DESY, 19.10.2000

# GEOMETRIC SCALING AT SMALL X

A. STAŚTO
J. KWIECIŃSKI
K. G-B

$\Big\}$ hep-ph/0007192

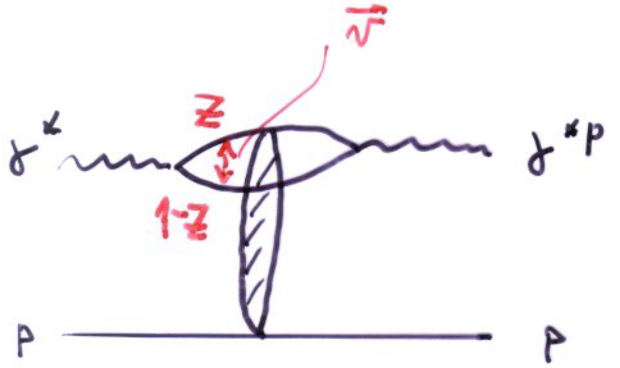
by

K. Golec-Biernat

# DIPOLE PICTURE OF SMALL-X SCATTERING

$$F_2 = \frac{Q^2}{4\pi^2 \alpha_{em}} \left( \sigma_T^{\gamma^* p} + \sigma_L^{\gamma^* p} \right)$$

$$\sigma_{T,L}^{\gamma^* p} = \int d^2r \, dz \, |\Psi_{T,L}(z, r, Q)|^2 \, \underbrace{\hat{\sigma}(x, r)}_{\text{DIPOLE CROSS SEC.}}$$



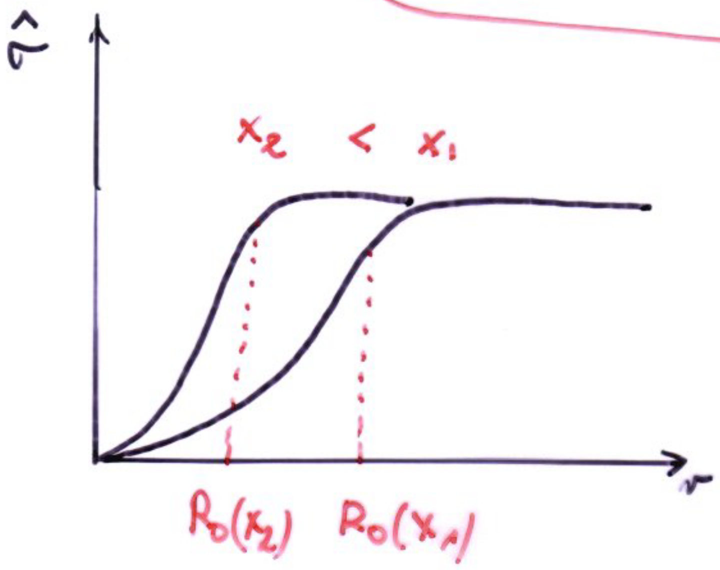

$$k_1 = z \cdot q' + k_\perp + \ldots$$

$$k_2 = (1-z)\, q' - k_\perp + \ldots$$

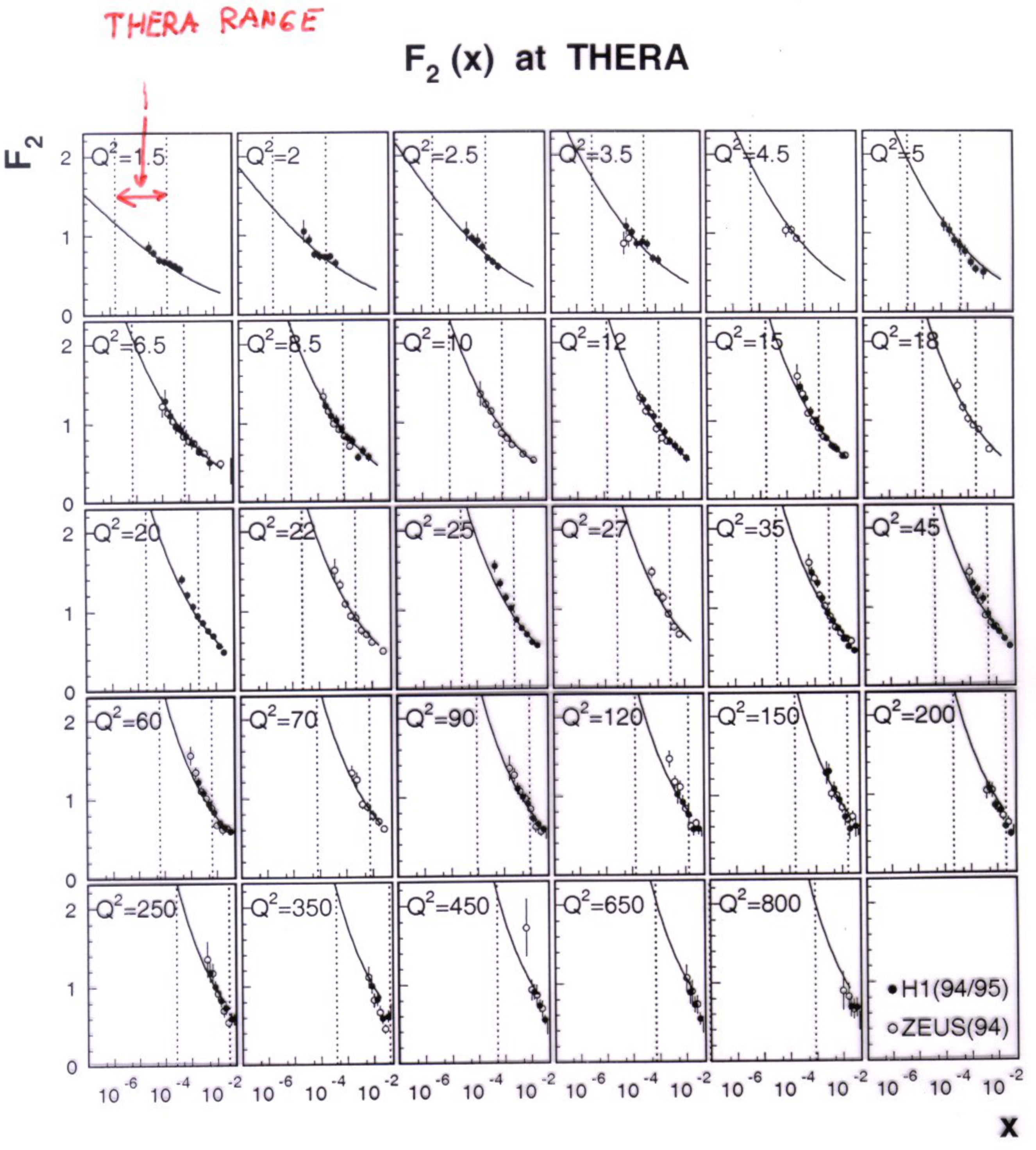
$$\vec{k}_\perp \longleftrightarrow \vec{r}$$

## MODEL FOR $\hat{\sigma}$ ( M. Wüsthoff, K. G-B )

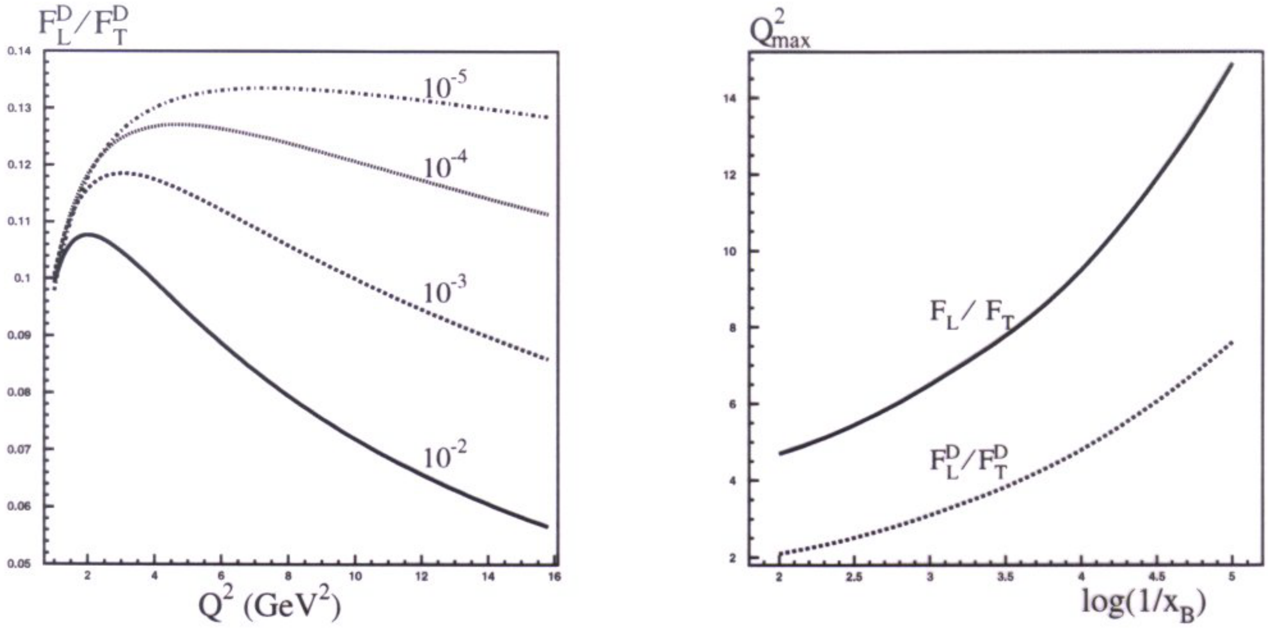
$$\hat{\sigma}(x, r) = \sigma_0 \, g\left( \frac{r}{R_0(x)} \right) \qquad R_0(x) = \frac{1}{Q_0} \left( \frac{x}{x_0} \right)^{\lambda/2}$$




THIS ASSUMPTION CRUCIAL FOR NEW SCALING


THERA RANGE
F2 (x) at THERA
F2
Q²=1.5
Q²=2
Q²=2.5
Q²=3.5
Q²=4.5
Q²=5
Q²=6.5
Q²=8.5
Q²=10
Q²=12
Q²=15
Q²=18
Q²=20
Q²=22
Q²=25
Q²=27
Q²=35
Q²=45
Q²=60
Q²=70
Q²=90
Q²=120
Q²=150
Q²=200
Q²=250
Q²=350
Q²=450
Q²=650
Q²=800
H1(94/95)
ZEUS(94)
x

## iv. Maxima of ratios.




We studied the $Q^2$ behaviour of the ratios: $F_L/F_T$ and $F_L^D/F_T^D$ for longitudinal and transverse structure functions for inclusive DIS and for diffraction in DIS. These ratios have maxima at $Q^2 = Q^2_{max}(x_B)$ which are moving as a function of $x_B$. It appears that $Q^2_{max}(x_B)$ is a simple function of the saturation scale $Q_s^2(x_B)$.

### Predictions:

- We expect different behaviour of the ratio $F_L/F_T$ and $F_L^D/F_T^D$ as a function of $Q^2$.
- $Q^2_{max} \approx 6 \div 7\text{GeV}^2$ in diffraction channel.
- we expect that the higher twist contributions will be of the same order as the leading twist one at sufficiently high value of $Q^2$, namely, for $F_L$ and for $F_T^D$ this value of $Q^2$ is about $5 \div 7\,GeV^2$ while for $F_L^D$ it is even larger, about $15\,GeV^2$. $\Rightarrow$ possibility to measure violations of DGLAP equation.

# NEW SCALING AT SMALL X

$$\sigma_T^{\gamma^* p} \sim$$

$$\int_0^1 dz \;\; z(1-z)\left[z^2+(1-z)^2\right] \int d^2r\, Q^2\; K_1^2\left(\sqrt{z(1-z)}\, Qr\right)\, \hat{\sigma}\left(\frac{r}{R_0}\right)$$

## CHANGE VARIABLES

$$r \longrightarrow \frac{r}{R_0} = \hat{r} \qquad \text{dimensionless}$$

$$Qr \longrightarrow \underbrace{(QR_0)}_{\text{dimensionless}}\, \hat{r}$$

## NOW

$$\sim \int_0^1 dz \ldots \qquad \int d^2\hat{r}\;\; Q^2R_0^2\;\; K_1^2\left(\sqrt{z(1-z)}\, QR_0\, \hat{r}\right)\, \hat{\sigma}\left(\hat{r}\right)$$

$$\boxed{\sigma^{\gamma^* p}(x, Q^2) = \sigma^{\gamma^* p}\left(\tau = Q^2 R_0^2(x)\right)}$$

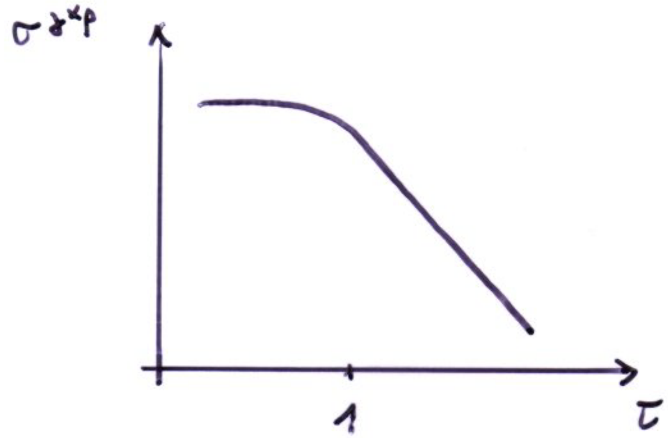
NEW SCALING VARIABLE

## IN THE SATURATION MODEL

$$\tau = Q^2 R_0^2 \gg 1 \qquad \sigma^{\gamma^* p} \sim \frac{1}{\tau} \ln \tau$$

$$\tau = Q^2 R_0^2 \ll 1 \qquad \sigma^{\gamma^* p} \sim \ln \frac{1}{\tau}$$

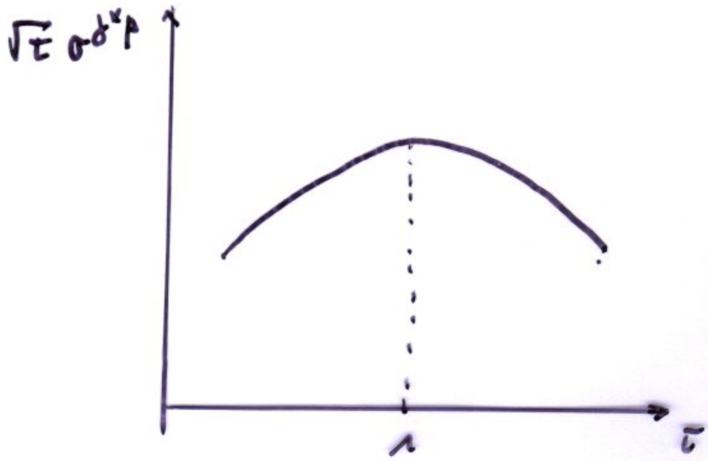
## WE EXPECT EXP. POINTS LYING ON



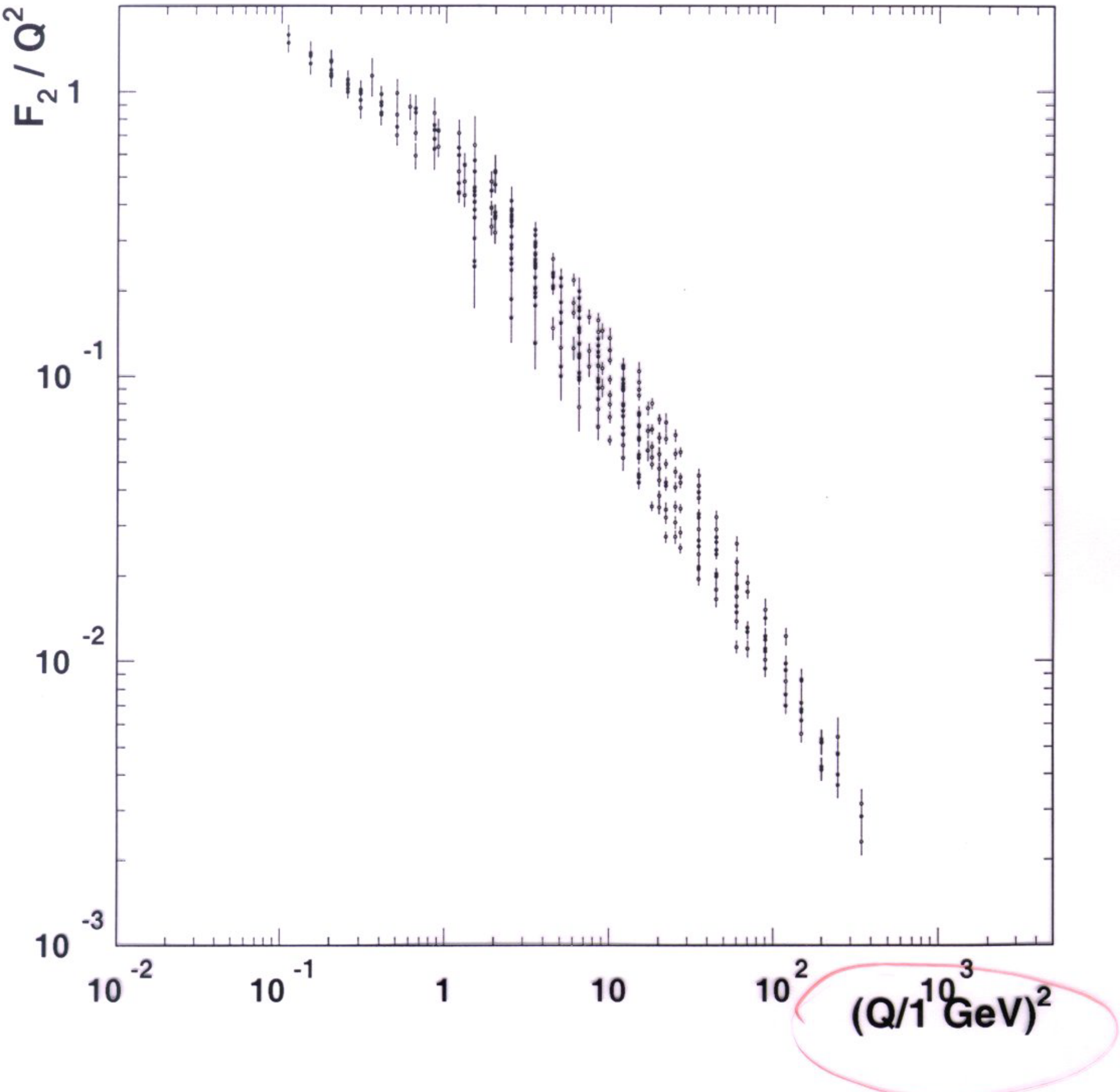

## OR

$$\sqrt{\tau}\, \sigma^{\gamma^* p} \sim \frac{1}{\sqrt{\tau}} \ln \tau \longleftrightarrow \sqrt{\tau}\, \sigma^{\gamma^* p} \sim \sqrt{\tau} \ln \frac{1}{\tau}$$

$$\tau \longleftrightarrow \frac{1}{\tau} \qquad \text{SYMMETRY}$$

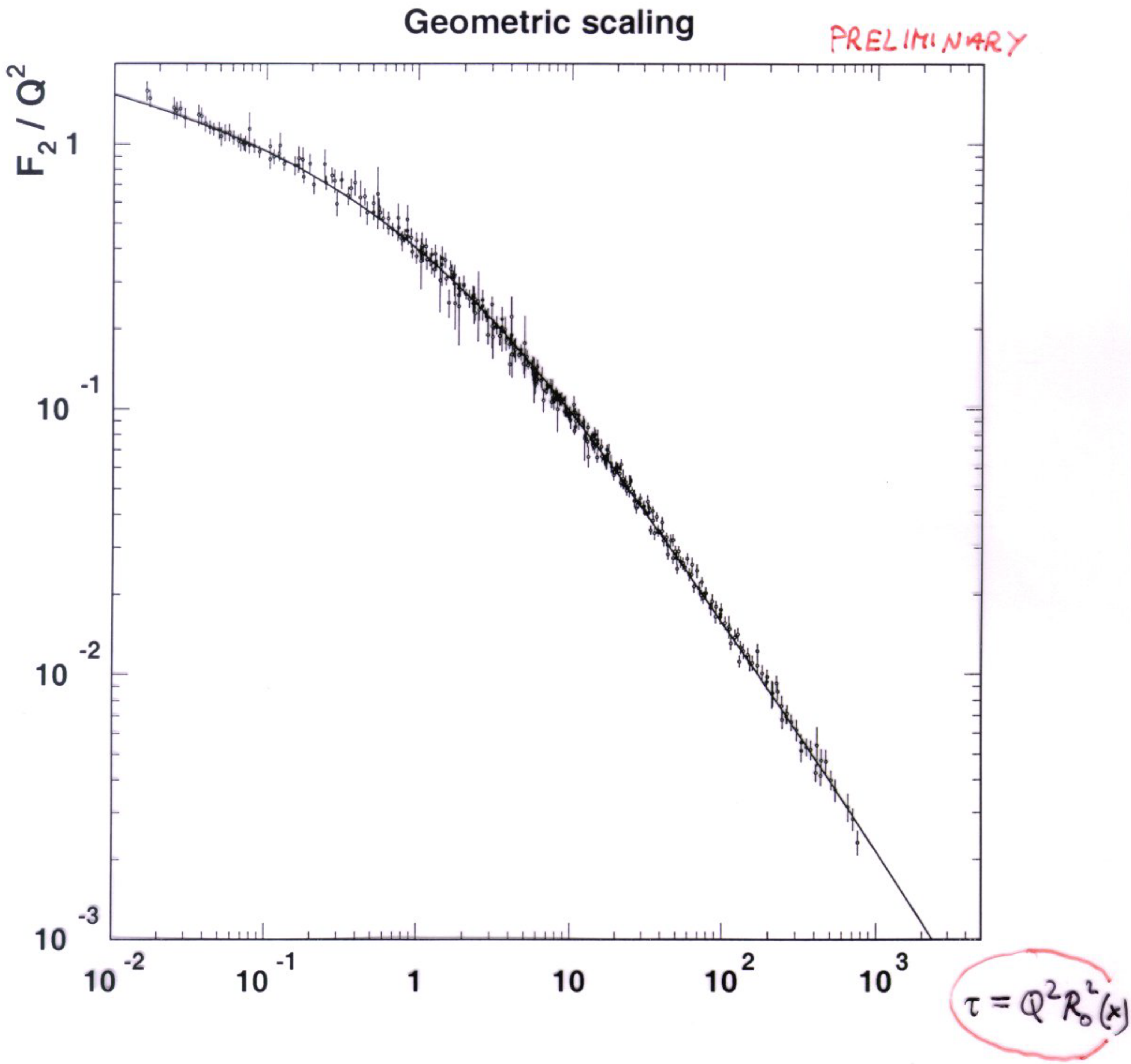


~~Geometric scaling~~ PRELIMINARY



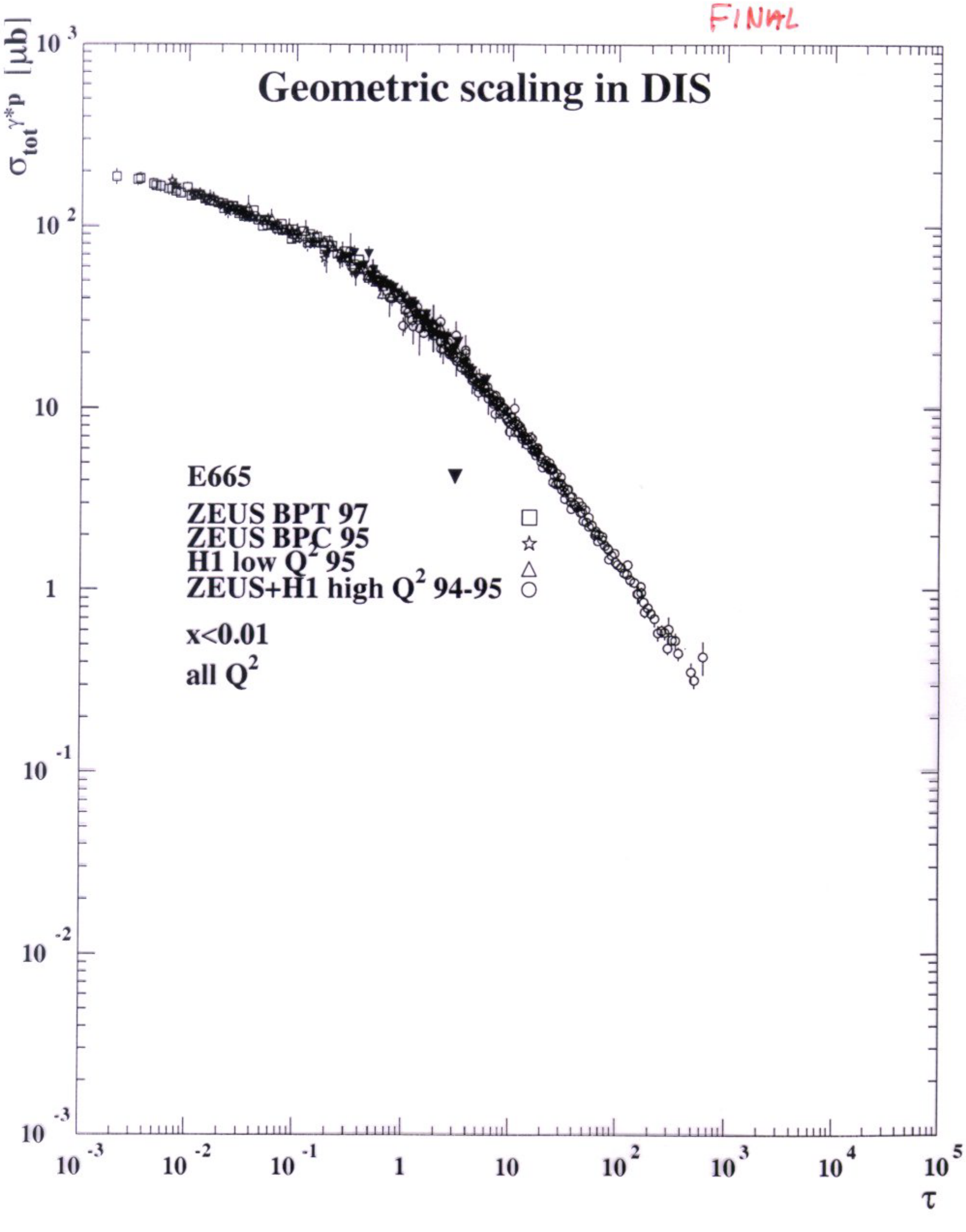

LOOK WHAT HAPPENS WHEN PLOTTED AGAINST

$\tau = Q^2 R_0^2(x) \sim Q^2 x^{0.29}$



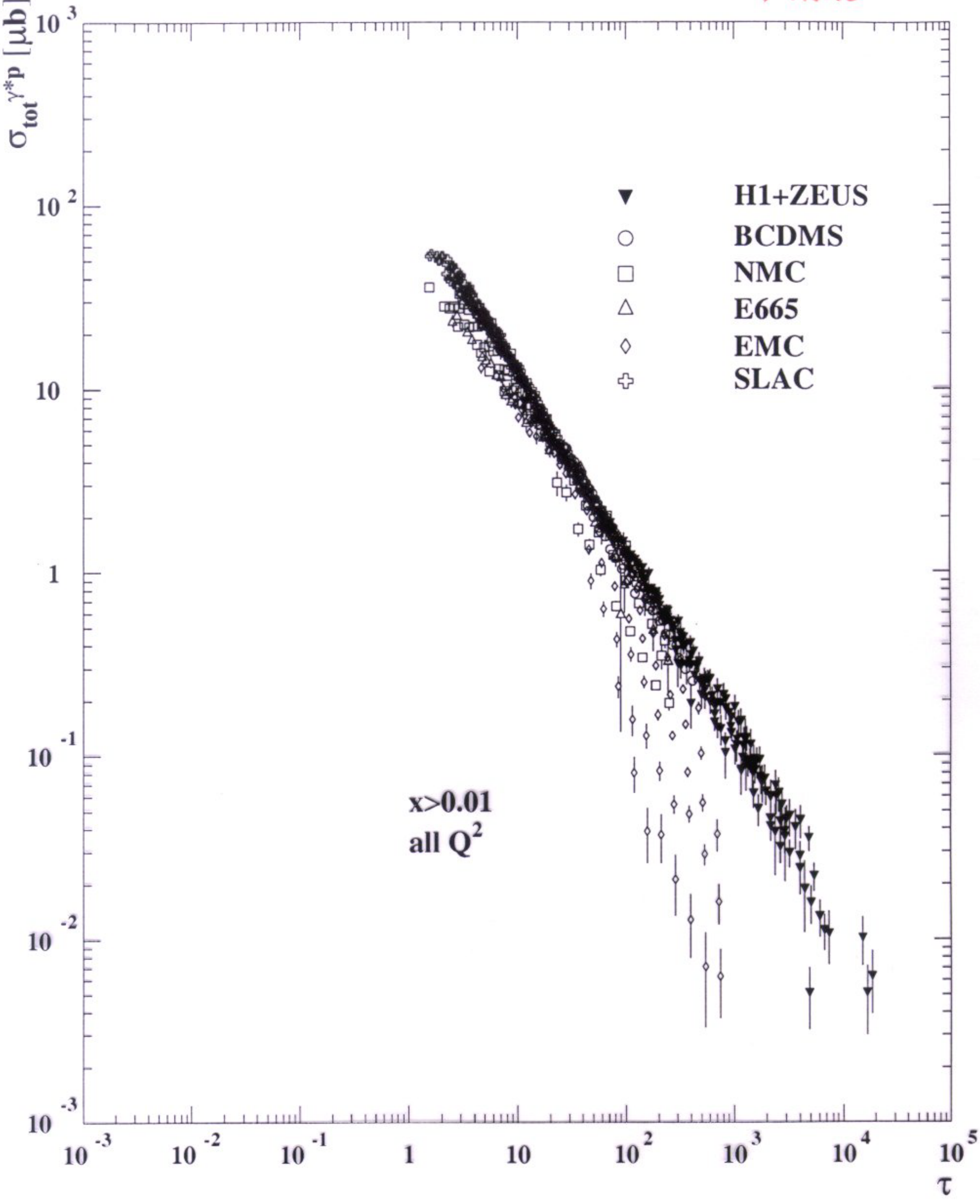
Geometric scaling
PRELIMINARY
$F_2 / Q^2$
1
$10^{-1}$
$10^{-2}$
$10^{-3}$
$10^{-2}$
$10^{-1}$
1
10
$10^2$
$10^3$
$\tau = Q^2 R_0^2(x)$

FINAL




DATA WITH $x < 0.01$

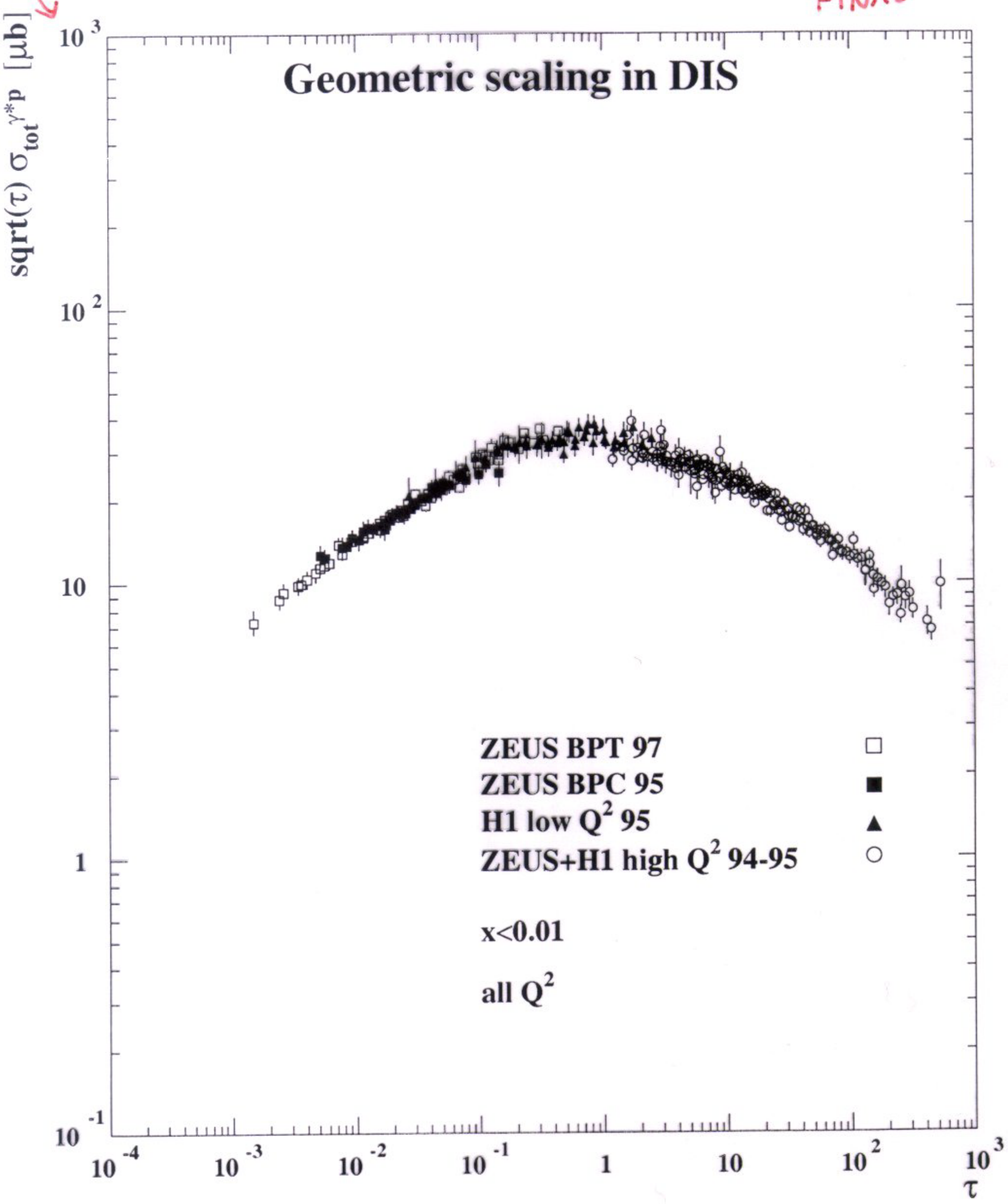
FINAL

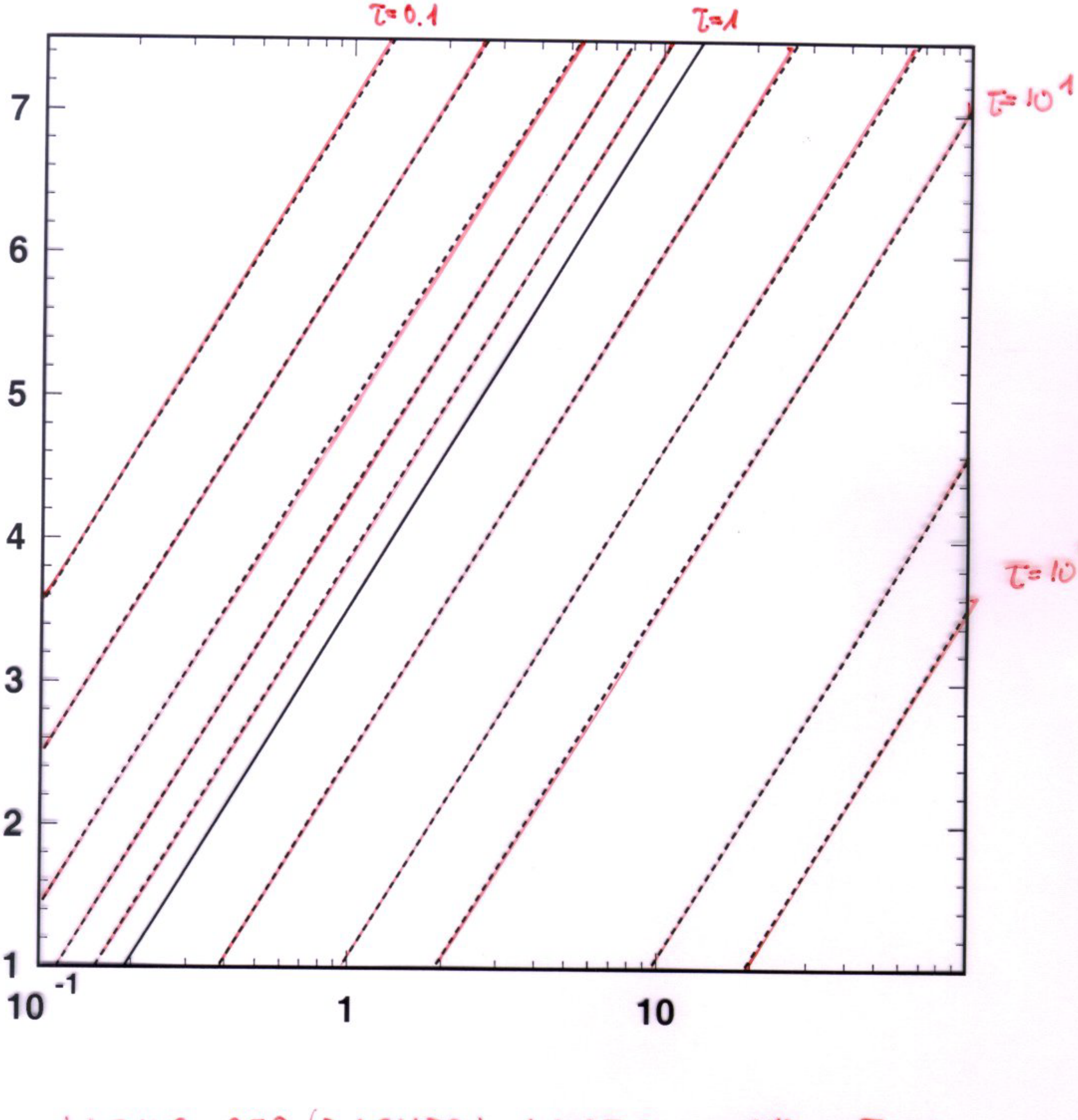



DATA : x > 0.01

$\sqrt{\tau}\cdot\sigma^{\gamma^* p}$

FINAL






ALONG RED (DASHED) LINES $\sigma^{\gamma^* p} \sim F_2/Q$

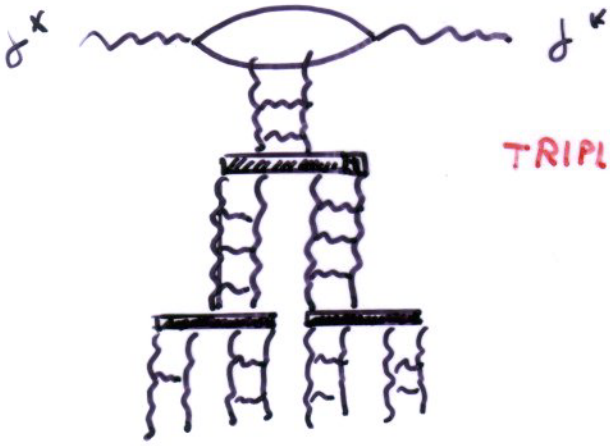
IS CONSTANT

# DO WE HAVE A THEORY ?

KOVCHEGOV EQS. PRD 60 (1999) 034008
61 (2000) 074018

( LEVIN, TUCHIN, BRAUN ; BARTELS, MCLERRAN, VENUGOPALAN, WEIGERT... )

## SUMS BFKL POMERON FUN DIAGRAMS




TRIPLE POMERON VERTEX IN $N_c \to \infty$

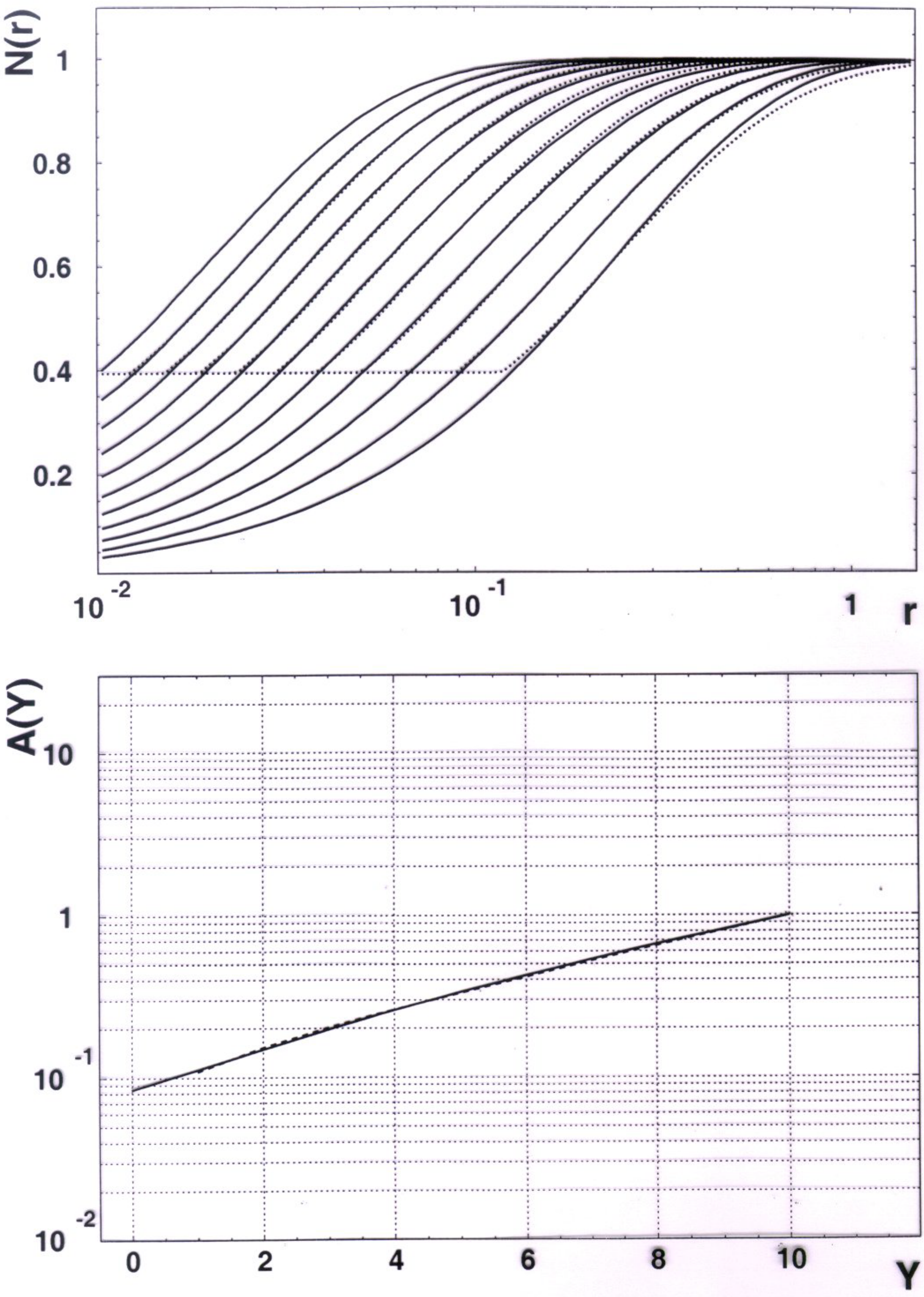
$$\hat{\sigma}(x, r) = \int d^2b \, N(x, \vec{r}, \vec{b}) \qquad Y = \ln \frac{1}{x}$$

$$\boxed{\frac{\partial N}{\partial Y} = K_{BFKL} \otimes N - \bar{\alpha}_s \int \frac{d^2 r'}{2\pi} \frac{r^2}{r'^2 (\vec{r} + \vec{r}')^2} N(\vec{r} + \vec{r}') N(r')}$$

SOLUTION EXHIBITS SCALING: $N(r \cdot Q_s(x))$

# KOVCHEGOV EVOLUTION

$1 - e^{-T}$

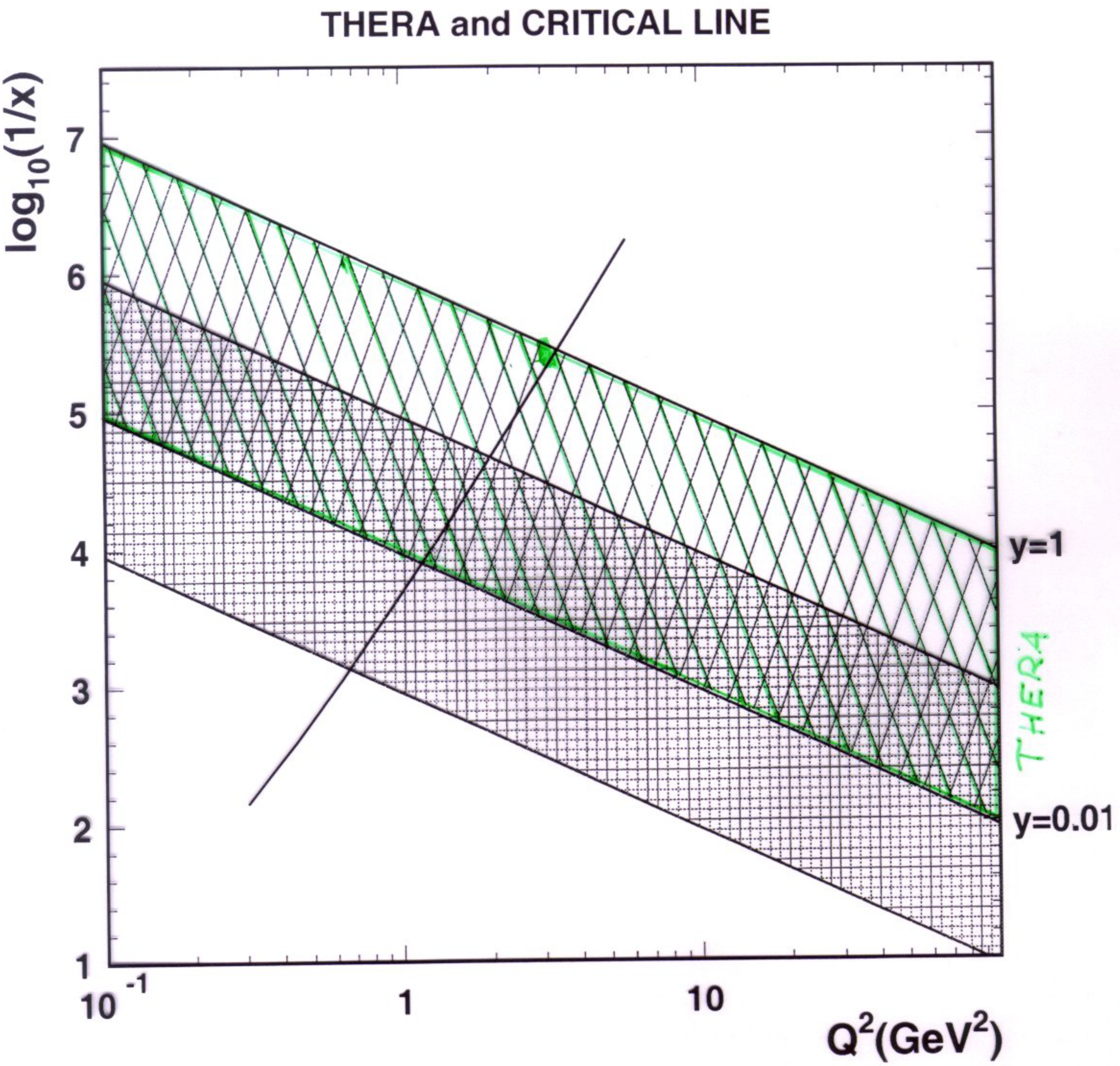


# SUMMARY

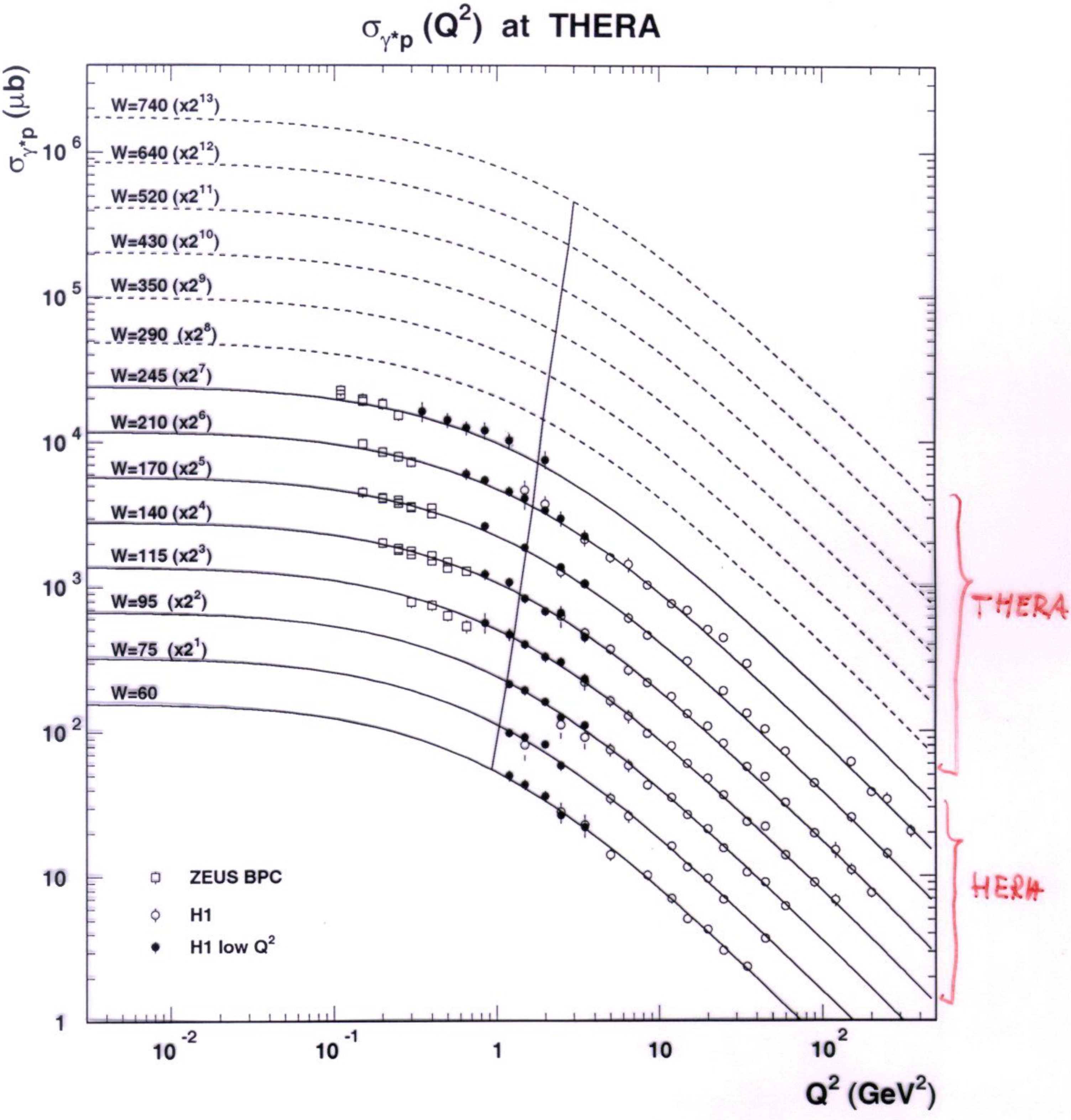
- NEW SCALING AT SMALL X IS HINTED

- INTERNAL SCALE OF PARTONIC DENSE $R_0(x) \sim \frac{1}{Q_s(x)}$ SYSTEM RESPONSIBLE FOR THAT

- THERA ALLOWS ~~TO~~ CONFIRMATION BY EXTENDING THE RANGE WHERE IT CAN BE TESTED



THERA and CRITICAL LINE
log10(1/x)
7
6
5
4
3
2
1
10 -1
1
10
Q2(GeV2)
y=1
THERA
y=0.01



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