

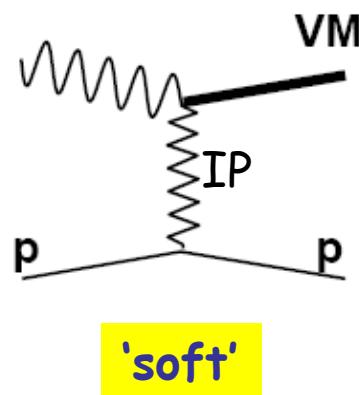
Exclusive ρ^0 electroproduction

$$\gamma^* p \rightarrow \rho^0 p$$

Aharon Levy
DESY/Tel Aviv University

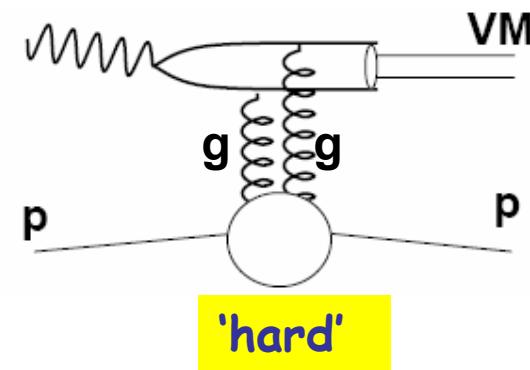
on behalf of
the ZEUS Collaboration

Why are we measuring



$$\sigma(W) \propto W^\delta$$

$$\frac{d\sigma}{dt} \propto e^{-b|t|}$$



- Expect δ to increase from soft (~ 0.2 , from 'soft Pomeron' value) to hard (~ 0.8 , from $xg(x, Q^2)^2$)
- Expect b to decrease from soft ($\sim 10 \text{ GeV}^{-2}$) to hard ($\sim 4-5 \text{ GeV}^{-2}$)

$\mathcal{M}(\pi\pi)$ - all

Data collected during
1996-2000, $\mathcal{L} \sim 120 \text{ pb}^{-1}$

$2 < Q^2 < 160 \text{ GeV}^2$

$32 < W < 160 \text{ GeV}$

For analysis:

$0.65 < M(\pi\pi) < 1.1 \text{ GeV}$

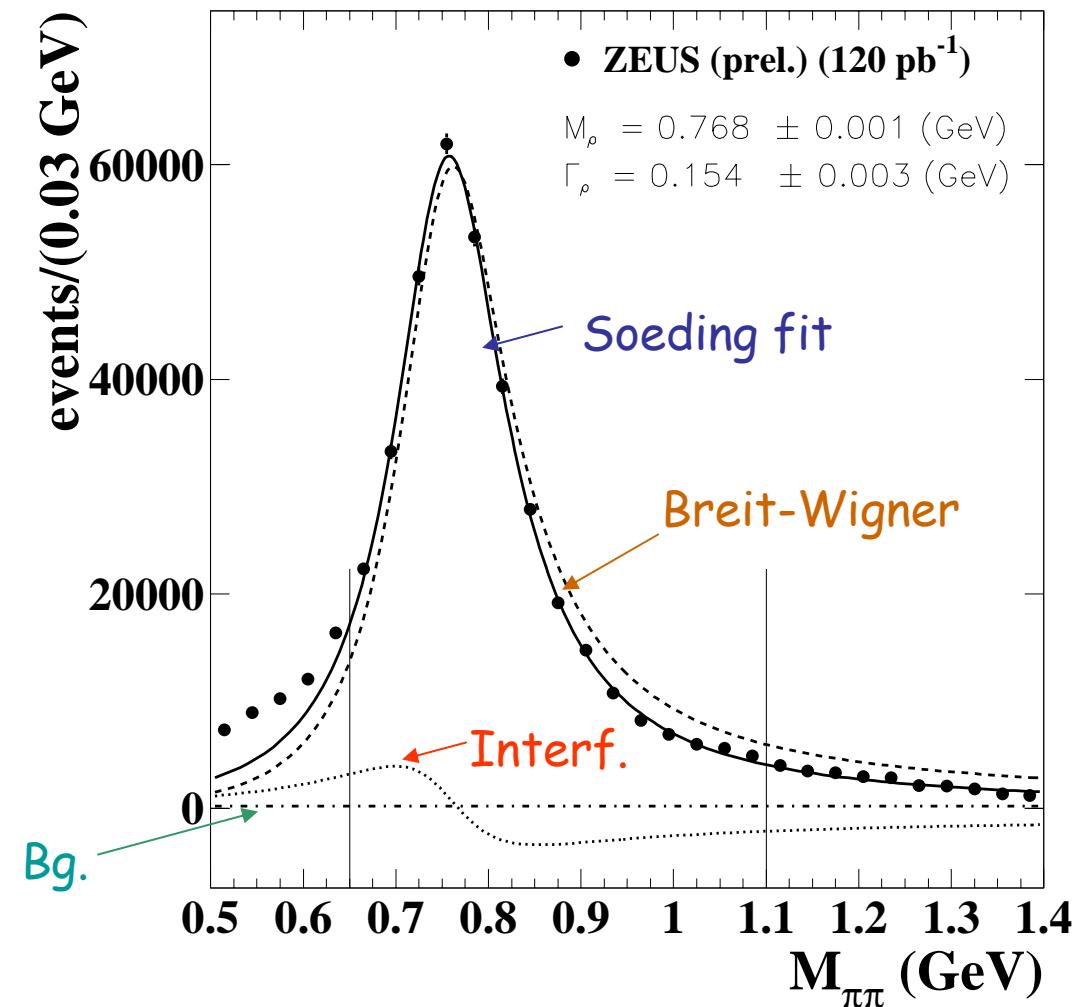
$|t| < 1 \text{ GeV}^2$

71,700 events

For cross sections:

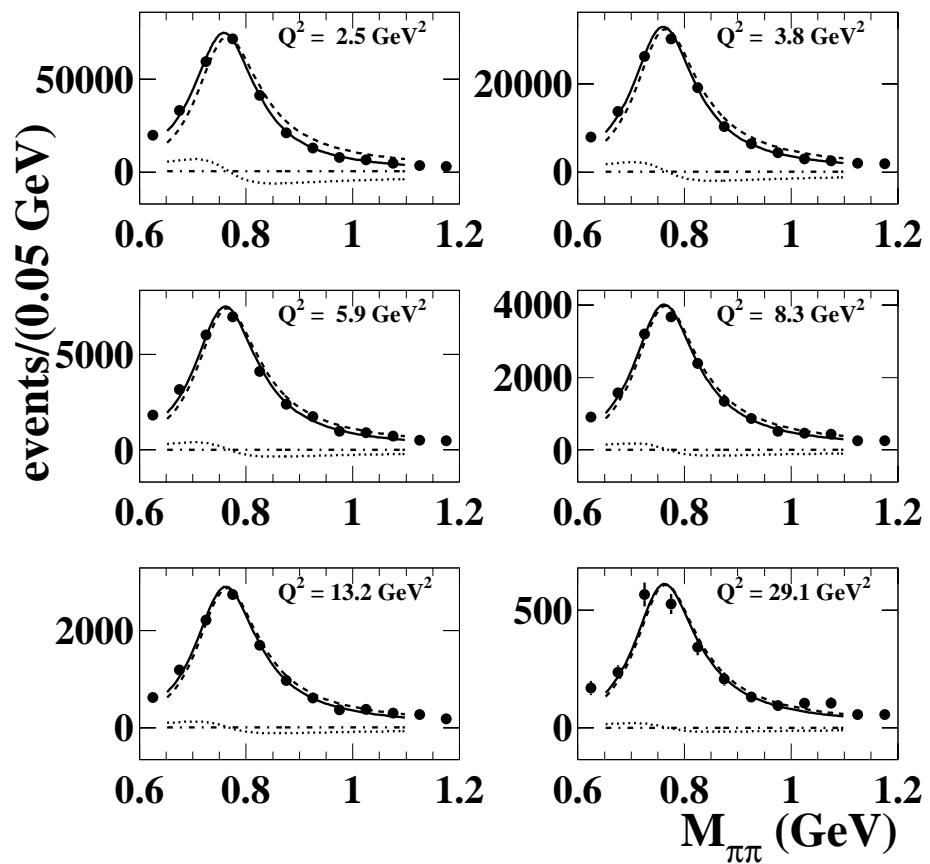
integrated over whole t and
 p^0 mass

ZEUS

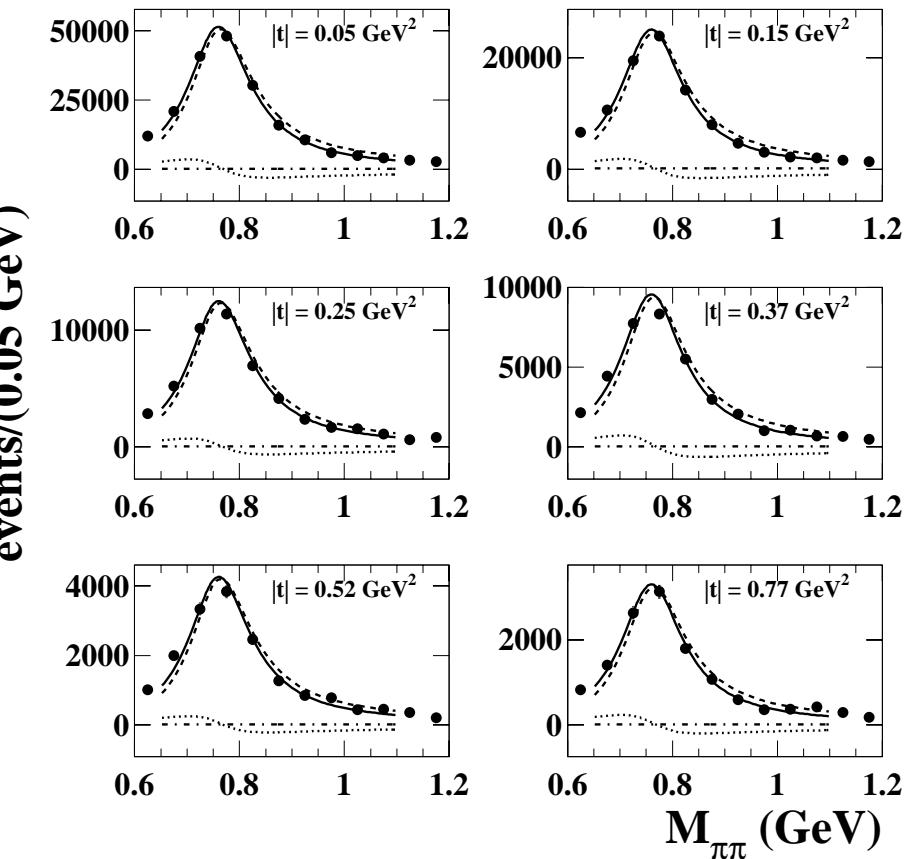


$\mathcal{M}(\pi\pi) - Q^2, t$

ZEUS

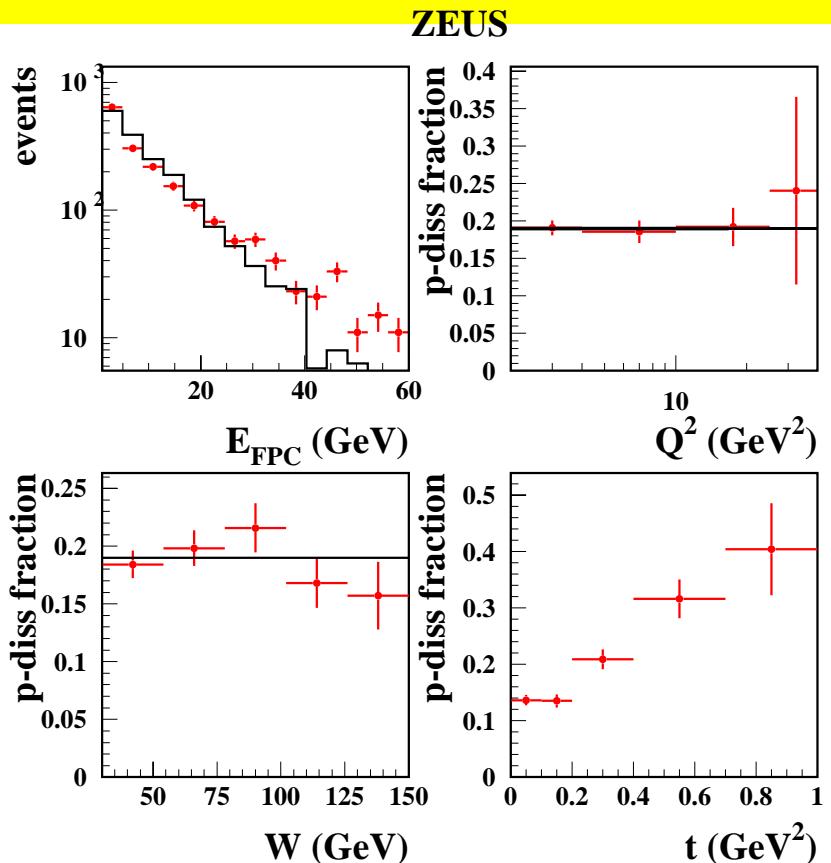


ZEUS

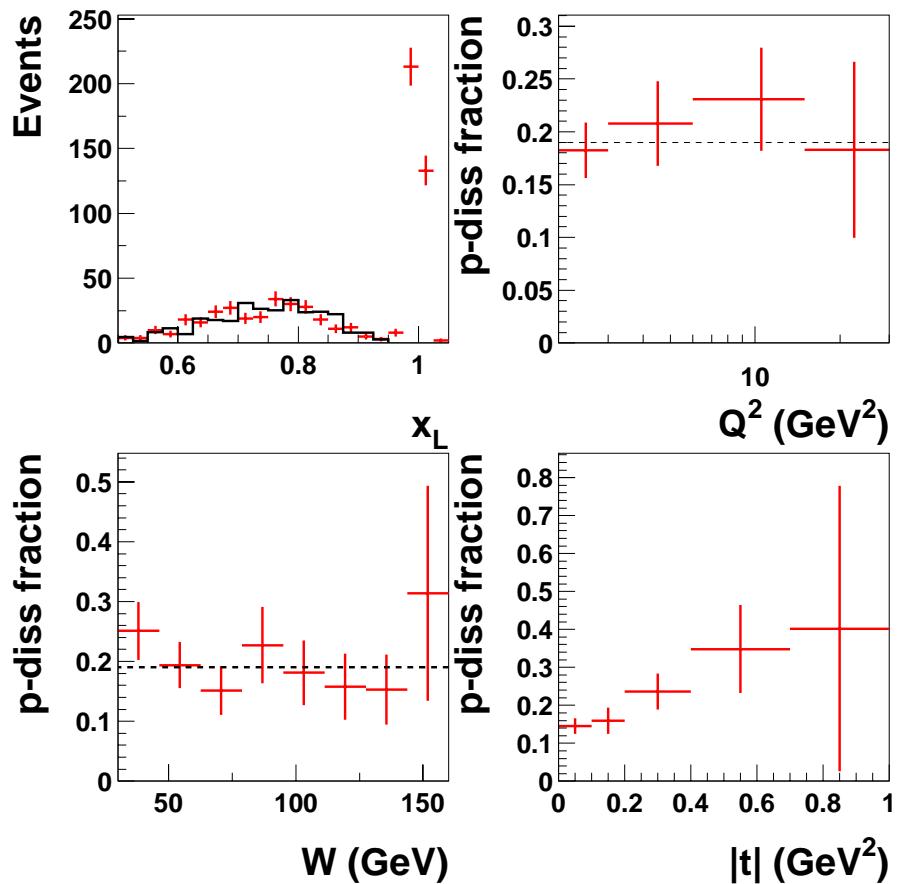


ρ^0 mass shape not dependent on Q^2 and t .
As Q^2 increases, interference term decreases - as expected.

Proton dissociation



MC: PYTHIA

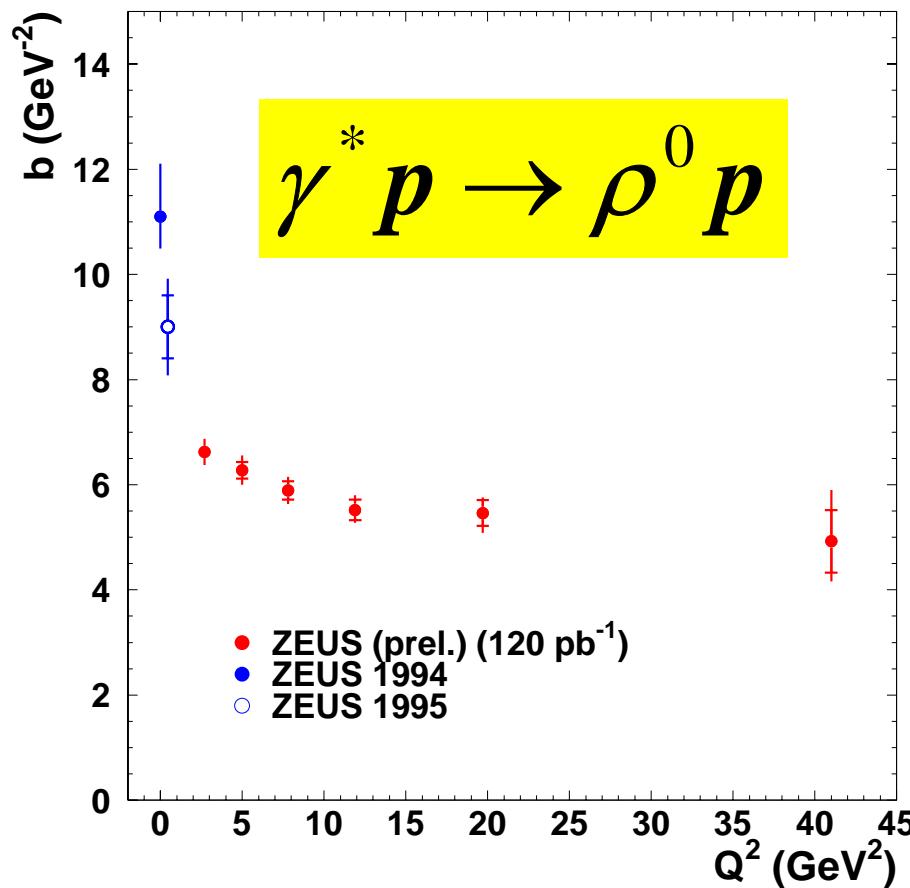


pdiss: $19 \pm 2(\text{st}) \pm 3(\text{sys}) \%$

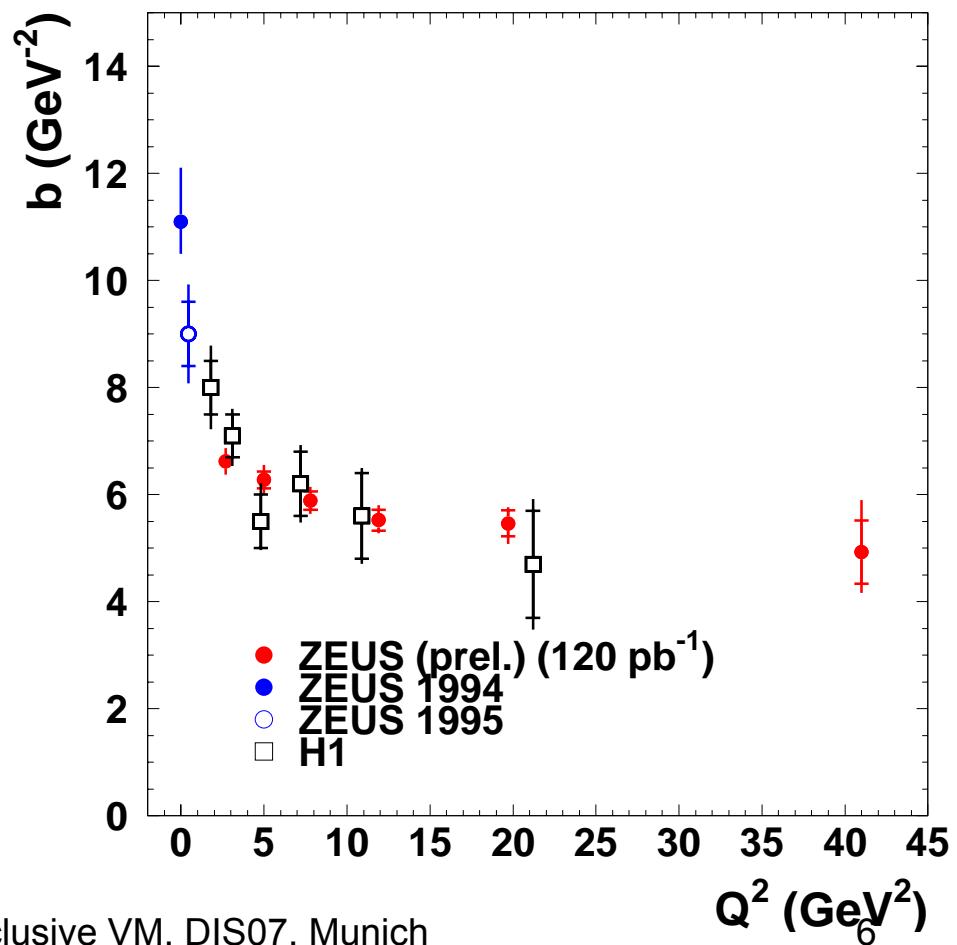
b(Q^2)

Fit $\frac{d\sigma}{dt} \propto e^{-b|t|}$ in different Q^2 bins:

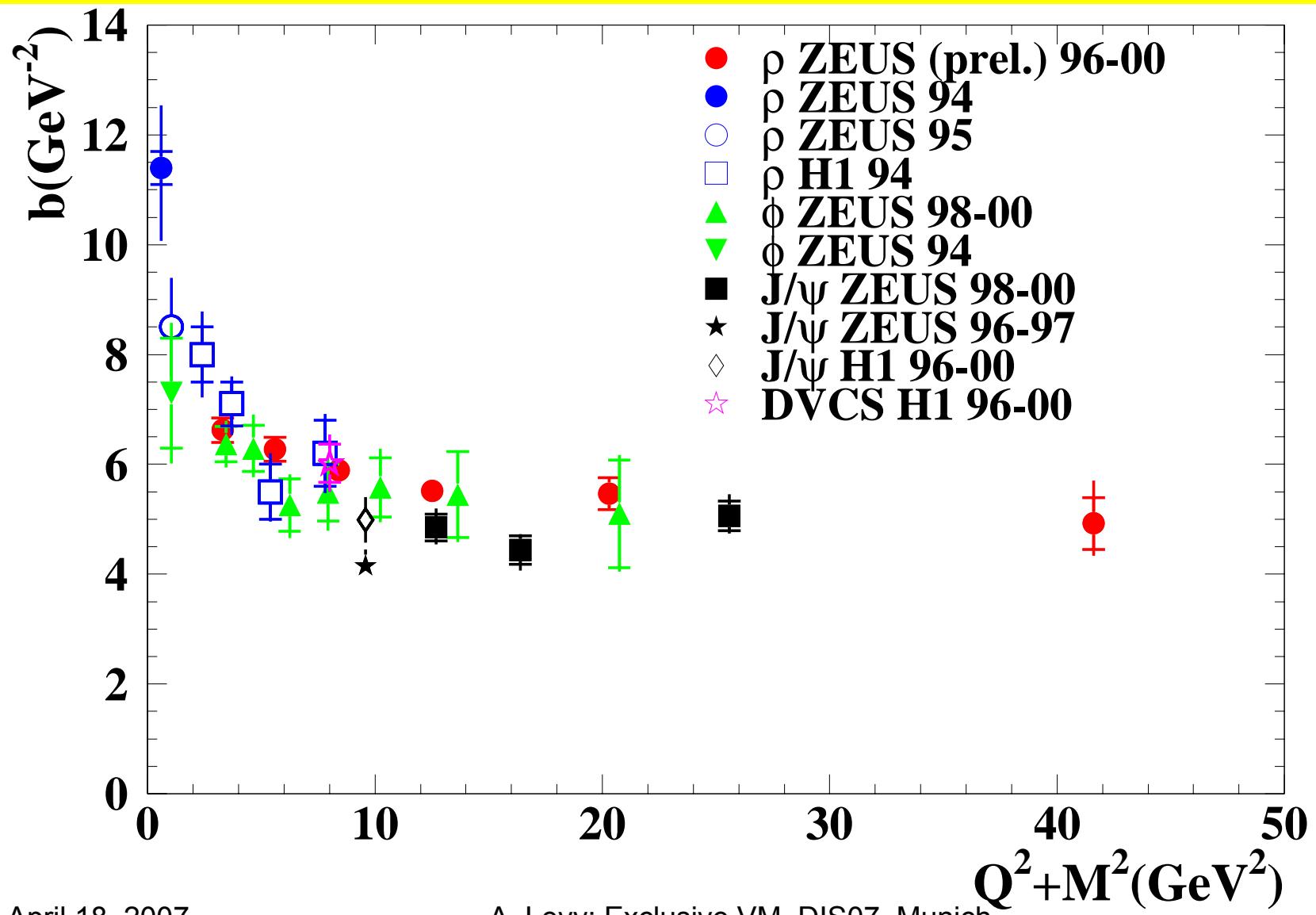
ZEUS



ZEUS

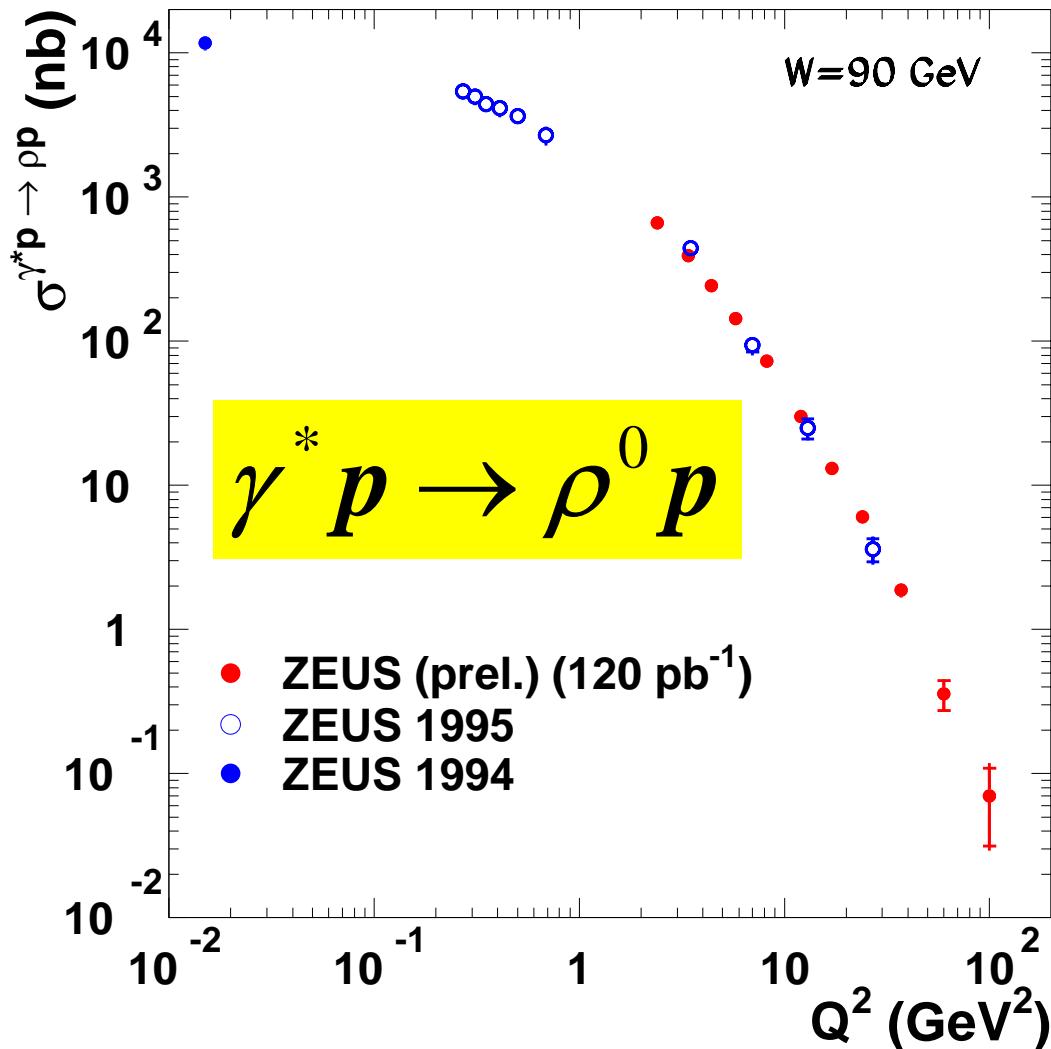


$b(Q^2 + M^2) - VM$



ZEUS

$\sigma(Q^2)$

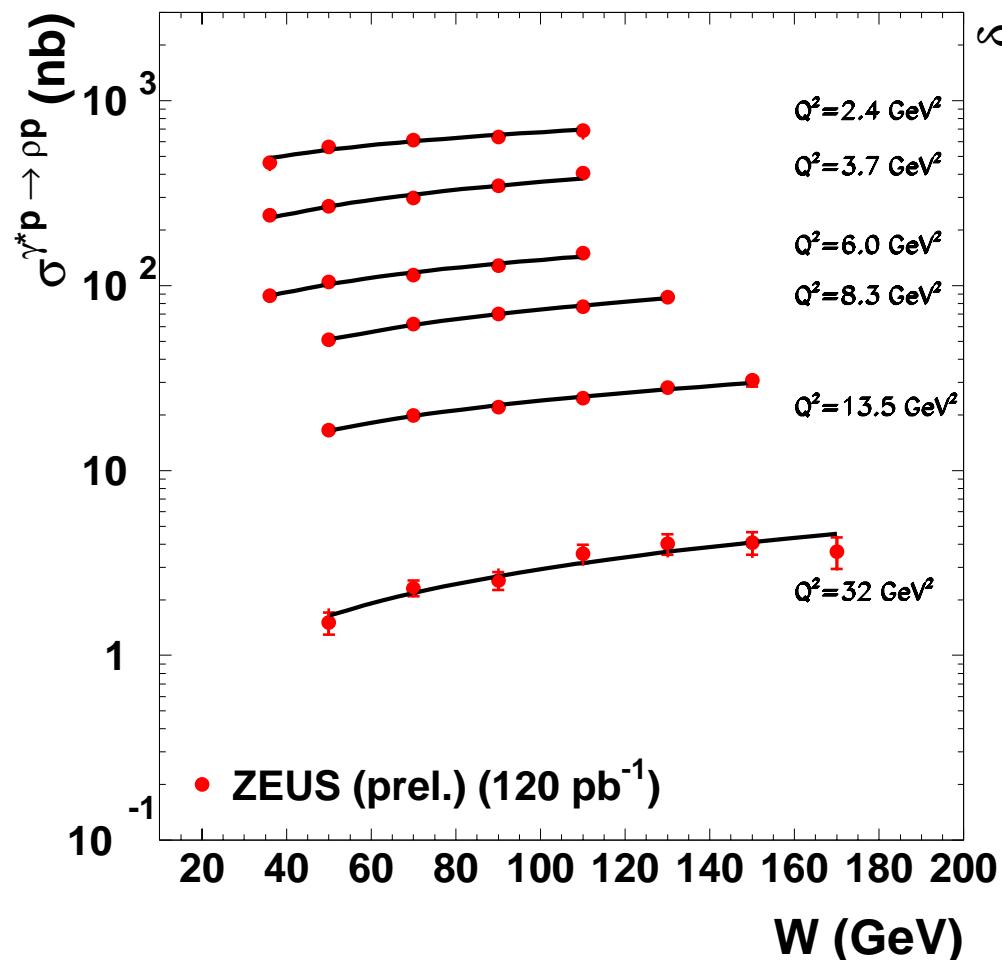


$$\sigma \propto (Q^2 + M^2)^{-n}$$

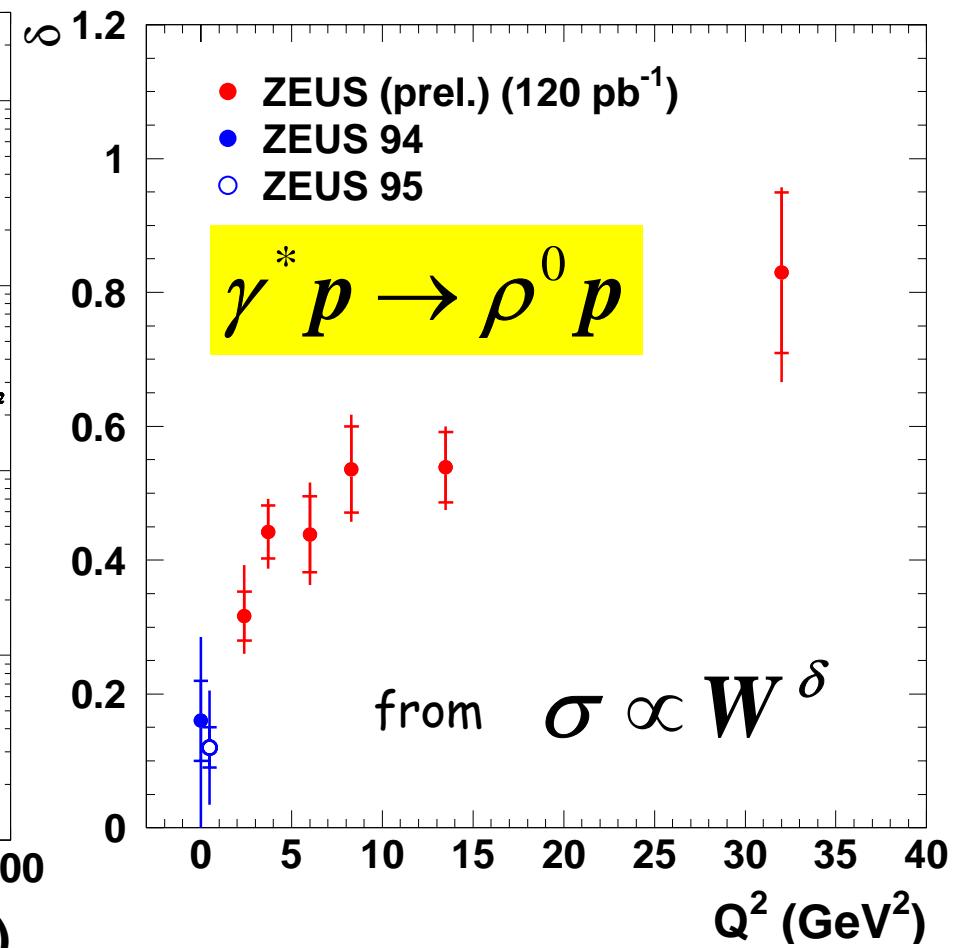
Fit to whole Q^2 range
gives bad $\chi^2/\text{df} (\sim 70)$

$\sigma(W)$

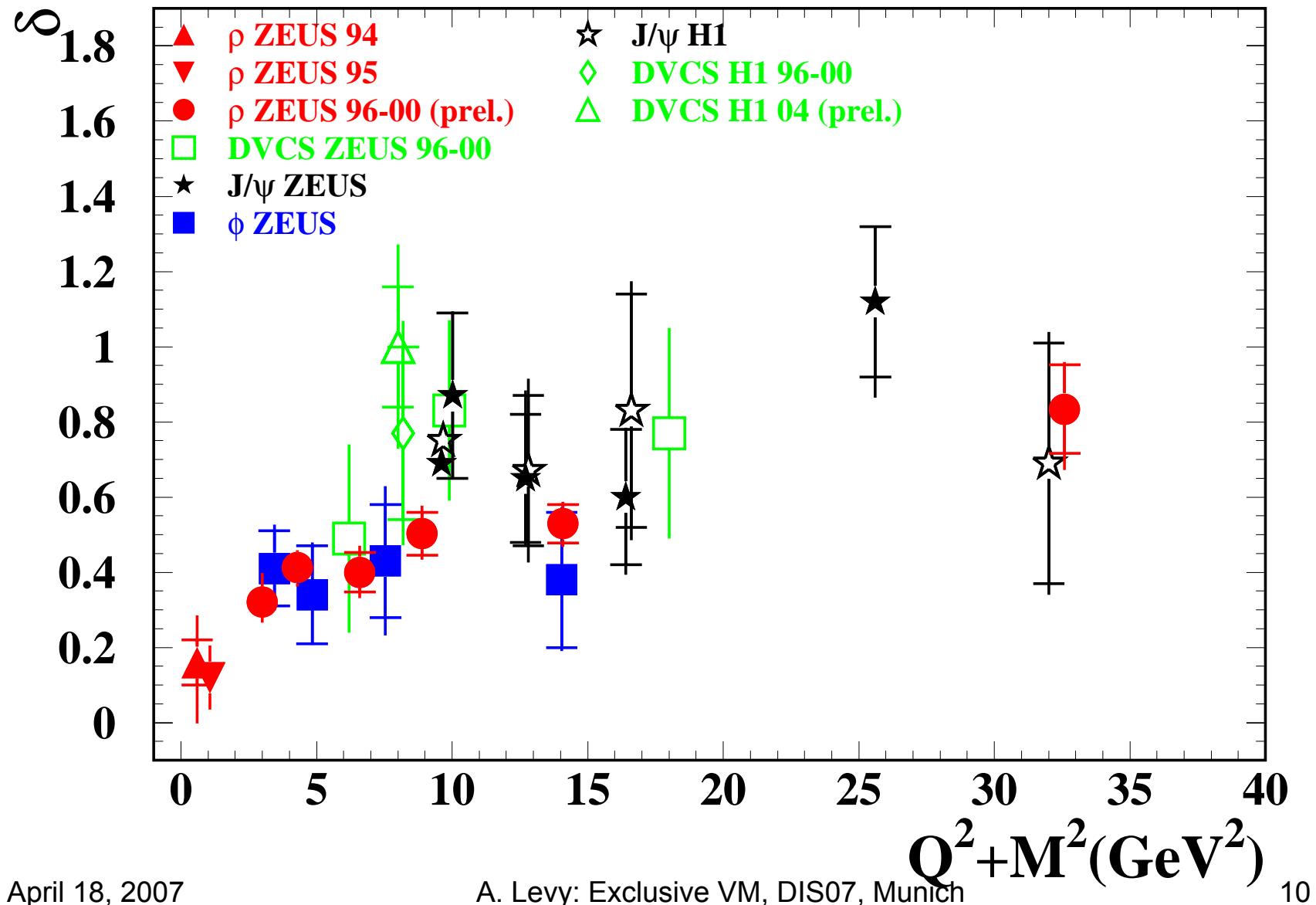
ZEUS



ZEUS

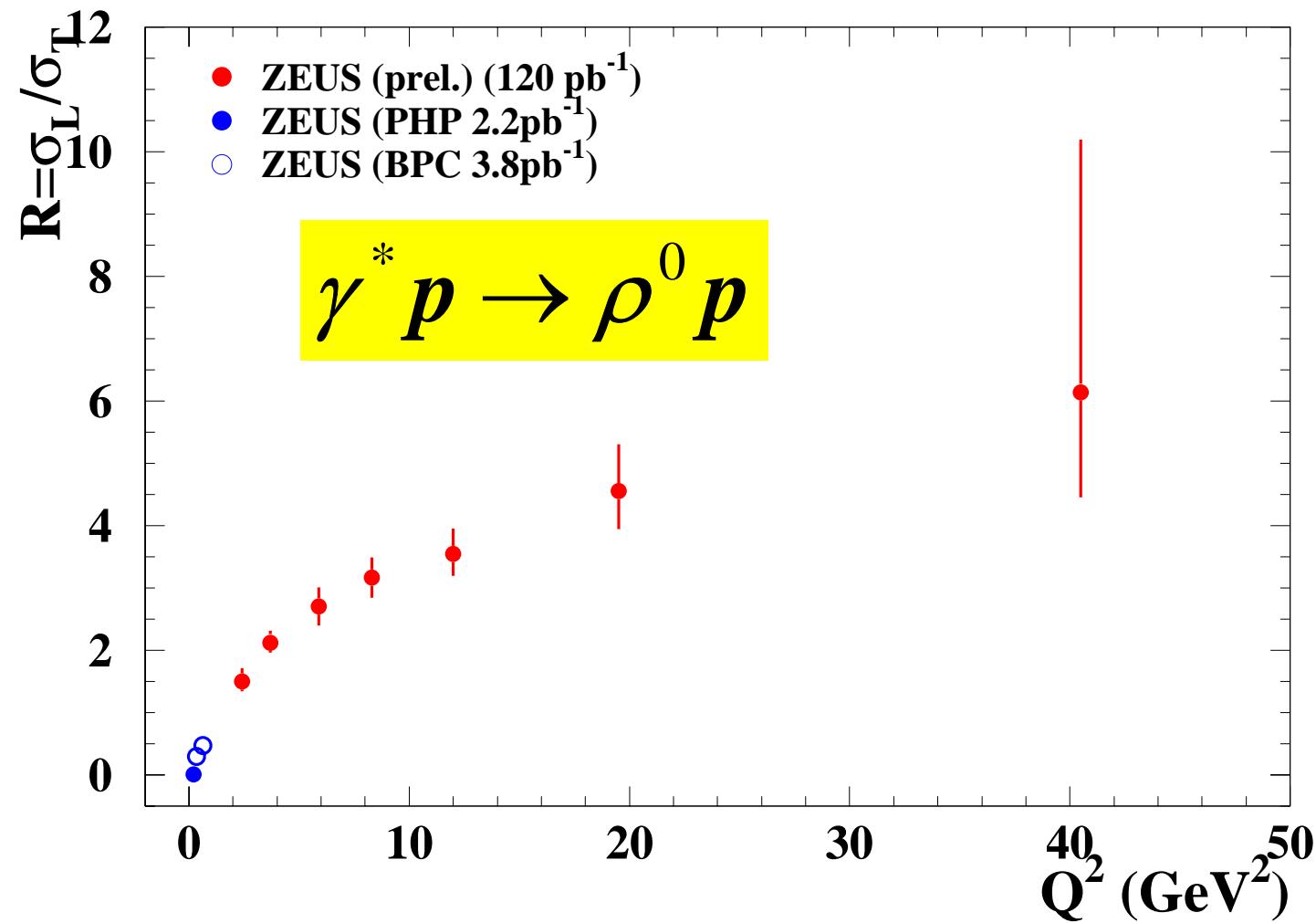


$\delta(Q^2) - \text{VM}$



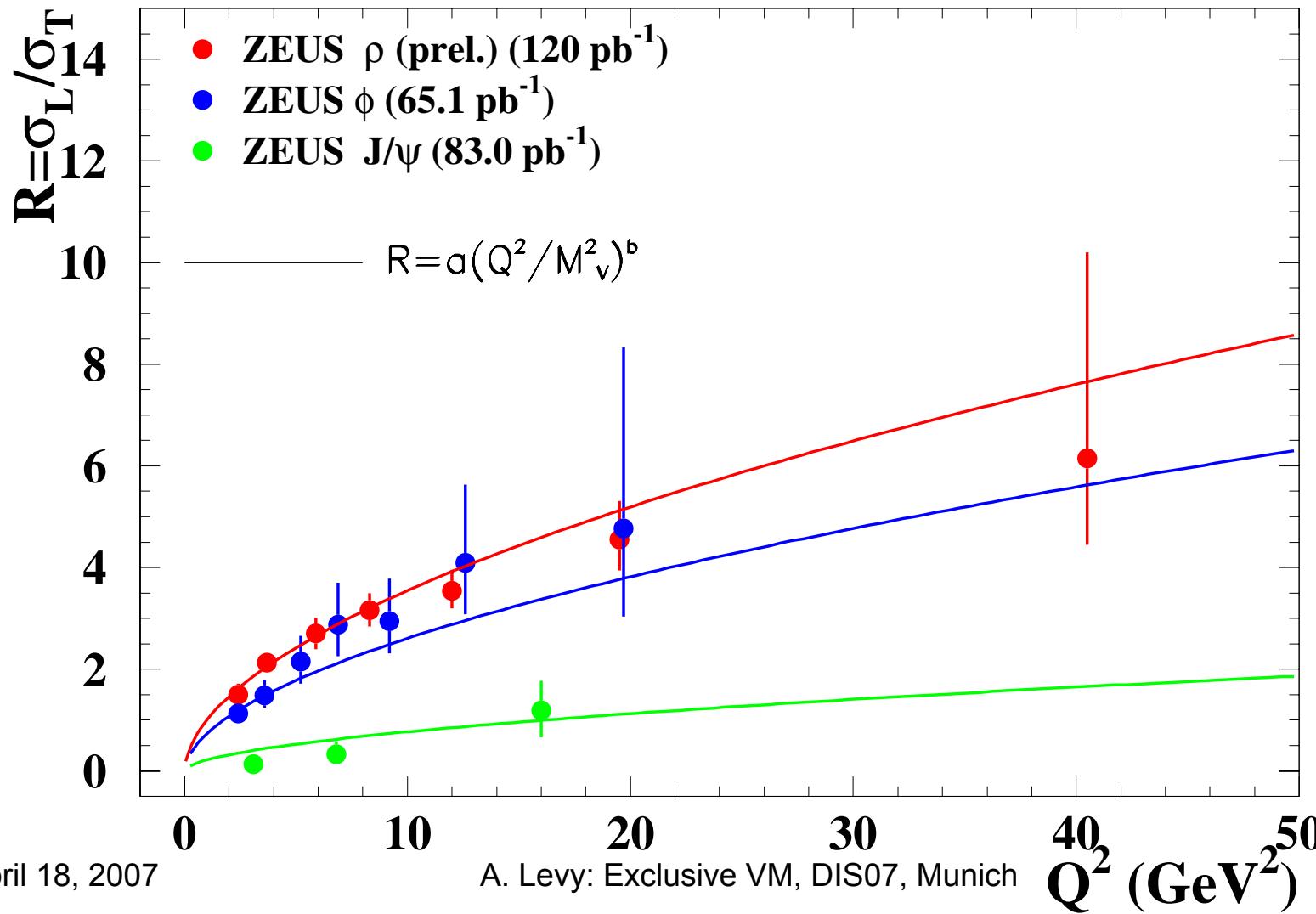
$$R = \sigma_L / \sigma_T (Q^2)$$

ZEUS

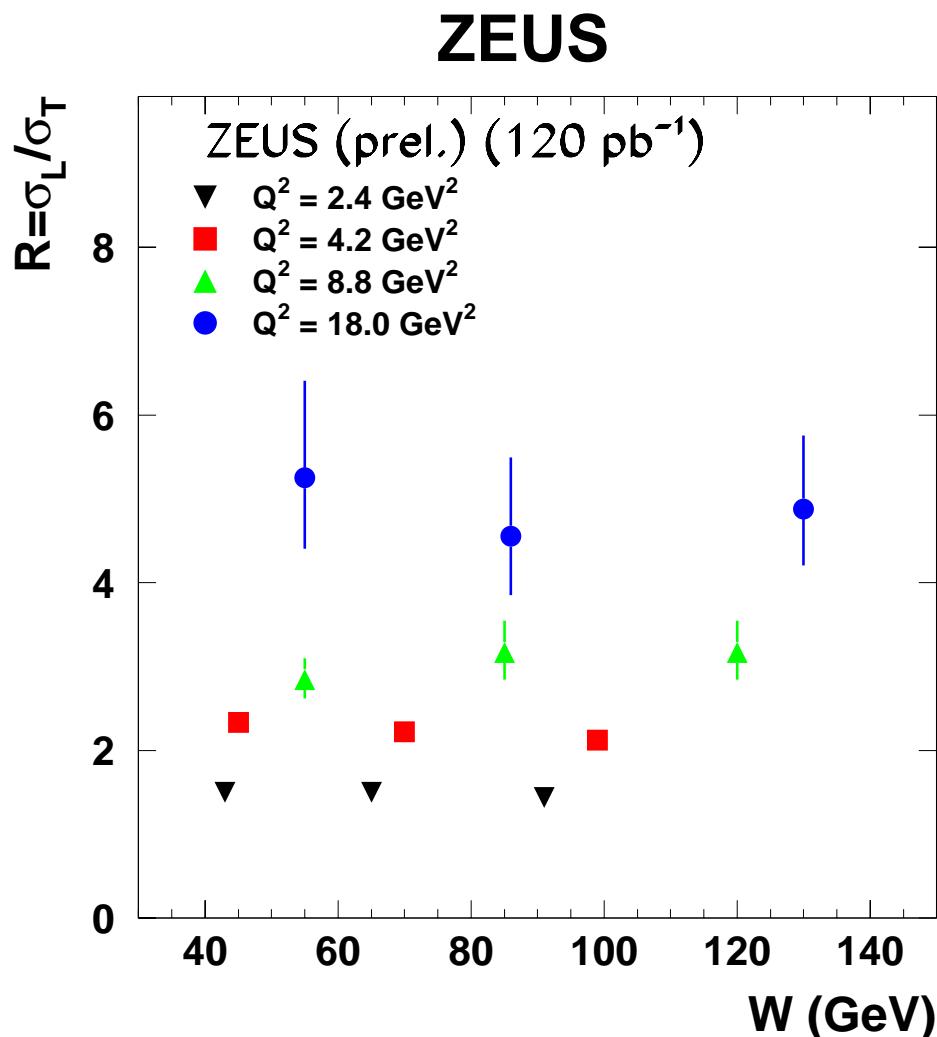


$$R = \sigma_L / \sigma_T (Q^2) - VM$$

ZEUS



R(W)



⇒ σ_L and σ_T same W dependence

???

$\sigma_L \Rightarrow (\text{qqbar})$ in small configuration

$\sigma_T \Rightarrow (\text{qqbar})$ in small and large configurations

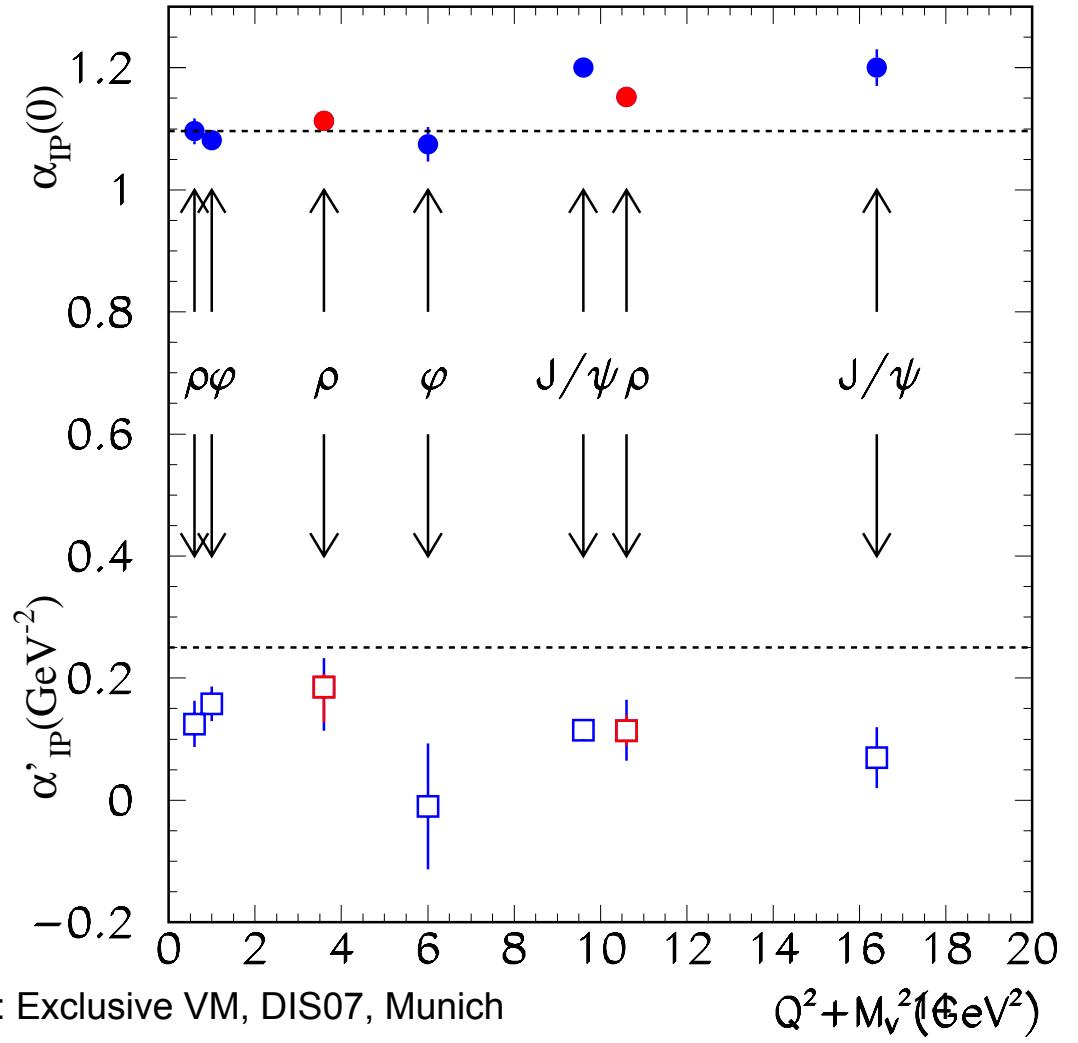
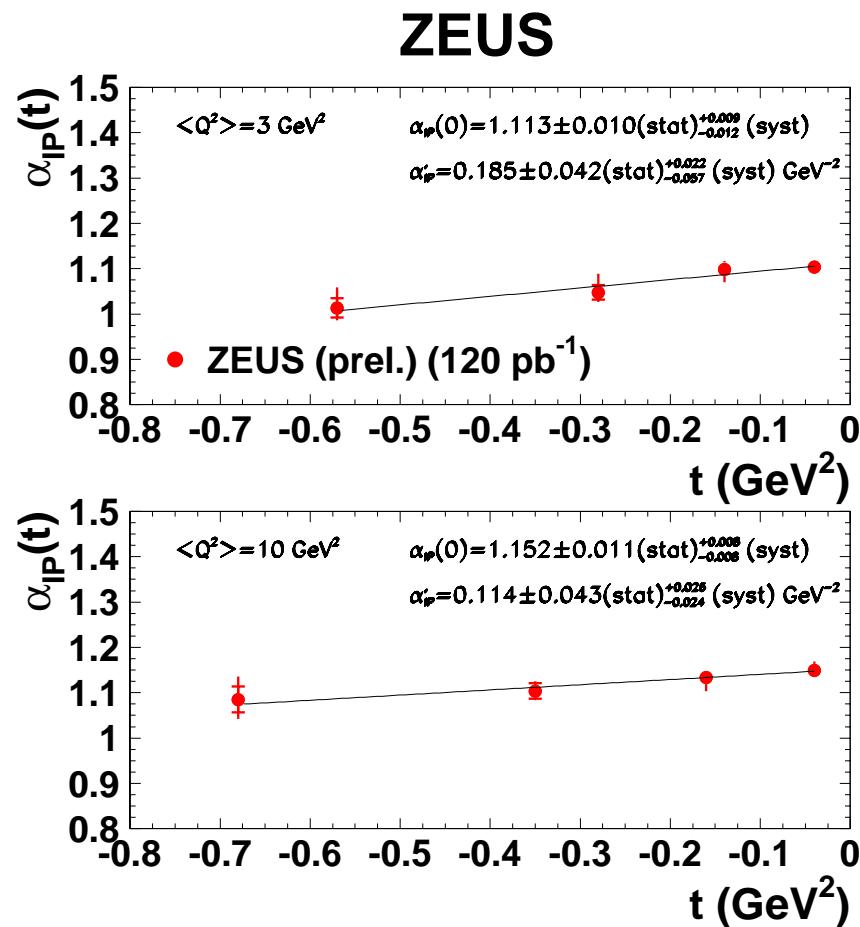
small configuration ⇒ steep W dep

large configuration ⇒ slow W dep

⇒ large (qqbar) configuration is suppressed

Pomeron trajectory

Get Pomeron trajectory from $d\sigma/dt(W)$ at fixed t

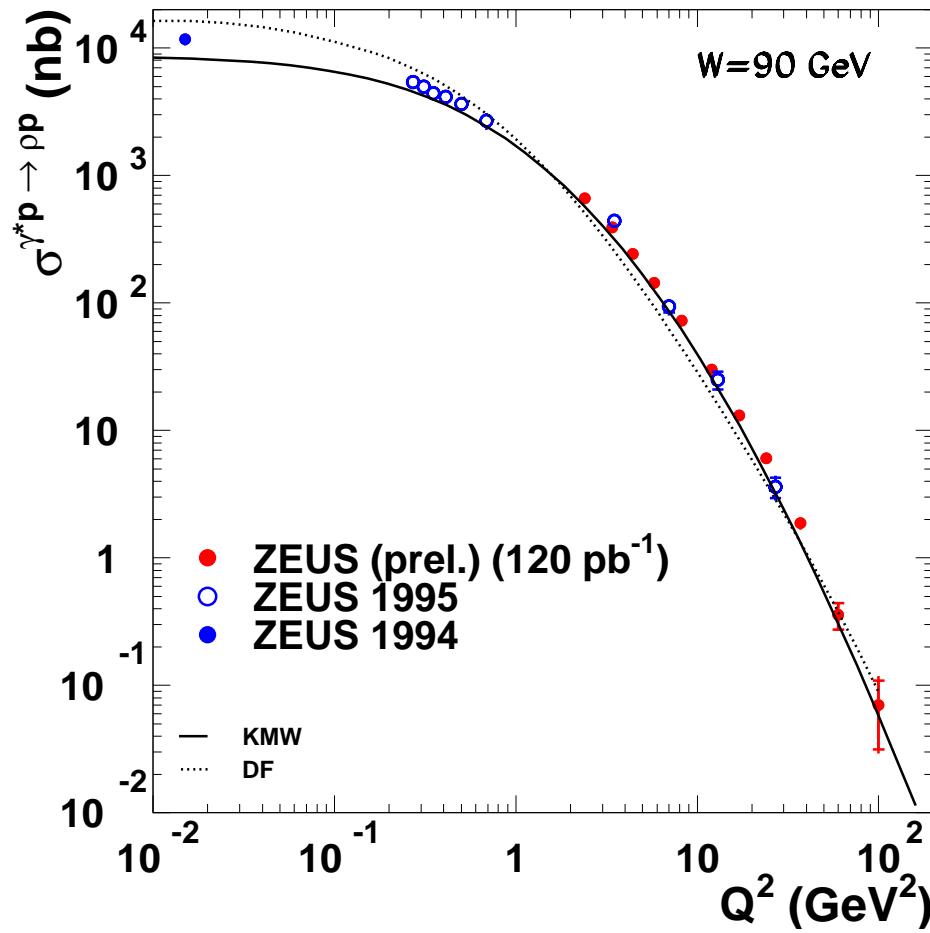


Comparison to theory

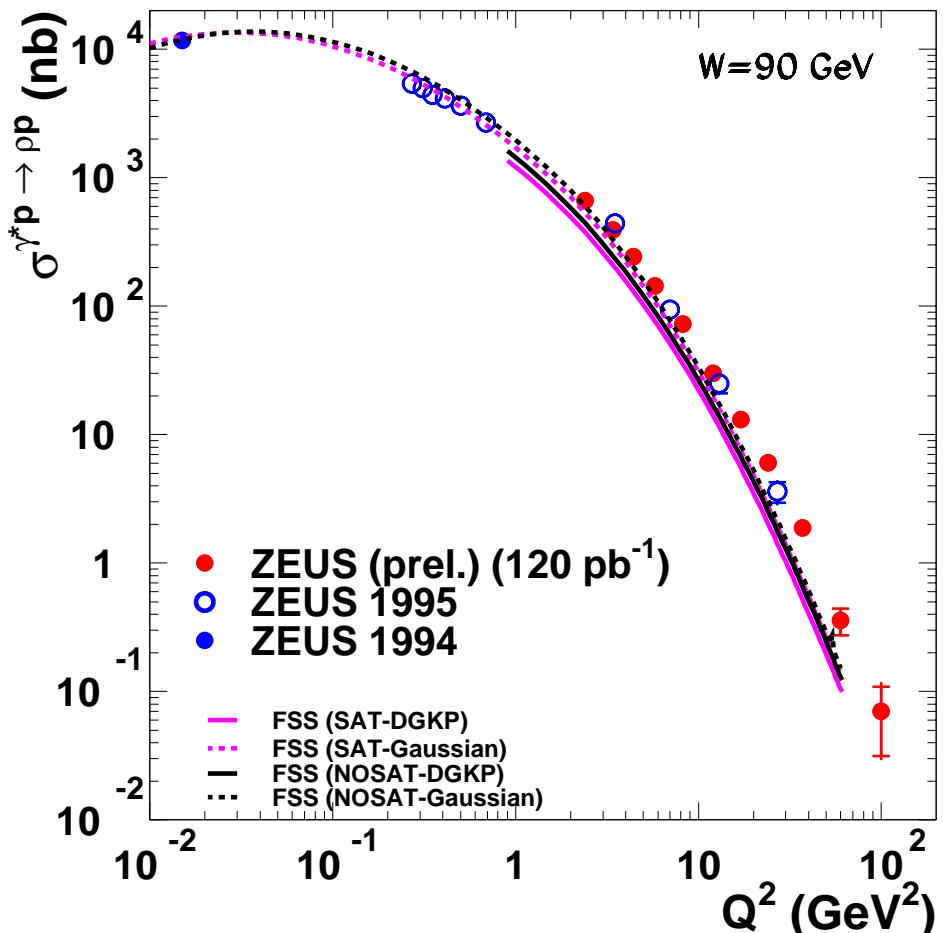
- Martin-Ryskin-Teubner (MRT) - work in momentum space, use parton-hadron duality, put emphasis on gluon density determination.
Phys. Rev. D 62, 014022 (2000).
- Forshaw-Sandapen-Shaw (FSS) - improved understanding of VM wf. Try Gaussian and DGKP (2-dim Gaussian with light-cone variables).
Phys. Rev. D 69, 094013 (2004).
- Kowalski-Motyka-Watt (KMW) - add impact parameter dependence, Q^2 evolution - DGLAP.
Phys. Rev. D 74, 074016 (2006).
- Dosch-Ferreira (DF) - focusing on the dipole cross section using Wilson loops. Use soft+hard Pomeron for an effective evolution.
hep-ph/0610311 (2006).

$\sigma(Q^2)$

ZEUS

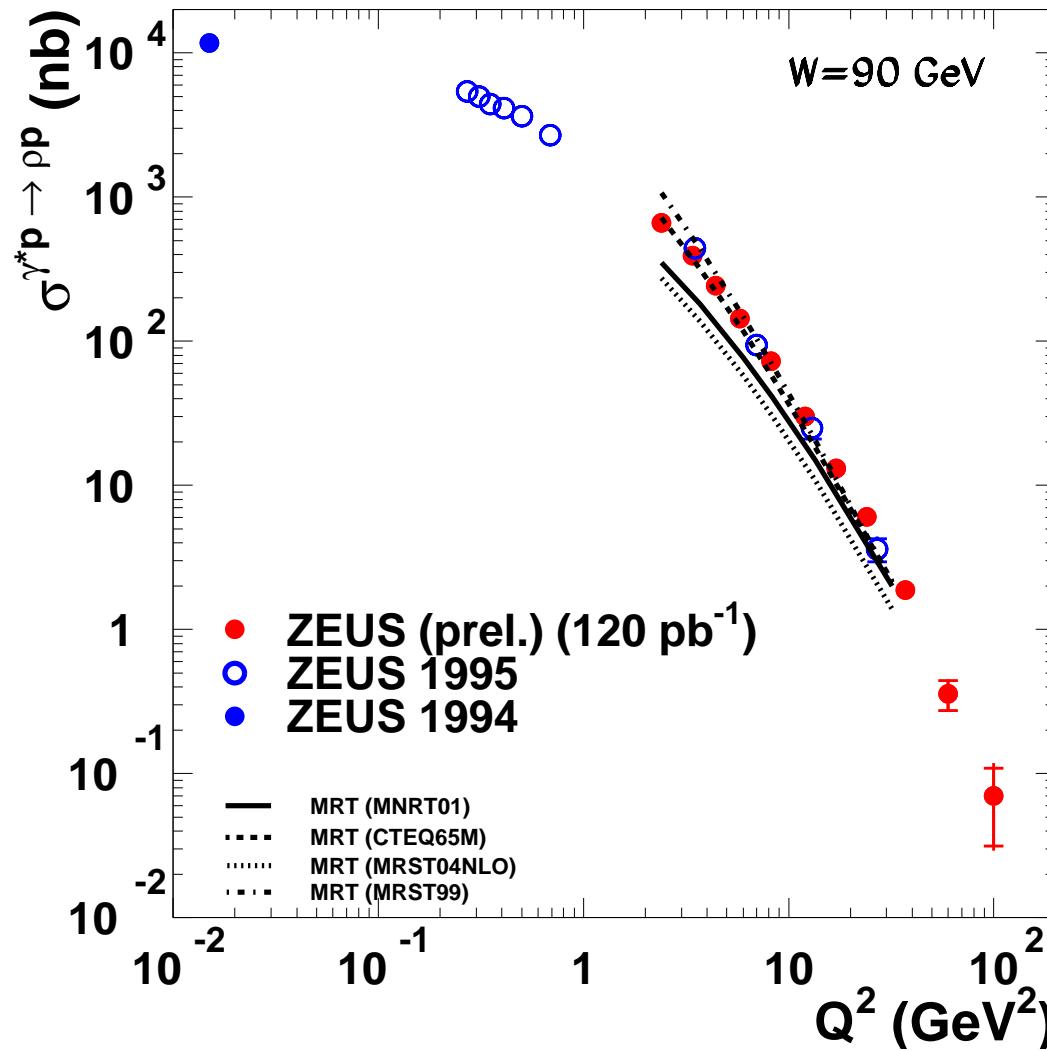


ZEUS



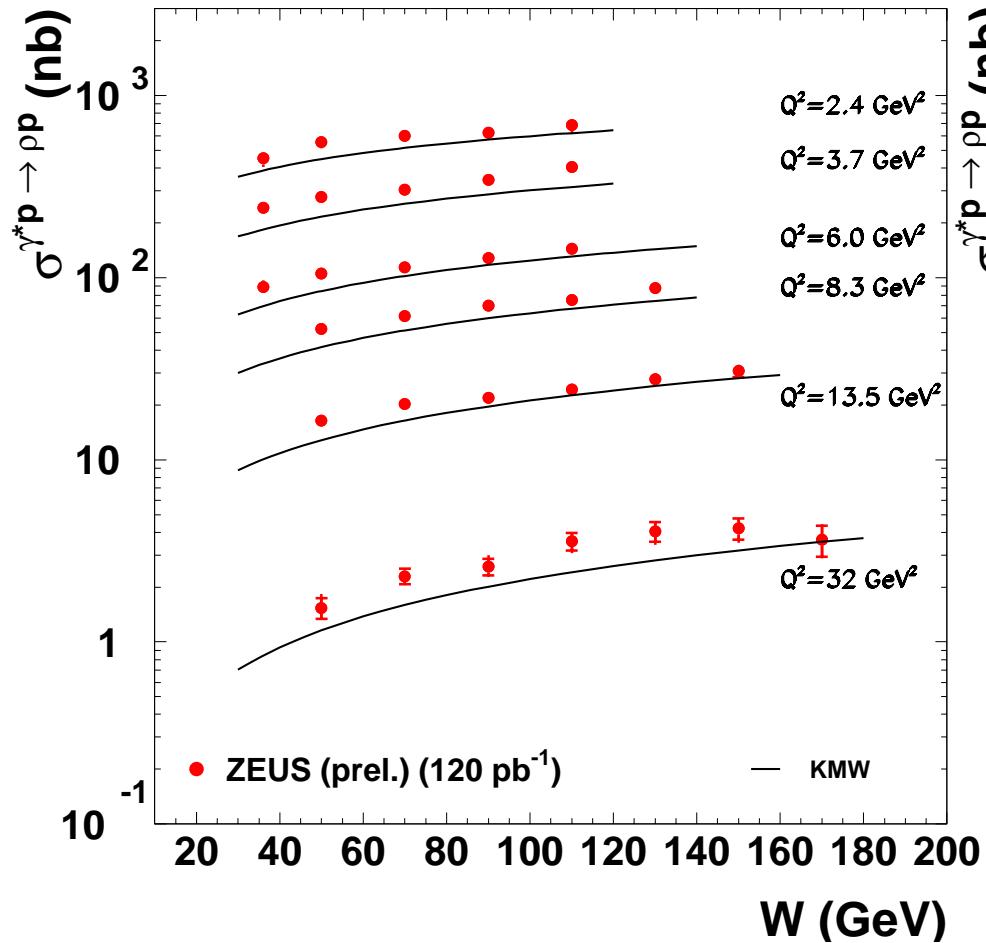
$\sigma(Q^2)$

ZEUS

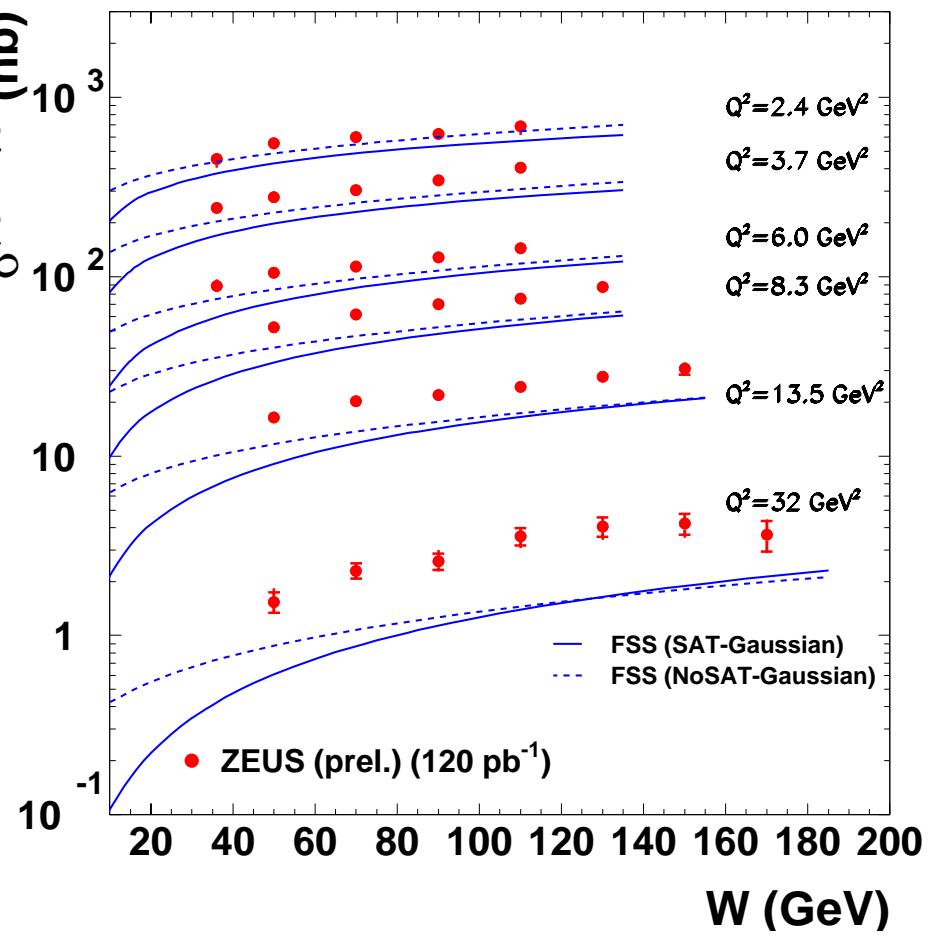


$$\sigma(W)$$

ZEUS

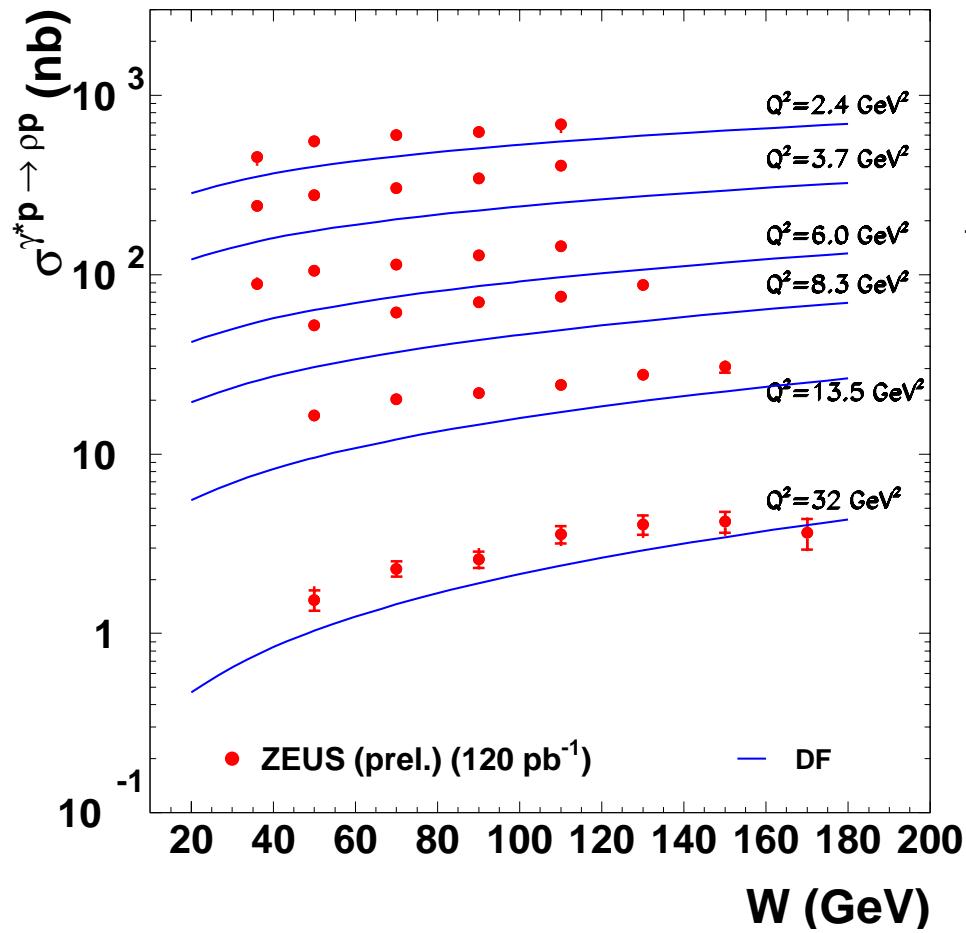


ZEUS

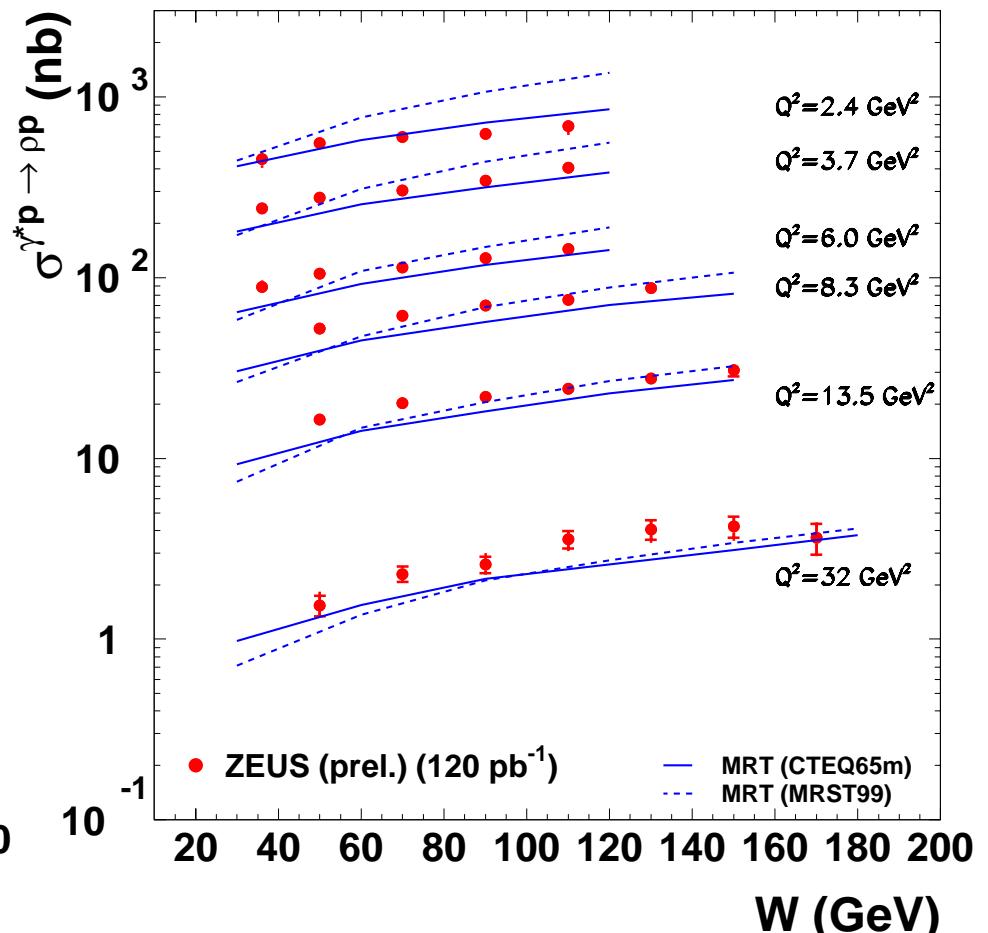


$$\sigma(W)$$

ZEUS



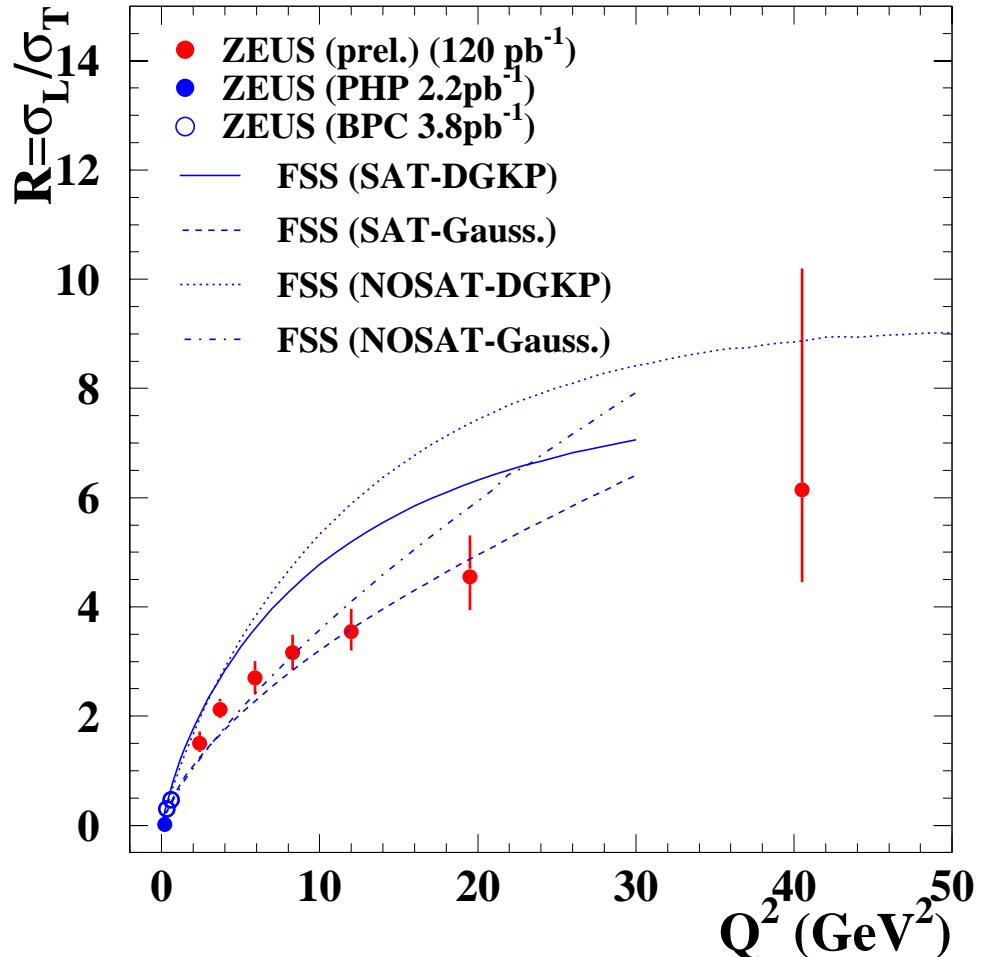
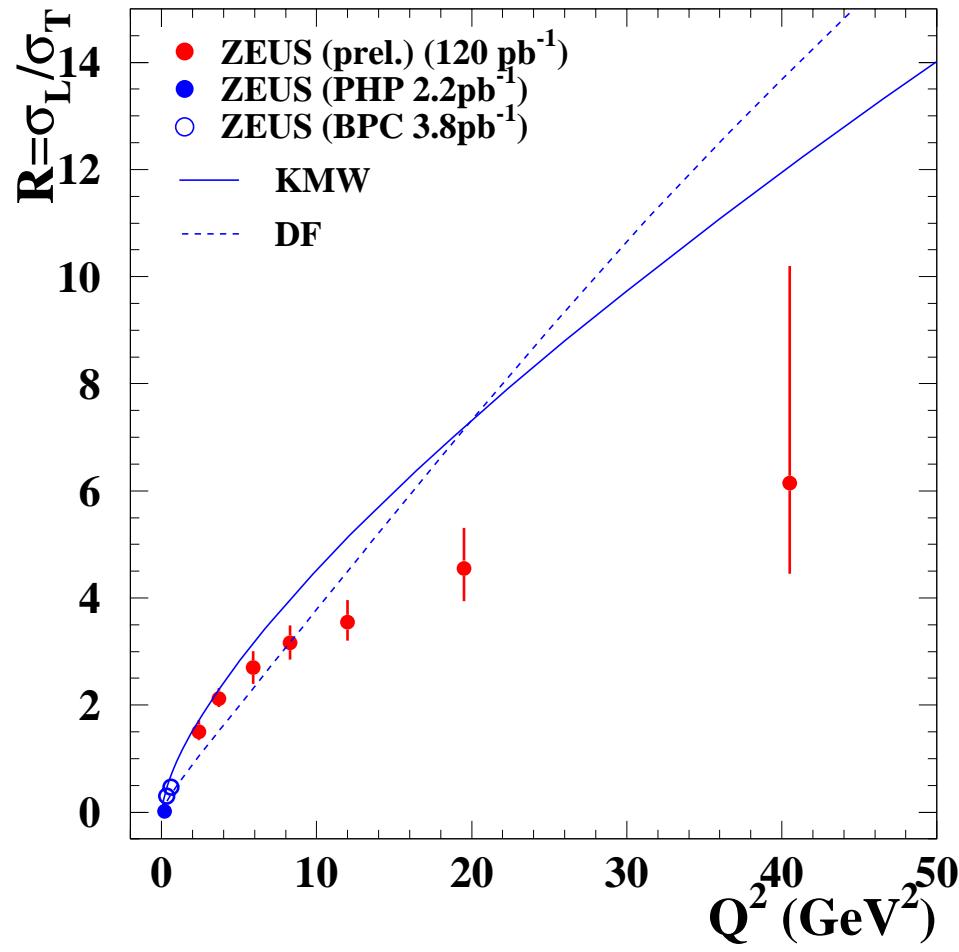
ZEUS



$R(Q^2)$

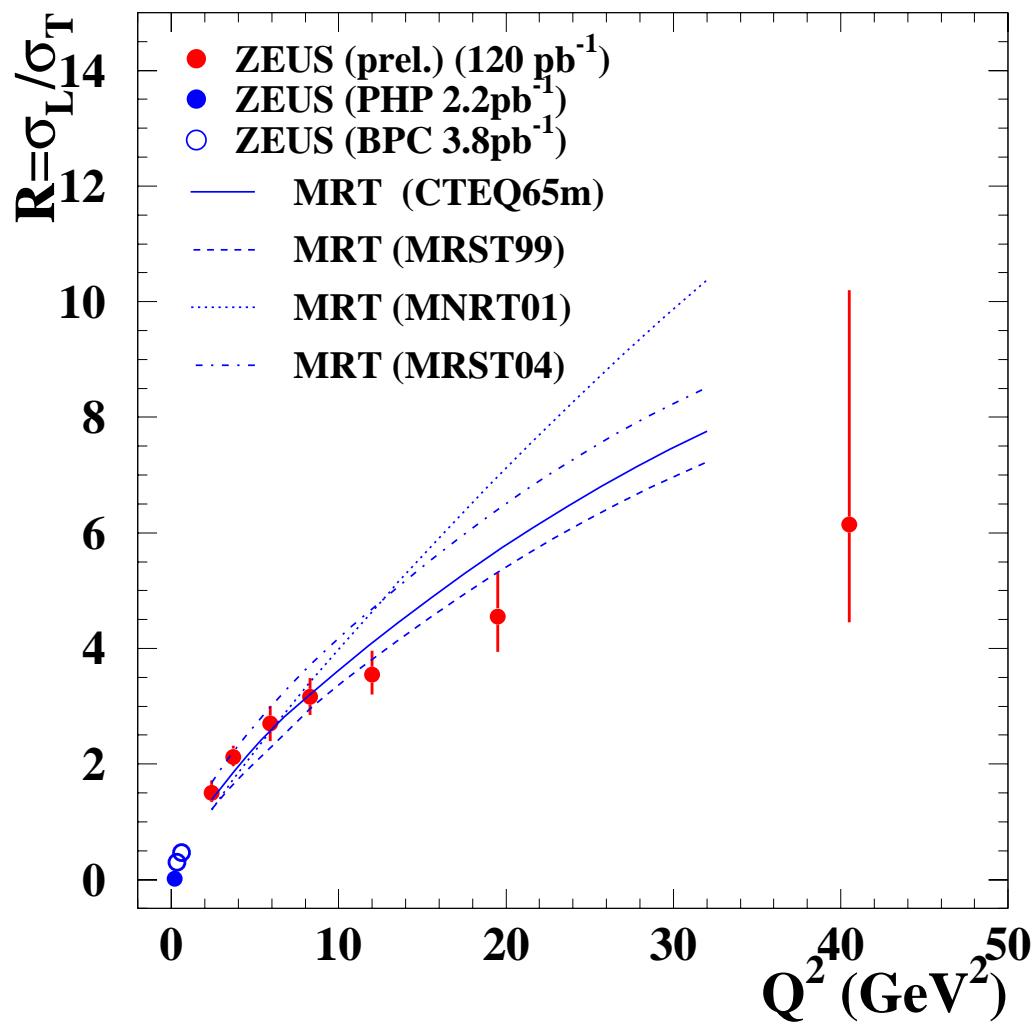
ZEUS

ZEUS



$R(Q^2)$

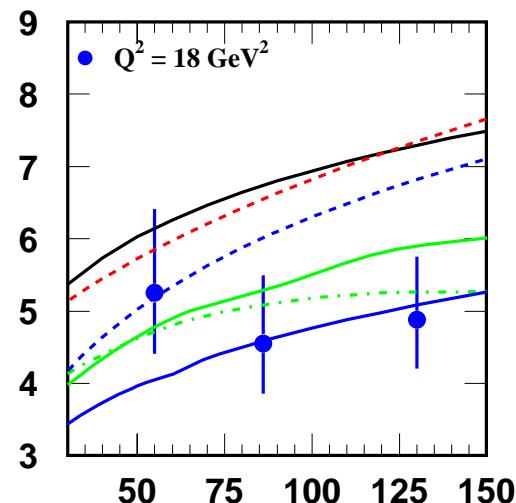
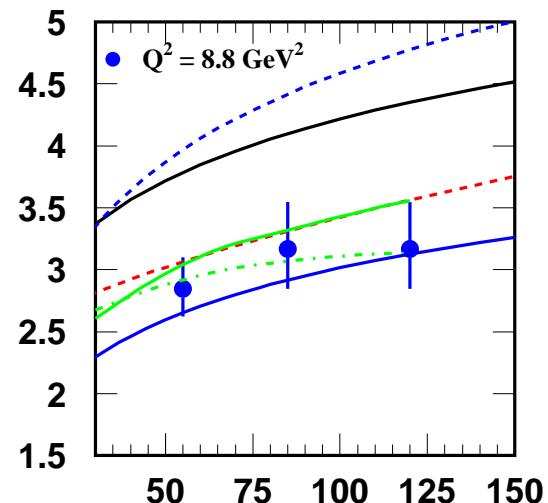
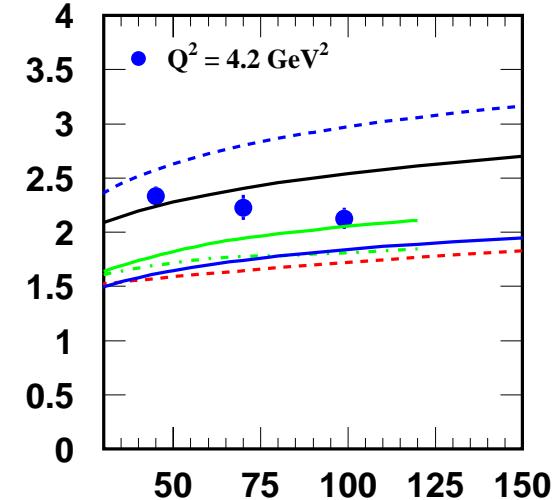
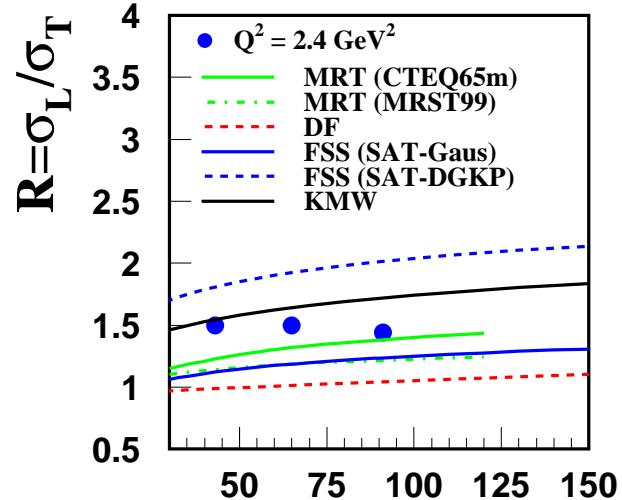
ZEUS



R(W)

ZEUS

ZEUS (prel.) (120 pb⁻¹)

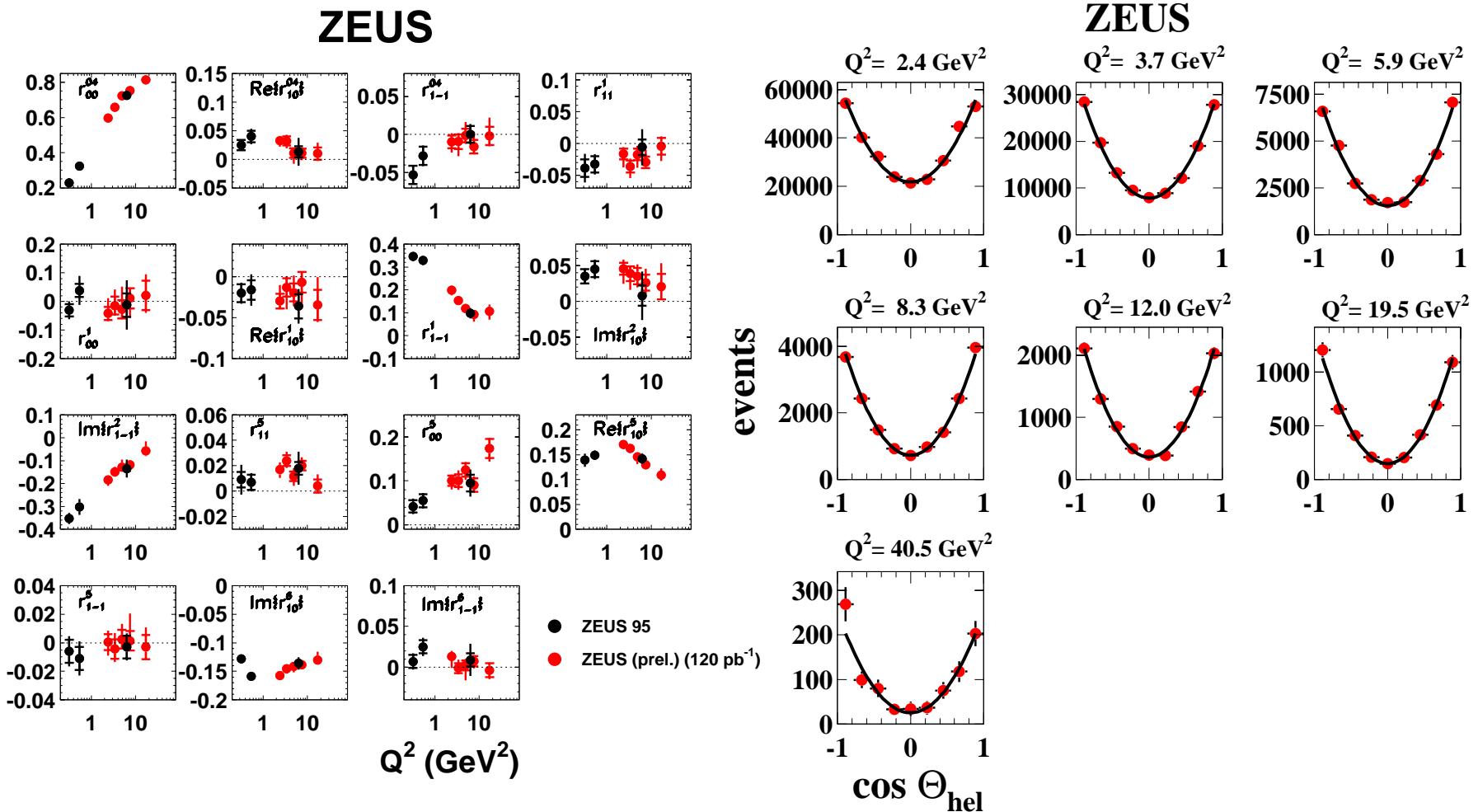


Summary and conclusions

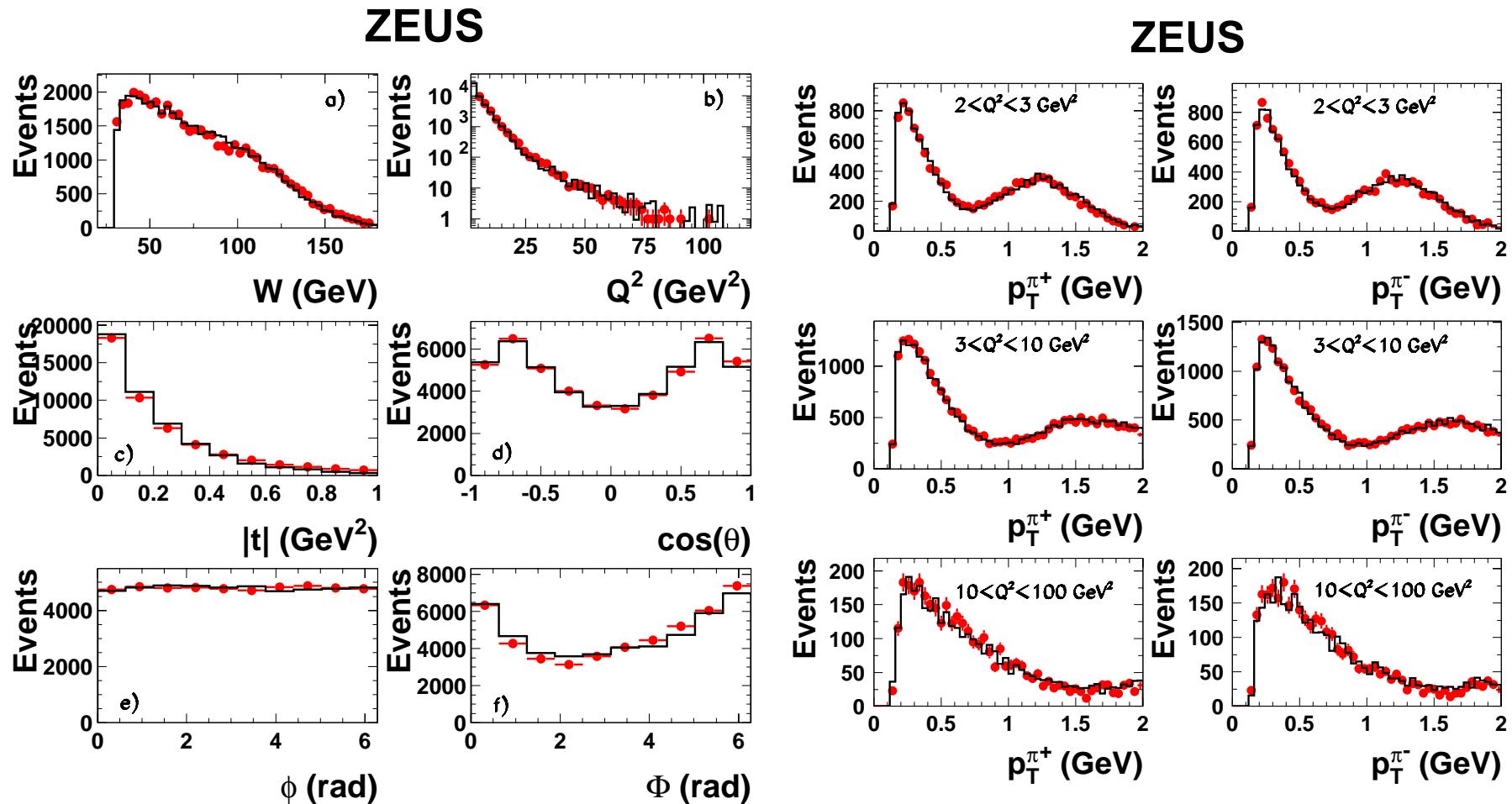
- The Q^2 dependence of $\sigma(\gamma^* p \rightarrow pp)$ cannot be described by a simple propagator term.
- The cross section is rising with W and its logarithmic derivative in W increases with Q^2 .
- The exponential slope of the t distribution decreases with Q^2 and levels off at about $b = 5 \text{ GeV}^{-2}$.
- The ratio of cross sections induced by longitudinally and transversely polarised virtual photons increases with Q^2 , but is independent of W .
- The effective Pomeron trajectory has a larger intercept and smaller slope than those extracted from soft interactions.
- All these features are compatible with expectations of perturbative QCD.
- None of the models which have been compared to the measurements are able to reproduce all the features of the data.

Backups

Density matrix elements



Control plots

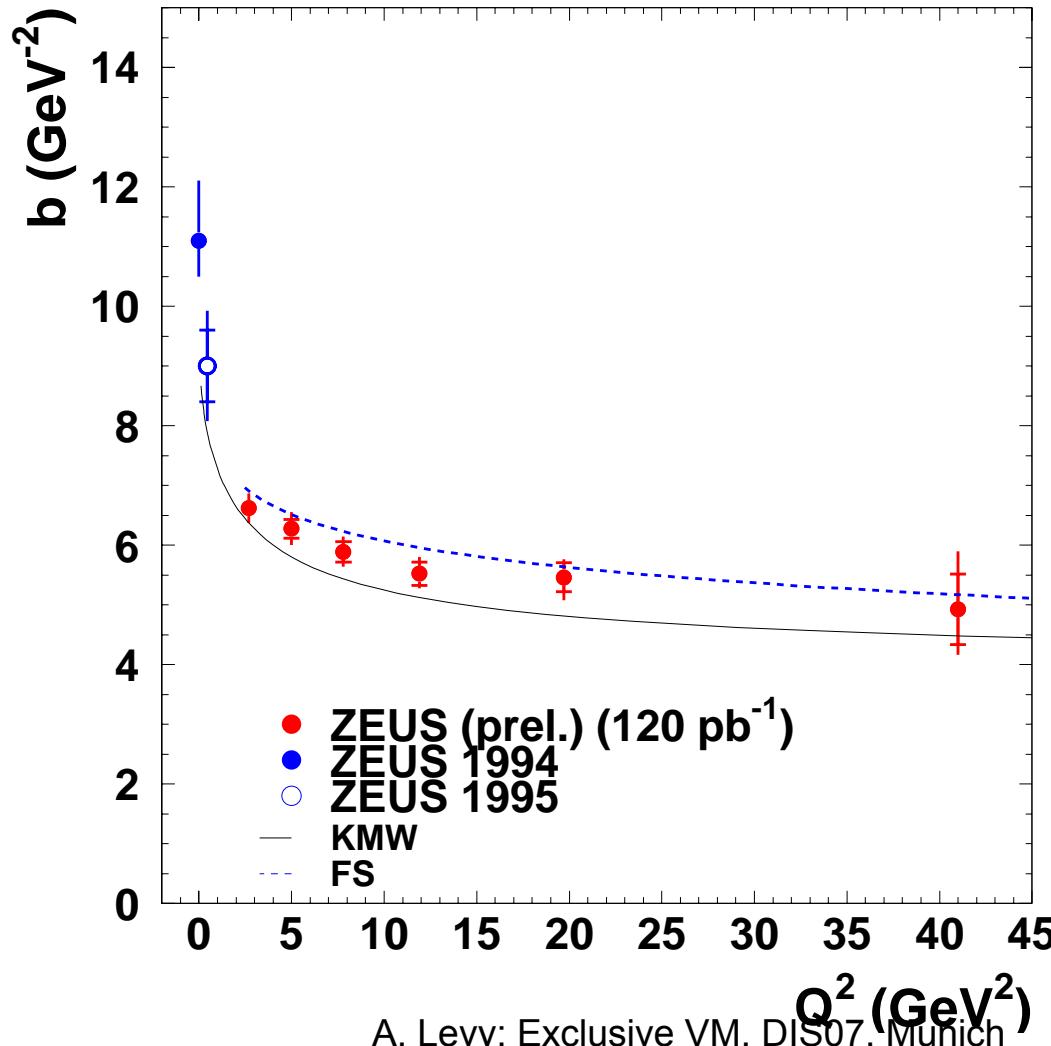


Systematics

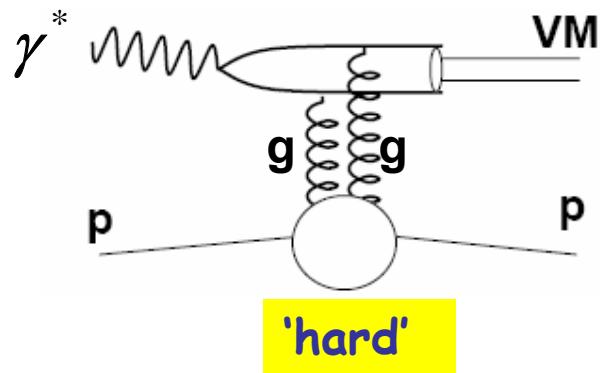
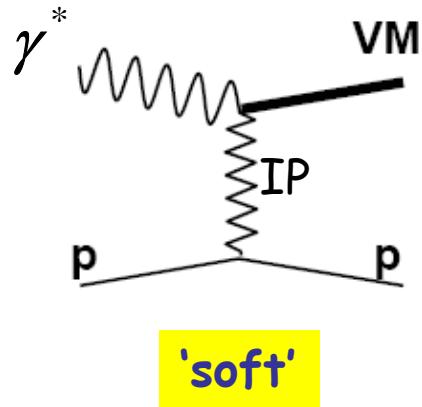
- $E - P_Z$ cut (default 45 GeV) was changed to 42 and 48 GeV
- p_T of the pions (default 0.15 GeV) was changed to 0.2 GeV
- elasticity cut. The energy of unmatched island (default 0.3 GeV) was changed to 0.25 and 0.35 GeV
- elasticity cut. The distance of closest approach of island and extrapolated track was changed from 30cm (default) to 20cm
- Z-vertex cut (default $|Z| < 50\text{cm}$) was varied from 40 to 60 cm
- Reconstruction position of electron shifted wrt MC by $\pm 1\text{mm}$ - alignment check
- Electron position resolution in MC varied by $\pm 10\%$
- Box cut (default 13.2X8 cm) was increased by 0.5 cm
- $\pi\pi$ mass window (default 0.65-1.1 GeV) was changed to 0.65-1.2 GeV
- generated W dependence in MC was reweighed by W^n , ($n = \pm 0.03$)
- generated t in MC was reweighed by $\exp(bt)$ $b = \pm 0.5 \text{ GeV}^{-2}$
- angular distributions in MC were reweighed according SCHC. Default reweighing comes from 15 matrix element fit.
- generated Q^2 in MC was reweighed by $(Q^2 + M_p^2)^k$, where $k = \pm 0.05$

b-slope

ZEUS



Comparison to theory



- All theories use dipole picture
- Use QED for photon wave function
- Use models for VM wave function - usually take a Gaussian shape (some take a $q\bar{q}$ bound state - "Cornell model")
- Use gluon density in the proton
- Some use saturation model, others take sum of nonperturbative + pQCD calculation, and some just start at higher Q^2
- Most work in configuration space, MRT works in momentum space. Configuration space - puts emphasis on VM wave function. Momentum space - on the gluon distribution.
- **W dependence** - information on the gluon
- **Q^2 and R** - properties of the wave function