THERA WORKING GROUP MEETING, DESY, 14.04.0

SATURATION MODEL

AT

THERA

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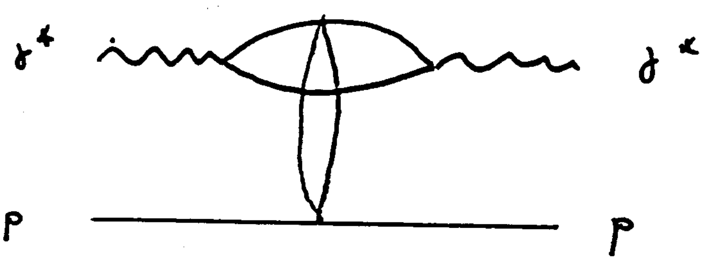
SATURATION MODEL (M. Wüsthoff, K.G-B)

SMALL-X CROSS SECTIONS: $\sigma_{\gamma^* p} \sim \frac{1}{Q^2} F_2(x, Q^2)$

$$\sigma_{\gamma^* p} = \int d^2 r \int_0^1 dz \; |\Psi(Q^2, r, z)|^2 \; \hat{\sigma}(x, r)$$



DIPOLE CROSS SECTION:

$$\hat{\sigma}(x, r) = \sigma_0 \left\{ 1 - e^{\frac{-r^2}{4 R_0^2(x)}} \right\}$$

$$R_0^2(x) = \frac{1}{Q_0^2} \left(\frac{x}{x_0} \right)^{\lambda} \qquad Q_0^2 = 1 \text{ GeV}^2$$

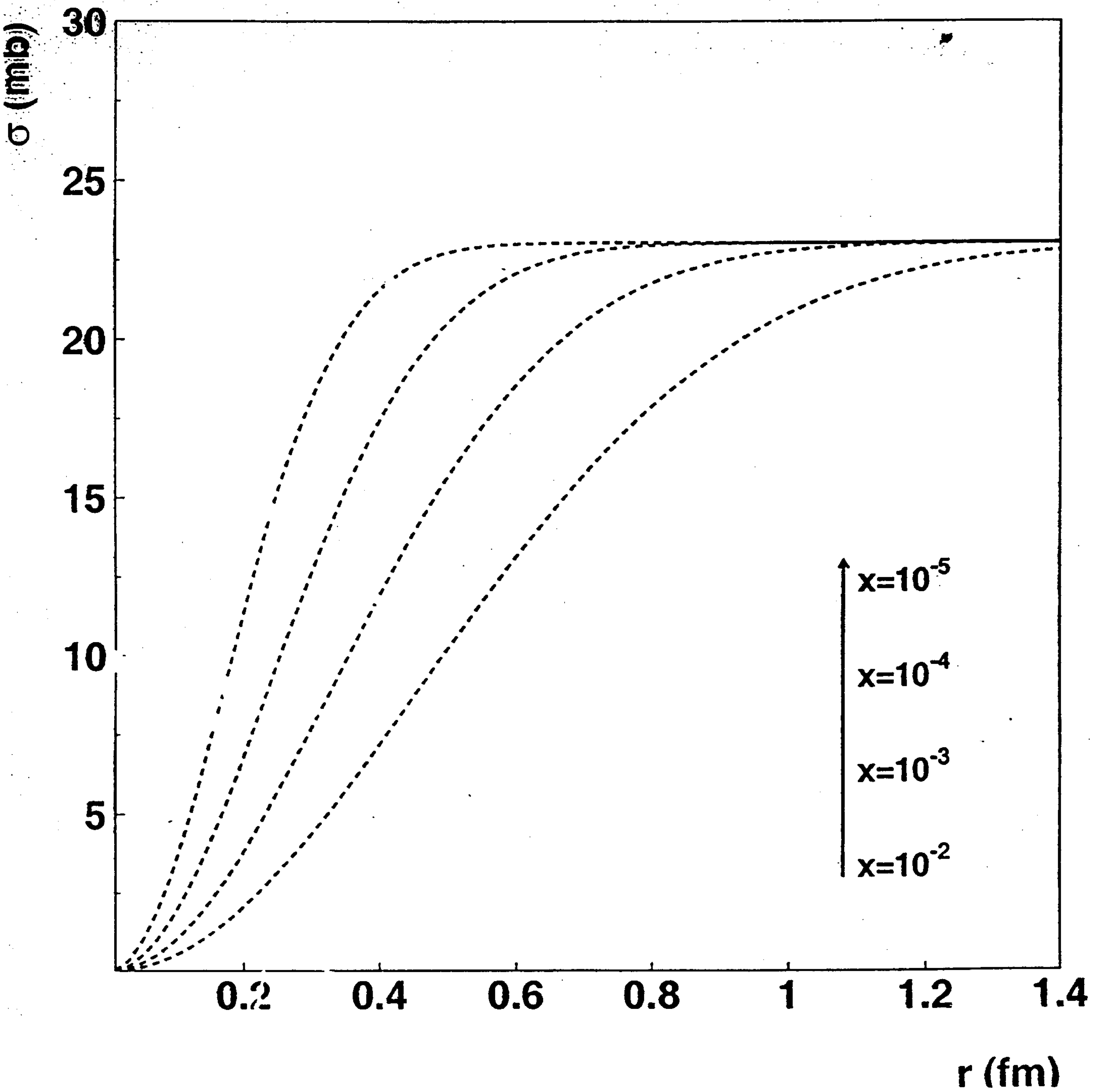
PARAMETERS: σ_0, x_0, λ fitted to inclusive data with $x < 0.01$

WORKS WELL: FOR INCLUSIVE $\gamma^* p$ FOR "0" $< Q^2 <$ 100 GeV^2

ALSO DIFFRACTIVE DIS: $Q^2 > 5$ GeV^2

2.

Dipole cross section



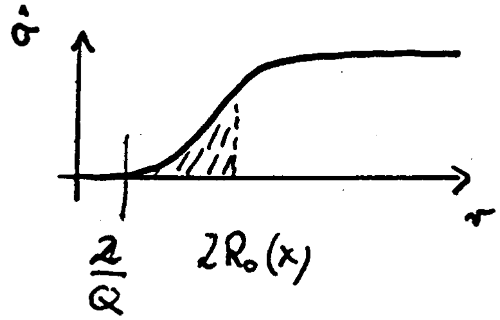
NATURAL EXPLANATION OF TRANSITION FROM:

Q^2	Small	Large
$\sigma_{\gamma^* p}$	σ_0	$\sim \frac{1}{Q^2}$
F_2	$\sim Q^2$	$\sim$ const
	SATURATION	SCALING

TWO SCALES: $\frac{1}{Q}$ $q\bar{q}$ dipole transverse size

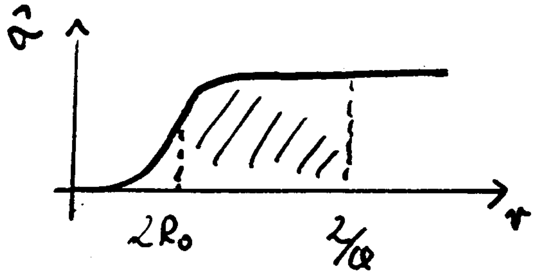
$R_0(x)$ mean distance between partons

1) $\frac{1}{Q} \ll R_0(x)$



$$\sigma \sim \int_{4/Q^2}^{4R_0^2} \frac{dr^2}{r^2} \left(\frac{1}{Q^2 r^2}\right)\left(\frac{\sigma_0 r^2}{4R_0^2(x)}\right) \sim \underbrace{\frac{\sigma_0}{Q^2 R_0^2(x)}}_{\text{SCALING}} \cdot \log(Q^2 R_0^2)$$

2) $\frac{1}{Q} \gg R_0(x)$



$$\sigma \sim \int_{4R_0^2}^{4/Q^2} \frac{dr^2}{r^2}\, \sigma_0 \sim \underbrace{\sigma_0}_{\text{SATURATION}} \log \frac{1}{Q^2 R_0^2}$$

CRITICAL LINE IN (x, Q^2) - PLANE

$$\underbrace{\frac{1}{Q} = R_0(x)} = \frac{1}{1\,\mathrm{GeV}} \cdot \left(\frac{x}{x_0}\right)^{\lambda/2}$$

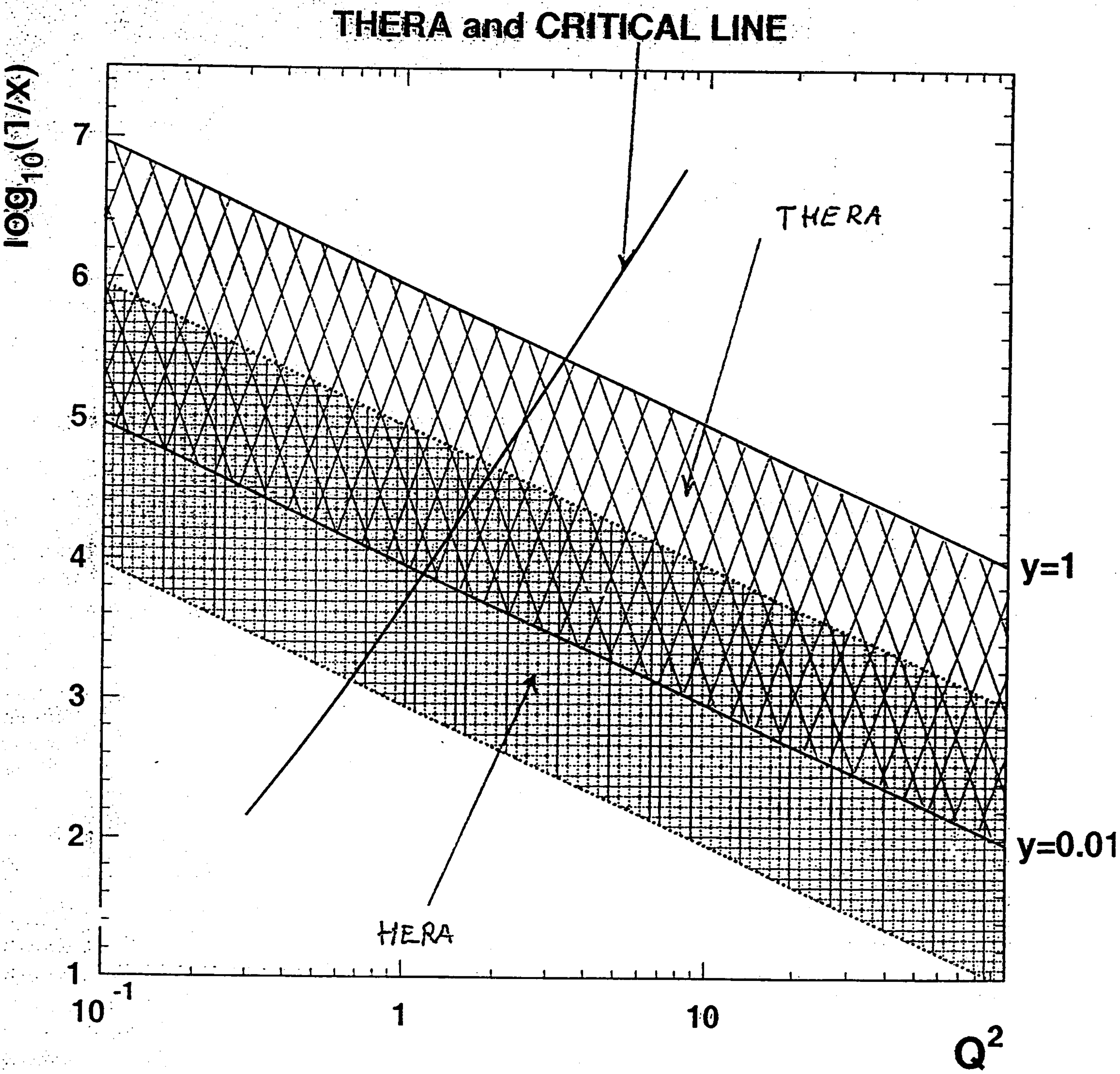
INDICATES TRANSITION FROM SCALING TO SATURATION

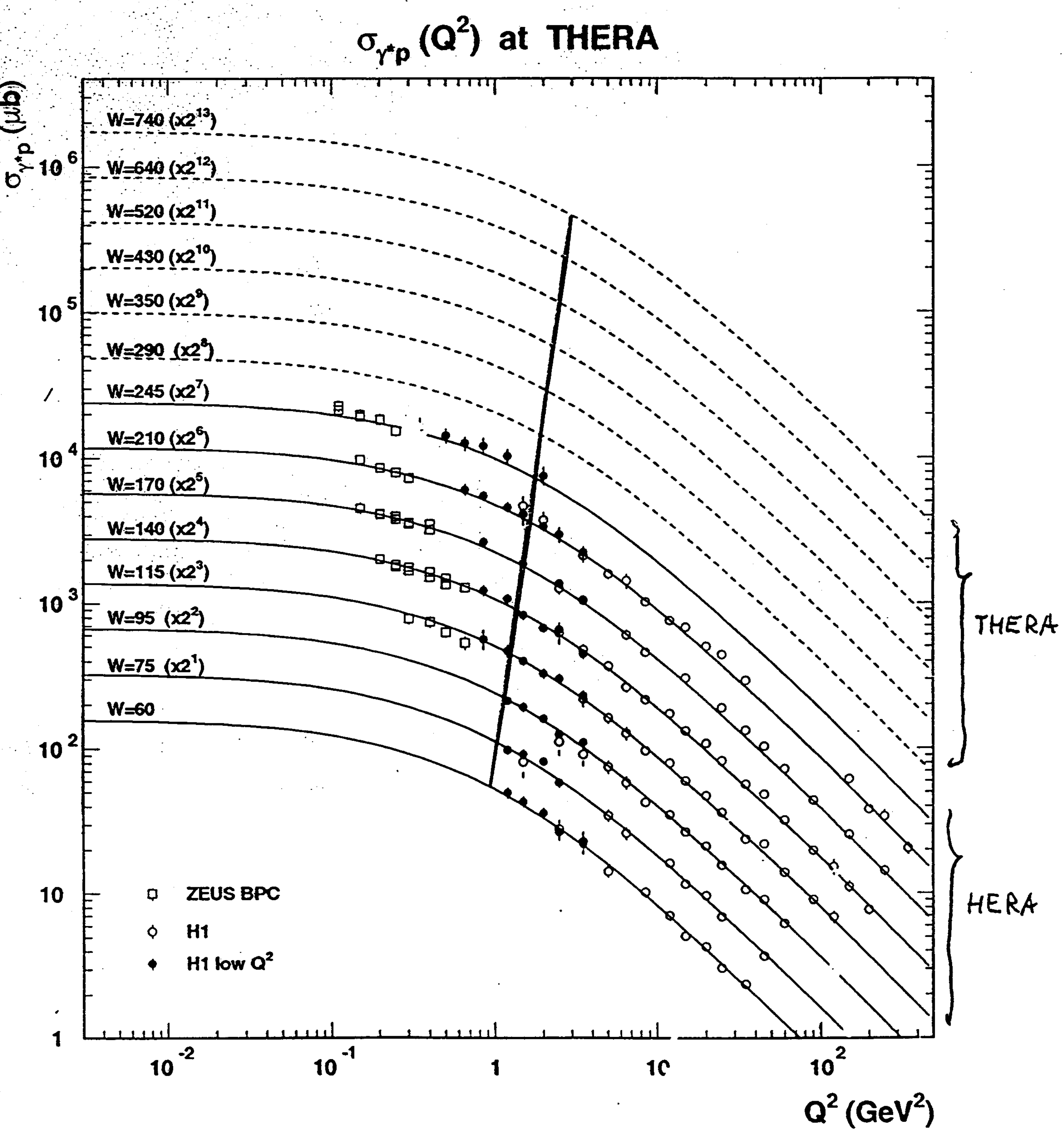
HERA : $\sim Q^2 \sim 1-2\ \mathrm{GeV}^2$

THERA : $Q^2 \sim 2-3\ \mathrm{GeV}^2$

AT THERA TRANSITION TO SATURATION MORE PERTURBATIVE.

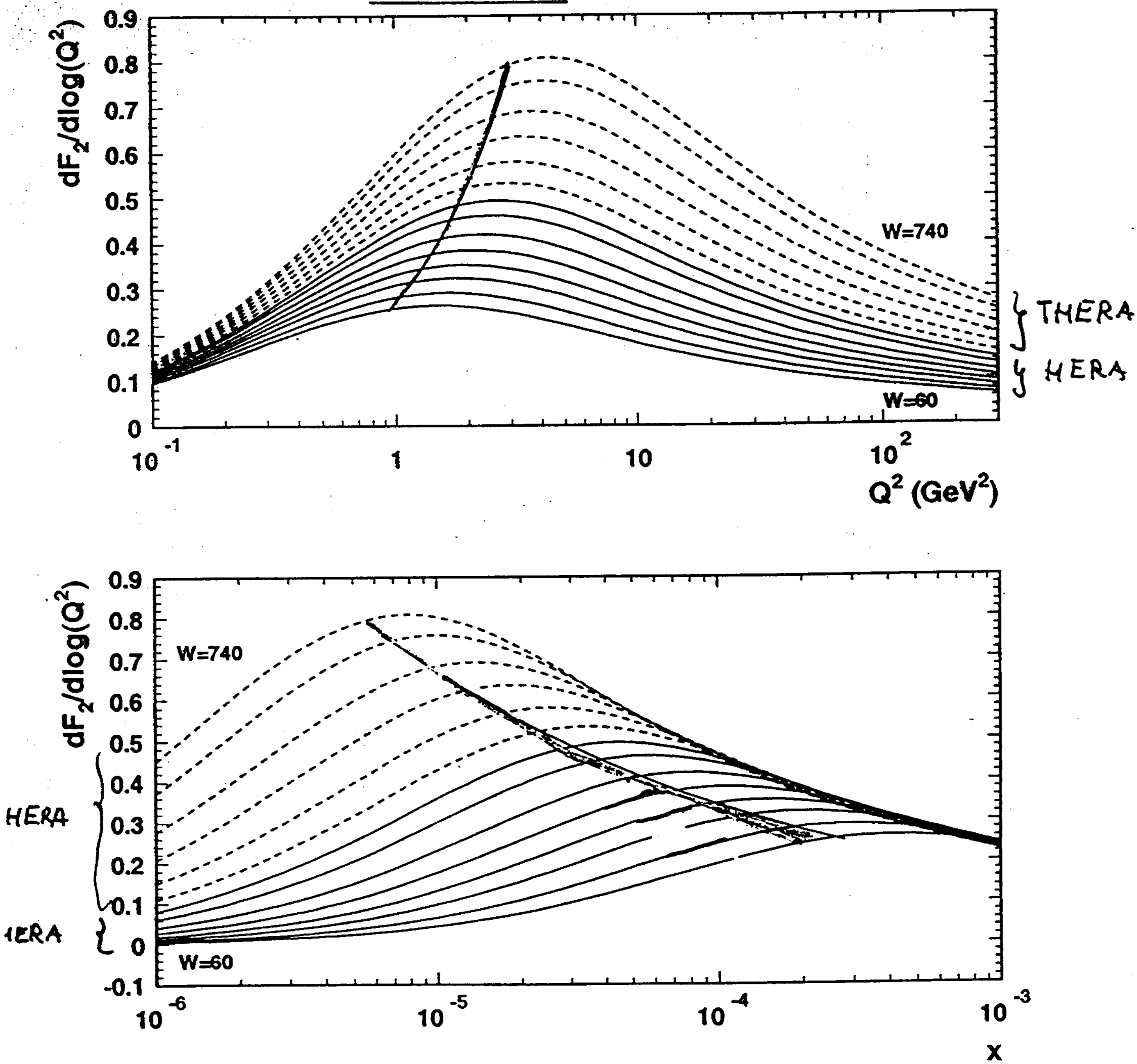
fig 5.


THERA and CRITICAL LINE
$\log_{10}(1/X)$
7
6
5
4
3
2
1
10^{-1}
1
10
Q^2
THERA
HERA
y=1
y=0.01

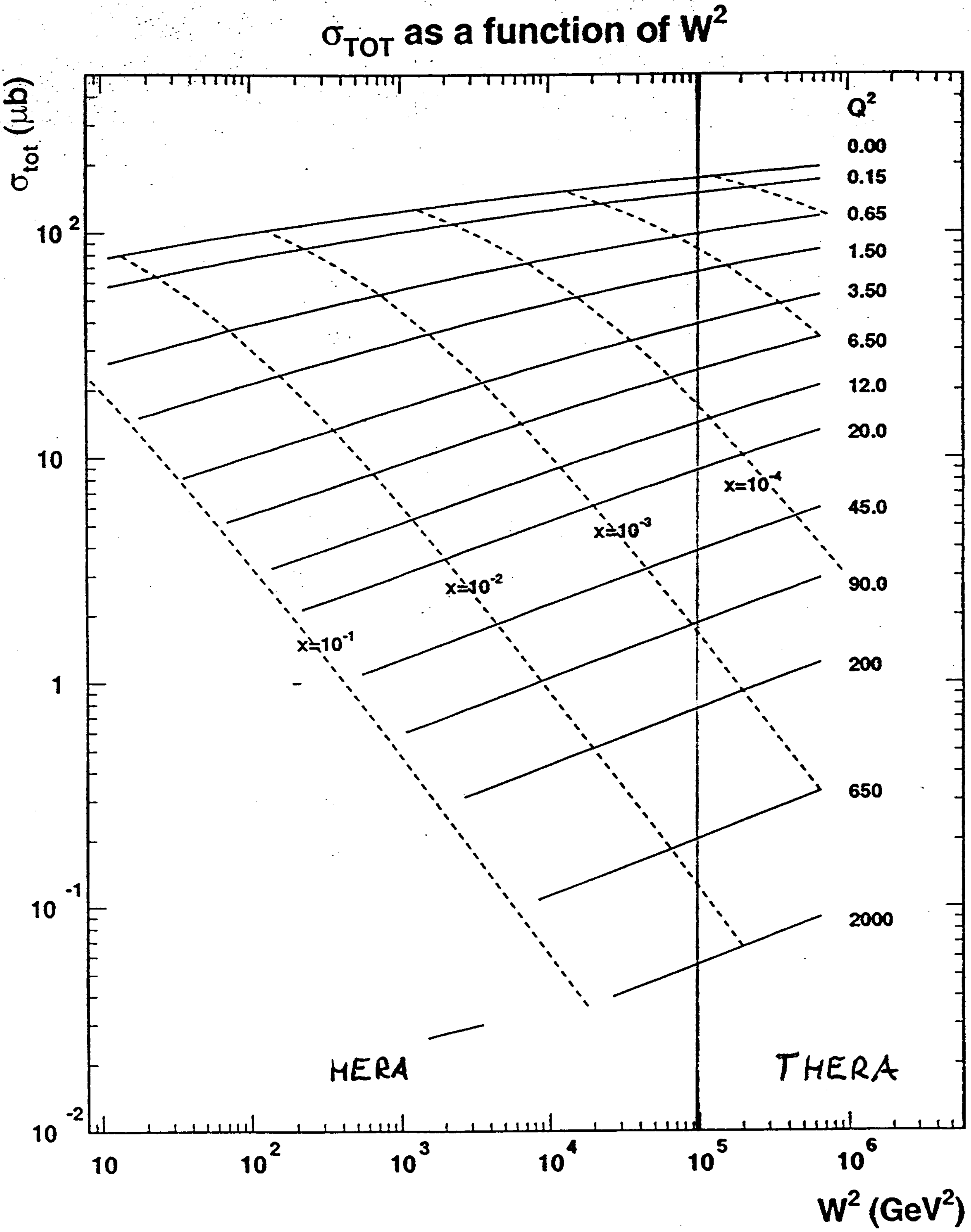


PREDICTION FROM SATURATION MODEL

dF₂/dlogQ² at THERA

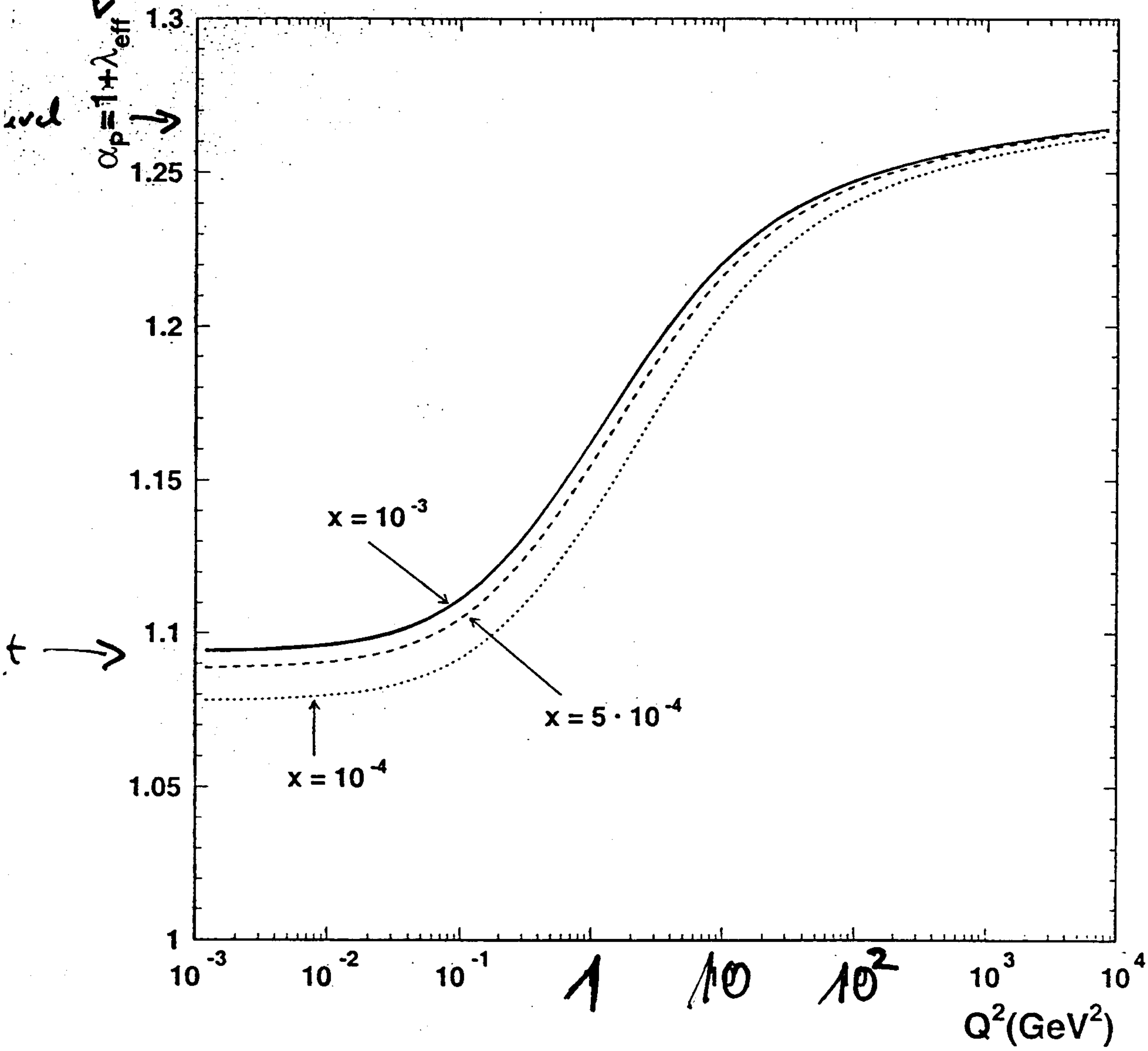


PREDICTIONS FROM SATURATION MODEL



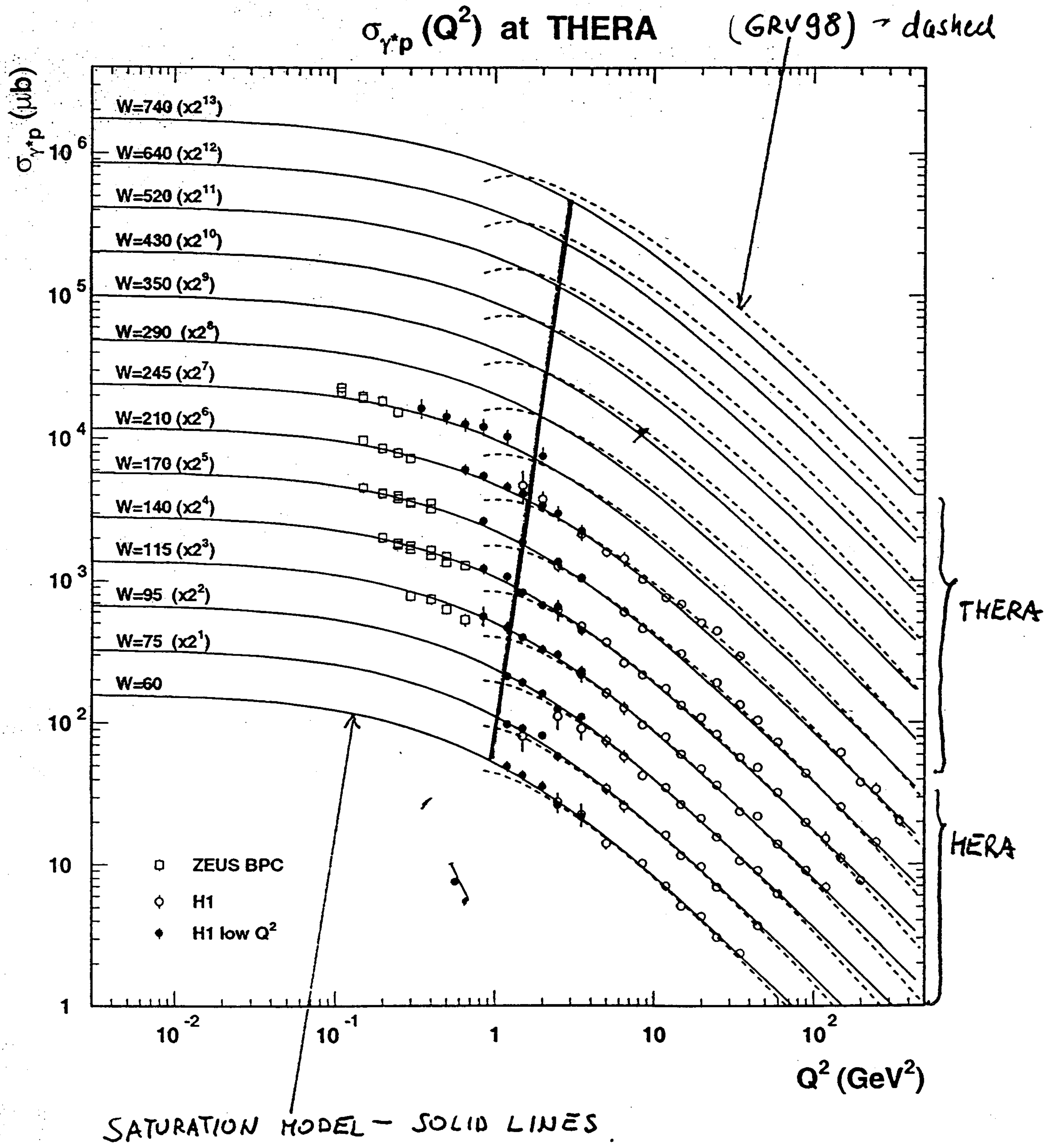
PREDICTIONS FROM SATURATION MODEL

$\alpha_P = 1 + \lambda_{eff}$



Effective Pomeron intercept computed from

$$\sigma^{Inc} \sim (W^2)^{\alpha_P - 1}$$



$\sigma_{\gamma^*p}(Q^2)$ at THERA
(GRV98) → dashed
σ_{γ^*p} (μb)
W=740 (x2^13)
W=640 (x2^12)
W=520 (x2^11)
W=430 (x2^10)
W=350 (x2^9)
W=290 (x2^8)
W=245 (x2^7)
W=210 (x2^6)
W=170 (x2^5)
W=140 (x2^4)
W=115 (x2^3)
W=95 (x2^2)
W=75 (x2^1)
W=60
ZEUS BPC
H1
H1 low Q^2
THERA
HERA
Q^2 (GeV^2)
SATURATION MODEL – SOLID LINES.

MVJT 15

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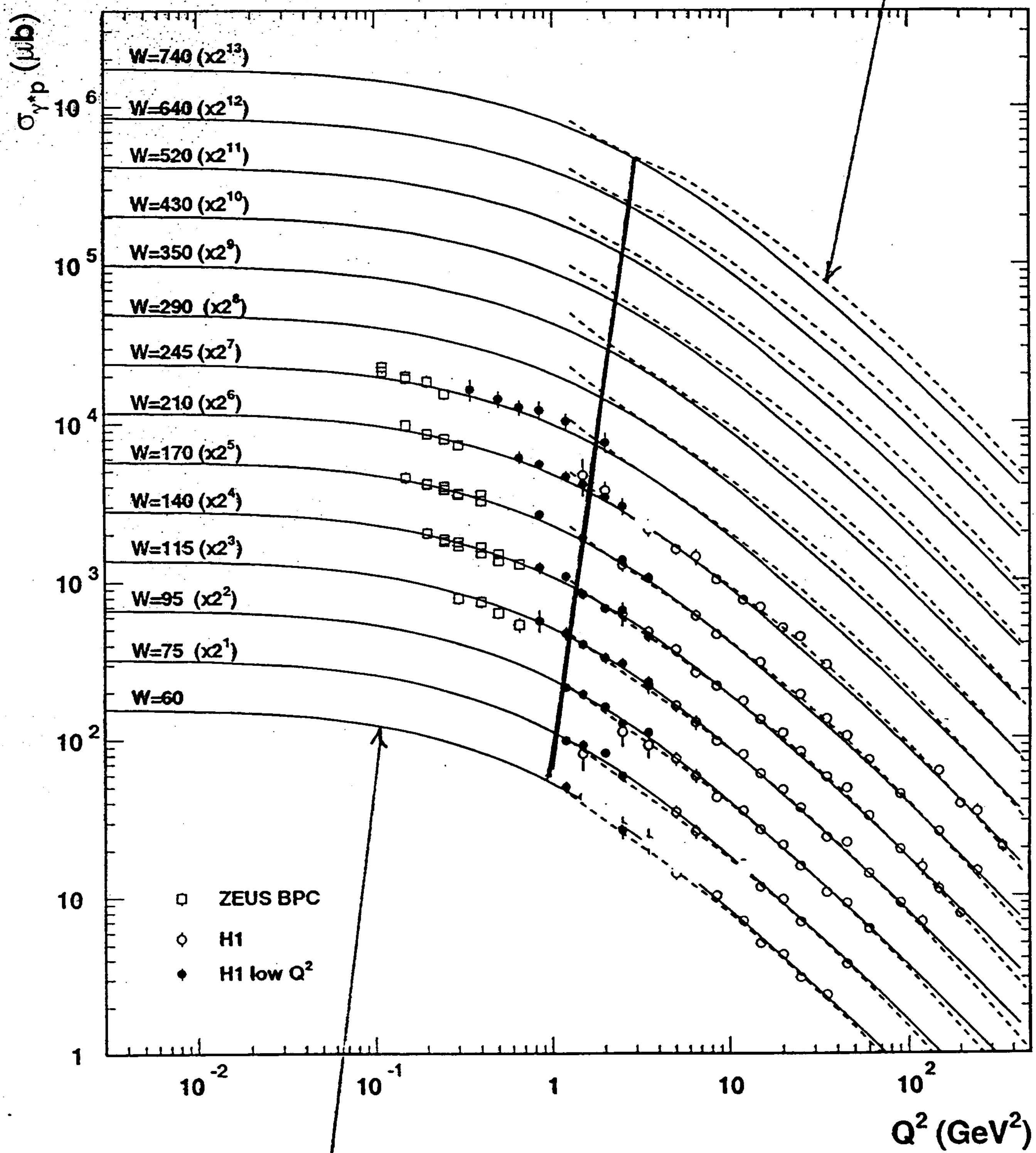
$\sigma_{\gamma^* p}(Q^2)$ at THERA

(HRST 99) - dashed



THERA

HERA

SATURATION MODEL - SOLID LINES.

CONCLUSIONS I

- THERA WILL ALLOW TO STUDY TRANSITION TO SATURATION OF $\sigma_{\gamma^* p}$ (STRUCTURE FUNCTIONS)

  (PERTURBATIVE $\longleftrightarrow$ NONPERTURBATIVE)

  IN A BROAD RANGE OF W^2 FOR HIGHER Q^2.
  (~ 3 GeV² – pQCD applies).

- UNITARIZATION WITHIN PERTURBATIVE QCD: CENTRAL ISSUE FOR DETAILED STUDIES.

• THE TRANSITION LOW $Q^2 \longleftrightarrow$ HIGH Q^2 CANNOT BE ADDRESSED BY PURE LEADING TWIST DGLAP ANALYSIS.

$F_L(x,Q^2)$ MEASUREMENT

① ACCEPTANCE REGIONS OF HERA AND THERA OVERLAP

$$\frac{d\sigma}{dx\,dQ^2}(s_H) = \frac{2\pi^2\alpha}{xQ^4}\left\{\left[1+(1-y_H)^2\right]\underline{F_2(x,Q^2)} - y_H^2\,\underline{F_L(x,Q^2)}\right\}$$

$$\frac{d\sigma}{dx\,dQ^2}(s_{TH}) = \frac{2\pi^2\alpha}{xQ^4}\left\{\left[1+(1-y_{TH})^2\right]\underline{F_2(x,Q^2)} - y_{TH}^2\,\underline{F_L(x,Q^2)}\right\}$$

$$y = \frac{W^2}{S} \longleftarrow S_H,\ S_{TH}$$

SOLVE F_2, F_L.

② IN SATURATION MODEL F_L HAS LARGE AND NEGATIVE TWIST-4

$$F_L = F_L^{(2)} - \Delta F_L^{(4)}$$

CAN WE SEE THIS AT THERA ?

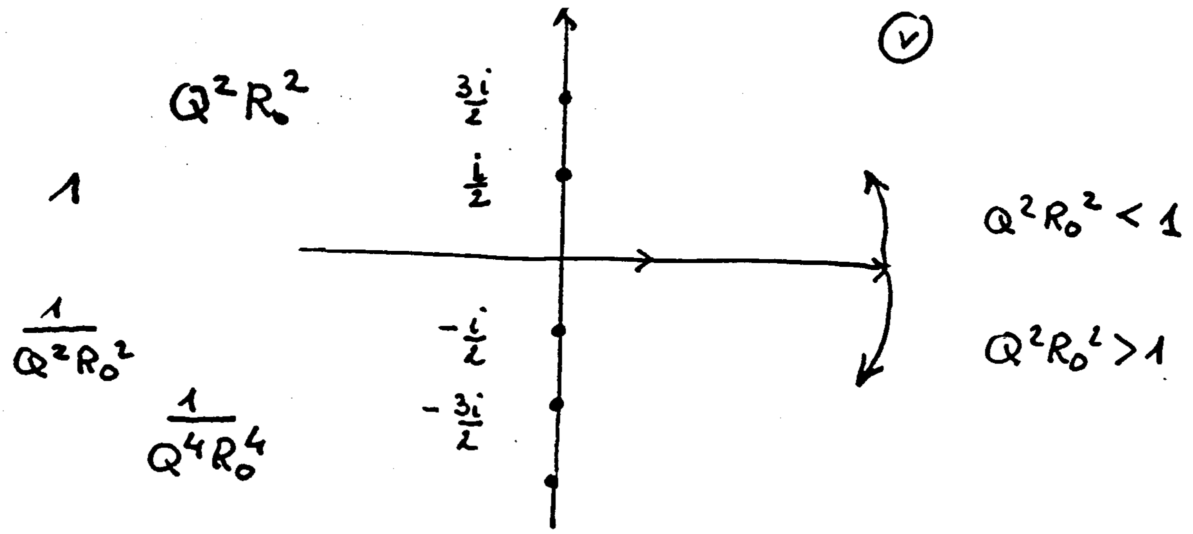
$\gamma^* p$ CROSS SECTION IN MELLIN REPRESENTATION

$$\sigma_{T,L}(x,Q^2) = \int d^2r \, dz \; |\Psi(r,z)|^2 \; \hat{\sigma}(x,r)$$

$\downarrow$ MELLIN TRANSFORM $r \Leftrightarrow \nu$

$$\sigma_{T,L}(x,Q^2) = \int_{-\infty}^{\infty} \frac{d\nu}{2\pi} \left[\frac{1}{Q^2R_0^2}\right]^{\frac{1}{2}+i\nu} H_{T,L}(\nu)$$

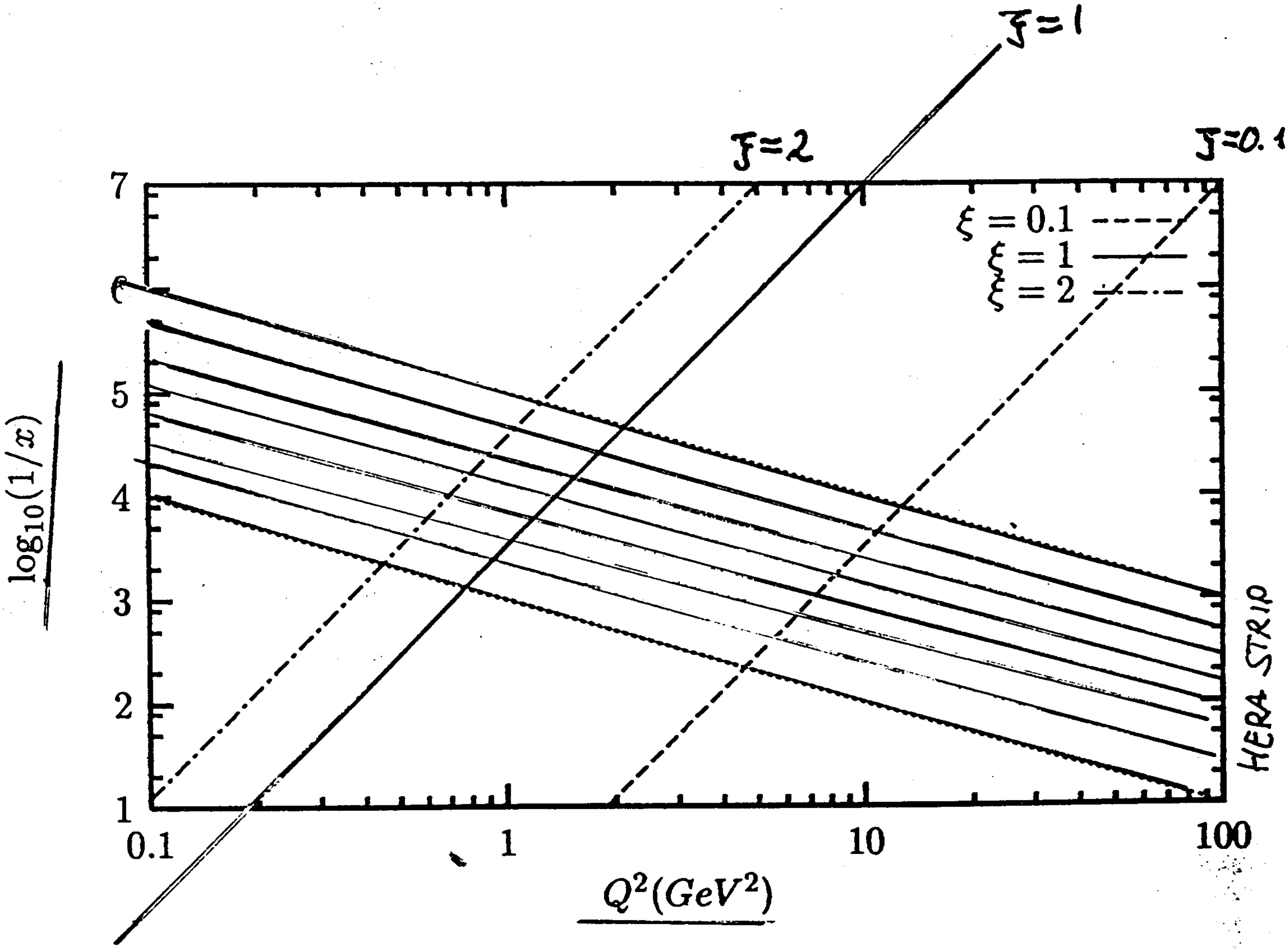
POLES IN COMPLEX ν-PLANE FROM $H_{T,L}(\nu)$



FOR $Q^2R_0^2 > 1$: TWIST EXPANSION $\left(\frac{1}{Q^2R_0^2}\right)^n$

FOR $Q^2R_0^2 < 1$: EXPANSION IN $(Q^2R_0^2)^n$

ANOTHER MOTIVATION FOR CRITICAL LINE



CRITICAL LINE

$Q^2 R_0^2(x) = \frac{1}{\xi} = 1$

TWIST ANALYSIS IN SATURATION MODEL

(J. BARTELS, K.G-B. K. PETERS)

hep-ph / 0003042

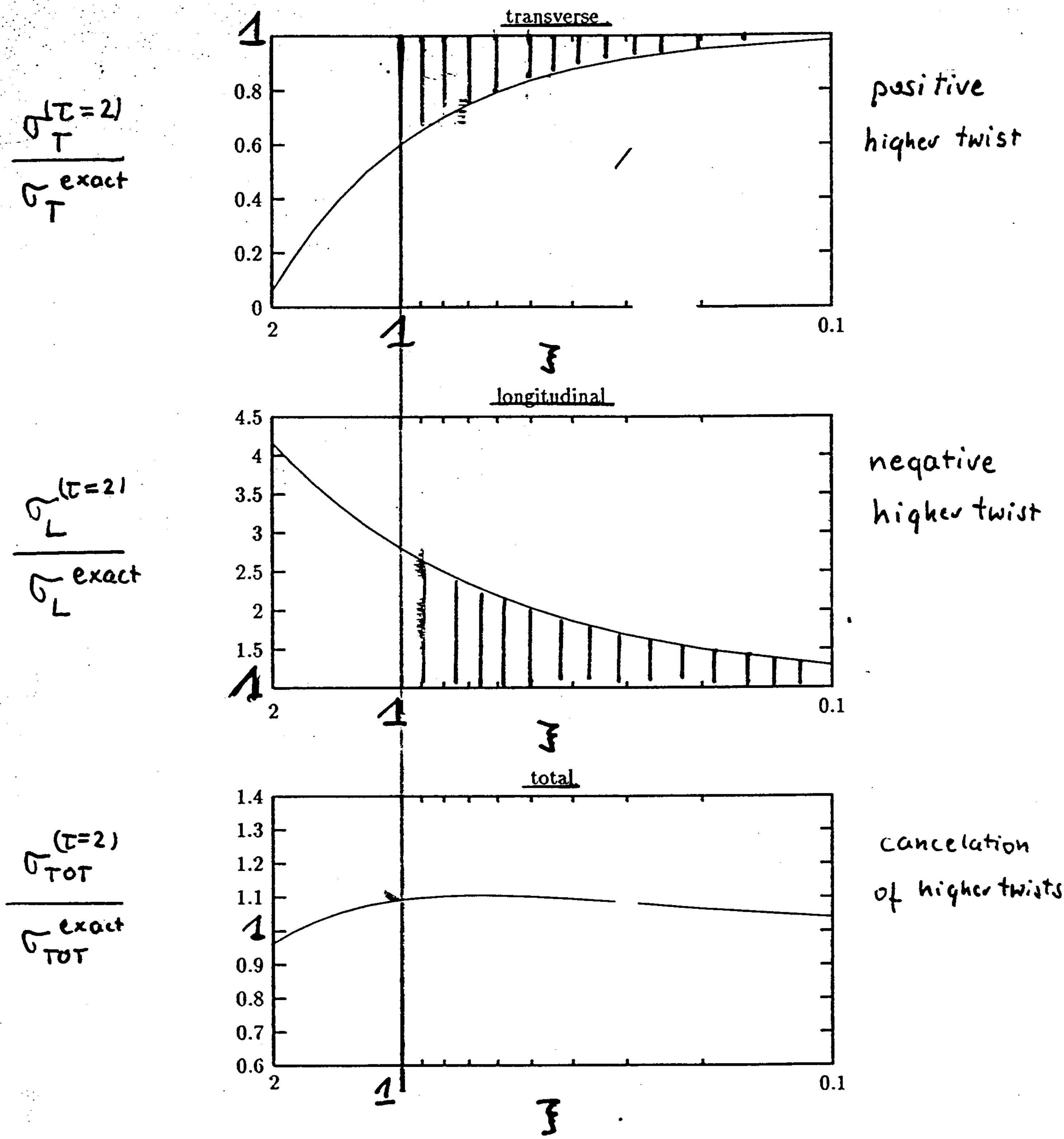


FIG. 4: The ratio of the leading-twist and the exact cross section in the saturation model: for the transverse, $\sigma_T^{\tau=2}/\sigma_T$, longitudinal, $\sigma_L^{\tau=2}/\sigma_L$, and the total, $\sigma_{T+L}^{\tau=2}/\sigma_{T+L}$, cross sections.

LONGITUDINAL SF

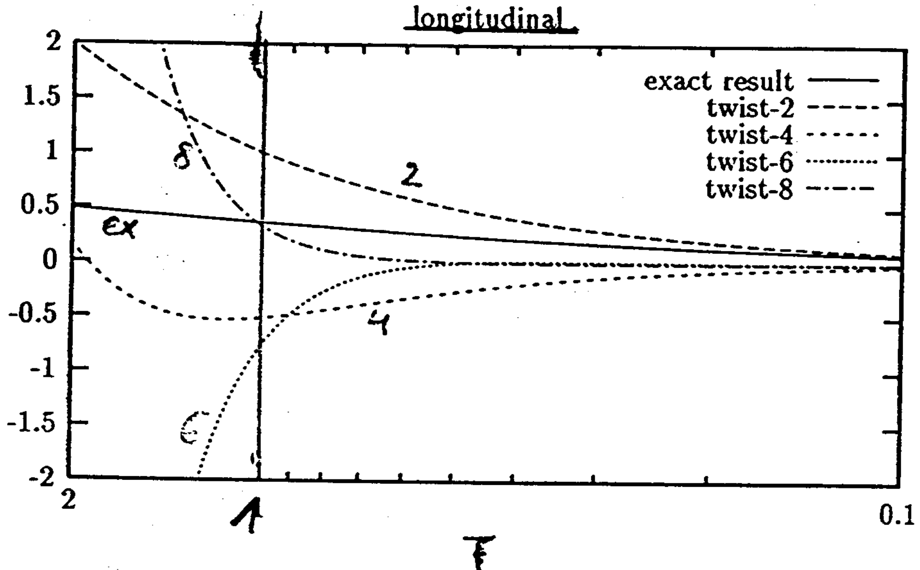
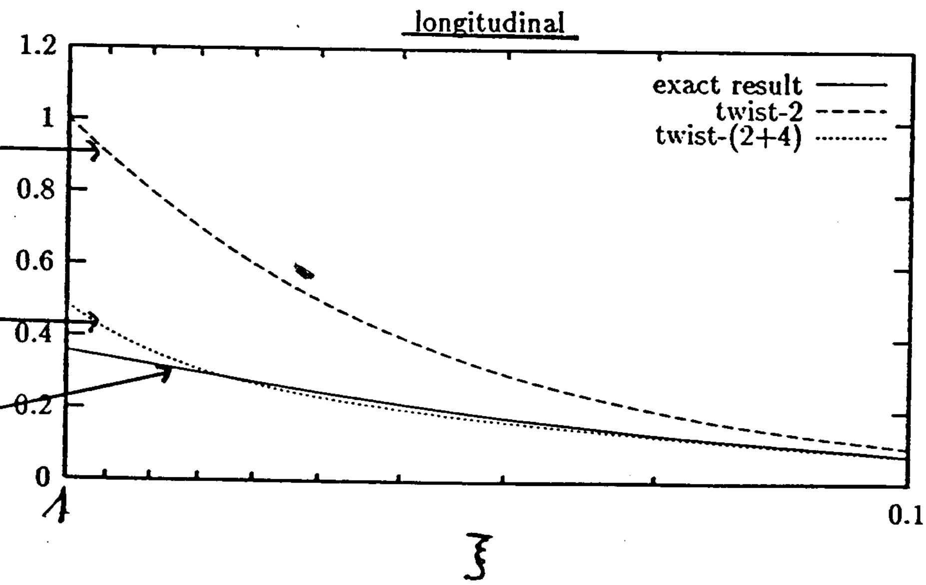


FIG. 7: The exact longitudinal cross section (solid line) and the higher twist logitudinal contributions in the saturation model as a function of the parameter ξ. The cross sections are renormalized by a common factor.

$\tau = 2$

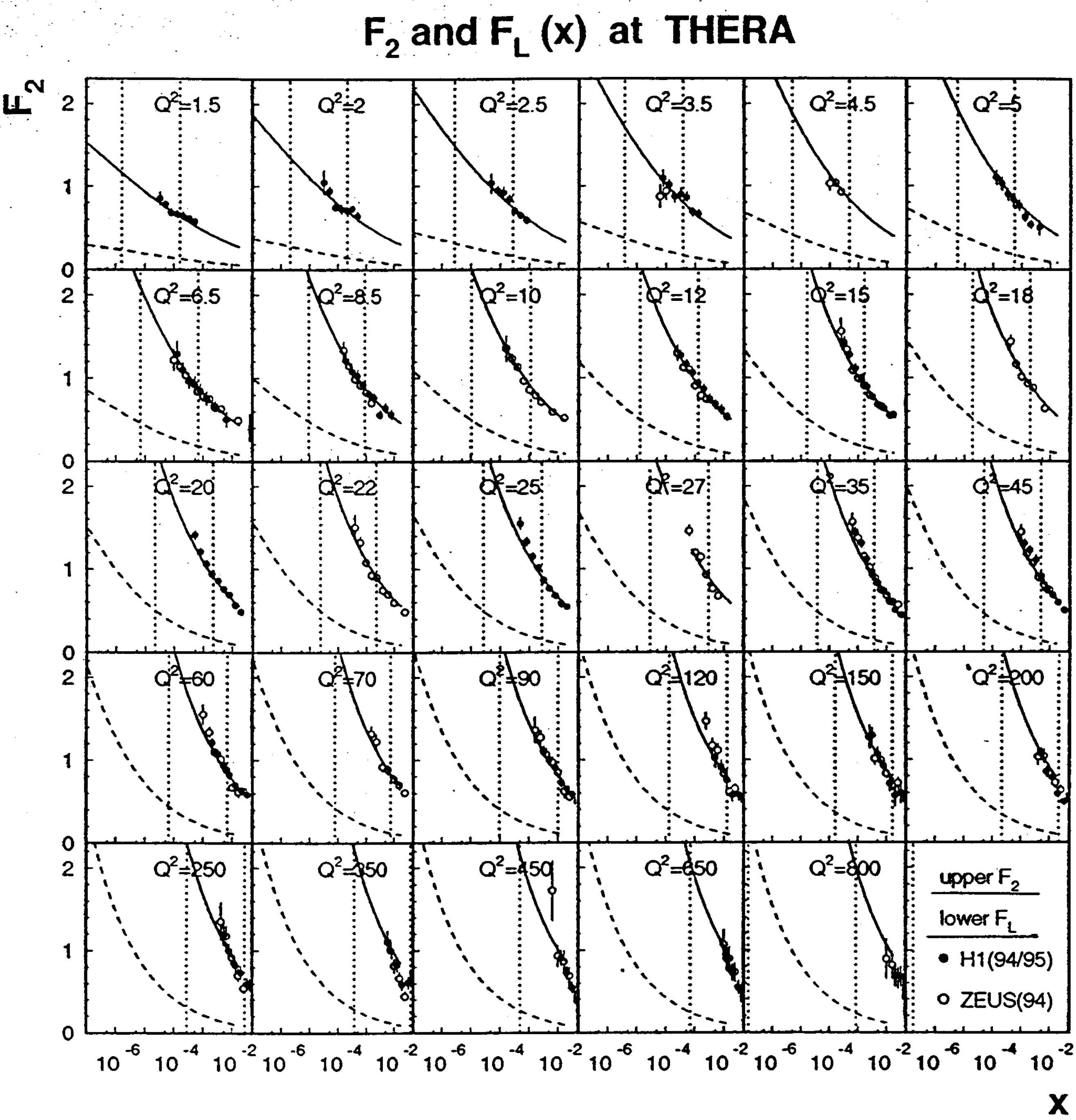
$\tau = (2+4)$

exact



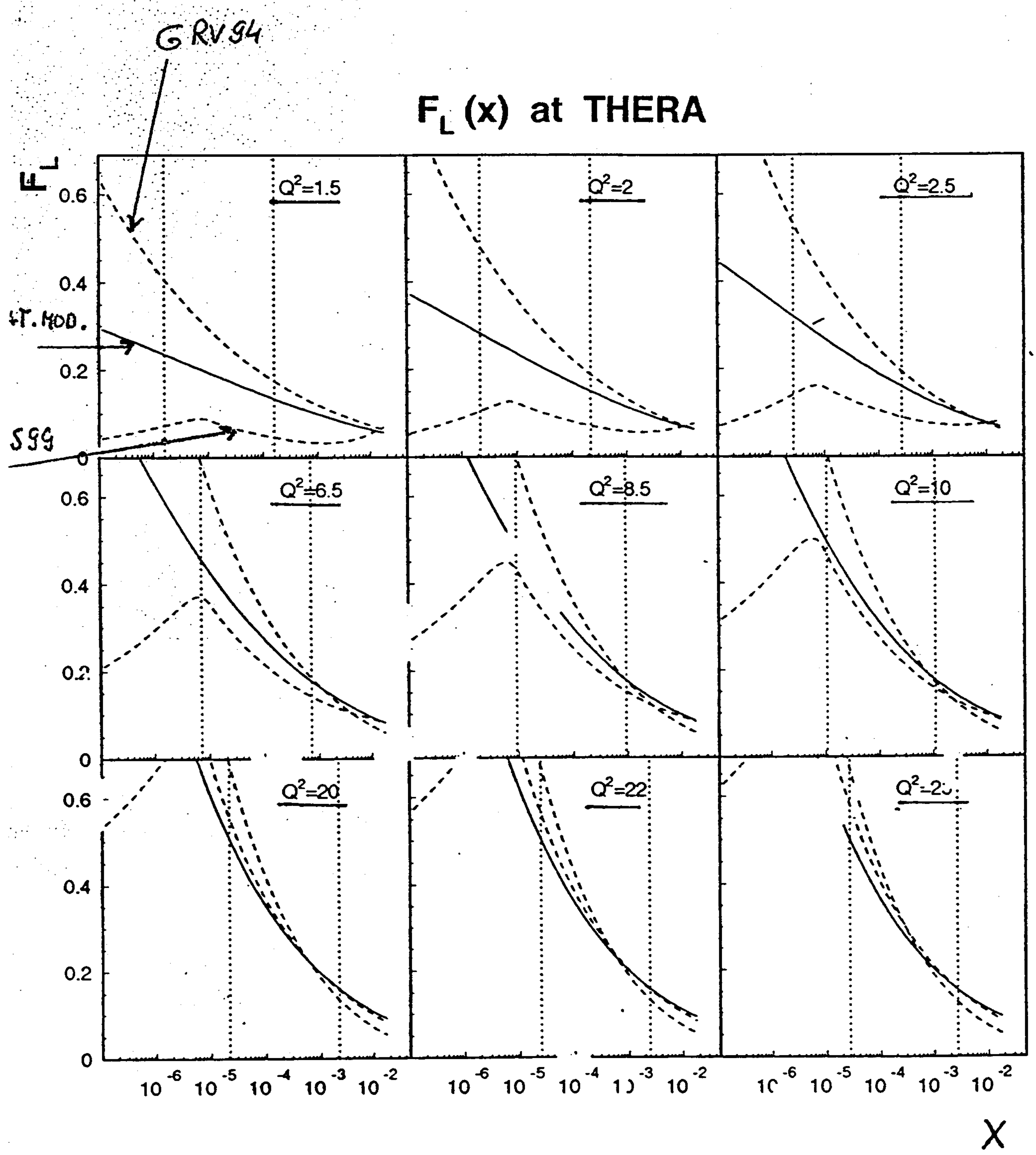
Large and negative twist-4

FIG. 8: The same as in Fig. 7 but with the leading twist and twist-4 added (dotted line).



SATURATION MODEL: F_2 - SOLID LINES

F_L - DASHED LINES


GRV94
F_L (x) at THERA
F_L
ST. MOD.
SGG
Q²=1.5
Q²=2
Q²=2.5
Q²=6.5
Q²=8.5
Q²=10
Q²=20
Q²=22
0.6
0.4
0.2
0
10⁻⁶ 10⁻⁵ 10⁻⁴ 10⁻³ 10⁻²
X

CONCLUSIONS II

- F_L CAN BE MEASURED AT THERA BY THE COMPARISON WITH HERA RESULTS IN COMMON ACCEPTANCE REGIION.

- F_L SIGNIFICANTLY MORE SENSITIVE TO HIGHER TWIST (DEVIATION FROM CONVENTIONAL DGLAP DESCRIPTION) FOR $Q^2 > 1$ GeV^2. THAN F_2. THIS CAN BE STUDIED AT THERA.