Double logarithmic Behaviour of $F_2(x, Q^2)$ for all Q^2 at $x < 0.005$

DIS 97, Chicago, April 16, 1997

D. Haidt, DESY, Hamburg

- Starting point

DIS 96 (Rome) : F_2 from H1

$$\boxed{F_2(x, Q^2) = a + m \log\frac{Q^2}{Q_0^2} \log\frac{x_0}{x}}$$

for $x < 0.01$ and $Q^2 > 5\ \mathrm{GeV}^2$

- Aim

New F_2 data from H1 at low Q^2

Published : C. Adloff et al., DESY 97-42 (March 1997)

log log behaviour also valid at low Q^2 ?

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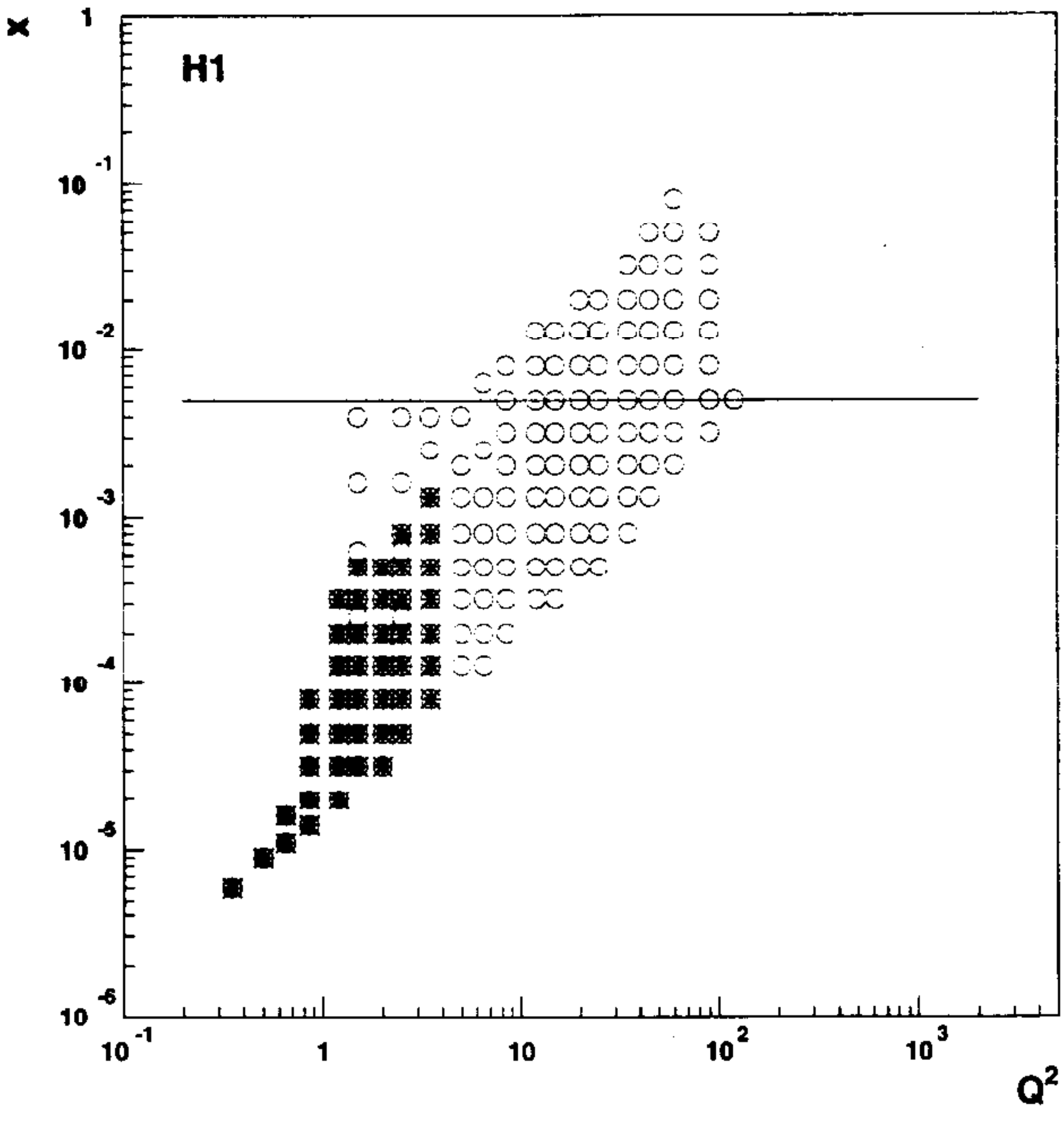


$$\log\frac{Q^2}{Q_0^2} < 0 \quad \text{for} \quad Q^2 < Q_0^2 \approx 0.5\ \mathrm{GeV}^2$$

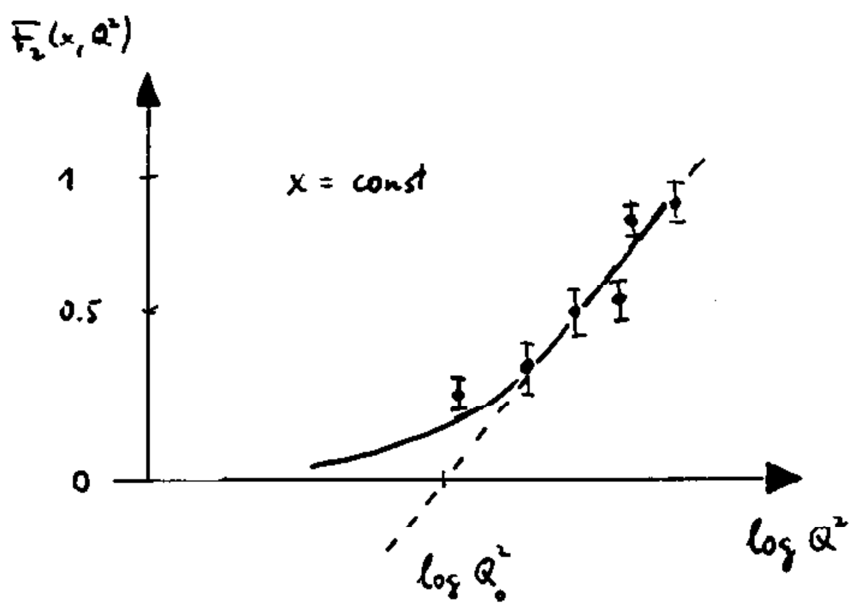
therefore

$$\boxed{\log\frac{Q^2}{Q_0^2} \longrightarrow \log\left(1+\frac{Q^2}{Q_0^2}\right)}$$

No new parameter

For $Q^2 \gg Q_0^2$ reproduce old variable

For $Q^2 \to 0$ $\quad \log\left(1+\frac{Q^2}{Q_0^2}\right) \approx \frac{Q^2}{Q_0^2} \to 0$



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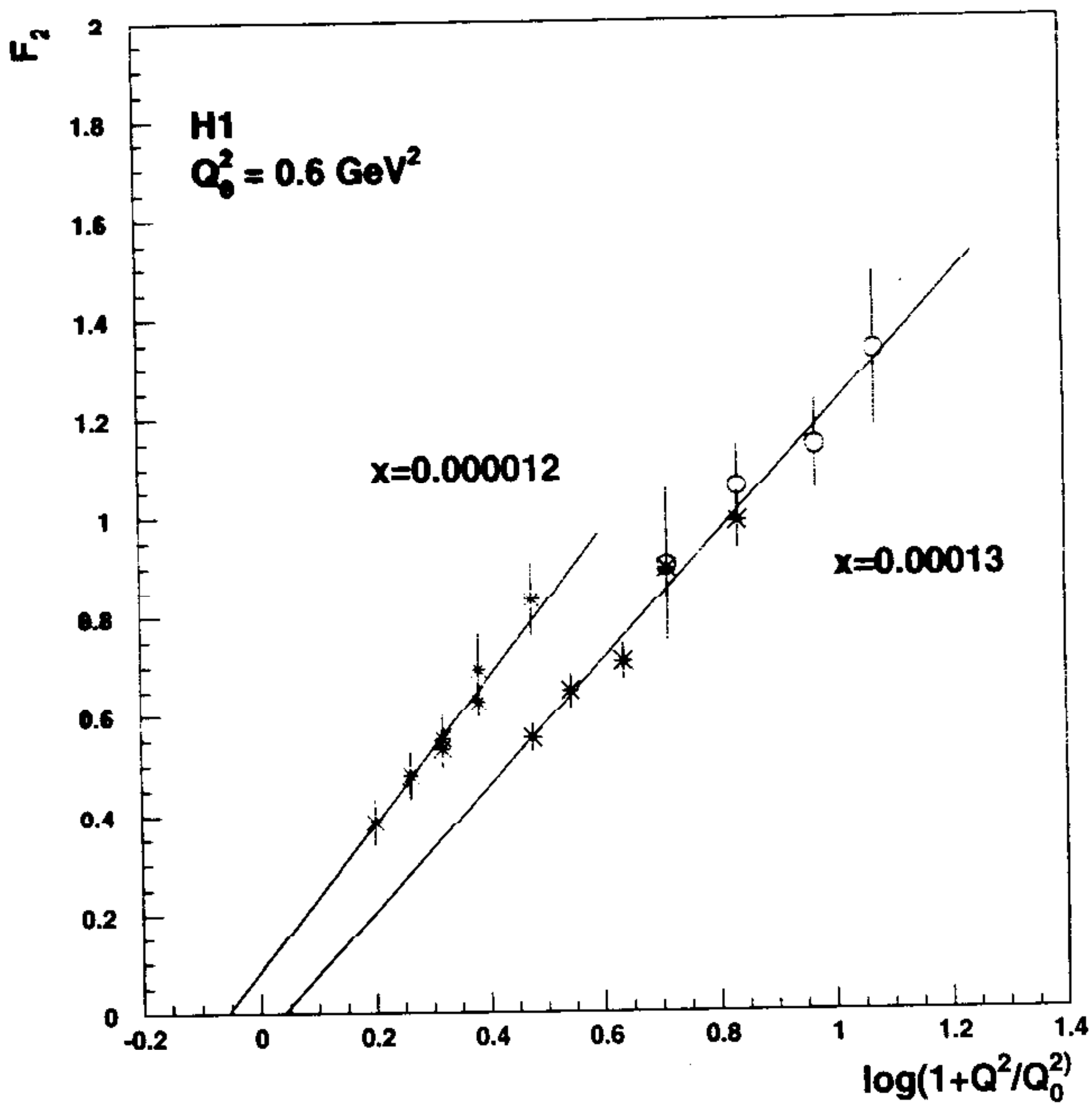
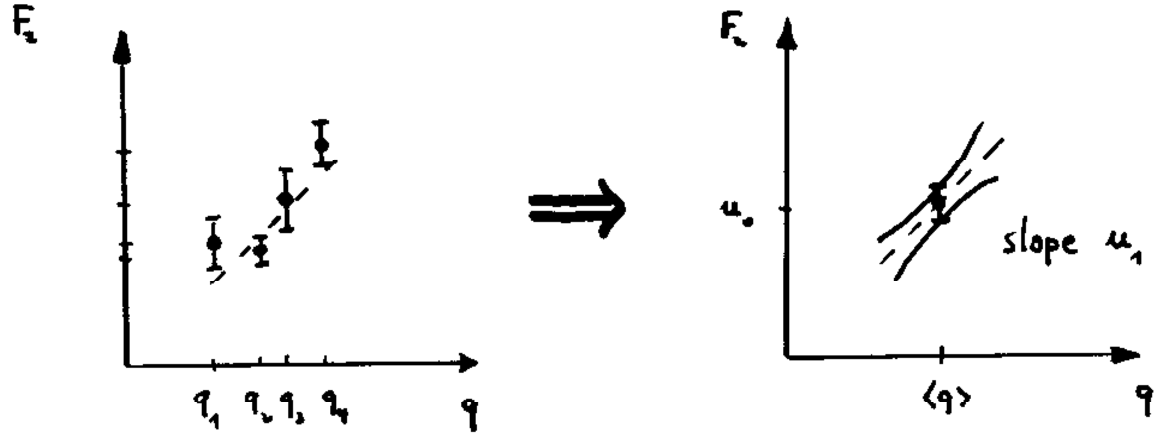


Method

$$X \longrightarrow F_2(x, Q^2) = u_0(x) + u_1(x)\left(q - \langle q\rangle\right)$$

$$q \equiv \log\left(1 + \frac{Q^2}{Q_0^2}\right)$$



<u>Empirical fact #1</u> : Data consistent with linearity in $q = \log\left(1 + \frac{Q^2}{Q_0^2}\right)$ for $Q_0^2 \approx 0.5\ \mathrm{GeV}^2$

Rewrite :

$$F_2(x, Q^2) = \boxed{u_0(x) - u_1(x)\langle q\rangle} + \boxed{u_1(x)}\, q$$

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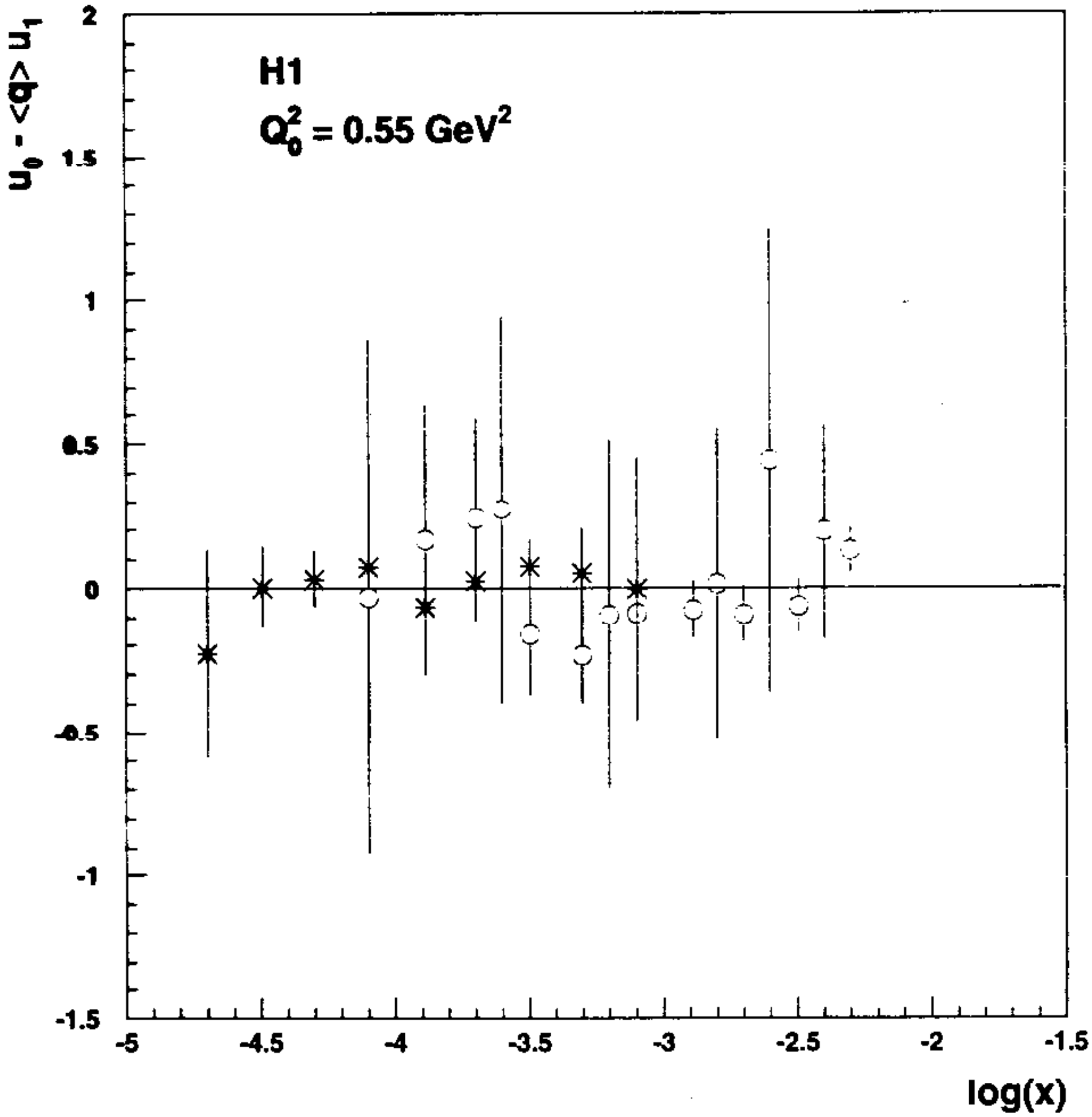

Empirical fact #2 :

For $Q_0^2 \approx 0.5$ GeV^2 $\quad u_0(x) - u_1(x)\langle q\rangle = 0$

within errors for all $x < 0.005$

$$\Rightarrow \quad F_2(x, q) \approx u_1(x)\, q$$

$$u_1(x) \approx \frac{u_0(x)}{\langle q\rangle}$$

measured slope

slope calculated from $(0,0)$ and $(\langle q\rangle, u_0(x))$

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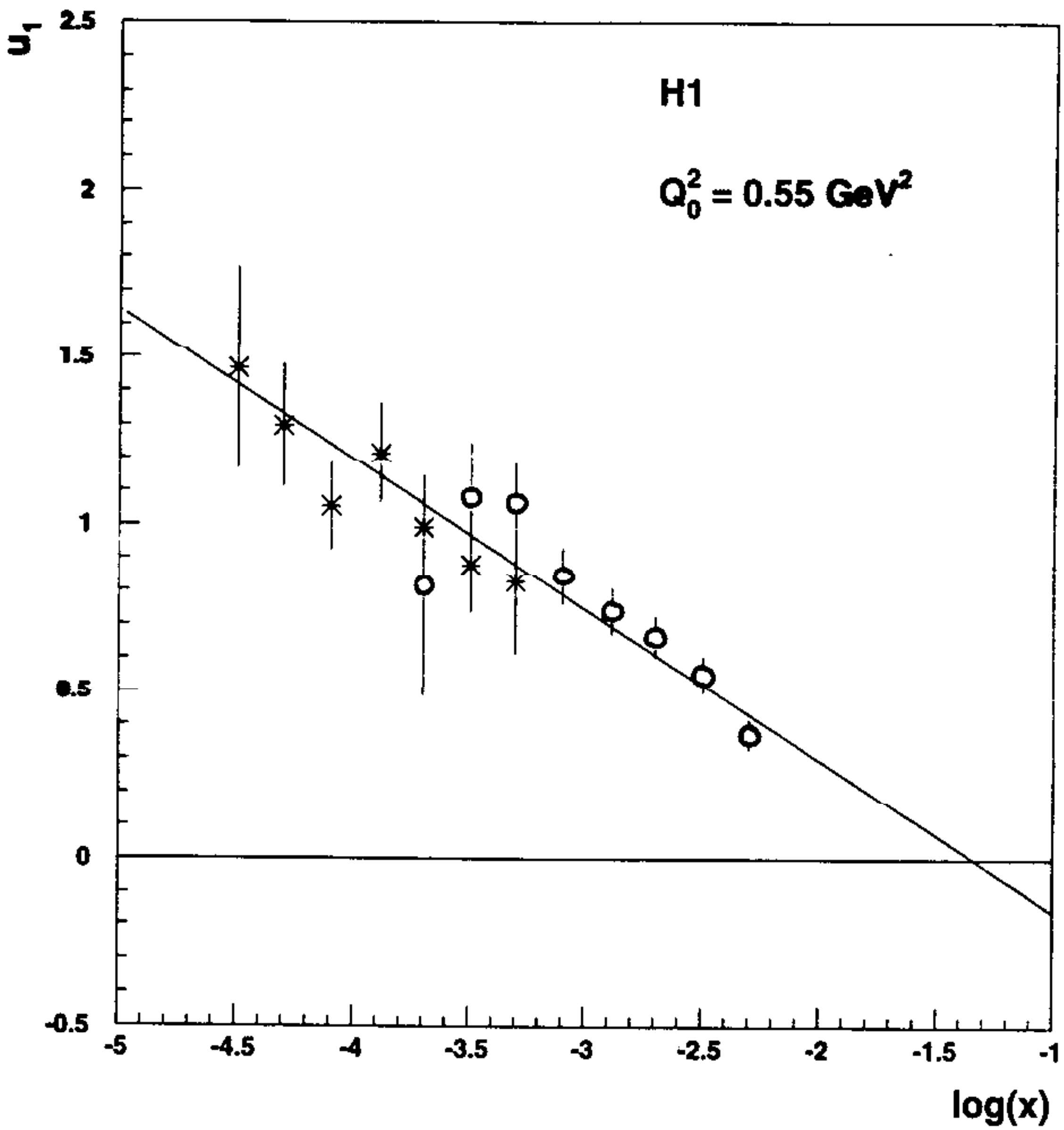

Empirical fact #3:

$$u_1(x) = m \log \frac{x_0}{x} \quad \text{with} \quad x_0 = 0.04 \; , \; m = 0.45$$

Consequences

1. $$F_2(x, \langle q \rangle) = u_0(x) = u_1(x) \langle q \rangle$$
$$= m \log \frac{x_0}{x} \langle q \rangle$$

plot $u_0(x)$ vs $\log \frac{x_0}{x} \langle q \rangle$

2. $F_2(x, Q^2)$ is linear in single variable

$$\xi \equiv \log \frac{x_0}{x} \log \left(1 + \frac{Q^2}{Q_0^2}\right)$$

linear fit in ξ gives $\chi^2/\mathrm{dof} = 63 / 115$

extrapolation $\xi \to 0$ gives -0.004 ± 0.016

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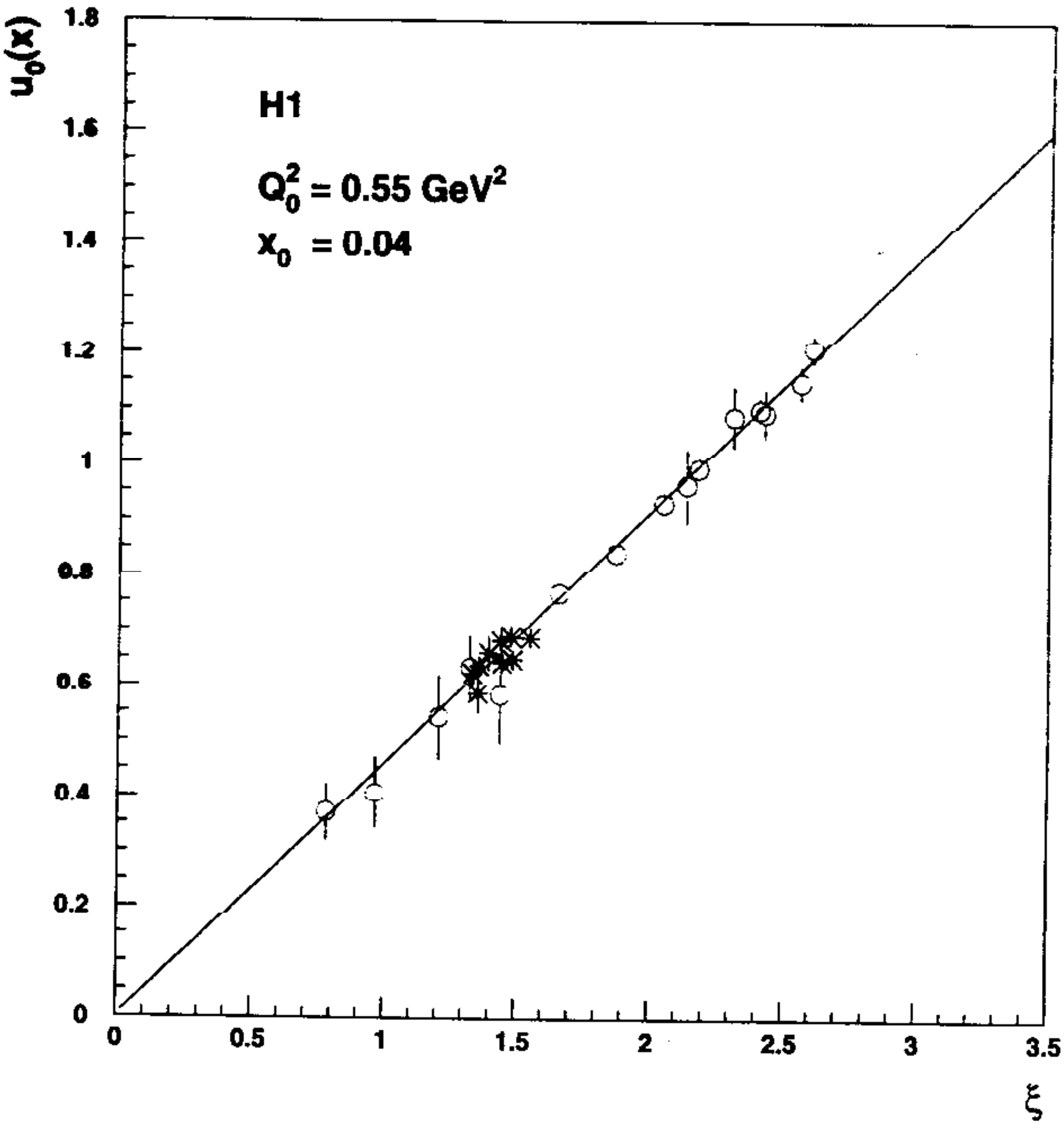
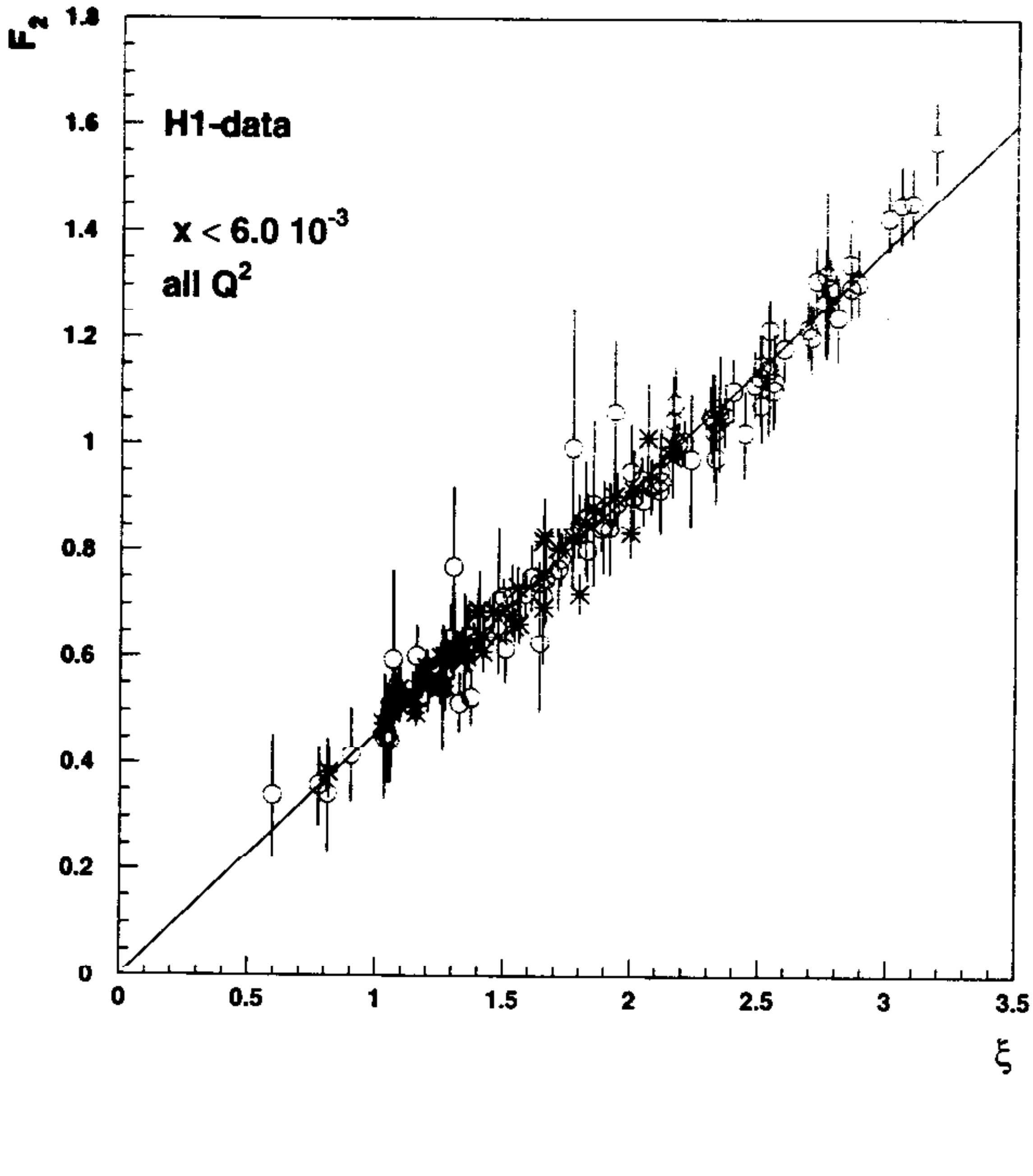


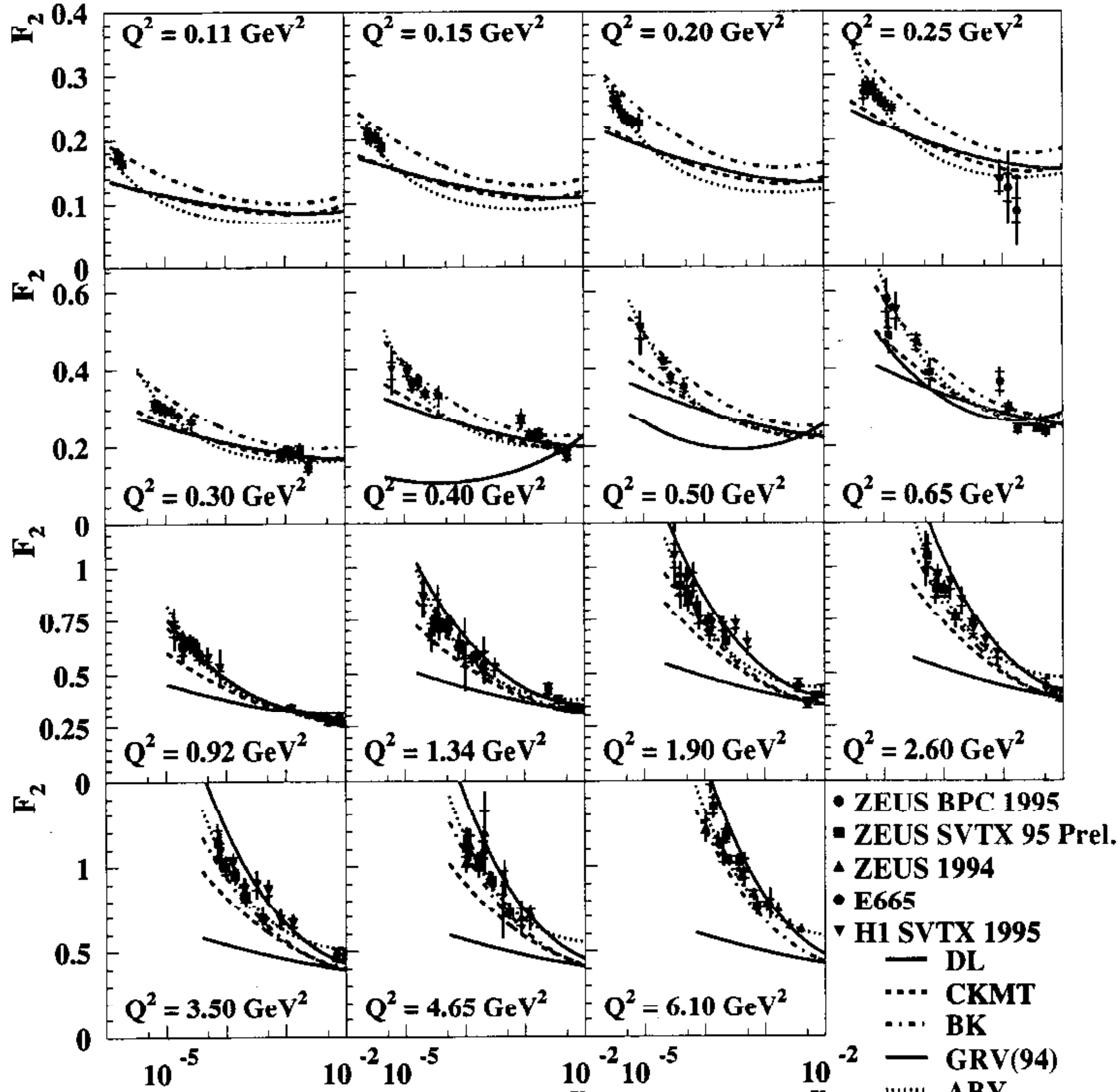
H1
$Q_0^2 = 0.55\ GeV^2$
$x_0 = 0.04$
$u_0(x)$
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
3
3.5
ξ

97/04/10 12.10



H1-data
x < 6.0 10^{-3}
all Q^2
F_2
ξ
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
0.5
1
1.5
2
2.5
3
3.5

ZEUS 1995



F2
0.4
0.3
0.2
0.1
0
$Q^2 = 0.11\ GeV^2$
$Q^2 = 0.15\ GeV^2$
$Q^2 = 0.20\ GeV^2$
$Q^2 = 0.25\ GeV^2$
0.6
0.4
0.2
$Q^2 = 0.30\ GeV^2$
$Q^2 = 0.40\ GeV^2$
$Q^2 = 0.50\ GeV^2$
$Q^2 = 0.65\ GeV^2$
1
0.75
0.5
0.25
$Q^2 = 0.92\ GeV^2$
$Q^2 = 1.34\ GeV^2$
$Q^2 = 1.90\ GeV^2$
$Q^2 = 2.60\ GeV^2$
1
0.5
$Q^2 = 3.50\ GeV^2$
$Q^2 = 4.65\ GeV^2$
$Q^2 = 6.10\ GeV^2$
10^{-5}
10^{-2}
x
ZEUS BPC 1995
ZEUS SVTX 95 Prel.
ZEUS 1994
E665
H1 SVTX 1995
DL
CKMT
BK
GRV(94)
ABY

Add lowest Q^2-data shown yesterday
by B. SURROW (ZEUS)

Q^2	y	F_2^{ZEUS}	linear fit
0.11	0.6	0.163 ± 0.010	0.154
0.11	0.7	0.174 ± 0.012	0.157
0.15	0.4	0.188 ± 0.015	0.190
0.15	0.6	0.200 ± 0.015	0.199

Conclusion

The $F_2(x,Q^2)$ of H1 are consistent with logarithmic behaviour in x and Q^2 for $x < 0.005$:

$$\boxed{\begin{aligned} F_2(x,Q^2) &= m\,\xi \\ \xi &\equiv \log\frac{x_0}{x}\,\log\left(1+\frac{Q^2}{Q_0^2}\right) \end{aligned}}$$

$x_0 = 0.04$

$Q_0^2 = 0.55\ \mathrm{GeV}^2$

$m = 0.455$