STRUCTURE FUNCTIONS AND QCD TESTS AT HERA

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APR. 14

1. KINEMATIC DOMAIN
2. $F_2(x, Q^2)$
3. QCD ANALYSIS
4. xG_3, FLAVOUR DISTRIBUTIONS & $e^{\pm}d$
5. CONCLUSIONS

1. KINEMATICAL DOMAINS

OPTIONS :

E_e / GeV	⊗	E_p / GeV	
30		820	DESIGN
30		300	LOW S
10		300	—,—
45		1140	UPGRADE

BOUNDARIES :

$E_{e'}, E_J > 5\,\text{GeV}$

$0.1 < y_e$ BECAUSE $\frac{\delta x}{x} \sim \frac{1}{y_e} \frac{\delta E'_e}{E'_e}$

$x_J < 0.7$, $y_J < 0.7$ $\frac{\delta x}{x} \sim \frac{1}{1-y_J}$

$5^\circ < \theta_e < 175^\circ$; $8^\circ < \theta_J < 172^\circ$

$y_e < 0.8$ RC's

2. MEASUREMENT OF F_2

$$\frac{d^2\sigma}{dx\,dQ^2} = \frac{d^2\sigma_0}{dx\,dQ^2} + O(\alpha)$$

RC to be carried out.

$$\frac{d^2\sigma_0^{\pm}}{dx\,dQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left\{ Y_+ \mathbb{F}_2^{\pm} + Y_- x\mathbb{F}_3^{\pm} \right\}$$

$Y_+ = 1 + (1-y)^2 - y^2 \frac{R}{1+R}$ $\longrightarrow$ REQUIRES R-meas. (LOW x WG)

$Y_- = 1-(1-y)^2$

$$\begin{array}{lcccc} & \gamma^2 & \gamma Z & & Z^2 \\ \mathbb{F}_2^{\pm} = & F_2 & + \; \chi_Z(Q^2)\,(-v \mp \lambda a)\, G_2 & + & \chi_Z^2(Q^2)\,(v^2+a^2 \pm 2\lambda v a)\, H_2 \\ x\mathbb{F}_3^{\pm} & & \chi_Z(Q^2)\,(\pm a + \lambda v)\, xG_3 & + & \chi_Z^2(Q^2)\,(\mp 2va - \lambda(a^2+v^2))\, xH_3 \end{array}$$

$$(F_2, G_2, H_2) = x \sum \left(Q_q^2,\, 2Q_q v_q,\, v_q^2 + a_q^2\right)(q+\bar{q})$$

$$(xG_3, xH_3) = 2x \sum \left(Q_q a_q,\, v_q a_q\right)(q-\bar{q}).$$

Z^2-terms are very small ($\mathcal{L} = 100\,\mathrm{pb}^{-1}$)

$\Longrightarrow$ ONE HAS TO KNOW xG_3 ONLY, SINCE $-v \mp \lambda a \simeq 0$; MEASURABLE.

$\curvearrowright$ POSSIBLE F_2 EXTRACTION IN A WIDE Q^2-RANGE.

3. QCD ANALYSIS

→ Λ & $\alpha_s(Q^2)$ FROM SCALING VIOLATIONS OF F_2.

HOW FAR ONE CAN USE AP-EVOLUTION ?

→ ONSET OF HT : $Q^2 \lesssim 10 \dots 20\ \mathrm{GeV}^2$

→ " " SHADOWING : $x < 10^{-3} \dots 2 \cdot 10^{-3}$

Fig.

→ low x DOMINATES THE STATISTICS

- $xG(x, Q_0^2)$ RULES THE EVOLUTION & DETERMINES $\partial F_2 / \partial \ln Q^2$ TO A WIDE EXTEND.

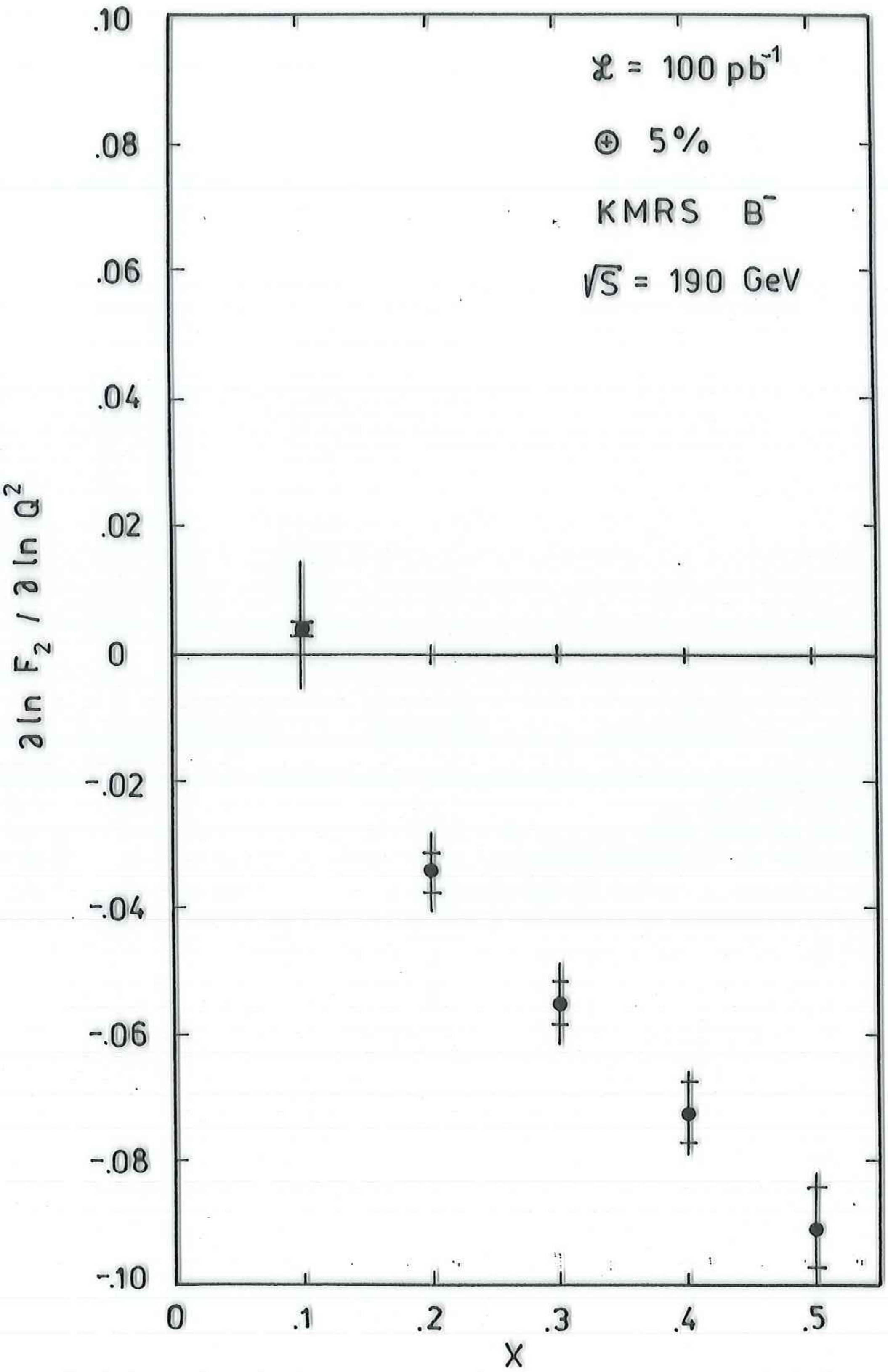
Fig.

$$\frac{\partial F_2}{\partial \ln Q^2} = \frac{\alpha_s}{2\pi} x \left\{ \frac{1}{6} P_{NS}(x) \otimes \Delta(x, Q^2) \frac{1}{x} + \frac{5}{18} \left[P_{FF}(x) \otimes \Sigma(x, Q^2) \frac{1}{x} + 2N_f\, P_{FG}(x) \otimes G(x, Q^2) \right] \right\}$$

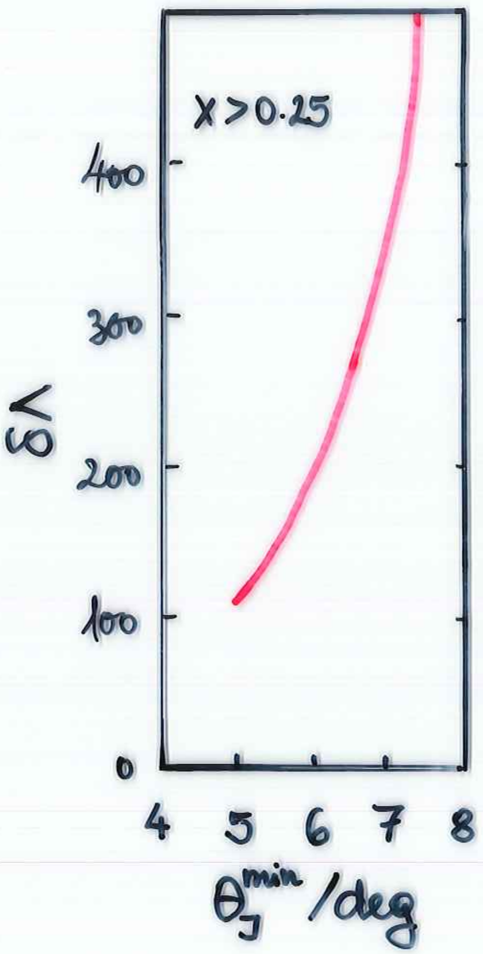
$$\frac{\partial G}{\partial \ln Q^2} = \frac{\alpha_s}{2\pi} \left[P_{Gq}(x) \otimes \Sigma(x, Q^2) + P_{GG} \otimes G(x, Q^2) \right].$$

NTLO IMPORTANT : $\lesssim 10\%$ EFFECTS SIZE OF F2

VAN NEERVEN, ZIJLSTRA ; GLÜCK, REYA, VOGT.



$\mathcal{L}$ = 100 pb^{-1}
⊕ 5%
KMRS B$^-$
$\sqrt{S}$ = 190 GeV
$\partial \ln F_2 / \partial \ln Q^2$
.10
.08
.06
.04
.02
0
-.02
-.04
-.06
-.08
-.10
0
.1
.2
.3
.4
.5
X



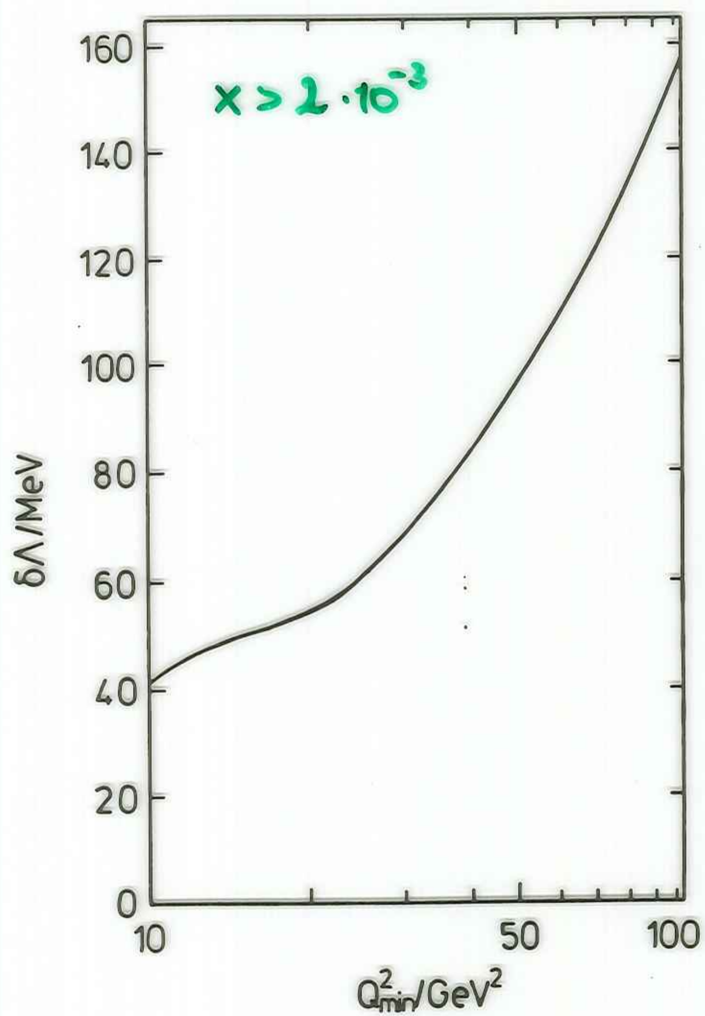
x > 0.25
400
300
200
100
0
4
5
6
7
8
θ_J^{min} /deg

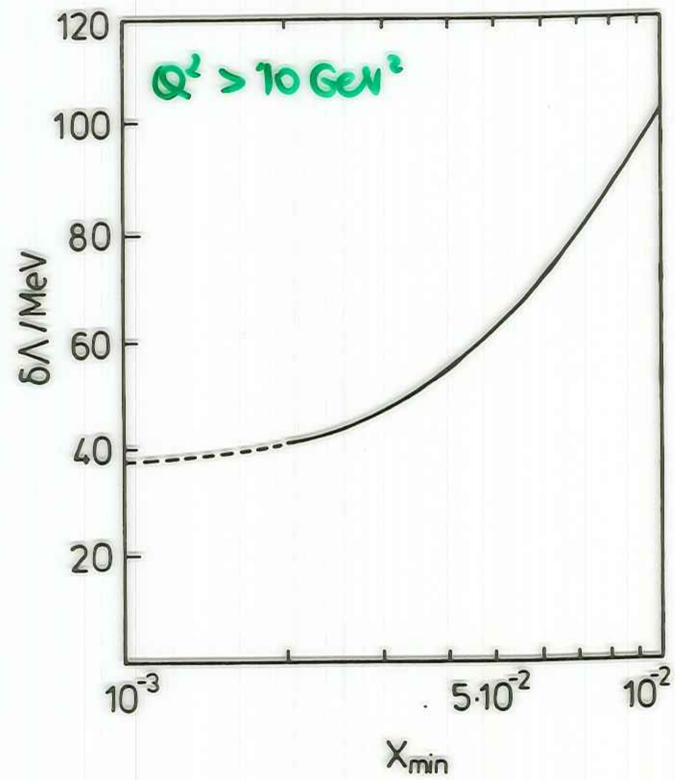
DATA SETS USED:

$S_1 = 4 \times 10 \times 300\ \mathrm{GeV}^2$

$S_2 = 4 \times 30 \times 820\ \mathrm{GeV}^2$

$\mathcal{L} = 100\ \mathrm{pb}^{-1}$ each.

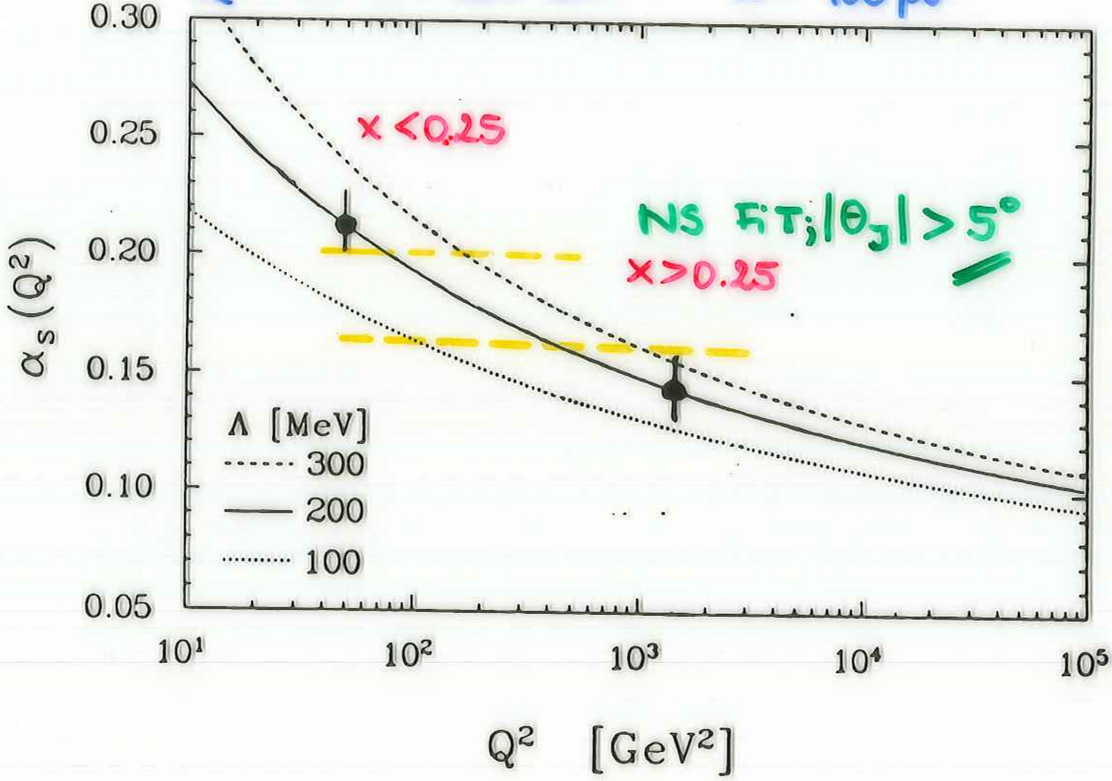




COMBINED FIT:

$S_1 = 4 \times 10 \times 300 \; GeV^2 \qquad \mathcal{L} = 100 \; pb^{-1}$

$S_2 = 4 \times 10 \times 820 \; GeV^2 \qquad \mathcal{L} = 100 \; pb^{-1}$



LOWER x : DIFFERENT FIT BEHAVIOUR

FOR $xG(x, Q_0^2) \propto$ const.

& $xG(x, Q_0^2) \propto \frac{1}{\sqrt{x}}$

DETERMINES $\delta\alpha$ FOR $xG \propto \frac{1}{x^\alpha}$

WITH

$\delta\alpha \simeq \pm 0.05$

4. xG_3, FLAVOUR DISTRIBUTIONS, $e^{\pm}d$

1) xG_3: γZ - INTERFERENCE TERM

$$\left[\frac{d^2\sigma}{dx\,dQ^2}(e^+p) - \frac{d^2\sigma}{dx\,dQ^2}(e^-p)\right]\frac{xQ^4}{2\pi\alpha^2}\,\frac{1}{Y_-}\,\frac{1}{\chi_Z(Q^2)}\,\frac{1}{2a}$$

$$= xG_3(x,Q^2) = 2x\sum_q e_q a_q\,(q-\bar{q})$$

$$\simeq 2x\left[e_u a_u\, u_v(x,Q^2) + e_d a_d\, d_v(x,Q^2)\right]$$

Fig.

2) UNFOLDING OF INDIVIDUAL PARTONDISTRIBUTIONS

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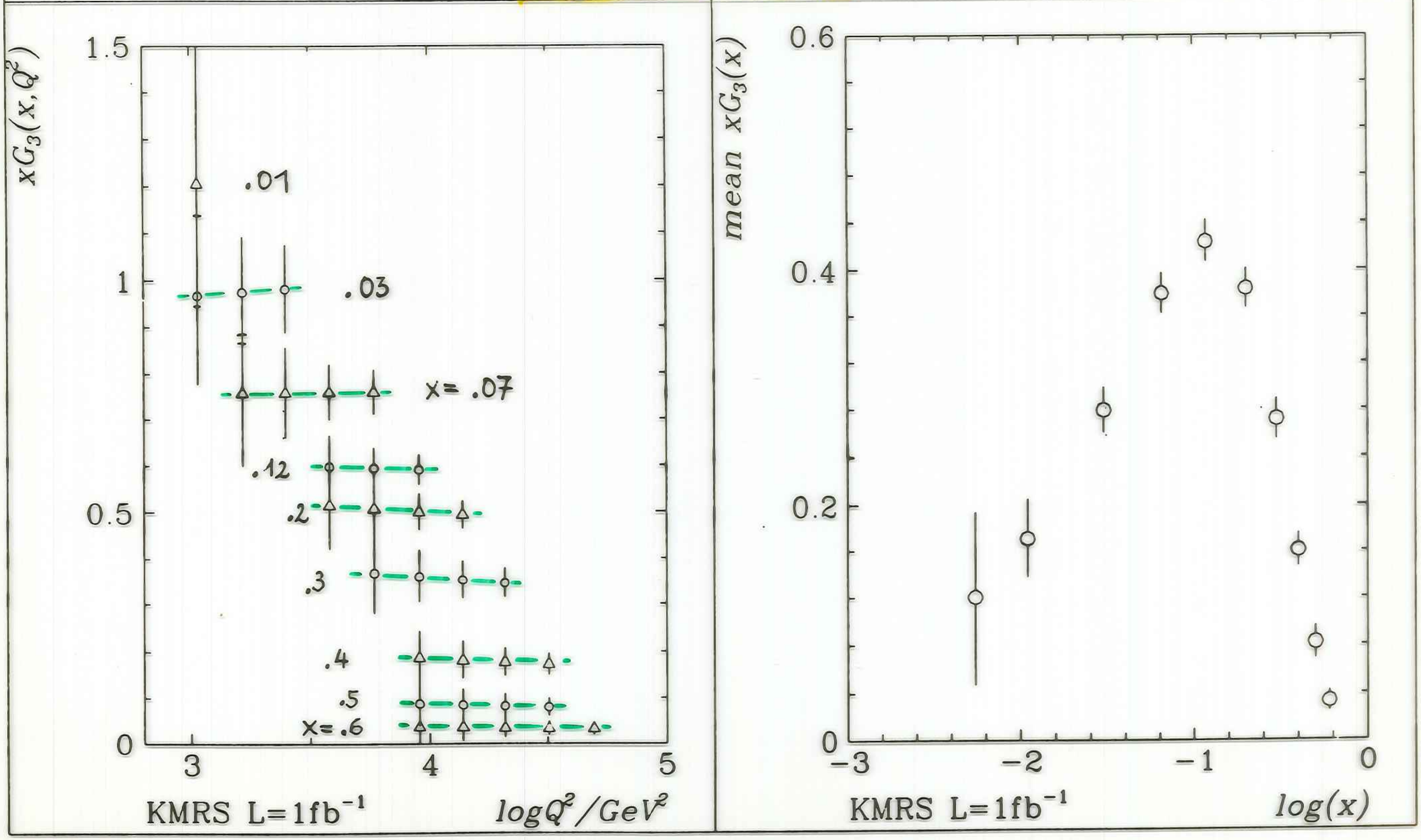
a)

$$\begin{pmatrix} xD_1 \\ xD_2 \\ xD_3 \\ xD_4 \end{pmatrix} = \left(A_{ij}(x,Q^2)\right)\begin{pmatrix} \sigma_{NC}^+ \\ \sigma_{NC}^- \\ \sigma_{CC}^+ \\ \sigma_{CC}^- \end{pmatrix}$$

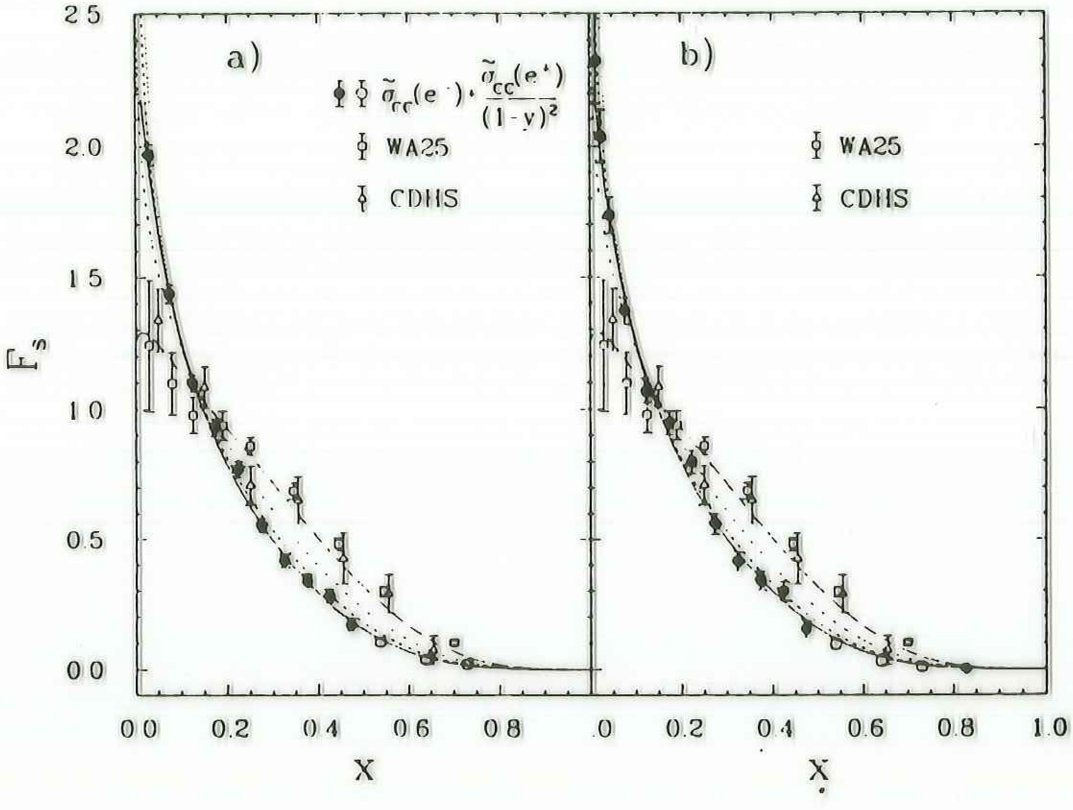
(CC dominates errors)

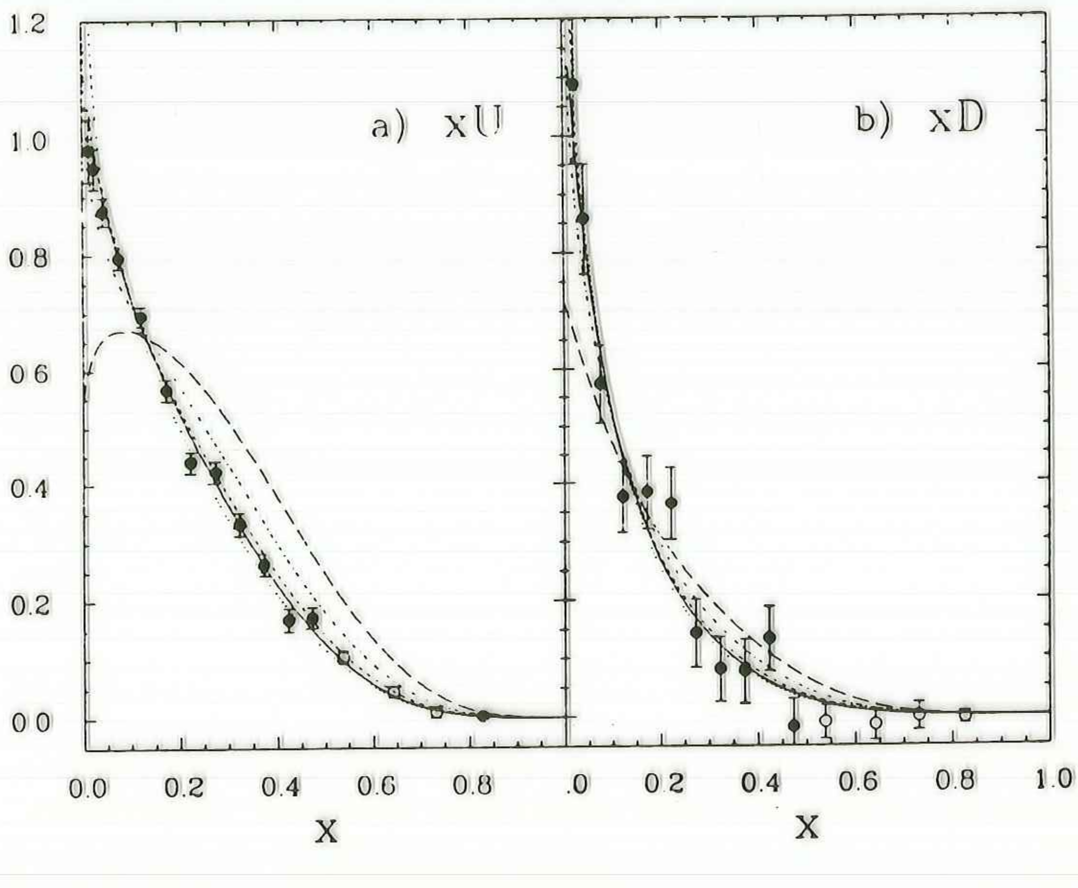
b) APPROXIMATE REPRESENTATIONS

Look – 30 x 820 GeV^2 $xG_3 = 2x \sum Q_q a_q (q-\bar{q})$ HERA e^-p e^+p

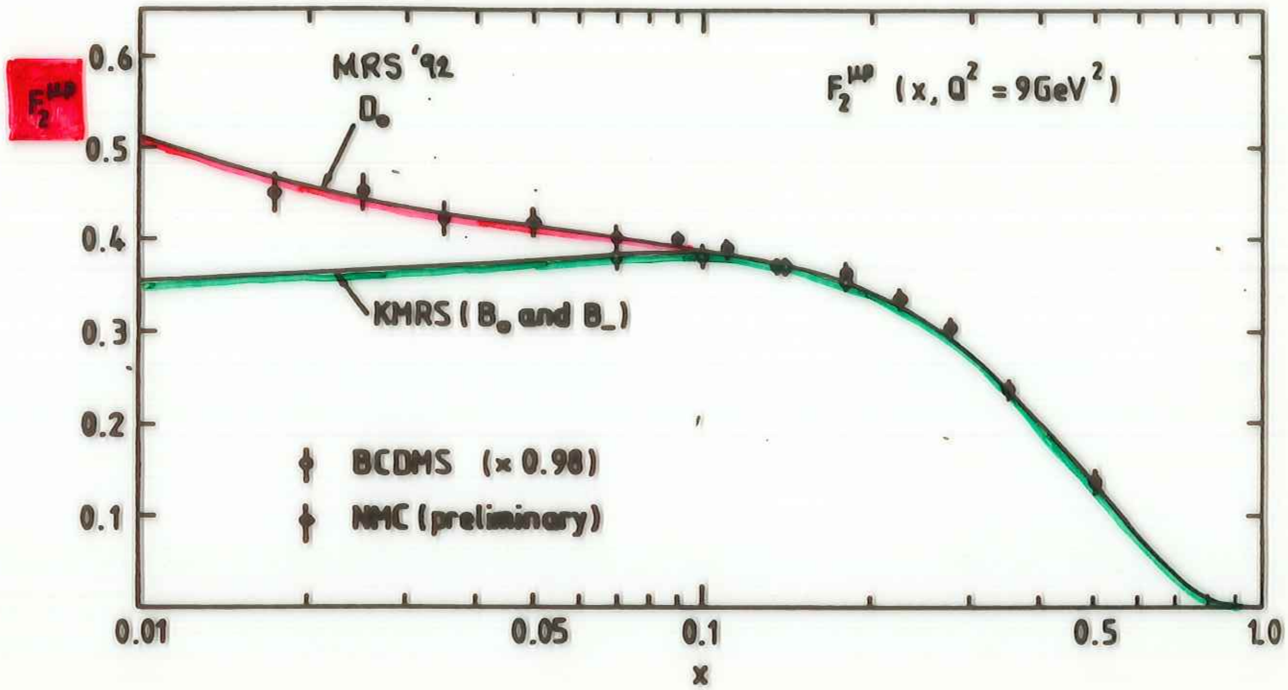


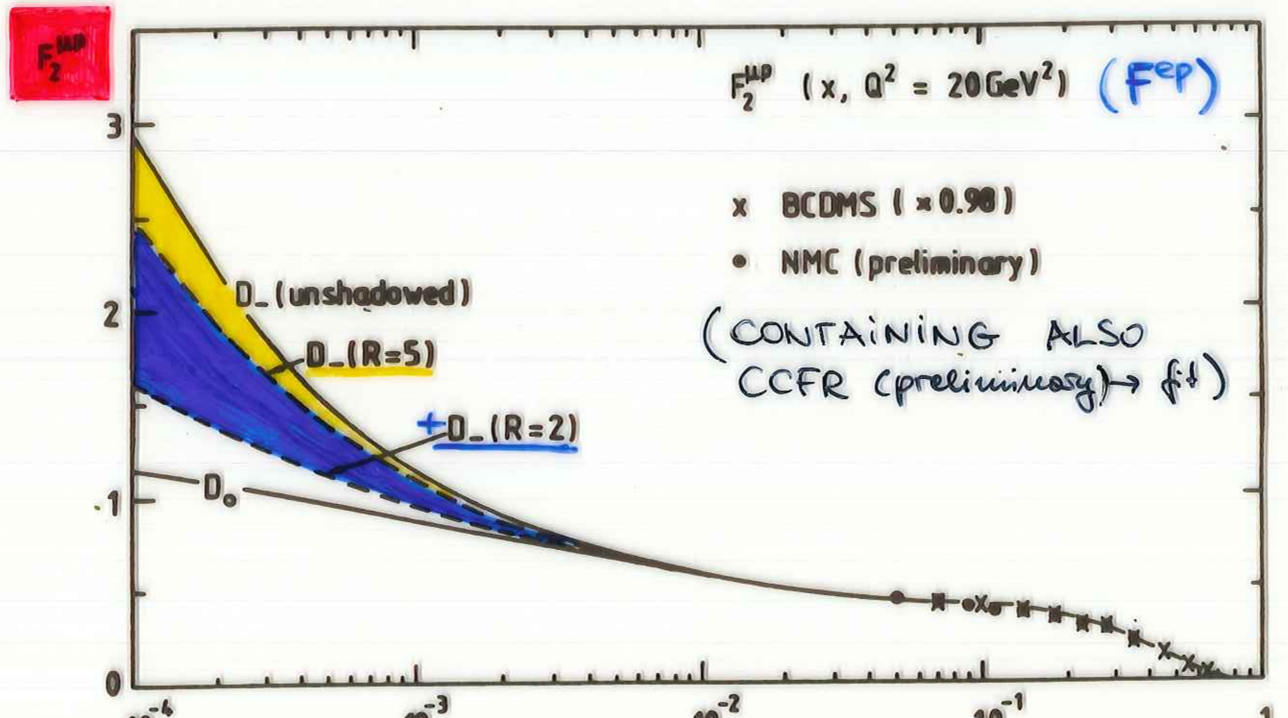
JNGELMAN
RÜCKL





MARTIN, ROBERTS, STIRLING





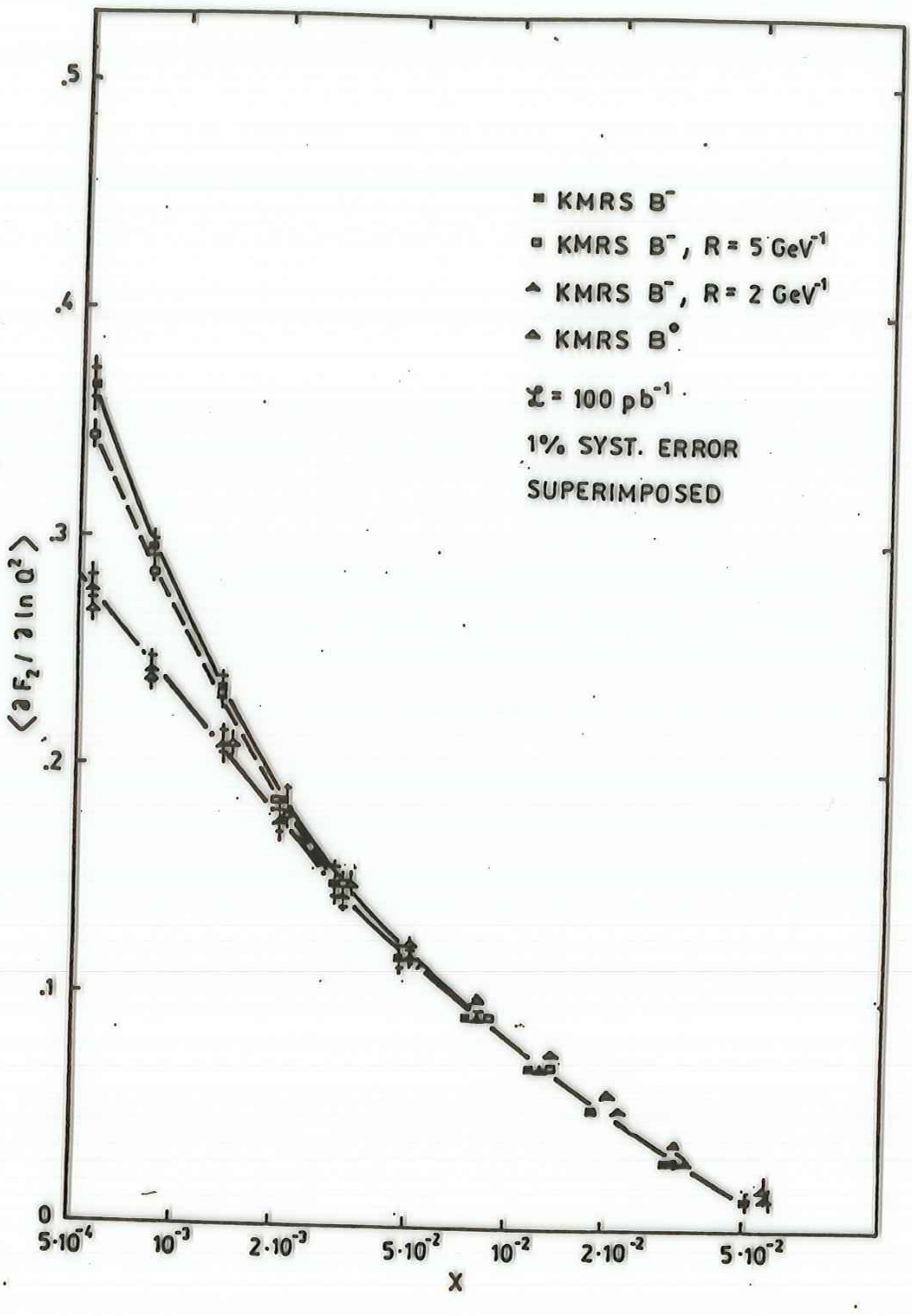


Figure 5: Average slope of F_2, *versus* x using the KMRS parton distributions. The full line corresponds to the B^- set with no screening, the broken line is B^- assuming weak screening ($R = 5$ GeV^{-1}) and the dashed-dotted line B^- with strong screening ($R = 2$ GeV^{-1}). The statistical errors (inner error bars) correspond to $\mathcal{L} = 100\ pb^{-1}$ and $\sqrt{s} = 314$ GeV. A systematical error of 1 % is superimposed.

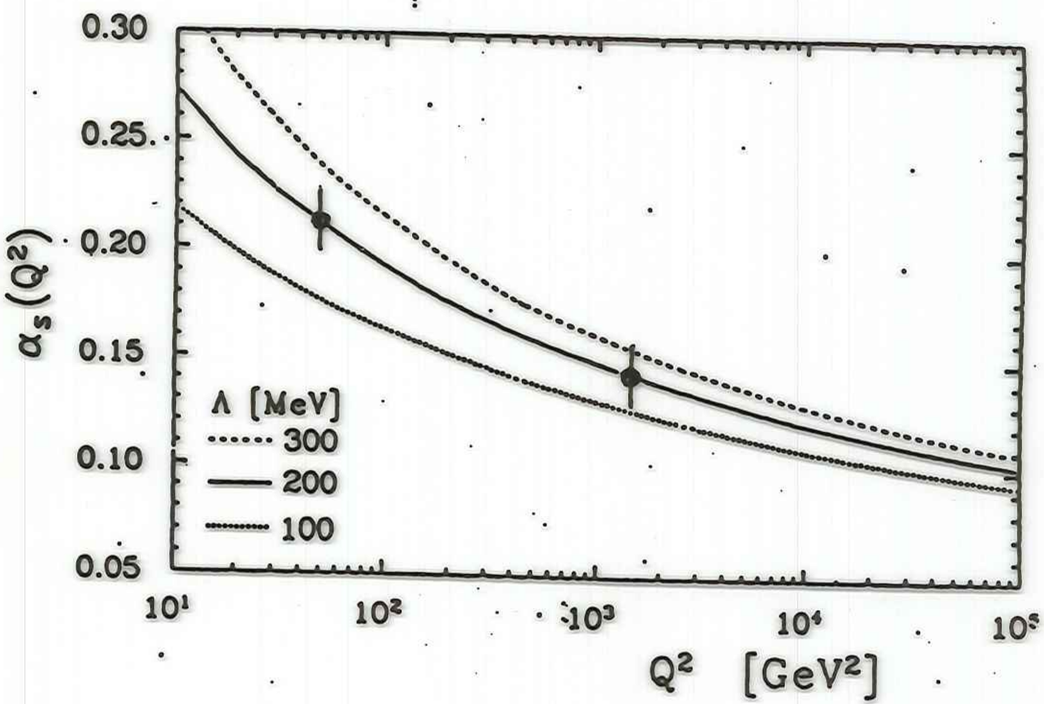


Figure 7: Dependence of α_s on Q^2 from a combined fit using two samples of $\sqrt{s} = 314$ GeV and $\sqrt{s} = 110$ GeV with $\mathcal{L} = 100\ pb^{-1}$ each. The upper point corresponds to a nonsinglet fit for $\theta_J > 5°$ and $x > 0.25$. The lower point at $Q^2 \sim 50$ GeV^2 corresponds to a fit in the range $x < 0.25$.

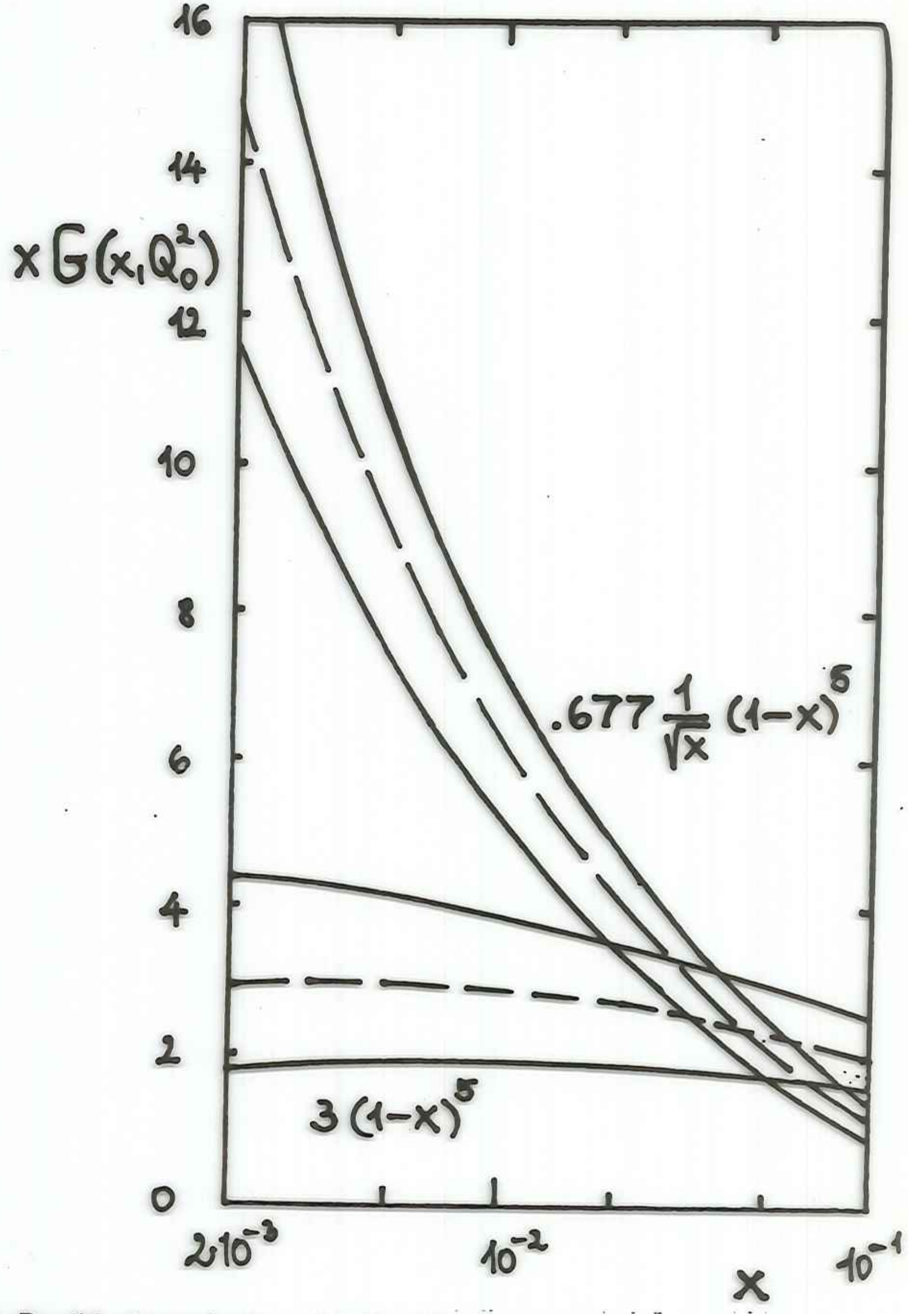


Figure 8: Possible determination of $xG(x, Q_0^2)$ in a QCD fit for $x < 0.1$, see text. The upper error band corresponds to the choice $\alpha = -0.5$ and the lower band to $\alpha = 0$, see eq. 15. The inner error denotes the statistical error for $\mathcal{L} = 100\ pb^{-1}$ for both the low and high s option.