SC at THERA

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The general question to answer:

Can we see SC at THERA ($x \longrightarrow 10^{-6}$) ?

The goal of this talk:

Can we see a manifestation of SC at ($x \longrightarrow 10^{-6}$) in old observables ?

1. $dF_2/\ln Q^2$
2. $\sigma(\gamma^* + p \rightarrow J/\Psi + p)$
3. σ^{DD}/σ_{tot} versus W

Two scales of DIS

1. Separation scale $r_\perp^{sep} \approx 1/M_0$:

$$r_\perp \quad < \qquad r_\perp^{sep} \qquad < \quad r_\perp$$

$\Psi(Q^2; r_t, z) \rightarrow$ pQCD

$\Psi(Q^2; r_t, z) \rightarrow$ npQCD

DOF: colour dipoles

DOF: constituent quarks

2. Saturation scale $r_\perp^{sat} \approx 1/Q_s(x)$:

$$\kappa \;=\; \frac{3\,\pi^2\alpha_S}{2Q_s^2(x)} \times \frac{xG(x, Q_s^2(x))}{\pi\, R^2} \;=\; 1$$

$$\boxed{r_\perp^{sat} \ll r_\perp^{sep}}$$

SC for F_2

- Mueller - Glauber formula:

$$x_B F_2(x_B, Q^2) \propto \int_{Q_0^2}^{Q^2} dQ'^2 \int db_t^2 \{ 1 - e^{-\frac{4}{9}\kappa(x_B, Q'^2)\, S(b_t)} \}$$

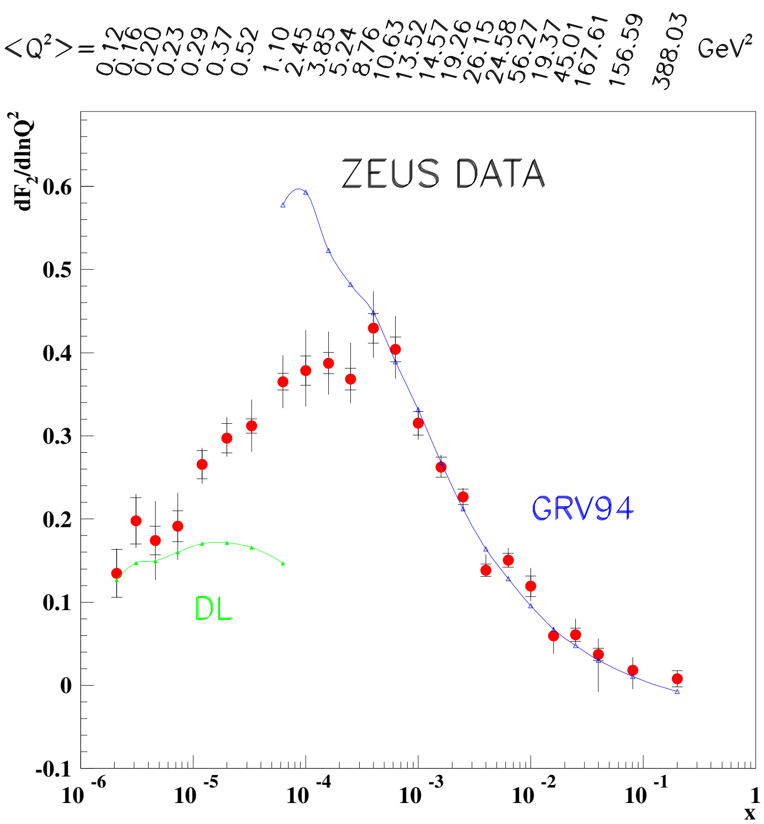
where $S(b_t) = e^{-\frac{b_t^2}{R^2}}$.

♣ In M-G formula:

- $F_2(x, Q^2) \Longrightarrow Q^2 R^2$;
- The values of κ and of F_2 depend on the value of R^2;
- The value of F_2 depends on Q_0^2;

$Q_s^2(x)$ from Q^2 - dependence of F_2 - slope

ZEUS 1995 Preliminary



- **ZEUS (1998)** **(Caldwell - plot)**

- **Hope to find a scale in the gluon channel ($Q_s^2(x)$) since:**

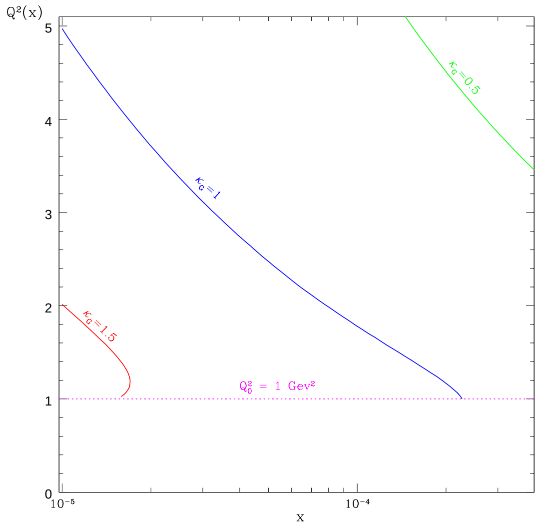
$$\frac{\partial F_2}{\partial \ln Q^2} = \frac{2\alpha_S}{9\,\pi}\, x\, G^{DGLAP}(x, Q^2)$$

Asymptotic predictions:

Asymptotic $= \kappa_G \gg 1$

1. $F_2^{SC}(x,Q^2) \Longrightarrow \frac{N_c}{2\pi^2} \sum_1^{N_f} Z_f^2\, Q^2\, R^2\, \ln \kappa_Q(x,Q^2)$;

2. $\frac{\partial F_2^{SC}(x,Q^2)}{\partial \ln(Q^2/Q_0^2)} \propto R^2 Q^2$
   for $Q^2 \leq Q^2(x)$;



3. $\lambda(Q^2) = \frac{\partial \ln F_2^{SC}(x,Q^2)}{\partial \ln(1/x)} \propto \frac{1}{\ln(1/x)\, \ln\ln 1/x)} \longrightarrow 0$
   for $Q^2 \leq Q^2(x)$;

4. $xG^{SC}(x,Q^2) \Longrightarrow \frac{2\,R^2\,Q^2}{\pi^2} \ln(1/x)\, \ln \kappa_G^{DGLAP}(x,Q^2)$;

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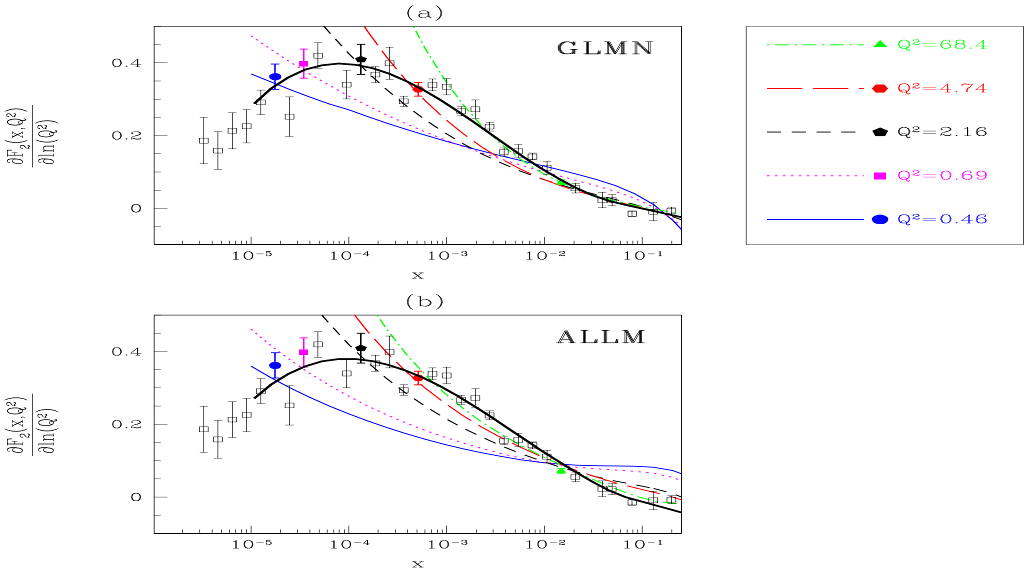
* *

It is
not
so bad,
is it?

* *
* *

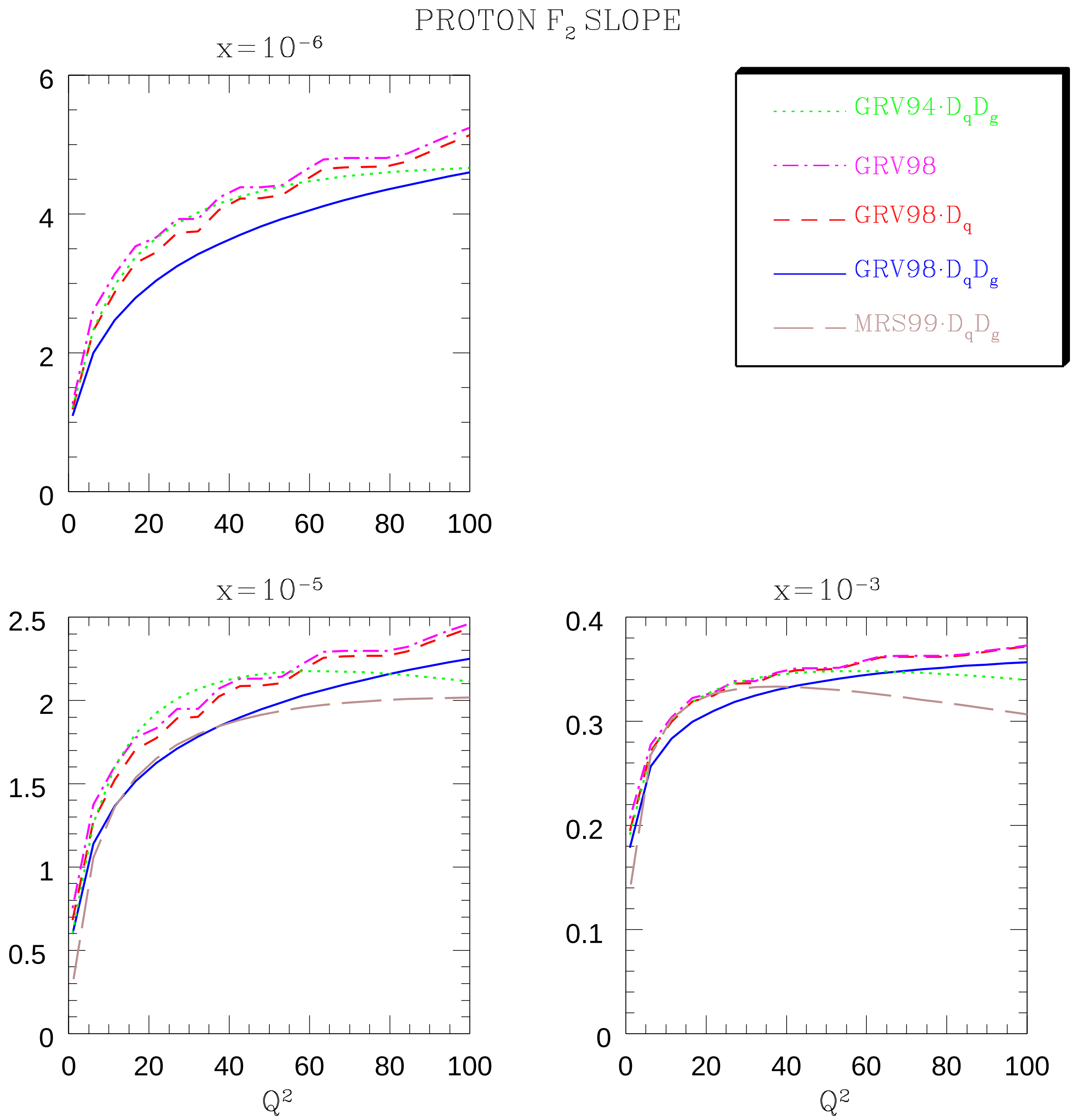


Alternative description:

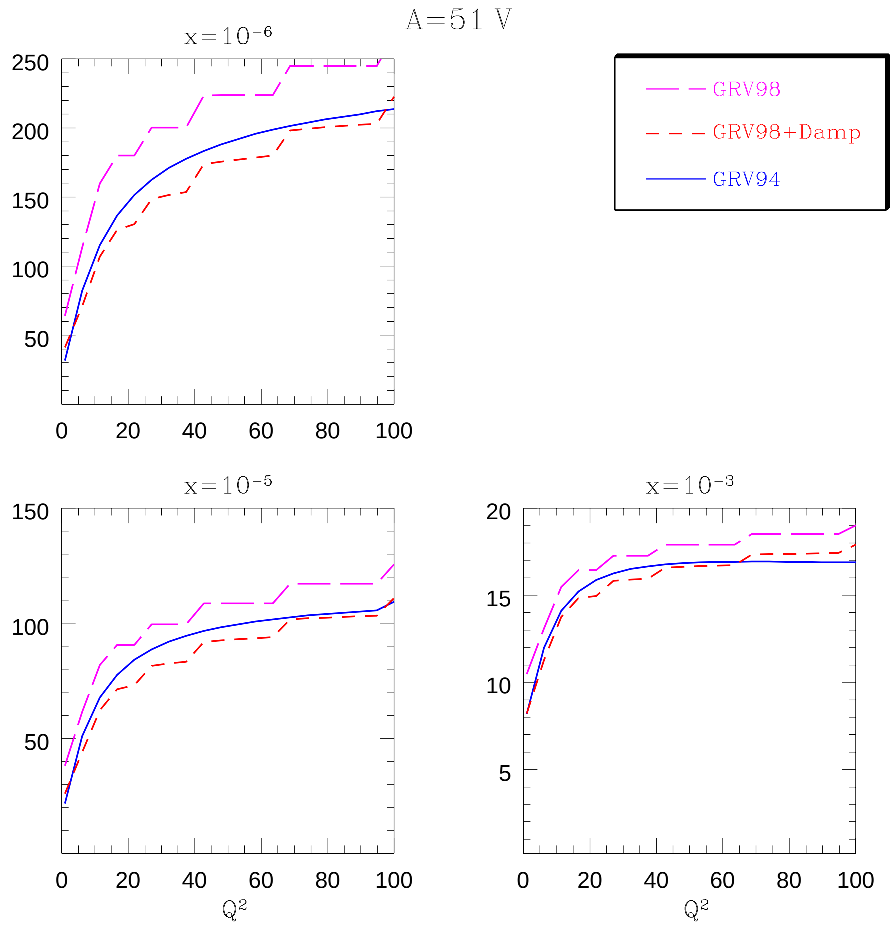
(MRST & GRV'98 parameterizations)

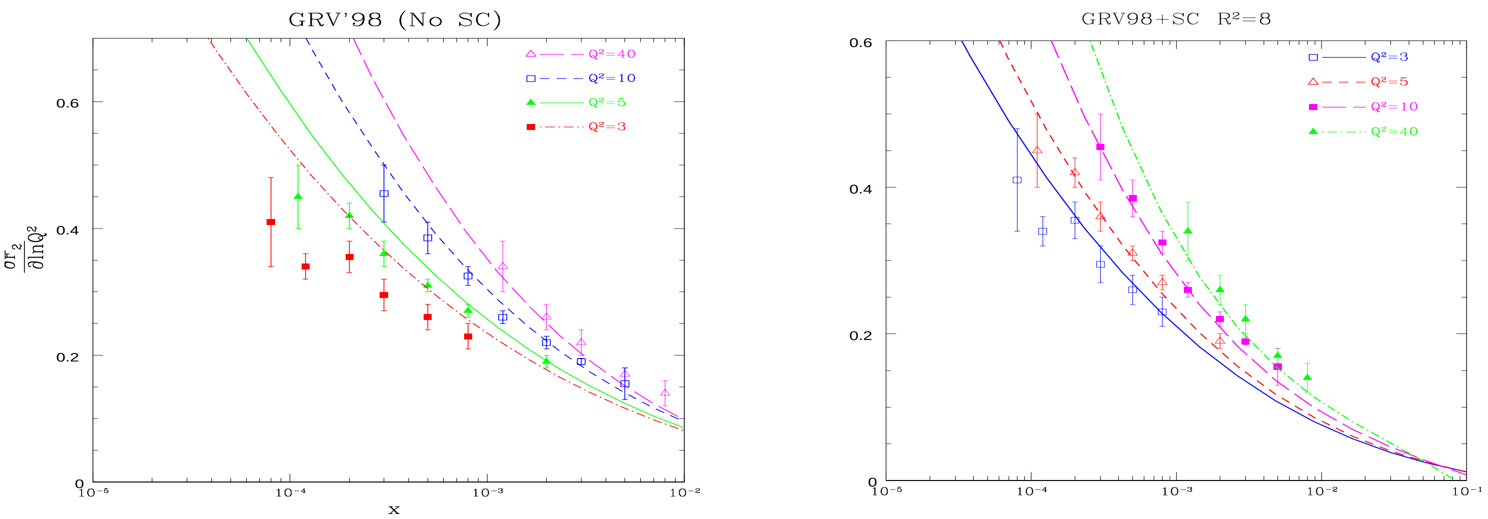
$$\frac{\partial F_2}{\partial \ln Q^2} = \frac{2\alpha_S}{9\,\pi}\,x\,G^{DGLAP}(x,Q^2)$$

- **The DGLAP evolution equation + essential decrease of xG at small x for initial gluon distribution .**



PROTON F2 SLOPE
x=10^-6
x=10^-5
x=10^-3
GRV94·DqDg
GRV98
GRV98·Dq
GRV98·DqDg
MRS99·DqDg
Q2
Q2

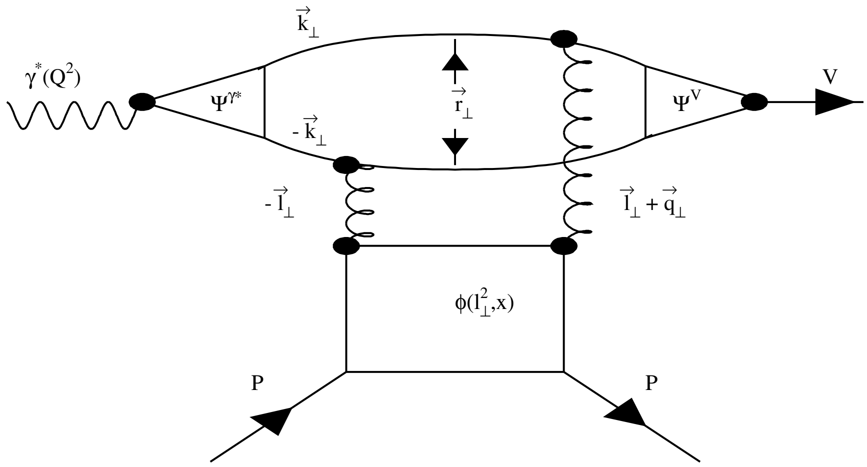




Important message:

GRV'94 and GRV'98 with SC are close to each other and describe the experimental data on $dF_2/dlnQ^2$

SC and diffractive J/Ψ-production in DIS



1. Ψ^V — **Nonrelativistic approach** (M.G. Ryskin (1993); M.Ryskin, R.Roberts, A. Martin & E.L. (1995); E.L, A. Martin,M.Ryskin and T.Teubner (1996))

2. Ψ^{γ^*} — **pQCD**

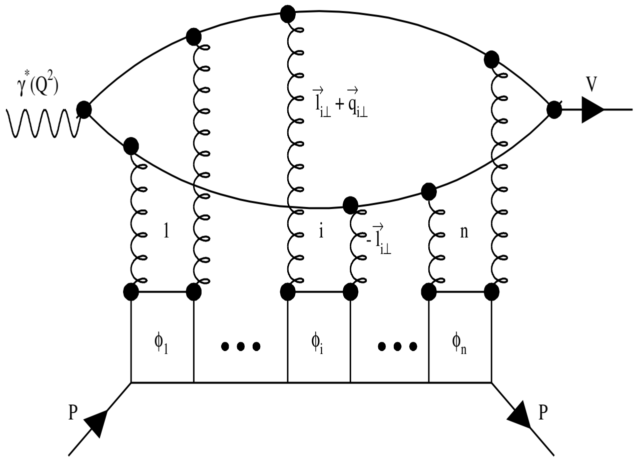
3. **Off-diagonal gluon structure function** — (K.Golec-Biernat, A. Martin and M.Ryskin (1999))

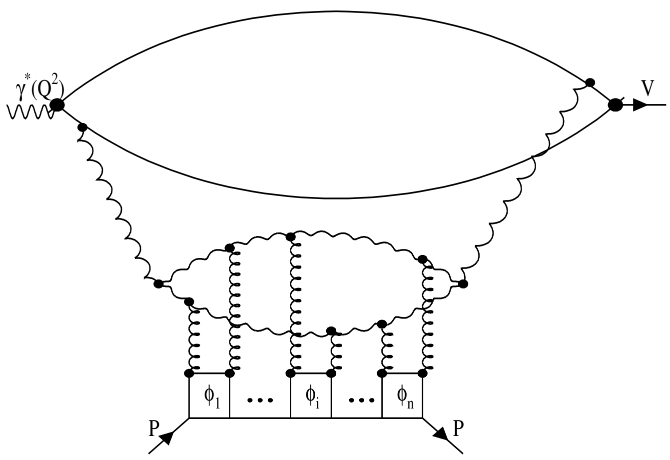
4. **Real part of the amplitude**

$$Re = \frac{\pi}{2}\frac{d}{d\ln(1/x)} Im$$

5. **SC**

GLM (1995)



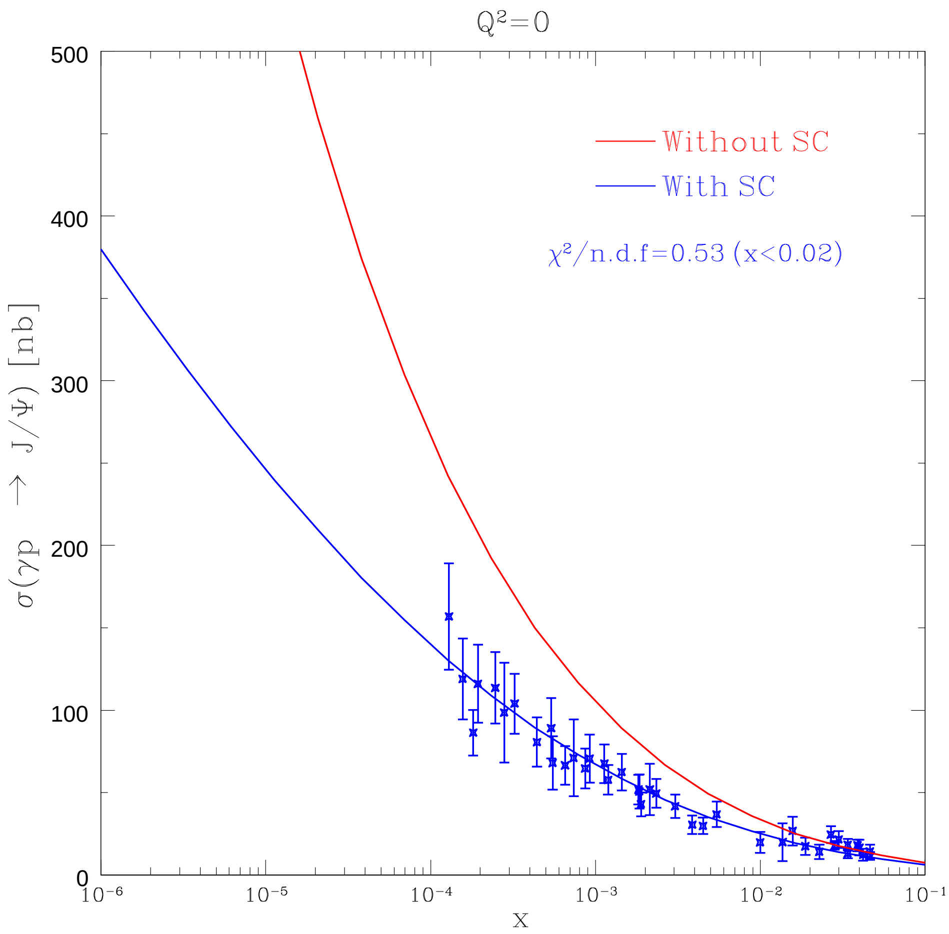


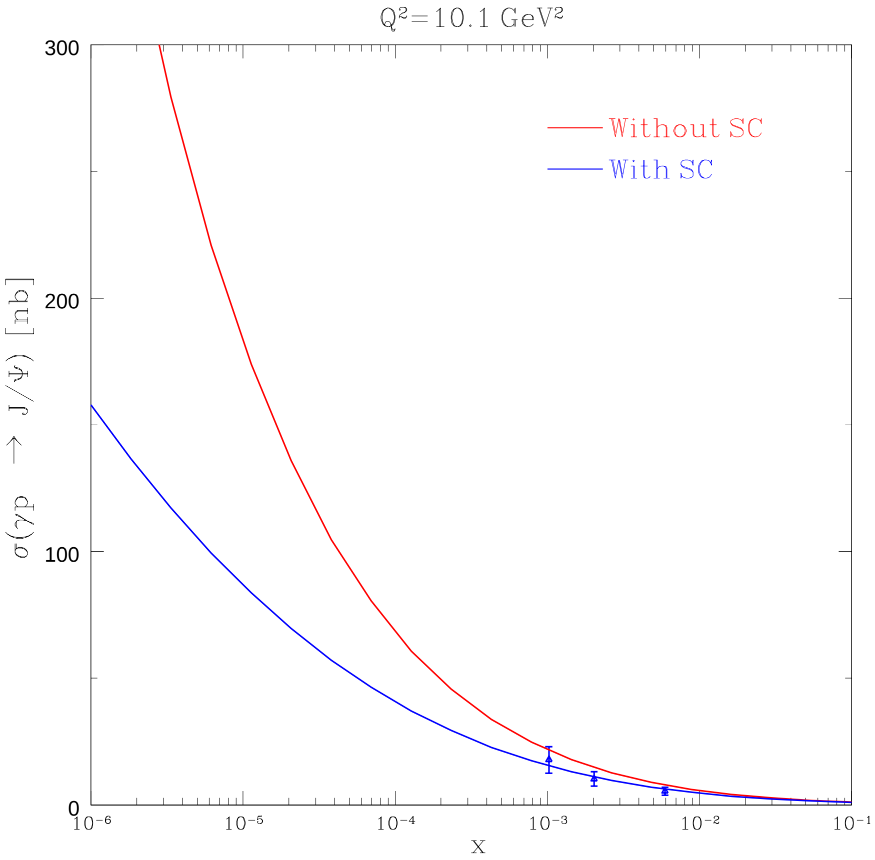
• **Quark rescatterings** • **Gluon rescatterings**

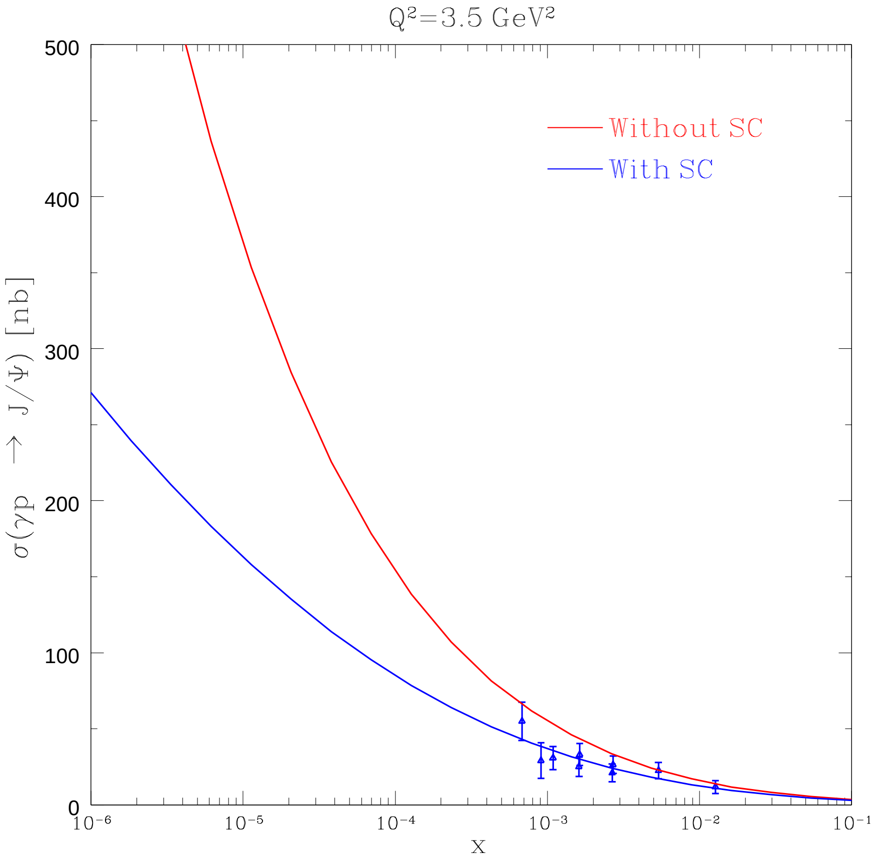
$$\boxed{\frac{dF_2}{d\ln Q^2} \quad \& \quad \sigma(\gamma^* p \to J/\Psi\, p)}$$

- **None of MRS parameterizations survives;**
- **All GRV parameterizations survive only with SC;**
- χ^2**/n.d.f. is excellent for GRV + SC;**

Data	χ^2/n.d.f.
All data	**0.73**
Low x ($x < 0.02$) data	**0.55**
All data for $Q^2 > 0$	**0.59**
Photoproduction data	**0.8**
Photoproduction data with low x ($x < 0.02$)	**0.55**




Q²=10.1 GeV²
Without SC
With SC
σ(γp → J/Ψ) [nb]
x


Q²=3.5 GeV²
Without SC
With SC
σ(γp → J/Ψ) [nb]
x

$\sigma^{diff}/\sigma_{tot}$ versus energy

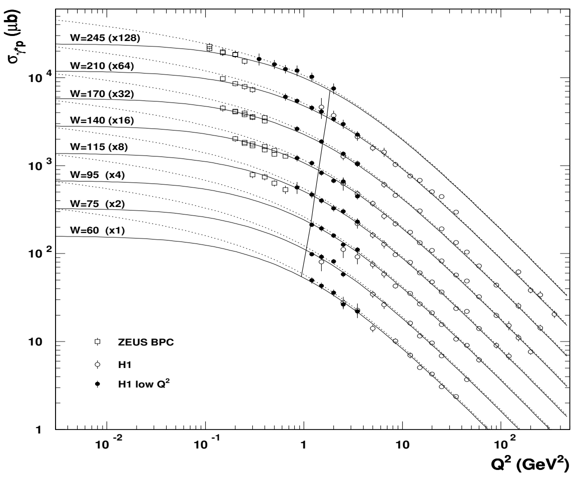
Golec - Bierat and Wüsthoff approach:

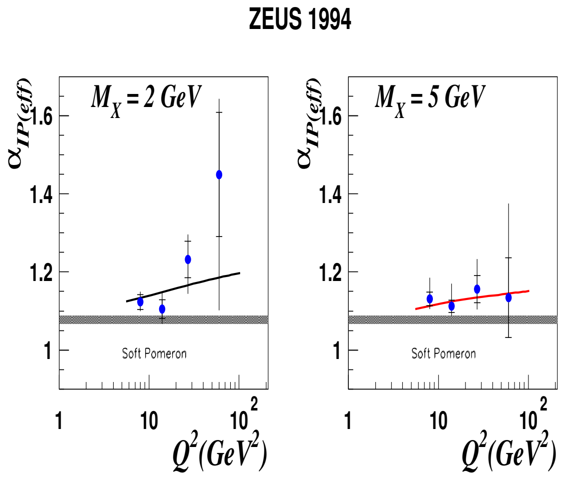
- $\sigma(\gamma^* p) \;=\; \int\int d^2 r_\perp\, dz\, |\Psi(Q^2; z, r_\perp)|^2\, \sigma(x, r_\perp)$;

- $\sigma(x, r_\perp) \;=\; \sigma_0\, \left(1 \;-\; \exp(-\frac{r^2_\perp}{R^2(x)}) \right)$;

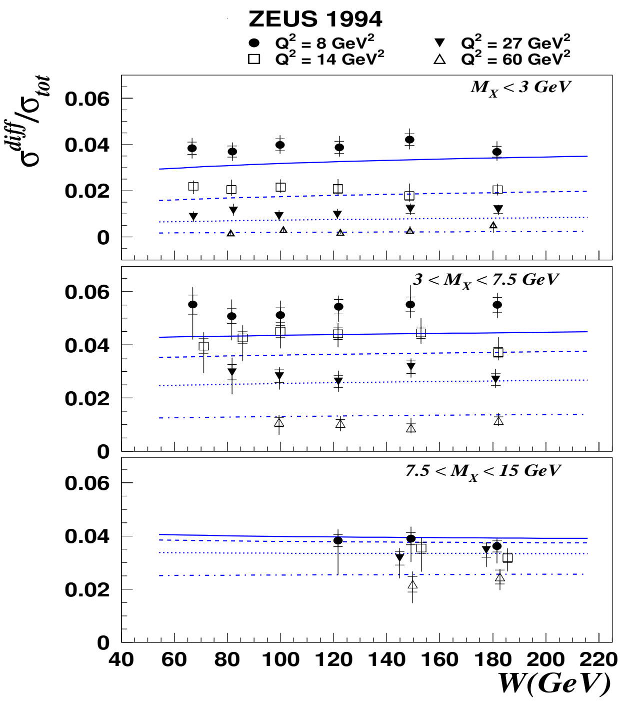
- $R^2(x) \;=\; 1/Q^2_0(x)$, where $Q^2_0(x) \;=\; Q^2_0 \left(\frac{x}{x_0} \right)^{-\lambda}$;

- $\sigma_0 = 23.03\,\text{mb}$
  $\lambda = 0.288$
  $x_0 = 3.04\,10^{-4}$
  $Q^2_0 = 1\,\text{GeV}^2$





- $\sigma_{\mathrm{tot}}(\gamma^* \mathrm{p})$
- **The effective $\alpha_{\mathrm{P}}(0)$**



Summary:

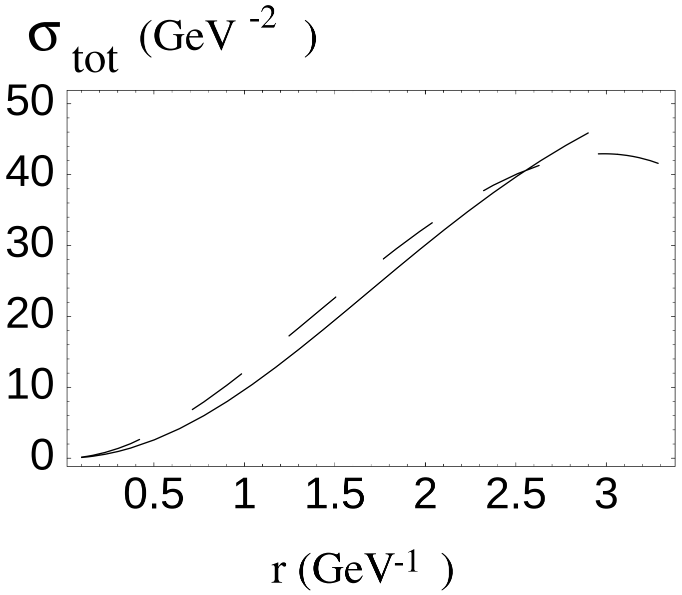
Scale $Q_s^2(x)$ alone without evolution equations can reproduce experiments !!!

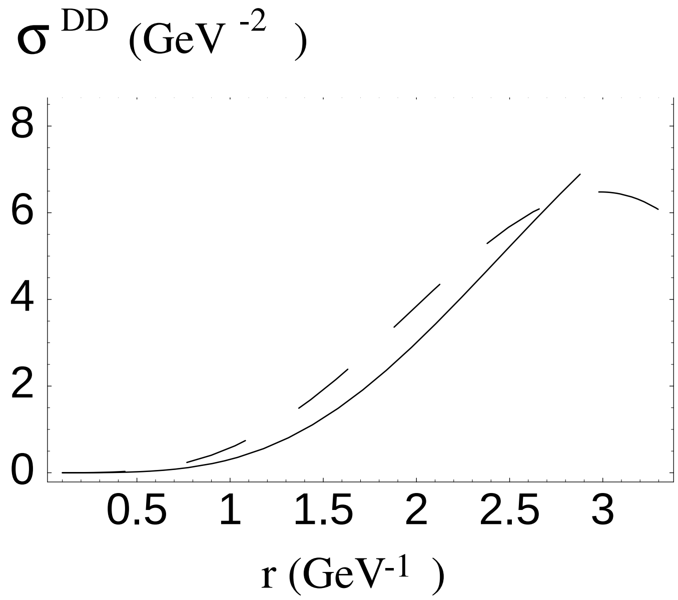
Our approach:

1. **Incorporates scale $Q_s^2(x)$;**

2. **Provides a natural matching with the DGLAP evolution equations;**

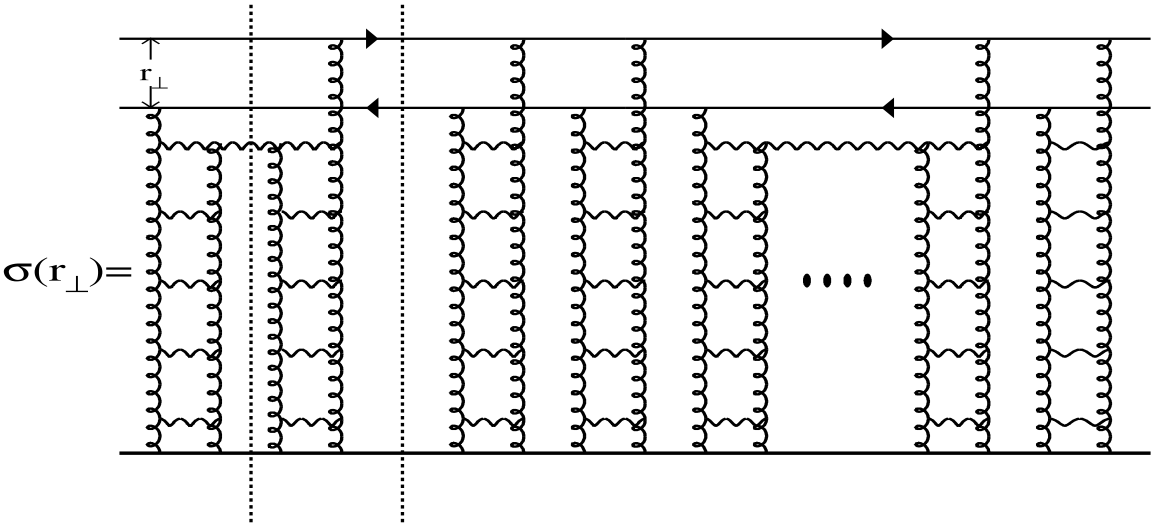
3. **Gives a natural b_t-dependence, which is needed for an application to a nuclear target**

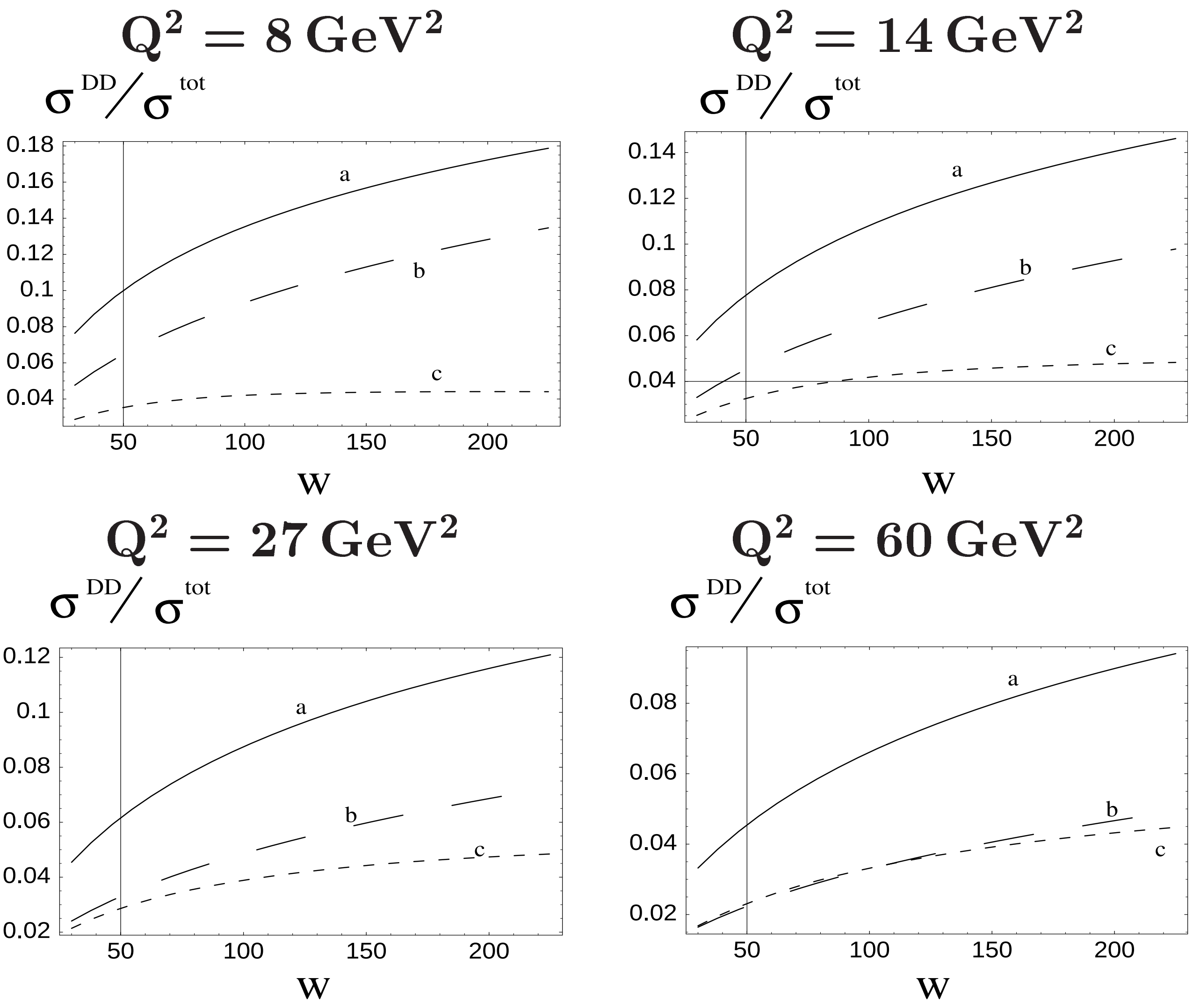




We do not reproduce the G-B & W results for $\sigma^{Diff}/\sigma_{tot}$! ?

HERA $\Longrightarrow$ $\frac{\sigma_{DD}}{\sigma_{tot}}$ $\Longrightarrow$ **Const (energy)**





- **a - total contribution ;**

- **b - $q\bar{q}$ contribution ;**

- **c - $q\bar{q} + G$ contribution ;**

SUMMARY

- **Measurements of $\frac{dF_2}{d\ln Q^2}$ and $\sigma(\gamma^* + p \longrightarrow J/\Psi)$ at THERA will provide a useful test of the SC;**

- **The energy behaviour of the ratio $\sigma^{Diff}/\sigma_{tot}$ has not been explained even taking into account SC and it gives a window to alternative explanations, hypothesis and approaches;**

- **It is important to measure inclusive σ^{Diff} without an additional cutoff in mass, which induces a large uncertainties in theoretical estimates;**