99	-0.99	-0.99	-3.98	-6.28	-13.08
C_1	-0.57	-0.33	-2.78	-1.54	-1.54	-1.54	0.72	2.62	8.54
C_2	-0.08	-0.10	0.13	0.10	0.10	0.10	-0.63	-1.18	-2.70
A_1									
C_0	0.15	0.11	-0.33	-0.33	-0.33	-0.33	-0.15	-0.18	-0.40
C_1	0.16	0.14	0.10	0.03	0.03	0.03	-0.06	0.02	0.31
C_2	-0.02	-0.01	-0.04	-0.03	-0.03	-0.03	0.00	-0.03	-0.12
A_2									
C_0	5.30	3.68	7.52	8.53	8.53	8.53	7.46	6.56	15.35
C_1	0.43	0.53	-1.13	-1.08	-1.08	-1.08	0.96	1.40	-11.83
C_2	0.06	0.03	0.04	0.39	0.39	0.39	-0.30	-0.38	4.16
A_3									
C_0	-1.96	-1.94	-1.34	-1.55	-1.55	-1.55	0.35	0.65	-0.43
C_1	1.08	0.87	2.92	2.02	2.02	2.02	0.89	1.13	3.18
C_2	-0.03	0.02	-0.49	-0.39	-0.39	-0.39	-0.04	-0.16	-0.82
Equivalent "Conventional Parametrization" Coefficients at $Q_c^2 = 5.0GeV^2$ $f(x,Q_c^2) = e^{B_0}x^{B_1}(1-x)^{B_2}(1+B_3x)$									
B_0	-0.49	-0.31	0.48	-2.65	-2.65	-2.65	0.00	0.00	0.00
B_1	0.43	0.36	-0.15	-0.14	-0.14	-0.14	0.00	0.00	0.00
B_2	5.36	3.70	8.02	9.58	9.58	9.58	0.00	0.00	0.00
B_3	10.68	11.82	8.20	13.60	13.59	13.59	0.00	0.00	0.00

Table Ib - Fit S - MS-bar scheme									
$\Lambda(2,4) = 0.212GeV$						$Q_0^2 = 4GeV^2$			
	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
A_0									
C_0	1.75	2.03	1.09	-0.14	-0.14	-0.15	-2.36	-2.19	-24.77
C_1	-1.02	-0.78	-2.41	-1.98	-1.98	-1.98	-1.42	-3.86	-23.00
C_2	0.05	0.03	-0.12	0.23	0.23	0.23	0.21	1.57	34.44
A_1									
C_0	0.11	0.06	-0.24	-0.49	-0.49	-0.49	-0.49	-1.07	7.52
C_1	0.26	0.24	0.08	0.02	0.02	0.02	0.44	1.56	0.48
C_2	-0.06	-0.04	0.02	-0.02	-0.02	-0.02	-0.22	-0.73	-6.26
A_2									
C_0	6.20	4.43	5.97	10.24	10.24	10.23	9.00	11.30	-99.51
C_1	-0.41	-0.18	-0.90	-1.43	-1.44	-1.44	-0.46	-7.20	-16.45
C_2	0.29	0.22	-0.35	0.44	0.45	0.45	0.29	3.85	97.19
A_3									
C_0	-2.35	-2.35	-0.64	-2.57	-2.57	-2.57	-1.74	-4.85	36.02
C_1	1.68	1.52	2.71	2.32	2.32	2.32	3.93	10.51	16.51
C_2	-0.24	-0.19	-0.20	-0.47	-0.47	-0.47	-1.34	-4.36	-40.40
Equivalent "Conventional Parametrization" Coefficients at $Q_c^2 = 5.0GeV^2$ $f(x,Q_c^2) = e^{B_0}x^{B_1}(1-x)^{B_2}(1+B_3x)$									
B_0	0.03	0.23	0.68	-2.26	-2.26	-2.26	0.00	0.00	0.00
B_1	0.53	0.46	-0.14	-0.10	-0.10	-0.10	0.00	0.00	0.00
B_2	6.08	4.33	5.88	10.12	10.11	10.11	0.00	0.00	0.00
B_3	7.96	8.93	0.43	11.40	11.39	11.39	0.00	0.00	0.00

Figure Captions

Fig. 1 Results of B1-fit (solid) and E-fit (dashed) compared to BCDMS H2 measurement of $F_2(x, Q)$.

Fig. 2 Results of B1-fit (solid) and E-fit (dashed) compared to EMC H2 measurement of $F_2(x, Q)$.

Fig. 3 Results of B1-fit (solid) and E-fit (dashed) compared to CDHSW Iron measurement of $F_2(x, Q)$.

Fig. 4 Results of the S-fit compared to BCDMS D2 measurement of $F_2(x, Q)$.

Fig. 5 Results of the S-fit compared to EMC D2 measurement of $F_2(x, Q)$.

Fig. 6 Results of the S-fit compared to the E605 Drell-Yan cross section measurement.

Fig. 7 Comparison of the EHLQ, Duke-Owens-2, MRS-B, DFLM, and present parametrizations of the parton distribution functions to BCDMS H2 measurements of F_2 at four representative x values.

Fig. 8 Comparison of $xG(x)$ and $xu(x)$ as fit in the DIS scheme and as converted to the MSbar scheme.

Fig 9. The shape parameters A_i for the different partons as a function of $T(Q)$.

Fig 10. Predicted values of $F_2(x)$ and $xG(x)$ from fits B1 and B2 at ultra low x for $Q^2 = 10GeV^2$ and $Q^2 = 10^4 GeV^2$.

Fig 11. The ratio of predictions (the uncertainty) for $F_2(x)$ and $xG(x)$ as a function of x for three typical values of Q^2.

Fig 12. The predictions for W-production, Z production, the W-production asymmetry, and the W/Z production ratio at the Tevatron Collider using the parton distribution function of MRS-B, DFLM, and the B1- and B2-fits from the present analysis.

Fig. 13. Prediction for low mass ($Q = 20GeV$) Drell-Yan pair production at the Tevatron Collider for parton distribution functions as in Fig. 12.

Figure 1

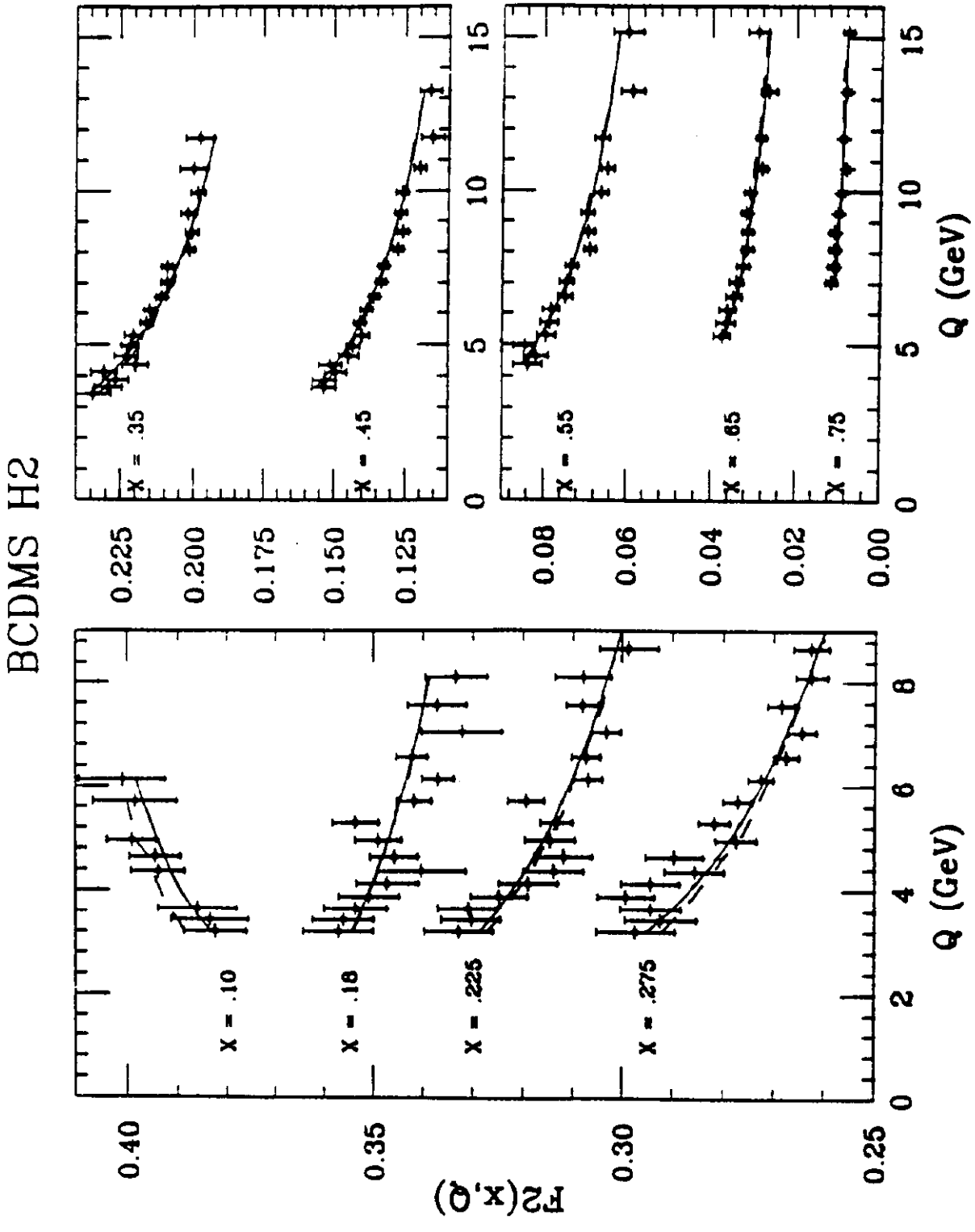

BCDMS H2
F2(x,Q)
0.40
0.35
0.30
0.25
x = .10
x = .18
x = .225
x = .275
0
2
4
6
8
Q (GeV)
0.225
0.200
0.175
0.150
0.125
x = .35
x = .45
0.08
0.06
0.04
0.02
0.00
x = .55
x = .65
x = .75
0
5
10
15
Q (GeV)

Figure 2

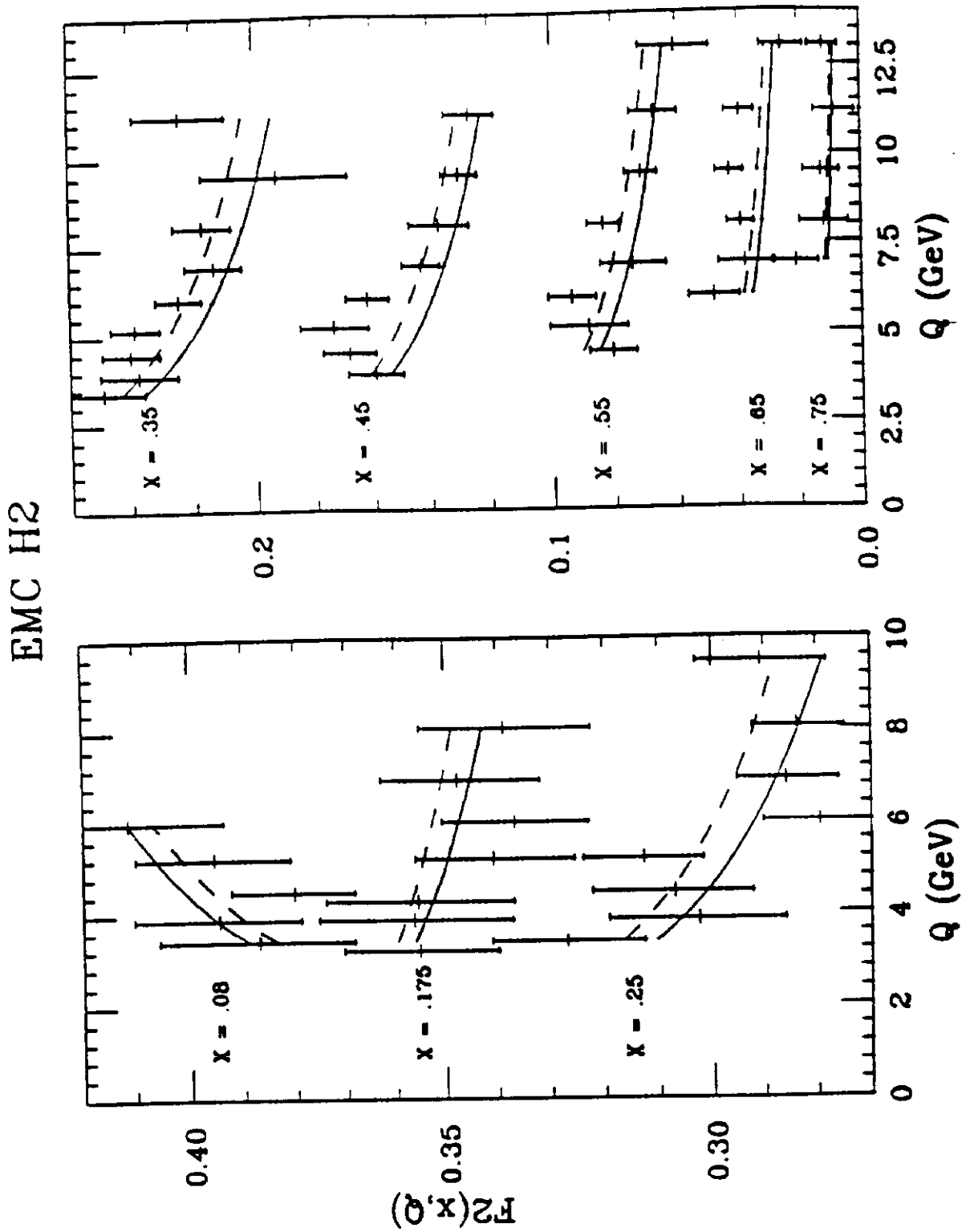

EMC H2
F2(x,Q)
0.40
0.35
0.30
x = .08
x = .175
x = .25
0
2
4
6
8
10
Q (GeV)
0.2
0.1
0.0
x = .35
x = .45
x = .55
x = .65
x = .75
0
2.5
5
7.5
10
12.5
Q (GeV)

Figure 3

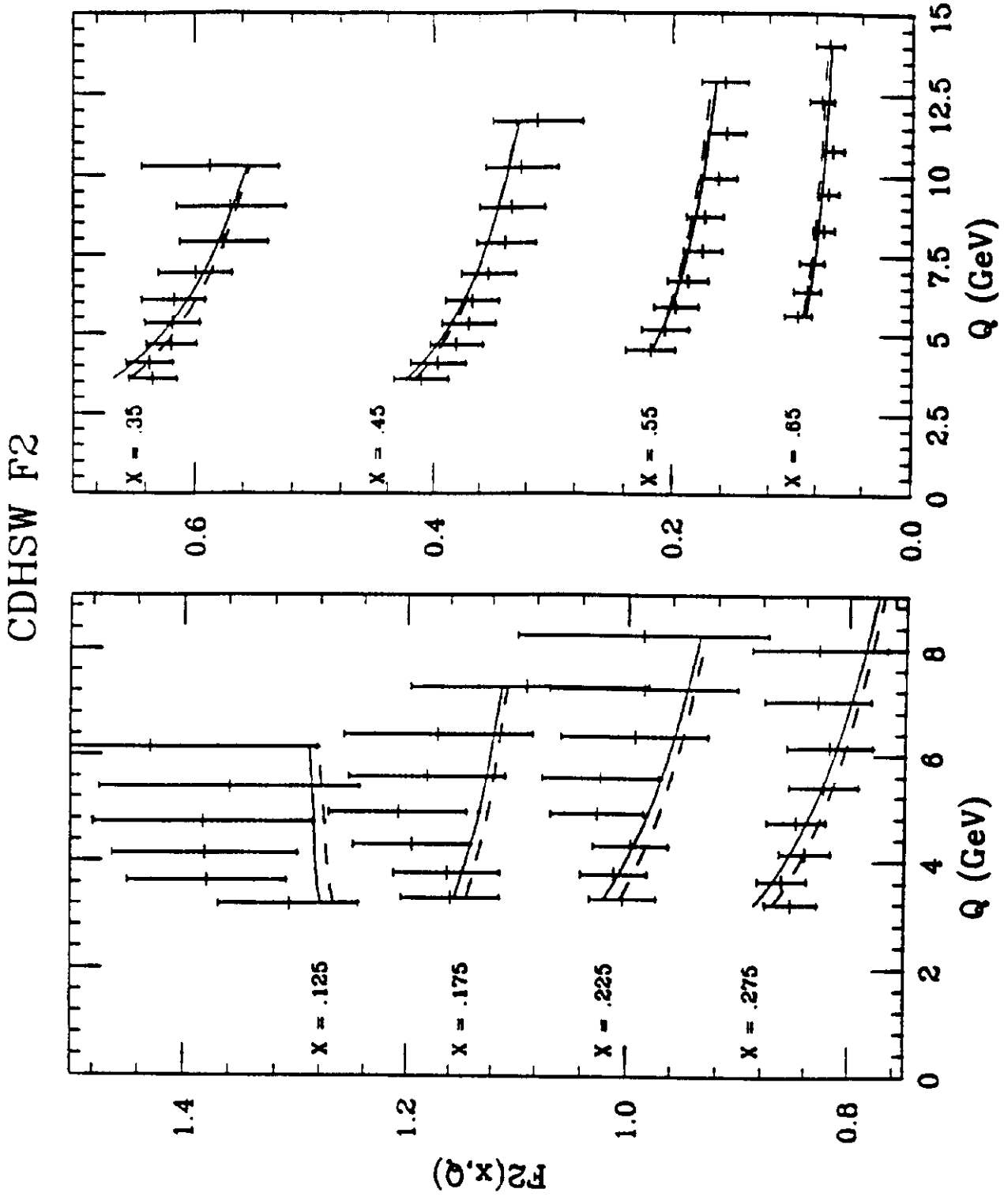

CDHSW F2
F2(x,Q)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
x = .125
x = .175
x = .225
x = .275
x = .35
x = .45
x = .55
x = .65
0
2
4
6
8
0
2.5
5
7.5
10
12.5
15
Q (GeV)
Q (GeV)

Figure 4

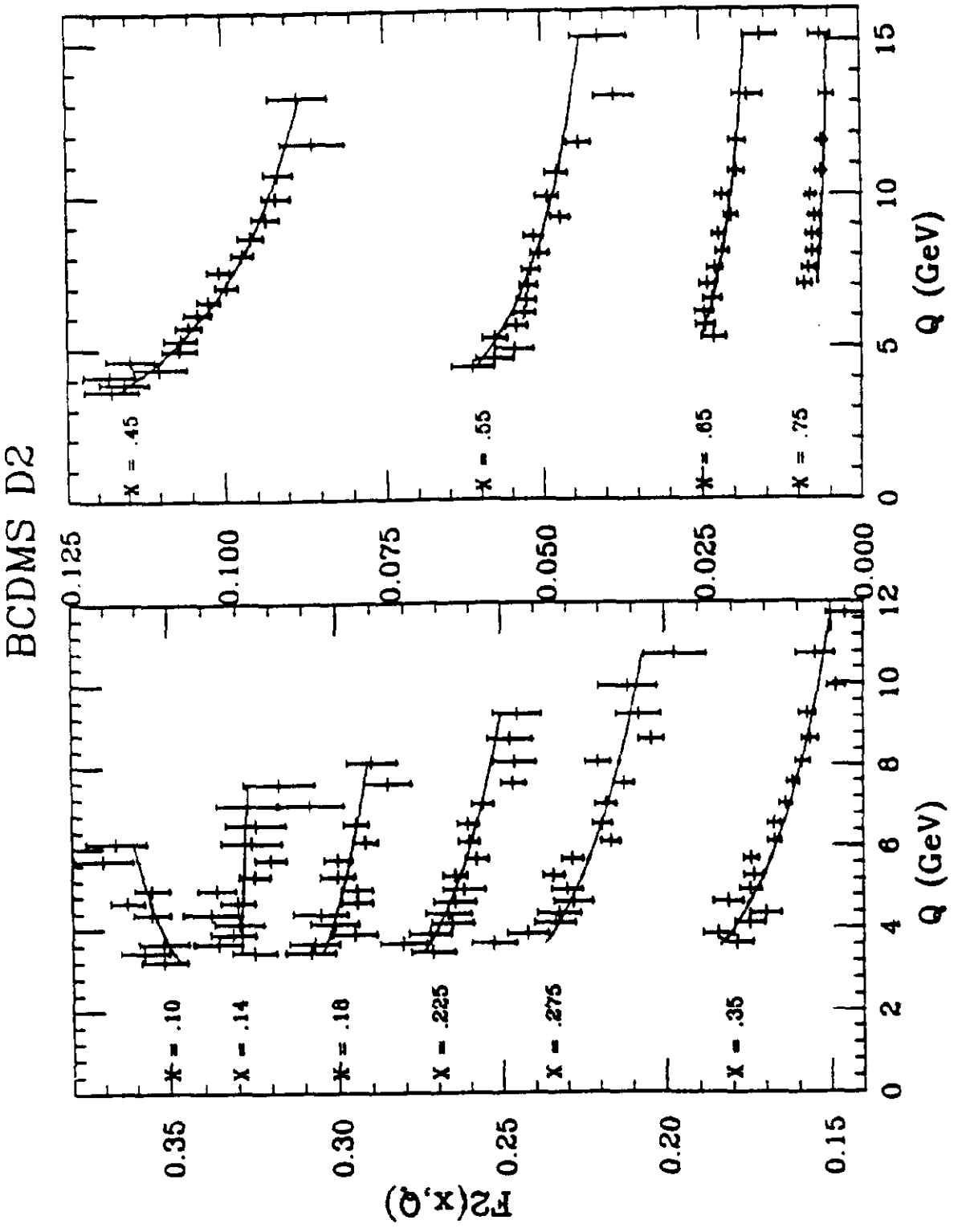

BCDMS D2
F2(x,Q)
0.35
0.30
0.25
0.20
0.15
x = .10
x = .14
x = .18
x = .225
x = .275
x = .35
x = .45
x = .55
x = .65
x = .75
0.125
0.100
0.075
0.050
0.025
0.000
0
2
4
6
8
10
12
5
15
Q (GeV)

Figure 5

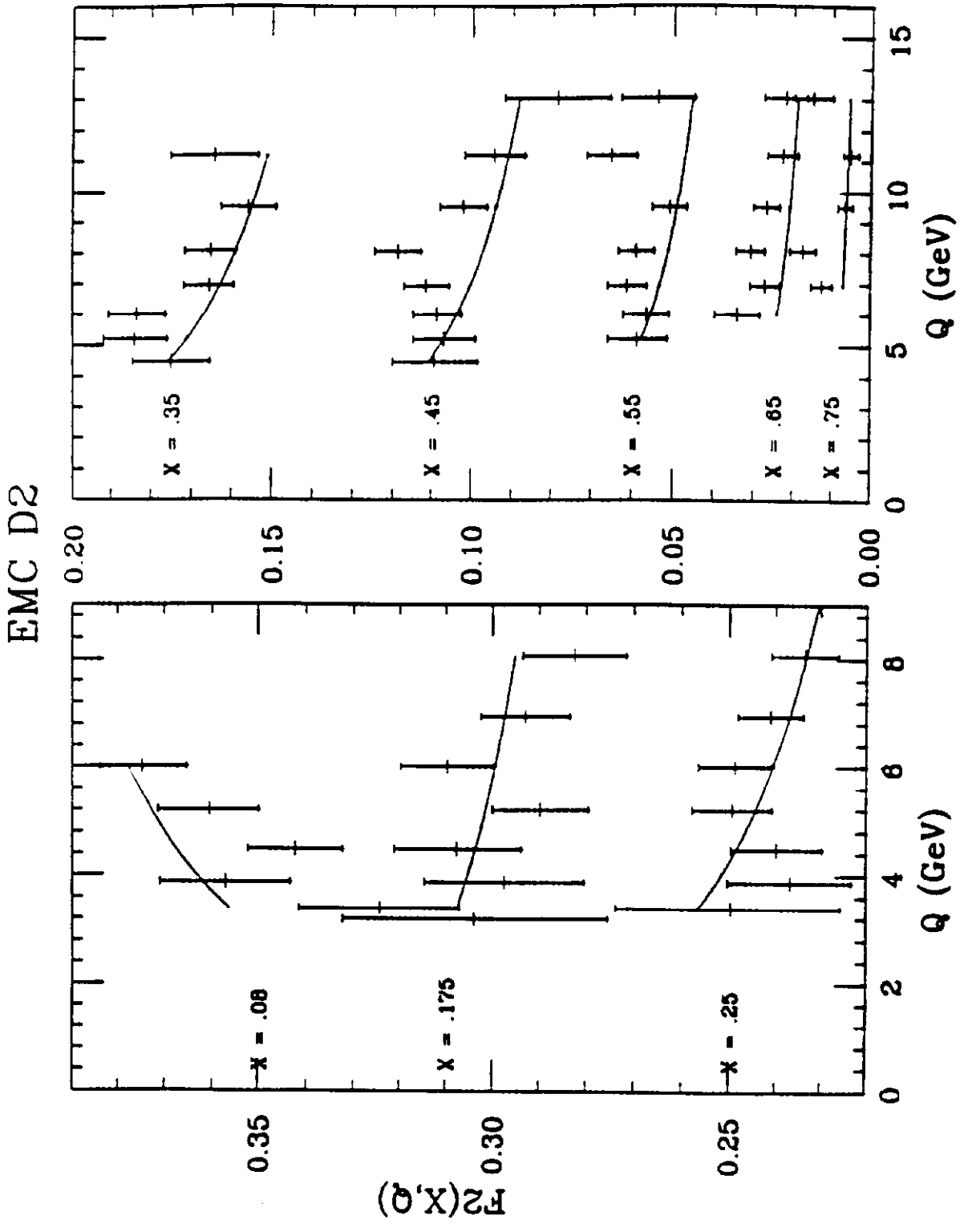

EMC D2
F2(X,Q)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
X = .08
X = .175
X = .25
X = .35
X = .45
X = .55
X = .65
X = .75
0
2
4
6
8
5
10
15
Q (GeV)
Q (GeV)

Figure 6

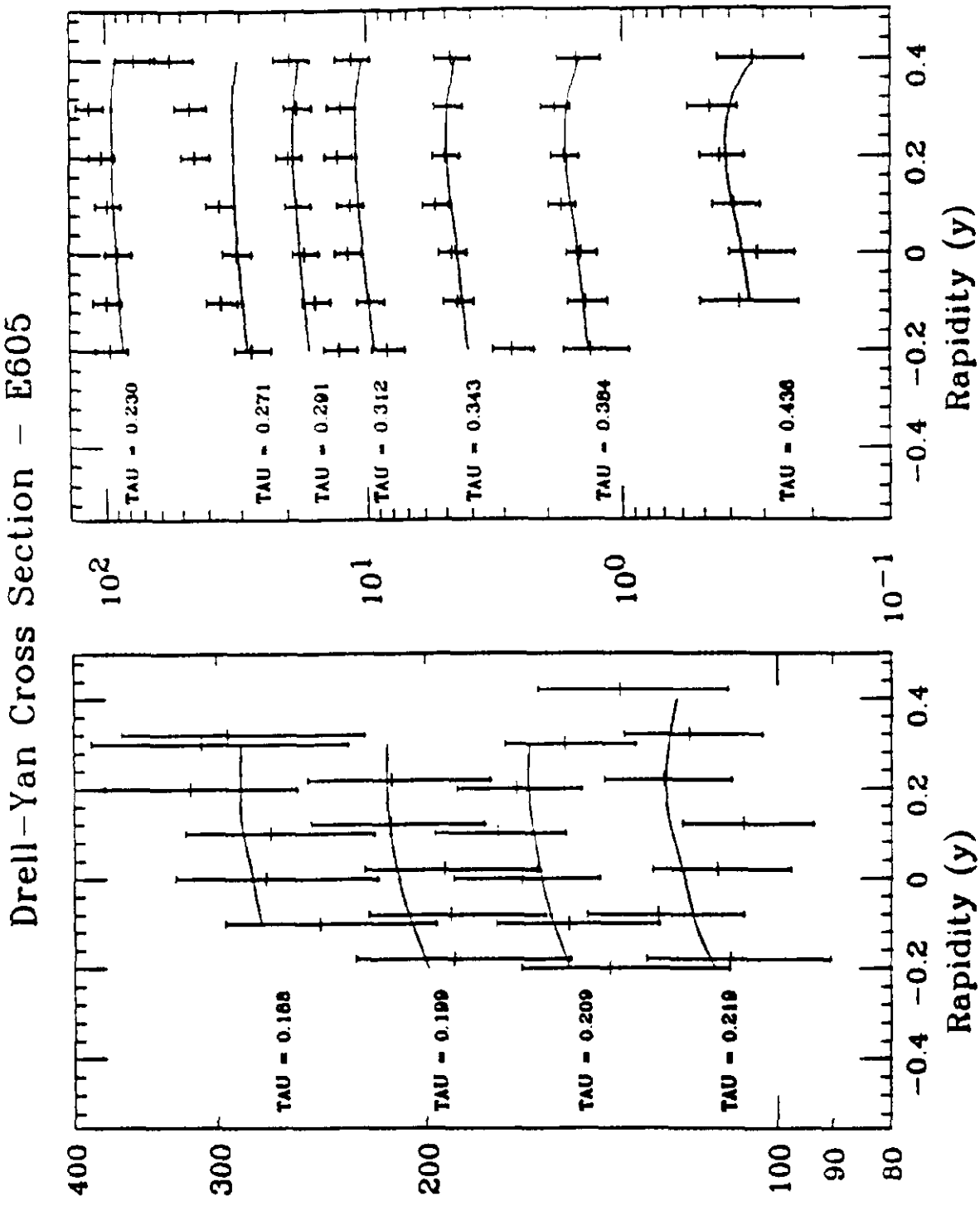

Drell-Yan Cross Section – E605
TAU = 0.230
TAU = 0.271
TAU = 0.291
TAU = 0.312
TAU = 0.343
TAU = 0.384
TAU = 0.436
TAU = 0.188
TAU = 0.199
TAU = 0.209
TAU = 0.219
Rapidity (y)
Rapidity (y)

Figure 7

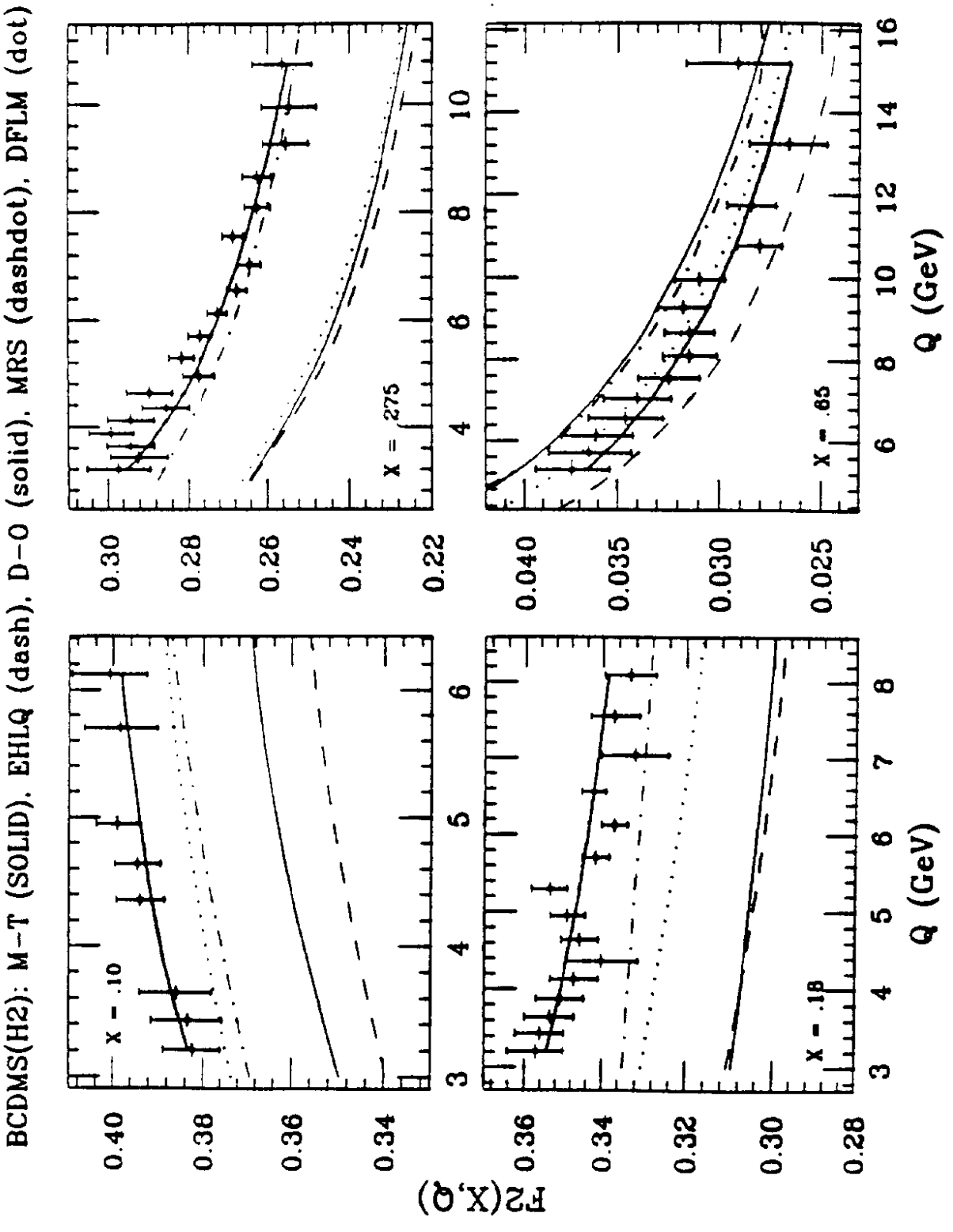

BCDMS(H2): M-T (SOLID), EHLQ (dash), D-O (solid), MRS (dashdot), DFLM (dot)
F2(X,Q)
Q (GeV)
Q (GeV)
X = .10
X = .275
X = .18
X = .65

Figure 8

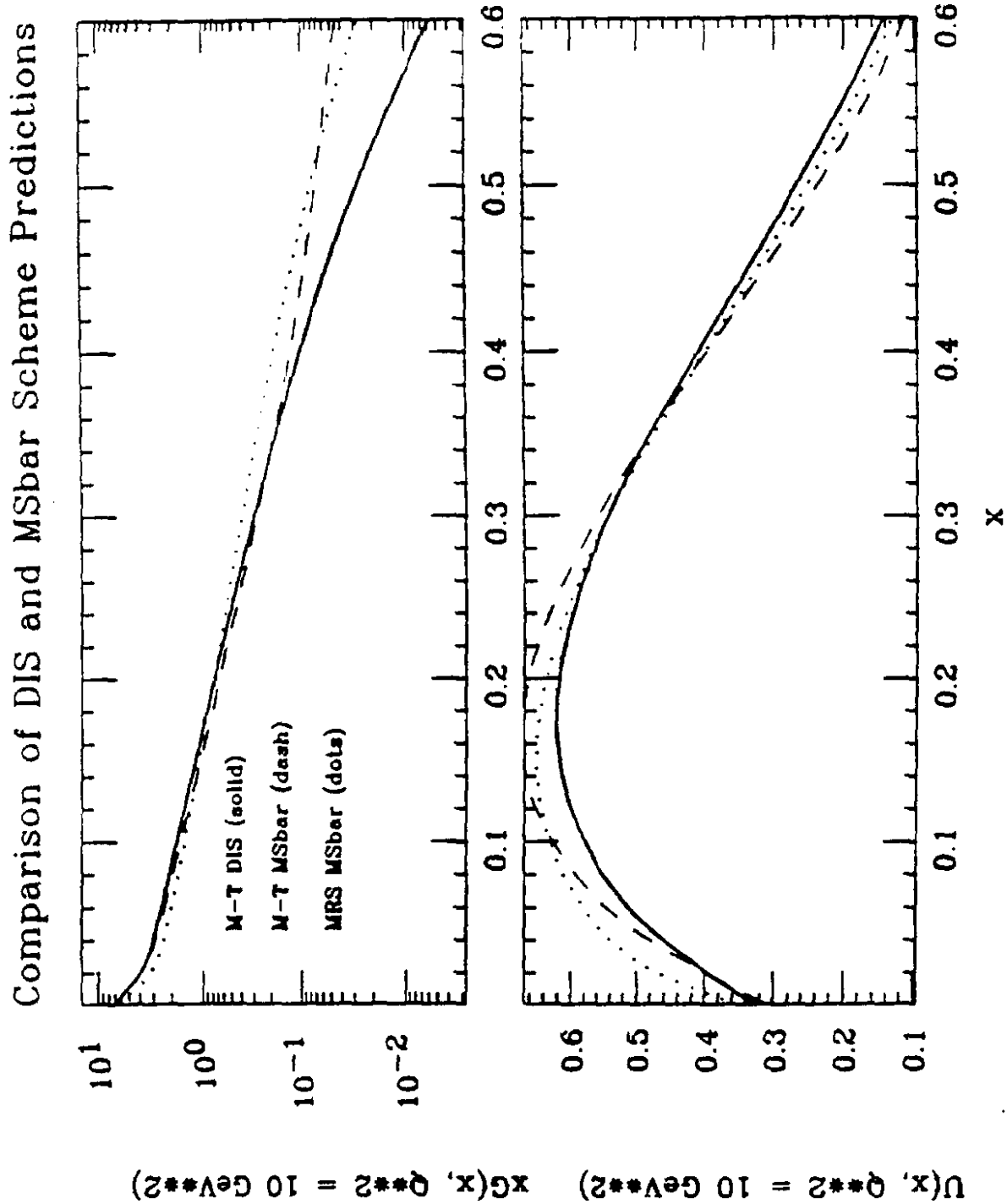

Comparison of DIS and MSbar Scheme Predictions
M-T DIS (solid)
M-T MSbar (dash)
MRS MSbar (dots)
10^1
10^0
10^{-1}
10^{-2}
0.1
0.2
0.3
0.4
0.5
0.6
U(x, Q**2 = 10 GeV**2)
xG(x, Q**2 = 10 GeV**2)
x

Figure 9

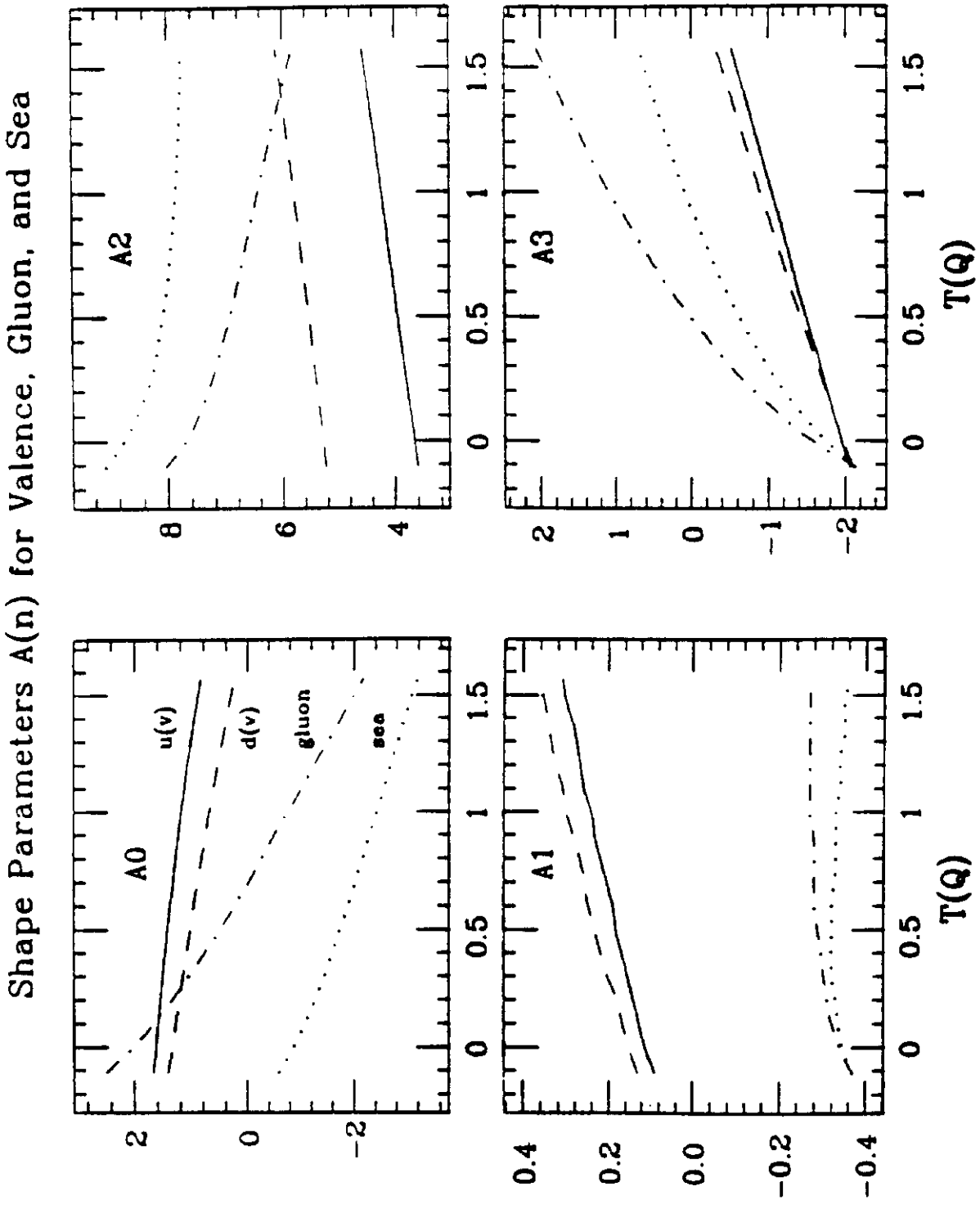

Shape Parameters A(n) for Valence, Gluon, and Sea
A0
u(v)
d(v)
gluon
sea
A1
A2
A3
T(Q)
T(Q)

Figure 10

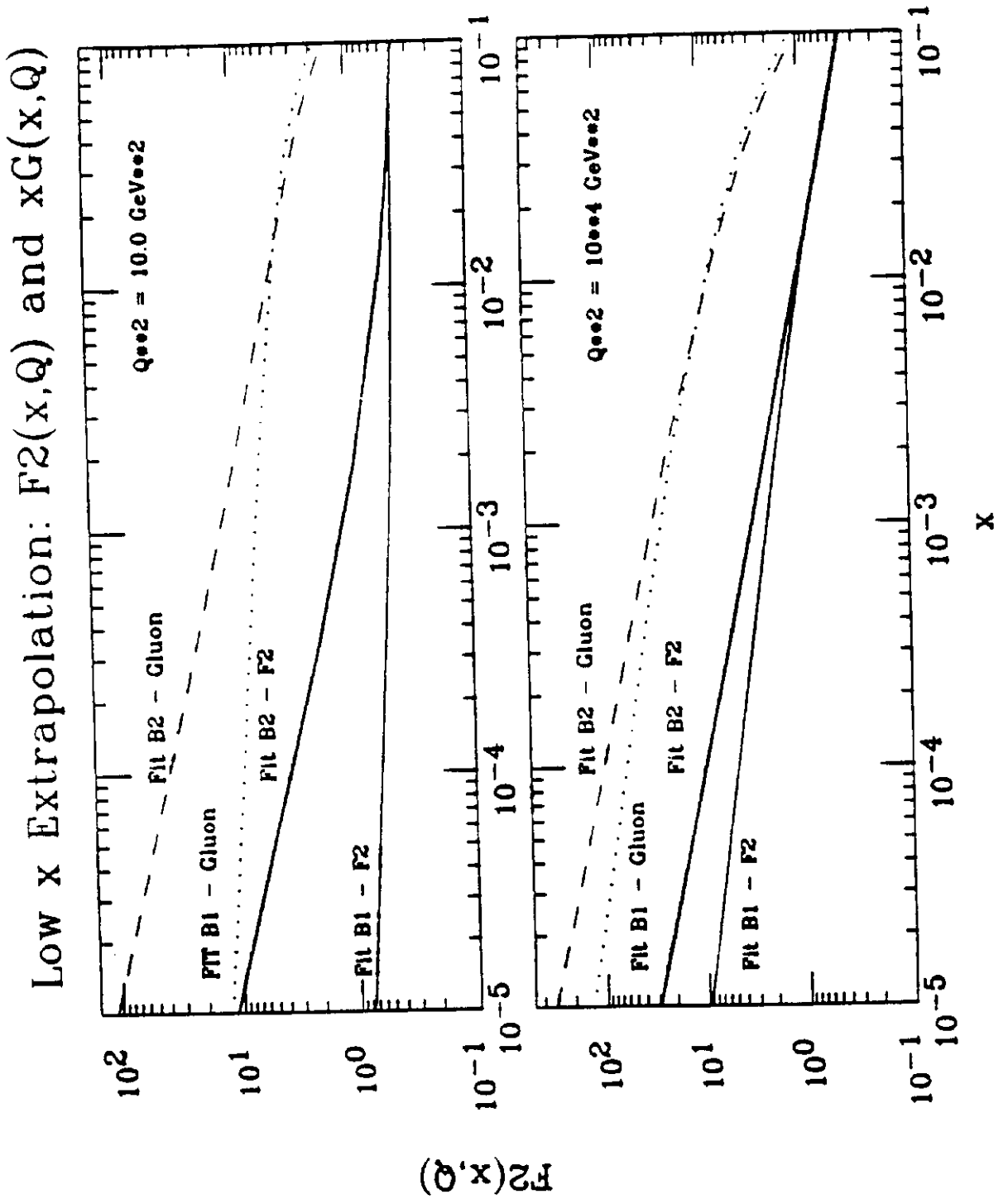

Low x Extrapolation: F2(x,Q) and xG(x,Q)
Q**2 = 10.0 GeV**2
Fit B2 - Gluon
Fit B1 - Gluon
Fit B2 - F2
Fit B1 - F2
Q**2 = 10**4 GeV**2
Fit B2 - Gluon
Fit B1 - Gluon
Fit B2 - F2
Fit B1 - F2
F2(x,Q)
x

Figure 11

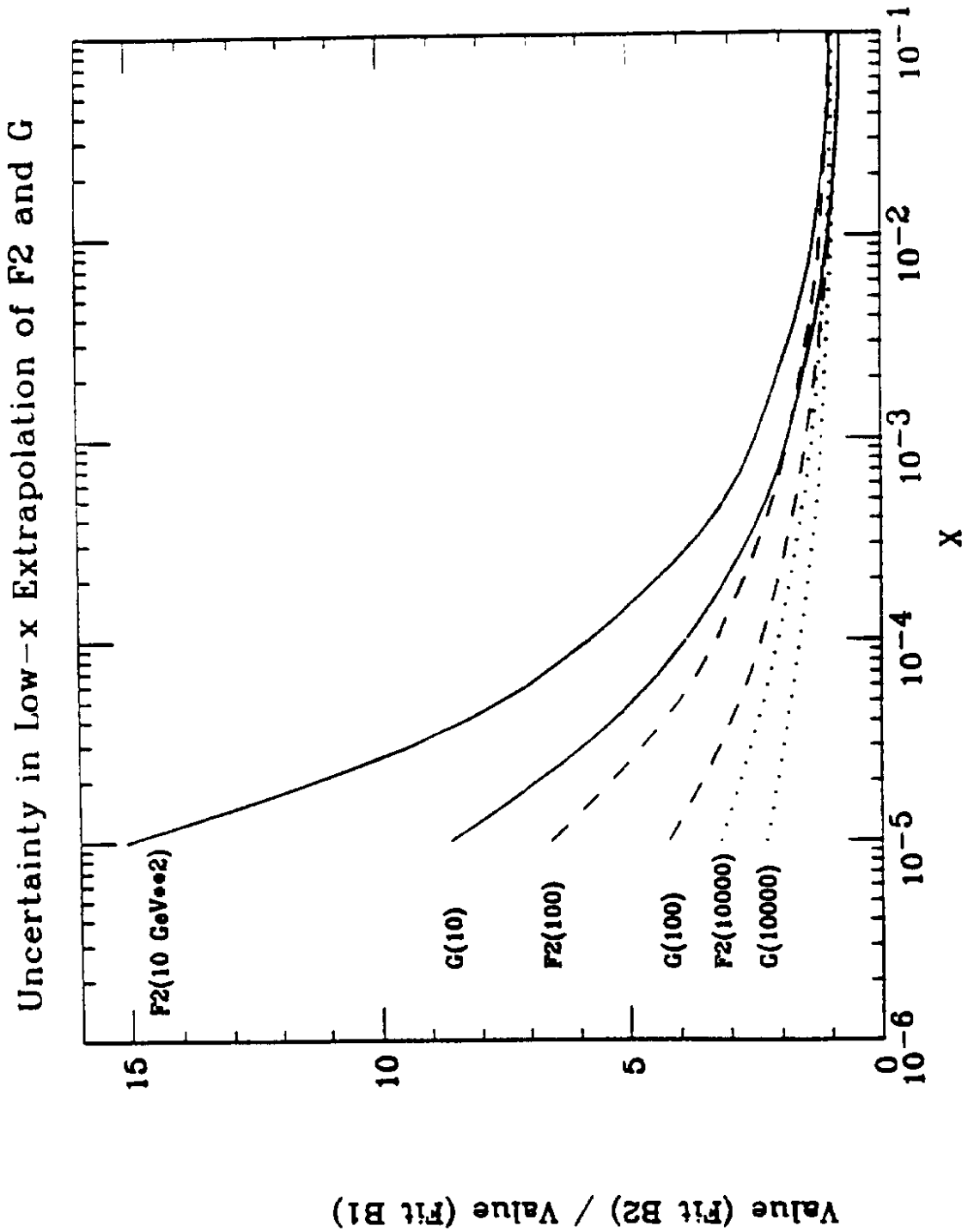

Uncertainty in Low-x Extrapolation of F2 and G
F2(10 GeV**2)
G(10)
F2(100)
G(100)
F2(10000)
G(10000)
15
10
5
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
X
Value (Fit B2) / Value (Fit B1)

Figure 12

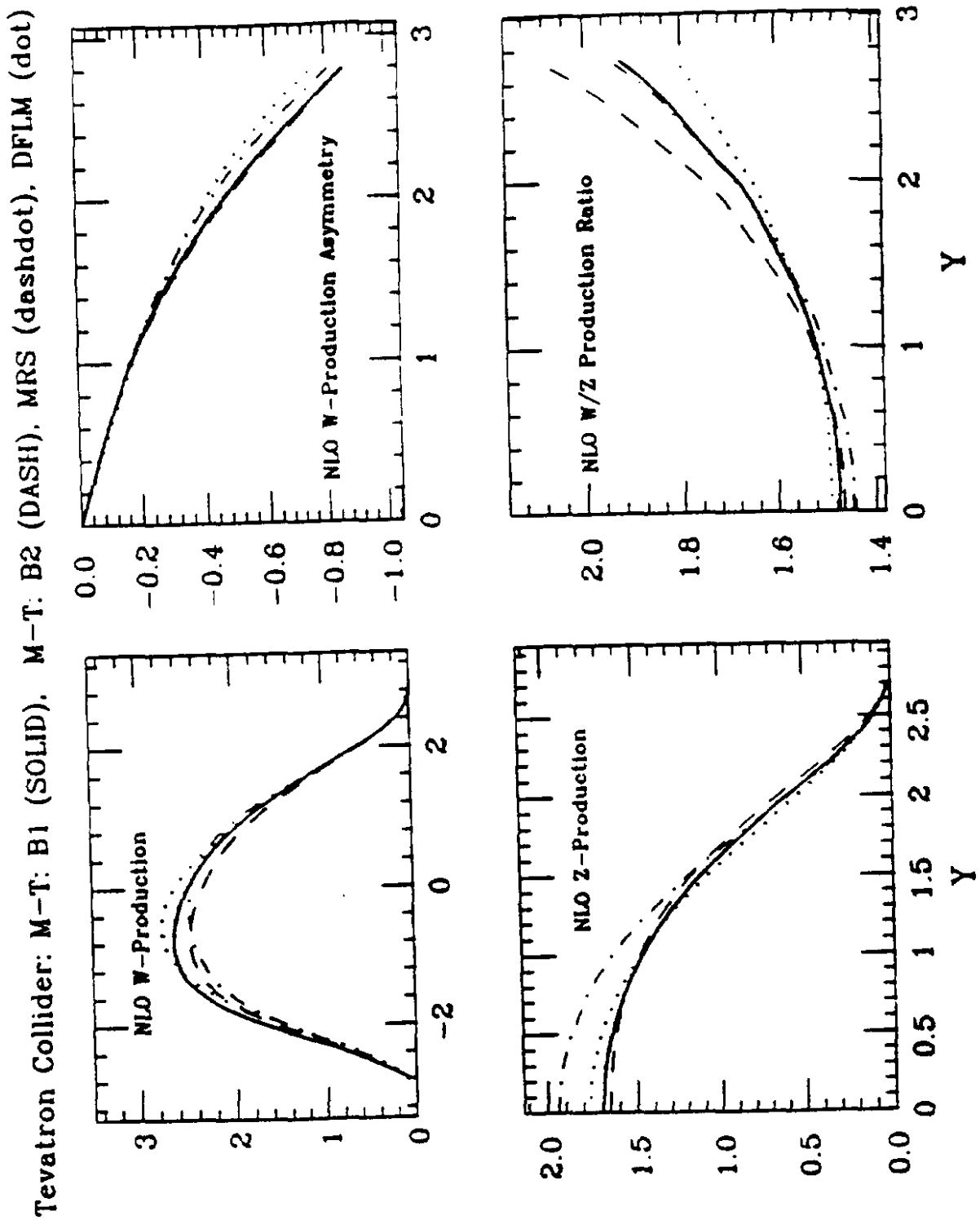
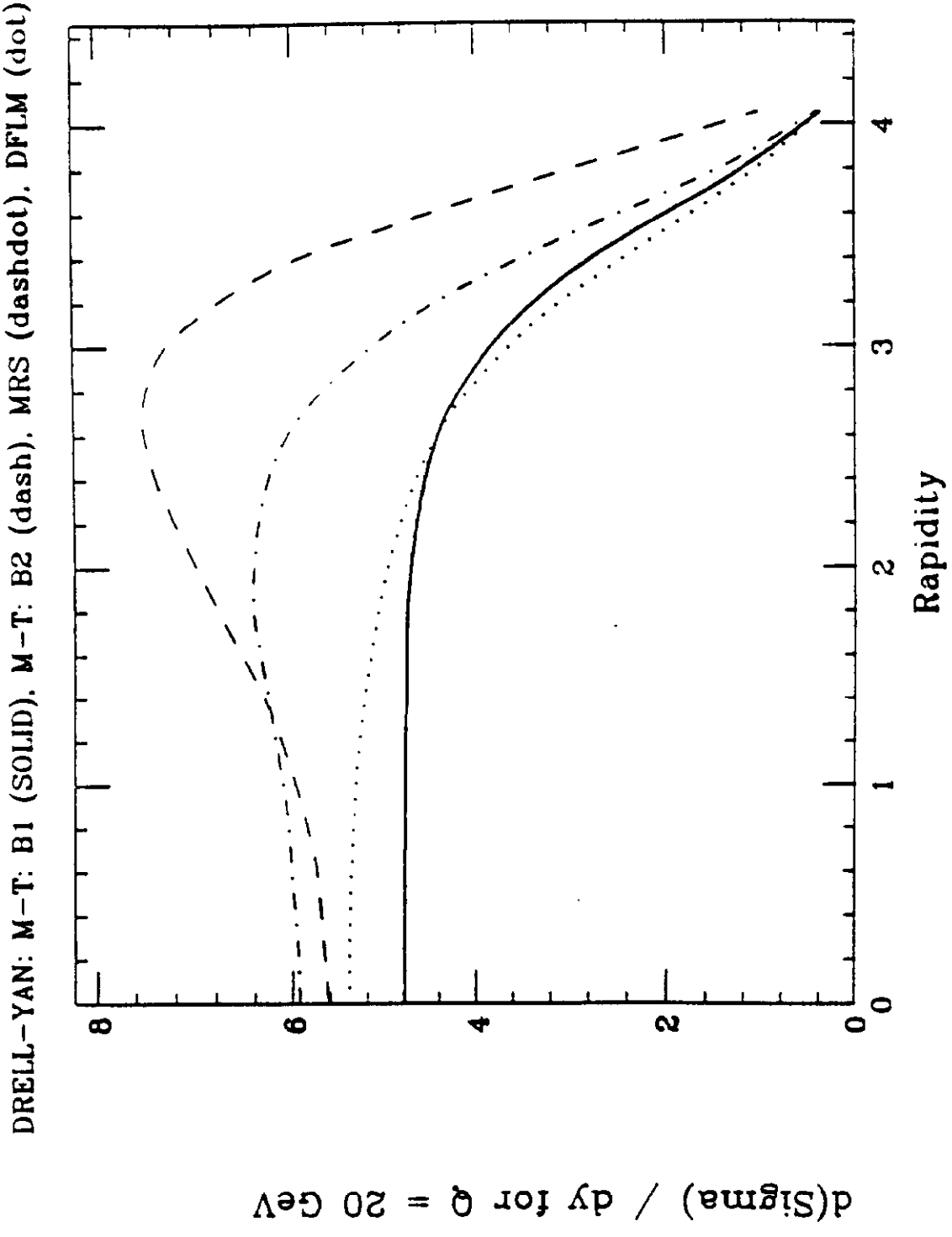

Tevatron Collider: M-T: B1 (SOLID), M-T: B2 (DASH), MRS (dashdot), DFLM (dot)
NLO W-Production
NLO W-Production Asymmetry
NLO W/Z Production Ratio
NLO Z-Production
Y
Y

Figure 13


DRELL-YAN: M-T: B1 (SOLID), M-T: B2 (dash), MRS (dashdot), DFLM (dot)
d(Sigma) / dy for Q = 20 GeV
Rapidity
0
2
4
6
8
0
1
2
3
4

Appendix I

Following are the parton distribution function sets E, B1, and B2 discussed in the main body of this report. The parton distributions are given both in the DIS and MS-bar renormalization schemes. Note that Fit B1 and B2 are representative of the variation in low-x extrapolation allowed by the currently available data.

As a reminder, the general expression for each parton flavor is:

$$f^a(x,Q) = e^{A_0^a} x^{A_1^a} (1-x)^{A_2^a} \ln^{A_3^a}(1+\frac{1}{x}) \tag{A1}$$

where the shape parameters are defined as:

$$A^i(Q) = C_0^i + C_1^i T(Q) + C_2^i T(Q)^2 \tag{A2}$$

with $i = 0-3$, and

$$T(Q) = \ln \frac{\ln \frac{Q}{\Lambda}}{\ln \frac{Q_0}{\Lambda}} \tag{A3}$$

Table I1 - Fit E - DIS Scheme

$\Lambda(2,4) = 0.155 GeV$ $\qquad$ $Q_0^2 = 4 GeV^2$

	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
				A_0					
C_0	1.43	1.69	2.11	-0.84	-0.84	-0.84	-3.87	-6.09	-12.56
C_1	-0.65	-0.33	-3.01	-1.65	-1.65	-1.65	0.85	2.81	8.69
C_2	-0.08	-0.11	0.18	0.12	0.12	0.12	-0.73	-1.34	-2.93
				A_1					
C_0	0.16	0.11	-0.33	-0.32	-0.32	-0.32	-0.15	-0.17	-0.38
C_1	0.16	0.14	0.10	0.02	0.02	0.02	-0.07	0.01	0.30
C_2	-0.02	-0.01	-0.04	-0.03	-0.03	-0.03	0.00	-0.03	-0.12
				A_2					
C_0	6.17	3.69	7.93	8.96	8.96	8.96	7.83	6.75	14.62
C_1	0.43	0.54	-1.40	-1.24	-1.24	-1.24	1.00	1.74	-11.27
C_2	0.06	0.03	0.09	0.45	0.45	0.45	-0.36	-0.56	4.29
				A_3					
C_0	-1.94	-1.99	-1.51	-1.70	-1.70	-1.70	0.21	0.54	-0.41
C_1	1.12	0.90	3.14	2.15	2.15	2.15	0.93	1.15	3.19
C_2	-0.02	0.02	-0.55	-0.43	-0.43	-0.43	-0.03	-0.16	-0.87

Table I2 - Fit E - MS-bar Scheme									
$\Lambda(2,4) = 0.155GeV$						$Q_0^2 = 4GeV^2$			
	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
A_0									
C_0	1.79	2.12	1.58	-0.10	-0.10	-0.11	-2.53	-3.91	-6.57
C_1	-1.05	-0.85	-2.68	-2.29	-2.29	-2.29	-1.16	-0.19	1.15
C_2	0.03	0.07	0.01	0.35	0.35	0.35	0.12	-0.24	-0.48
A_1									
C_0	0.12	0.02	-0.28	-0.43	-0.43	-0.43	-0.35	-0.44	-0.90
C_1	0.24	0.32	0.05	0.09	0.09	0.09	0.26	0.38	0.95
C_2	-0.04	-0.08	0.00	-0.06	-0.06	-0.06	-0.15	-0.17	-0.33
A_2									
C_0	7.03	4.46	6.84	10.43	10.43	10.43	8.67	6.85	7.27
C_1	-0.38	-0.28	-0.93	-2.14	-2.14	-2.14	-0.10	2.15	-0.28
C_2	0.27	0.29	-0.26	0.73	0.73	0.73	0.27	-0.74	0.28
A_3									
C_0	-2.29	-2.57	-1.08	-2.49	-2.49	-2.48	-1.24	-1.56	-5.07
C_1	1.63	1.82	2.76	2.80	2.80	2.80	3.26	4.07	9.02
C_2	-0.18	-0.33	-0.32	-0.67	-0.67	-0.67	-1.06	-1.24	-2.75

Table I3 - Fit B1 - DIS Scheme									
$\Lambda(2,4) = 0.194GeV$						$Q_0^2 = 4GeV^2$			
	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
A_0									
C_0	1.30	1.59	1.48	-1.08	-1.08	-1.08	-4.22	-6.42	-12.92
C_1	-0.57	-0.34	-2.49	-1.33	-1.33	-1.33	0.88	2.67	8.33
C_2	-0.09	-0.10	0.04	-0.03	-0.03	-0.03	-0.69	-1.21	-2.68
A_1									
C_0	0.19	0.14	-0.14	-0.13	-0.13	-0.13	-0.02	-0.09	-0.36
C_1	0.15	0.13	-0.11	-0.21	-0.21	-0.21	-0.17	-0.03	0.32
C_2	-0.02	-0.01	0.03	0.06	0.06	0.06	0.03	-0.02	-0.13
A_2									
C_0	5.24	3.65	6.75	8.40	8.39	8.39	7.29	6.47	15.74
C_1	0.44	0.53	-0.54	-0.51	-0.50	-0.50	1.08	1.39	-12.73
C_2	0.05	0.03	-0.15	0.07	0.07	0.07	-0.39	-0.42	4.51
A_3									
C_0	-1.81	-1.81	-0.50	-0.88	-0.88	-0.88	0.90	1.03	-0.30
C_1	1.06	0.86	2.13	1.18	1.18	1.18	0.50	1.00	3.35
C_2	-0.02	0.02	-0.24	-0.05	-0.05	-0.05	0.08	-0.14	-0.91

Table I4 - Fit B1 - MS-bar Scheme									
$\Lambda(2,4) = 0.194 GeV$						$Q_0^2 = 4 GeV^2$			
	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
A_0									
C_0	1.66	2.00	0.92	-0.60	-0.60	-0.60	-2.94	-2.95	-3.88
C_1	-0.94	-0.81	-2.28	-1.76	-1.76	-1.76	-1.12	-3.21	-1.59
C_2	0.03	0.05	-0.07	0.13	0.13	0.14	0.15	1.38	-0.05
A_1									
C_0	0.18	0.09	-0.07	-0.13	-0.13	-0.13	-0.19	-0.62	-0.78
C_1	0.18	0.24	-0.16	-0.27	-0.27	-0.27	0.16	0.99	-0.07
C_2	-0.03	-0.05	0.06	0.09	0.09	0.09	-0.13	-0.51	0.40
A_2									
C_0	6.04	4.40	5.79	9.31	9.31	9.31	7.94	9.97	3.80
C_1	-0.25	-0.20	-0.68	-0.94	-0.94	-0.94	-0.05	-6.33	2.13
C_2	0.23	0.25	-0.23	0.21	0.21	0.21	0.27	3.71	0.96
A_3									
C_0	-2.09	-2.24	-0.01	-1.18	-1.18	-1.18	-0.46	-3.00	-2.37
C_1	1.42	1.53	1.93	1.31	1.31	1.31	2.93	8.42	0.48
C_2	-0.14	-0.23	-0.11	-0.10	-0.10	-0.10	-1.05	-3.61	2.30

Table I5 - Fit B2 - DIS Scheme									
$\Lambda(2,4) = 0.191 GeV$						$Q_0^2 = 4 GeV^2$			
	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
A_0									
C_0	1.38	1.64	1.52	-0.85	-0.85	-0.85	-3.74	-6.07	-12.08
C_1	-0.59	-0.33	-2.71	-1.43	-1.43	-1.43	0.21	2.33	7.31
C_2	-0.08	-0.10	0.15	-0.03	-0.03	-0.03	-0.50	-1.15	-2.35
A_1									
C_0	0.18	0.09	-0.72	-0.82	-0.82	-0.82	-0.58	-0.52	-0.73
C_1	0.16	0.14	0.45	0.35	0.35	0.35	0.24	0.22	0.54
C_2	-0.02	-0.01	-0.15	-0.09	-0.10	-0.10	-0.07	-0.07	-0.18
A_2									
C_0	5.40	3.74	7.75	9.19	9.19	9.19	9.63	8.33	21.14
C_1	0.42	0.54	-1.56	-0.92	-0.92	-0.92	-1.13	0.28	-19.17
C_2	0.06	0.03	0.16	0.12	0.12	0.12	0.25	-0.28	6.64
A_3									
C_0	-1.91	-2.02	-2.18	-2.76	-2.76	-2.76	-1.09	-0.52	-1.92
C_1	1.11	0.88	3.75	2.56	2.56	2.56	2.10	1.91	4.59
C_2	-0.03	0.02	-0.76	-0.40	-0.40	-0.40	-0.33	-0.31	-1.25

Table I6 - Fit B2 - MS-bar Scheme									
$\Lambda(2,4) = 0.191 GeV$						$Q_0^2 = 4 GeV^2$			
	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
A_0									
C_0	1.77	2.04	0.74	-0.43	-0.43	-0.43	-3.07	-4.44	-7.03
C_1	-0.98	-0.75	-2.44	-1.96	-1.96	-1.96	-1.03	-0.13	1.10
C_2	0.03	0.02	0.07	0.20	0.20	0.20	0.04	-0.23	-0.41
A_1									
C_0	0.13	0.03	-0.59	-0.86	-0.86	-0.86	-0.66	-0.68	-1.13
C_1	0.23	0.26	0.42	0.43	0.43	0.43	0.45	0.50	1.07
C_2	-0.04	-0.05	-0.15	-0.14	-0.14	-0.14	-0.17	-0.18	-0.35
A_2									
C_0	6.28	4.48	6.31	10.16	10.16	10.16	8.57	6.90	8.56
C_1	-0.34	-0.15	-1.62	-1.91	-1.91	-1.91	-0.32	1.46	-2.33
C_2	0.26	0.21	0.18	0.53	0.53	0.53	0.17	-0.53	0.87
A_3									
C_0	-2.30	-2.47	-1.37	-3.14	-3.14	-3.14	-1.68	-1.82	-5.47
C_1	1.60	1.52	3.56	3.14	3.14	3.14	3.48	4.11	9.08
C_2	-0.18	-0.19	-0.77	-0.68	-0.68	-0.68	-0.98	-1.16	-2.66

Appendix II

Table II1 (DIS scheme) and II2 (MS-bar scheme) represent a next-to-leading order fit (SN-fit) of the combined data which assumes a *non-SU(3)-symmetric sea* as suggested by some neutrino di-muon studies. The ratio of 2s/(u+d) is set at 0.50 for the input distribuitions. Table II3 represents a *leading order* fit of the combined data (SL-fit) which should be used in applications where leading order hard scattering matrix elements are employed.

Table II1 - Fit SN - Non-Symmetric Sea - DIS

$\Lambda(2,4) = 0.237GeV$ $\quad Q_0^2 = 4GeV^2$

	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
				A_0					
C_0	1.42	1.68	0.90	-1.48	-1.48	-2.26	-4.68	-6.83	-14.41
C_1	-0.59	-0.33	-1.86	-0.89	-0.89	-0.90	0.92	2.68	9.65
C_2	-0.08	-0.10	-0.09	-0.12	-0.13	-0.06	-0.62	-1.13	-2.98
				A_1					
C_0	0.16	0.08	-0.17	-0.13	-0.13	-0.15	-0.06	-0.12	-0.28
C_1	0.17	0.15	-0.10	-0.19	-0.19	-0.10	-0.12	-0.01	0.15
C_2	-0.02	-0.01	0.02	0.04	0.04	0.01	0.01	-0.03	-0.06
				A_2					
C_0	5.40	3.75	5.27	7.83	7.83	7.47	5.55	5.24	11.48
C_1	0.41	0.53	0.43	-0.06	-0.05	-0.61	1.16	1.14	-7.50
C_2	0.06	0.03	-0.26	0.01	0.00	0.28	-0.26	-0.24	2.54
				A_3					
C_0	-1.99	-2.09	-0.20	-0.38	-0.38	-0.23	1.13	1.19	0.65
C_1	1.12	0.89	1.67	0.68	0.68	1.22	0.50	0.93	1.99
C_2	-0.03	0.02	-0.14	0.05	0.05	-0.16	0.03	-0.13	-0.43

Table II2 - Fit SN - Non-Symmetric Sea - MS-bar

$\Lambda(2,4) = 0.237GeV$ $\quad Q_0^2 = 4GeV^2$

	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
				A_0					
C_0	1.84	2.08	0.31	-1.13	-1.13	-1.82	-3.69	-5.06	-9.92
C_1	-0.97	-0.66	-1.84	-1.26	-1.26	-1.40	-0.47	0.39	4.60
C_2	0.03	-0.02	-0.06	-0.01	-0.01	0.09	-0.10	-0.35	-1.53
				A_1					
C_0	0.12	0.02	-0.10	-0.15	-0.15	-0.18	-0.15	-0.25	-0.38
C_1	0.22	0.19	-0.10	-0.16	-0.16	-0.06	0.04	0.16	0.24
C_2	-0.04	-0.01	0.01	0.03	0.03	-0.01	-0.05	-0.08	-0.08
				A_2					
C_0	6.34	4.53	4.18	8.43	8.43	7.94	5.72	4.42	-1.27
C_1	-0.34	-0.04	0.05	-0.39	-0.39	-0.82	0.93	2.38	9.17
C_2	0.25	0.15	-0.12	0.05	0.05	0.30	-0.11	-0.63	-2.88
				A_3					
C_0	-2.40	-2.51	0.34	-0.64	-0.64	-0.56	0.26	-0.14	-1.60
C_1	1.53	1.24	1.64	1.01	1.01	1.65	1.85	2.72	4.40
C_2	-0.16	-0.05	-0.16	-0.06	-0.06	-0.31	-0.50	-0.75	-1.08

Table II3 - Fit SL - Leading Order									
$\Lambda(1,4) = 0.144 GeV$						$Q_0^2 = 4 GeV^2$			
	d(val)	u(val)	gluon	u(sea)	d(sea)	s	c	b	t
A_0									
C_0	1.38	1.67	1.52	-0.81	-0.81	-0.81	-3.62	-6.16	-12.68
C_1	-0.62	-0.33	-3.17	-1.13	-1.13	-1.13	0.03	2.37	8.36
C_2	-0.10	-0.13	0.25	-0.26	-0.26	-0.26	-0.48	-1.24	-2.89
A_1									
C_0	0.16	0.08	-0.25	-0.07	-0.07	-0.07	-0.06	-0.11	-0.35
C_1	0.19	0.17	-0.01	-0.46	-0.46	-0.46	-0.21	-0.05	0.28
C_2	-0.02	-0.01	0.00	0.16	0.16	0.16	0.05	-0.02	-0.12
A_2									
C_0	5.40	3.75	7.01	9.19	9.19	9.19	8.30	6.49	14.87
C_1	0.59	0.70	-0.90	0.35	0.35	0.35	-0.60	1.28	-12.56
C_2	0.03	0.00	-0.08	-0.49	-0.49	-0.49	0.25	-0.41	4.75
A_3									
C_0	-1.97	-2.09	-0.79	-0.89	-0.89	-0.89	0.16	0.71	-0.17
C_1	1.24	0.98	2.90	0.33	0.33	0.33	1.26	1.37	3.39
C_2	-0.05	0.02	-0.54	0.40	0.40	0.40	-0.15	-0.26	-0.96