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A HYBRID MODEL FOR $\gamma^* p$ SCATTERING AT SMALL BJORKEN X

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Dipole model

Nikolaev-Zakharov

$$\sigma_{tot}^{\gamma^* N} = \sum_q \int dz \int d^2\rho \, |\Psi_{\gamma^* \to q\bar{q}}(Q, z, \rho)|^2 \times \sigma_{(q\bar{q})N}(x, \rho) \, . \quad (1)$$

Golec-Biernat-Wüsthoff Model

$$\sigma(x, \rho) = \sigma_0 \left[1 - \exp\left(-\frac{\rho^2}{4R_0^2(x)} \right) \right] \, , \quad (2)$$

$$R_0(x) = \frac{1}{1GeV} \left(\frac{x}{x_0} \right)^{\lambda/2} \, . \quad (3)$$

New parametrization

In exclusive reac. one needs $\mathcal{F}(x_g, \kappa_t^2)$

$$\begin{aligned} & \sigma_{(q\bar{q})N}(x_g, \rho) \\ = \quad & \frac{4\pi}{3} \int \frac{d^2\kappa_t}{\kappa_t^2} \left[1 - \exp(i\vec{\kappa}_t \vec{\rho})\right] \alpha_s \mathcal{F}(x_g, \kappa_t^2) \\ = \quad & \frac{4\pi^2}{3} \int \frac{d\kappa_t^2}{\kappa_t^2} \left[1 - J_0(\kappa_t \rho)\right] \alpha_s \mathcal{F}(x_g, \kappa_t^2) \ . \end{aligned} \tag{4}$$

In GBW: $\sigma_{dN} = \sigma_{dN}(x)$

In PS: $\sigma_{dN} = \sigma_{dN}(x_g)$

$$\sigma(x, \rho) \to \sigma(x_g, \rho) \ , \tag{5}$$

$x_g \to (M_{qq}^2 + Q^2)/(W^2 + Q^2)$,
where $M_{qq}^2 = m_q^2/(z(1-z))$
with m_q being an effective quark mass.

Higher Fock states

$$\sigma_{tot}^{\gamma^* N} =$$

$$= \sum_q \int d\Omega_2 \, |\Psi_{\gamma^* \to q\bar{q}}(\omega_2)|^2 \cdot \sigma_{(q\bar{q})N}(\omega_2)$$

$$+ \sum_q \int d\Omega_3 \, |\Psi_{\gamma^* \to q\bar{q}g}(\omega_3)|^2 \cdot \sigma_{(q\bar{q}g)N}(\omega_3)$$

$$+ \ldots \, . \tag{6}$$

- Higher Fock states necessary in diffraction (!)
- Higher Fock states → Bartels et al.
- Numerical calculation not yet available (!)

Phenomen. of resolved photon

dijet production in $\gamma^* N$ and $\gamma^*\gamma^*$ collisions
– Q^2-dependence consistent with VDM

$F_2^p(x,Q^2) - F_2^n(x,Q^2)$ at $Q^2 < 5$ GeV^2
inconsistent with QCD parton model
but consistent with a two-component model
(Badełek-Kwieciński, Szczurek-Uleshchenko)

$$F_2^p(x,Q^2) = \frac{Q^2}{Q^2+Q_0^2} F_{2p}^{PM}(x,Q^2) + F_2^{VDM}(x,Q^2)$$
$$F_2^n(x,Q^2) = \frac{Q^2}{Q^2+Q_0^2} F_{2n}^{PM}(x,Q^2) + F_2^{VDM}(x,Q^2) \tag{7}$$

Then

$$F_2^p(x,Q^2) - F_2^n(x,Q^2) = \frac{Q^2}{Q^2+Q_0^2}\left(F_{2p}^{PM}(x,Q^2) - F_{2n}^{PM}(x,Q^2)\right) \tag{8}$$

Vector dominance model

Take simple diagonal version:

$$\sigma_{VDM}^{\gamma^* N}(W, Q^2) = \sum_V \frac{4\pi}{\gamma_V^2} \frac{M_V^4 \sigma_{VN}^{tot}(W)}{(Q^2 + M_V^2)^2} \cdot (1 - x) \ . \tag{9}$$

with V = ρ, ω, ϕ

$$\sigma_{\rho N}^{tot} = \sigma_{\omega N}^{tot} = \frac{1}{2}\left[\sigma_{\pi^+ p}^{tot} + \sigma_{\pi^- p}^{tot}\right] \ , \tag{10}$$

A simple Regge parametrization of
πN cross section
by Donnachie and Landshoff
γ's from the leptonic decays of vector mesons, including finite width corrections.

Two fits

From structure function to cross section:

$$\sigma_{tot}^{\gamma^* N}(W, Q^2) = \frac{4\pi^2}{\alpha_{em}} \frac{F_2(x, Q^2)}{Q^2} \;. \qquad (11)$$

Two independent fits to HERA data:

$$FIT1: \quad \sigma_{tot}^{\gamma^* N} = \sigma_{dip}^{\gamma^* N} \;. \qquad (12)$$

$$FIT2: \quad \sigma_{tot}^{\gamma^* N} = \sigma_{dip}^{\gamma^* N} + \sigma_{VDM}^{\gamma^* N} \;. \qquad (13)$$

In these fits: $0.15 \text{ GeV}^2 < Q^2 < 10 \text{ GeV}^2$.

Two fits – parameters

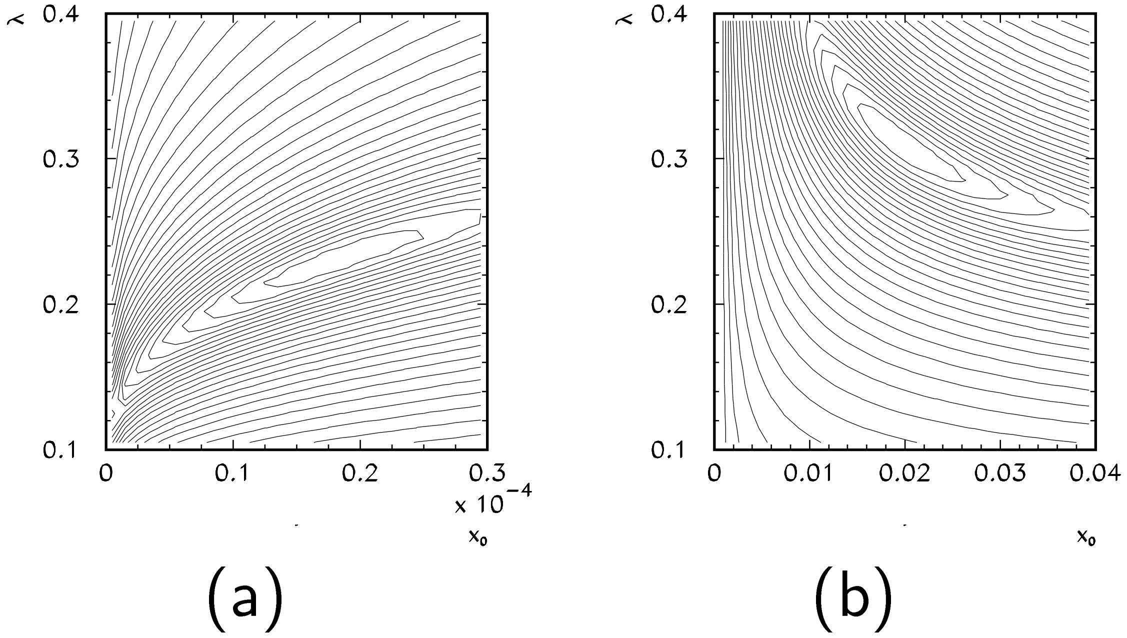
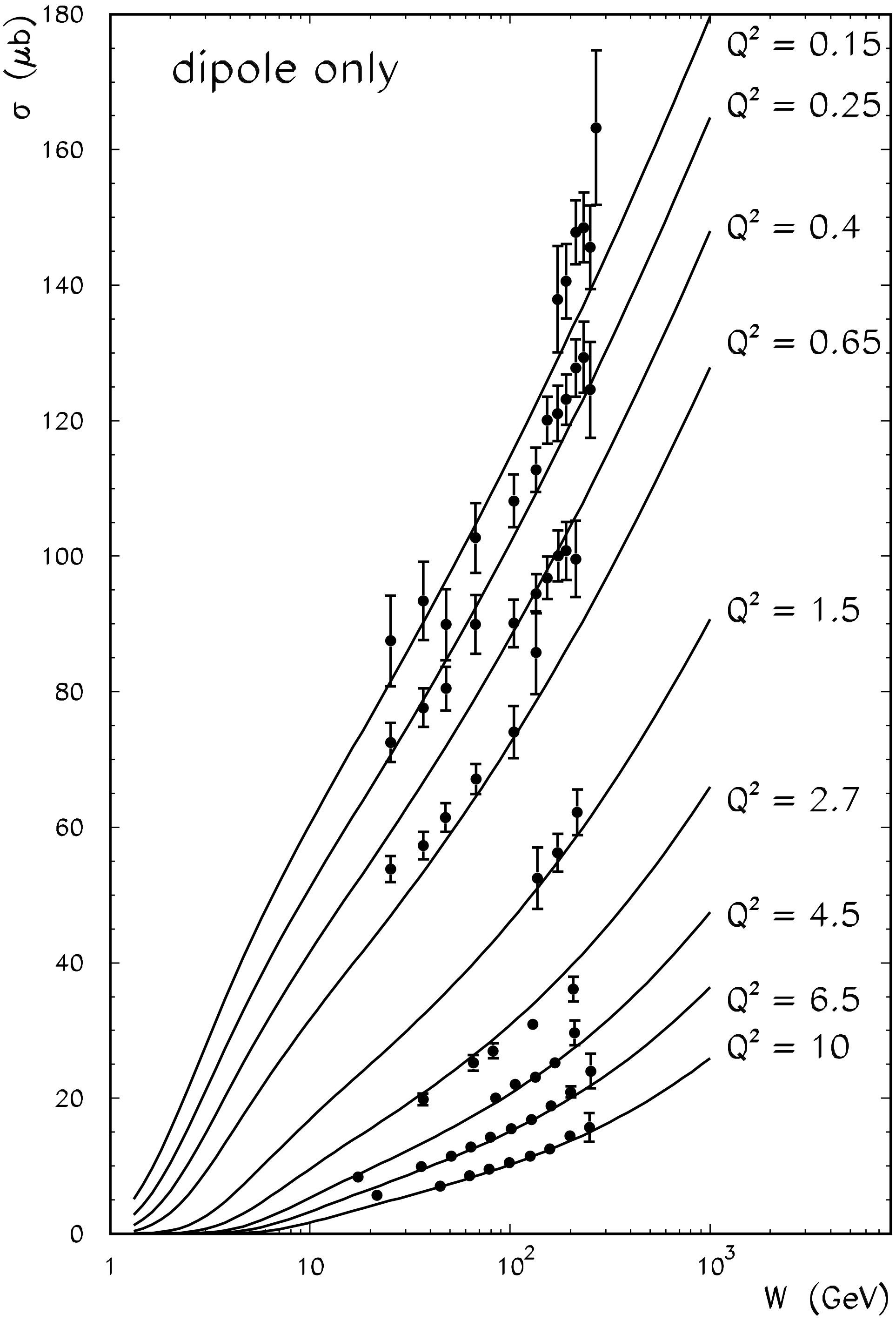


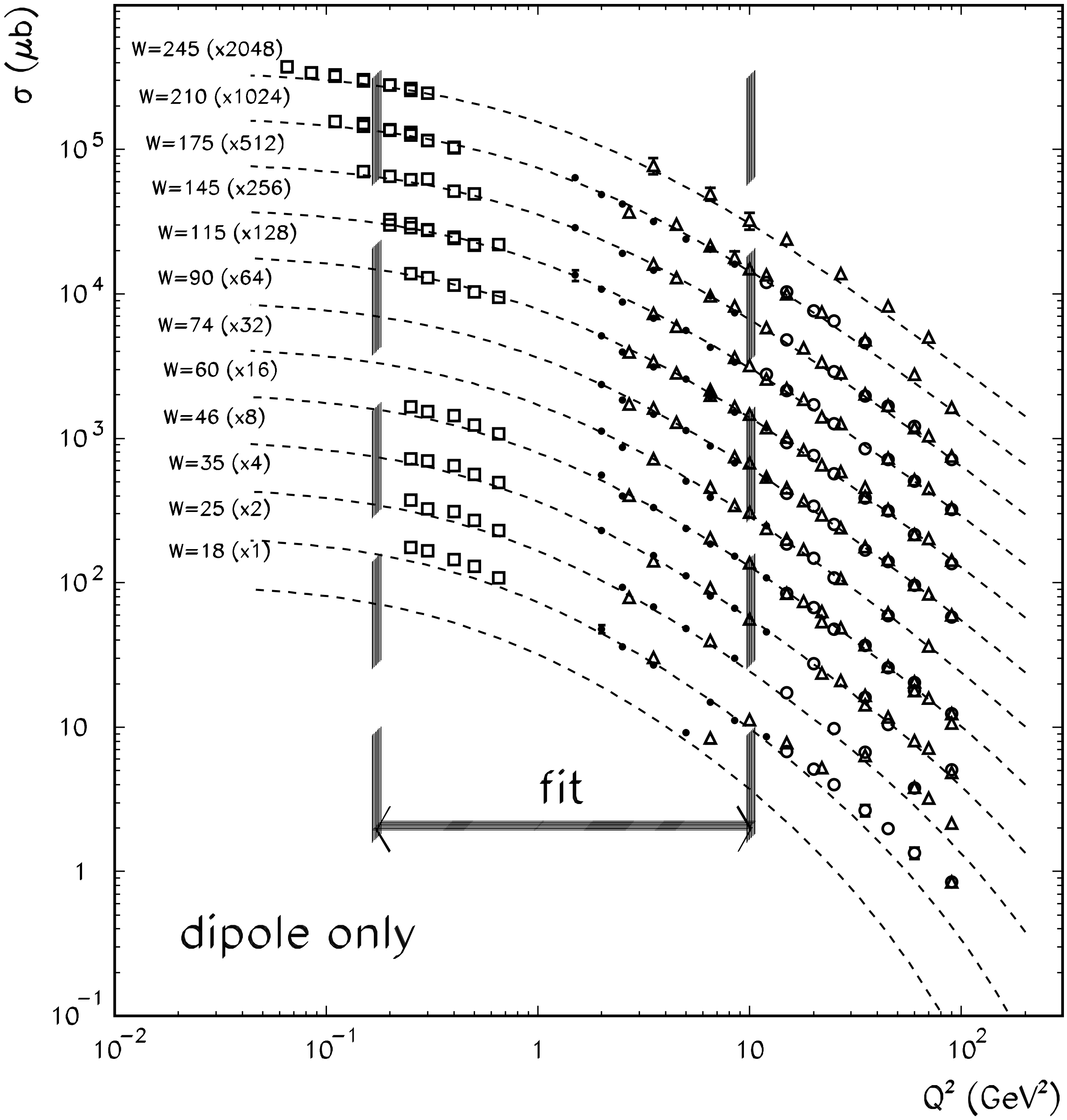
Table 1: Compilation of the fit parameters.

fit	m_0/GeV	σ_0/mb	x_0	λ	χ^2
FIT1	0.10	17.0	9.50e-4	0.302	8.125
dip.	0.15	23.5	2.00e-4	0.268	4.764
	0.20	36.0	1.95e-5	0.235	3.080
FIT2	0.10	7.5	0.0238	0.3160	1.696
dip.	0.15	8.0	0.0194	0.3107	1.553
+ VDM	0.20	8.0	0.0198	0.3213	1.812

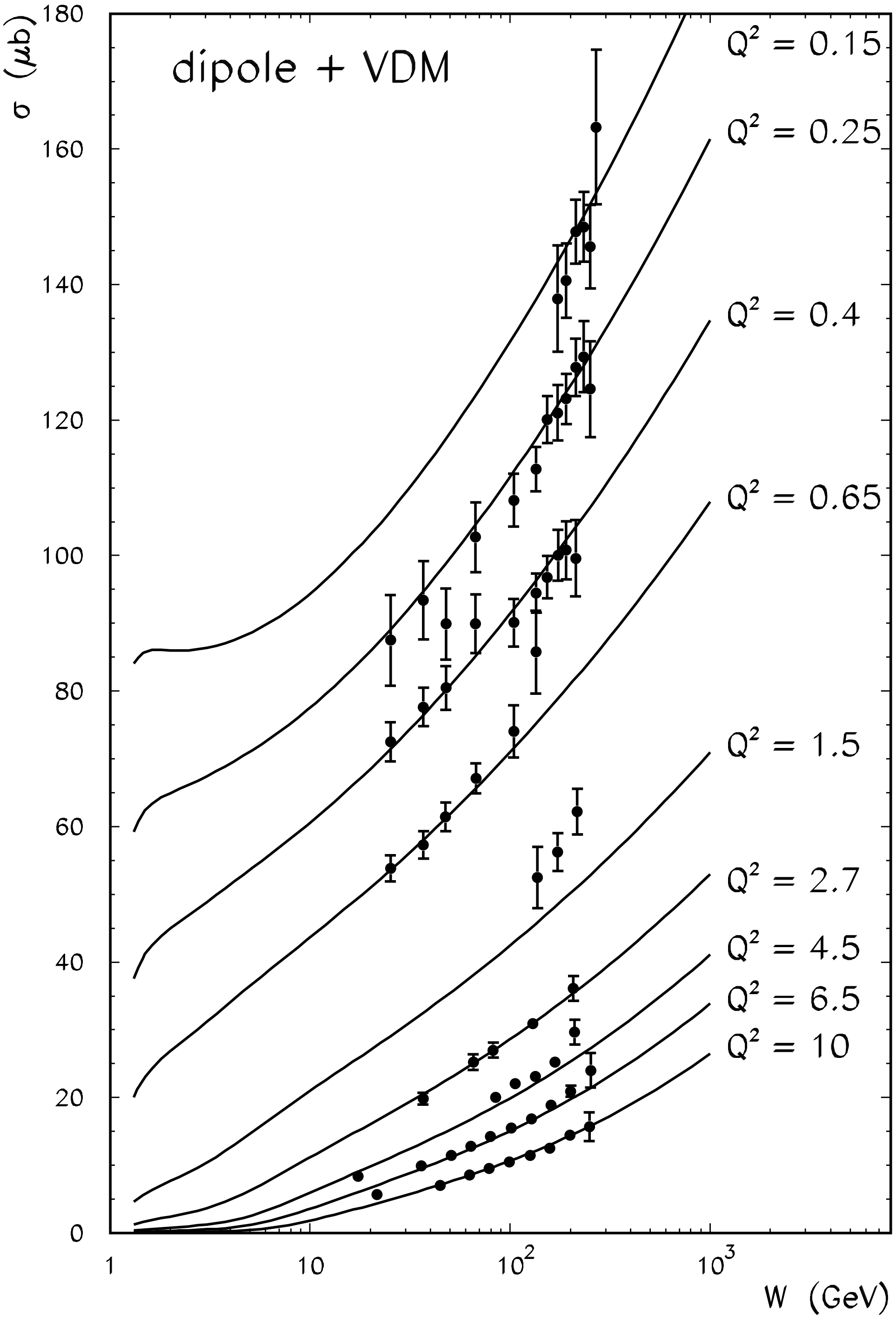
$q\bar{q}$ component only



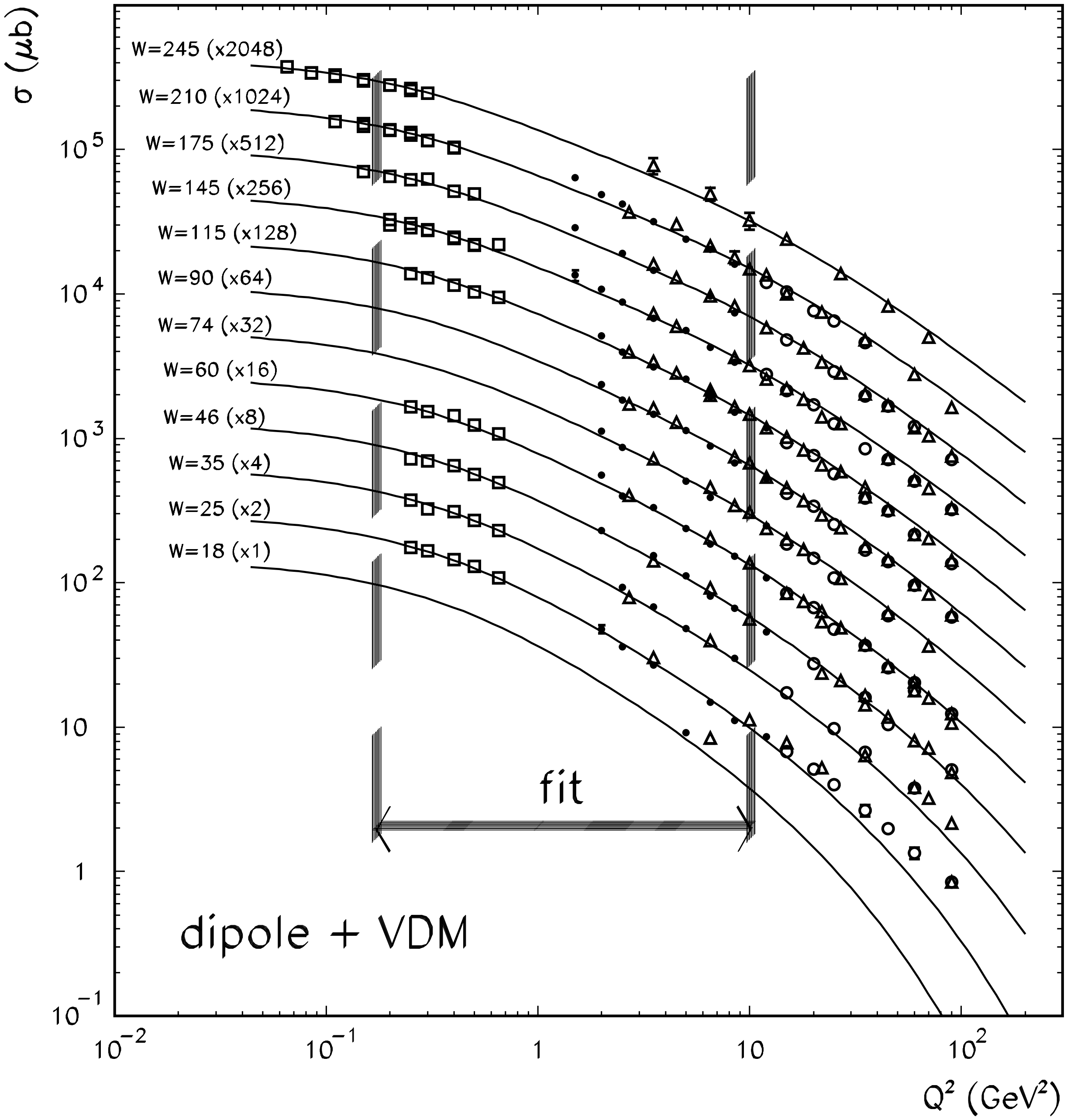
$q\bar{q}$ component only



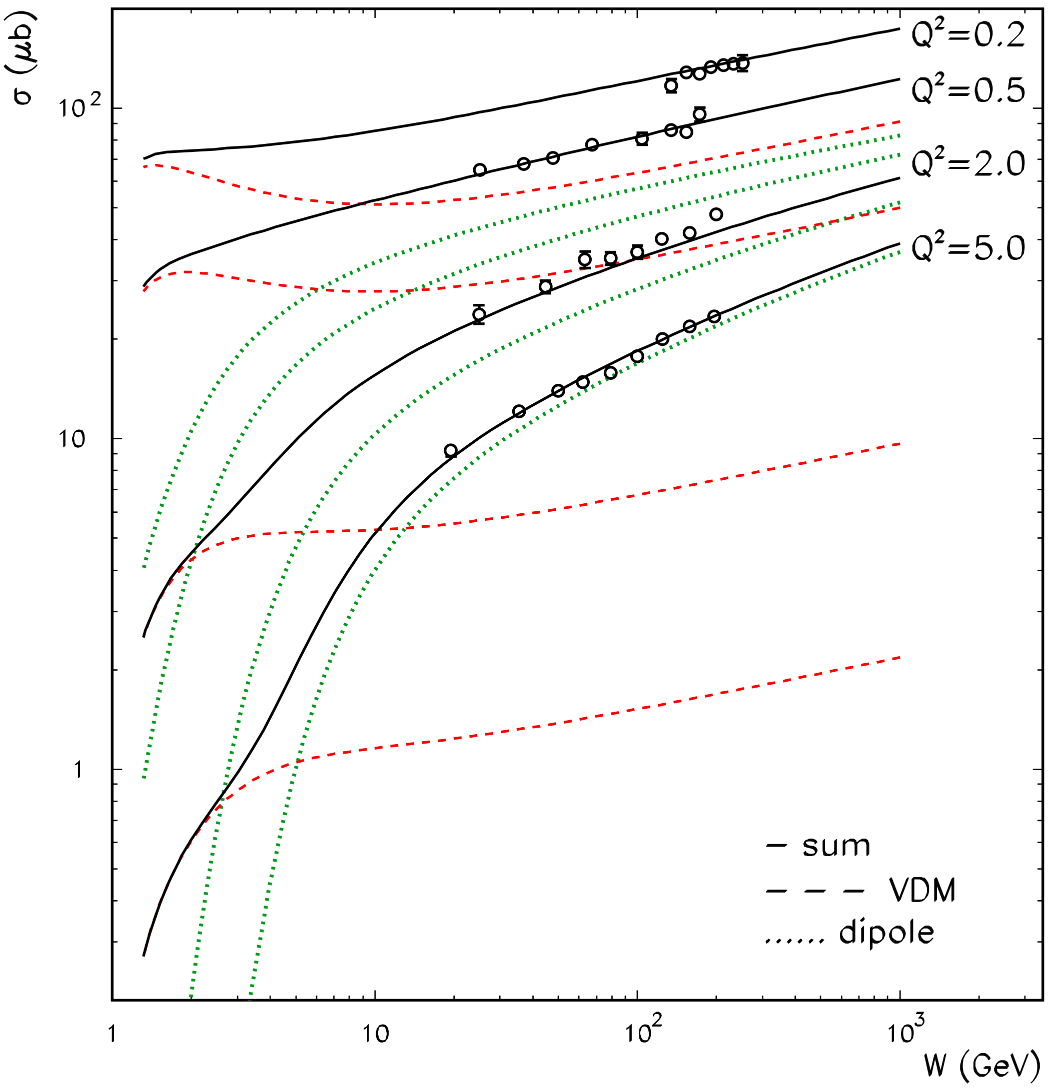
$q\bar{q}$ + VDM component



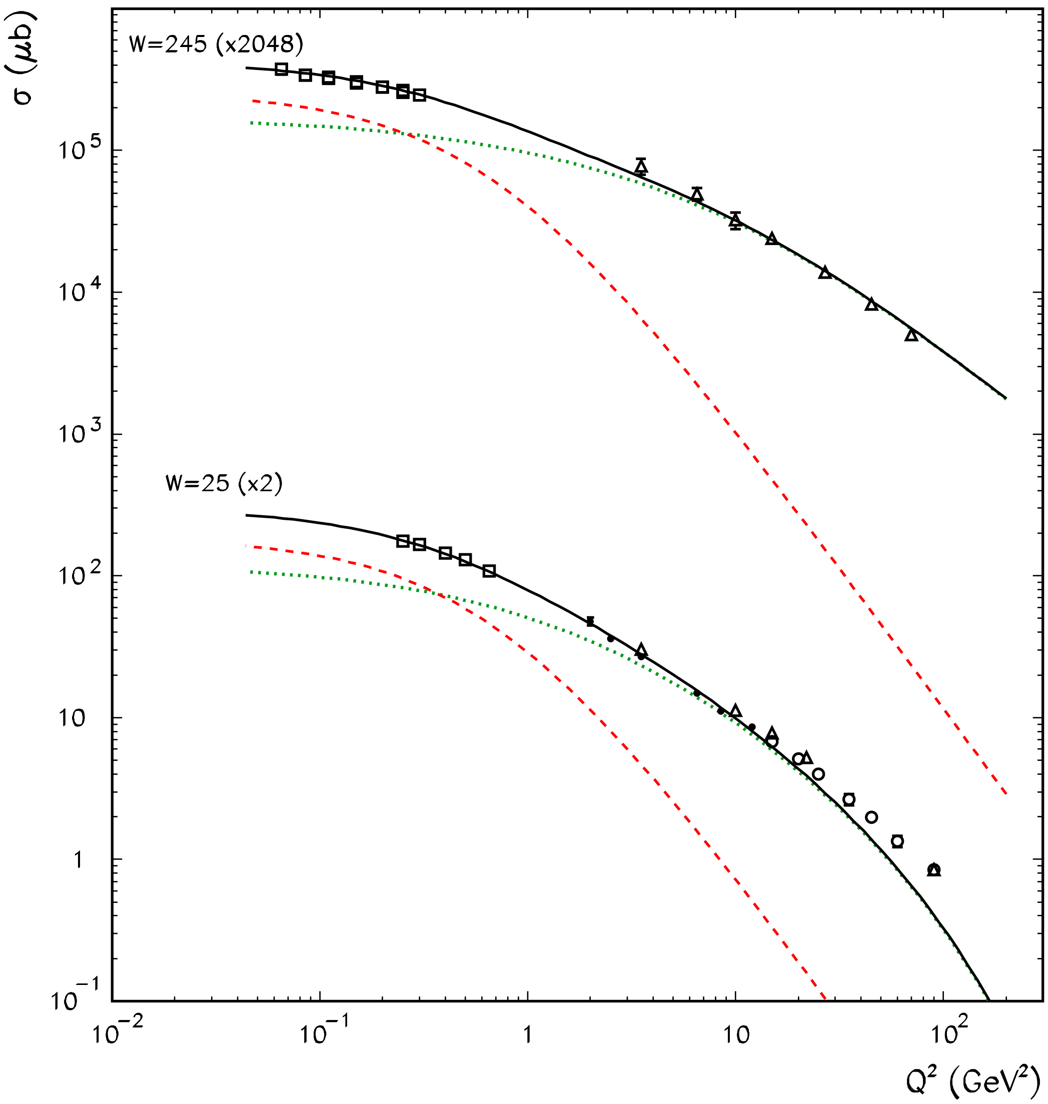
$q\bar{q}$ + VDM component



Model decomposition



Model decomposition



Fixed target data

From low x to higher x

Then three components:

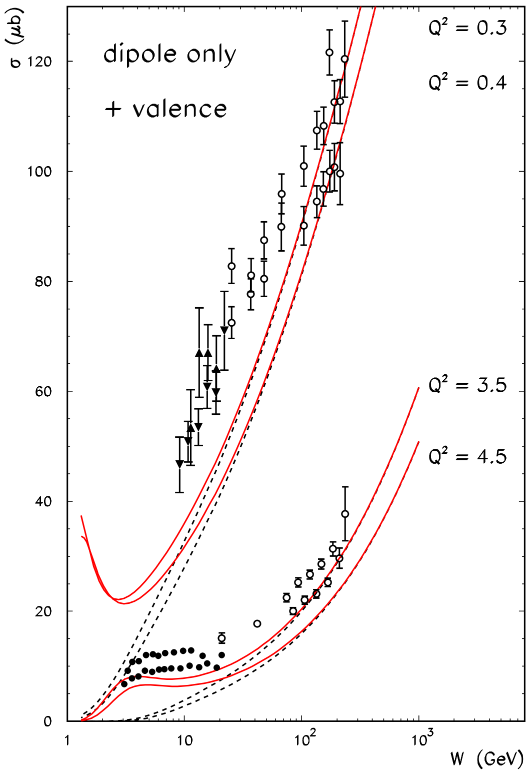
$$\sigma_{tot}^{\gamma^* N}(W,Q^2) =$$
$$\sigma_{dip}^{\gamma^* N}(W,Q^2) + \sigma_{VDM}^{\gamma^* N}(W,Q^2) + \sigma_{val}^{\gamma^* N}(W,Q^2) \tag{14}$$

Valence quarks modified at small Q^2

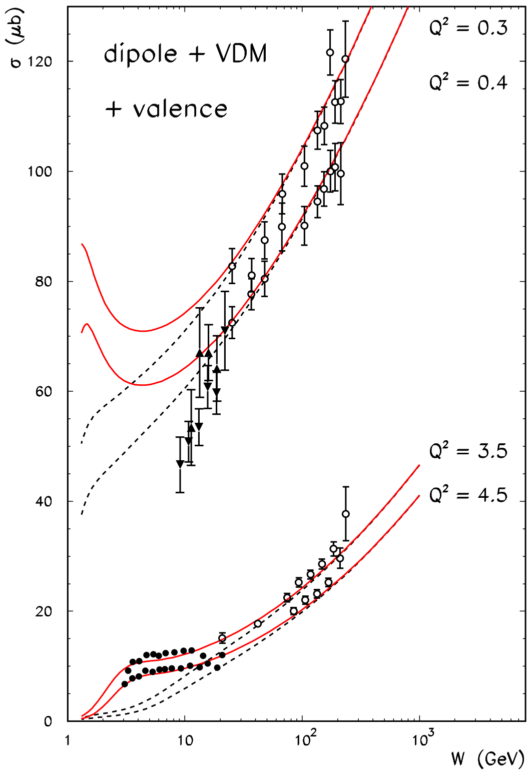
$$F_2^{val}(x,Q^2) \to \tilde{F}_2^{val}(x,Q^2) =$$
$$\frac{Q^2}{Q^2+Q_0^2}\left(\frac{4}{9}xu_{val}(x,Q^2) + \frac{1}{9}xd_{val}(x,Q^2)\right) . \tag{15}$$

Q^2 frozen below $Q^2_{min} = 0.25$ GeV^2.
LO valence quark distributions of GRV.
Q_0^2 =0.8 GeV^2 from a global analysis of data by Szczurek and Uleshchenko.

Fixed target data

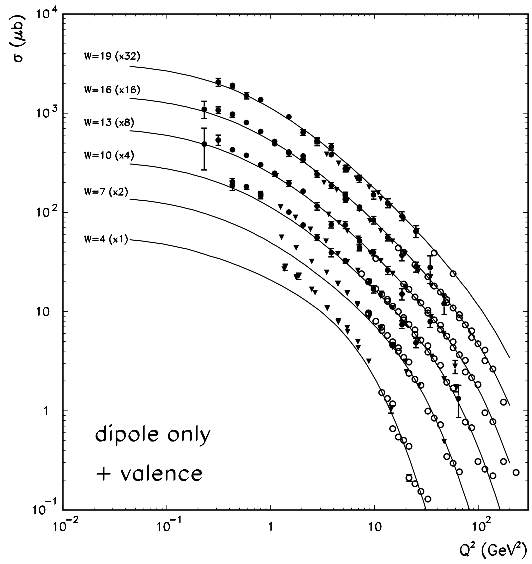


(c) dipole

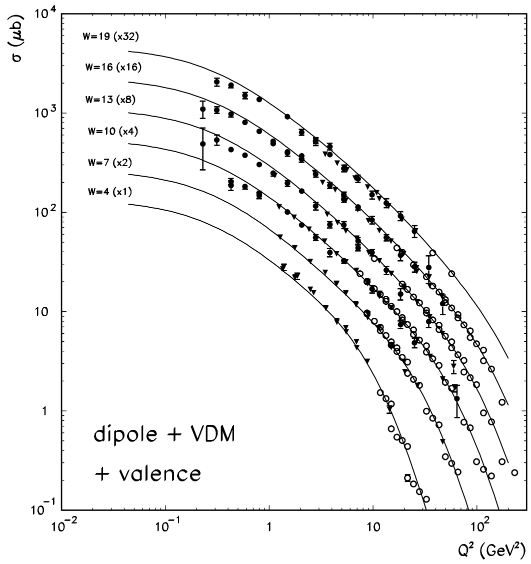


(d) dipole+VDM

Fixed target data



(e) dipole



(f) dipole+VDM

Summary/Conclusions

- Recent fits to $\sigma_{tot}^{\gamma^* p}$ include only $q\bar{q}$
- Exclusive processes badly need resolved photon
- We have performed two fits:
  - 1) including dipole only
  - 2) including dipole + VDM
- Good agreement with exp. data beyond range of the fit2
- Different predictions in unmeasured regions