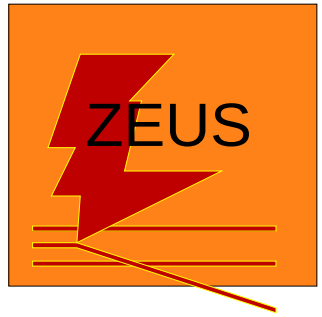
Xavier Janssen - Université Libre de Bruxelles

On behalf of H1 and ZEUS Collaborations



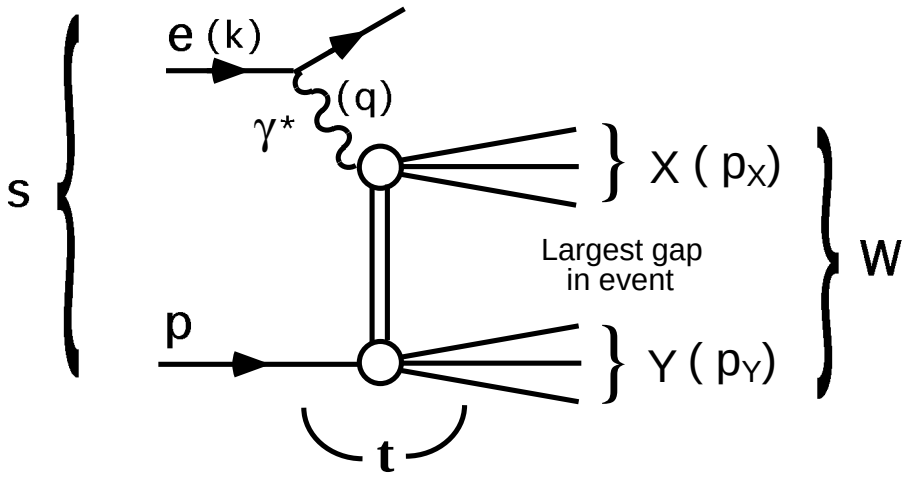
Deeply virtual Compton scattering and vector mesons production at ZEUS and H1 experiments

2nd Workshop on the QCD Structure of the Nucleon

Rome, Italy, 12th-16th June, 2006

Deeply Virtual Compton Scattering

$$e + p \longrightarrow e + \gamma + p$$



Diffraction: $e + p \rightarrow e + X + Y$

- Factorization theorem:

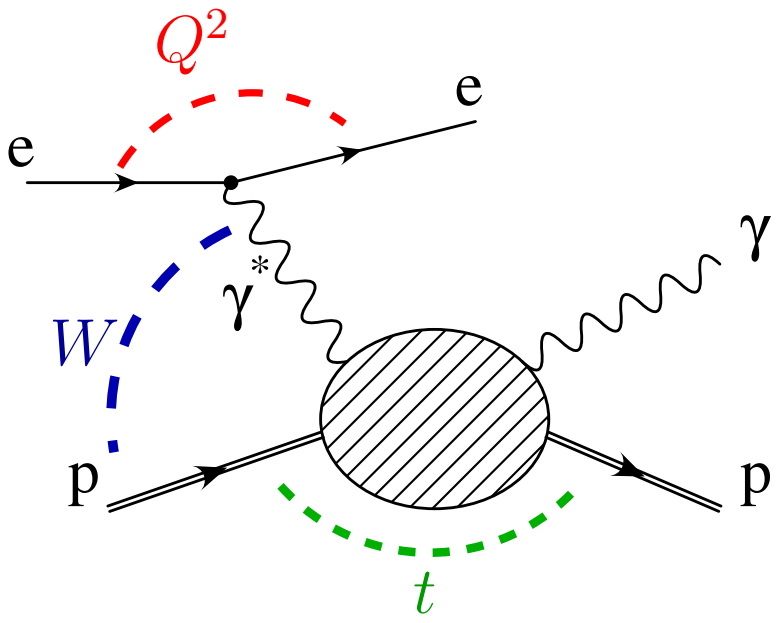
  $\longrightarrow$ First Diffractive process fully calculable in QCD

- No VM wave function uncertainty

- Access to Generalized Parton Distributions (GPDs)

Deeply Virtual Compton Scattering

$$e + p \longrightarrow e + \gamma + p$$



- Factorization theorem:

  $\longrightarrow$ First Diffractive process fully calculable in QCD

- No VM wave function uncertainty

- Access to Generalized Parton Distributions (GPDs)

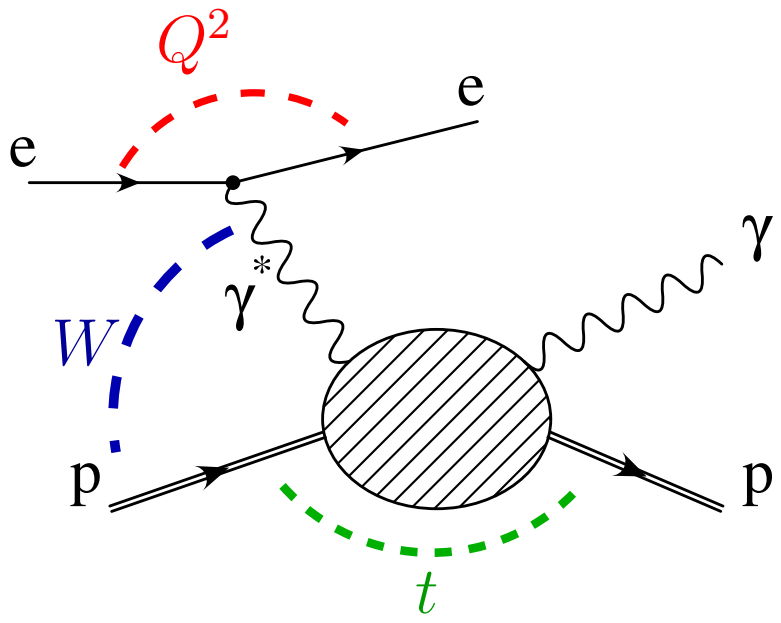
Q^2 : virtuality at which the proton is probed

W : energy in the $\gamma^* p$ center of mass system

t : square of the 4-momemtum transfer at the proton vertex

Deeply Virtual Compton Scattering

$$e + p \longrightarrow e + \gamma + p$$



- Factorization theorem:

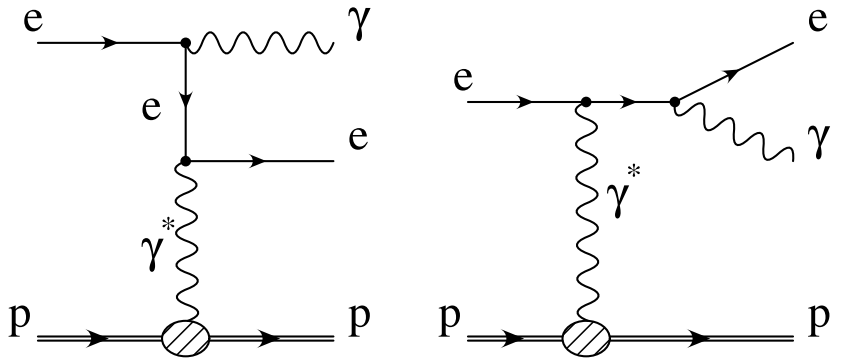
  $\longrightarrow$ First Diffractive process fully calculable in QCD

- No VM wave function uncertainty

- Access to Generalized Parton Distributions (GPDs)

- Interference with Bethe-Heitler which is a pure QED process.

  ($\rightarrow$ Access to Amplitudes in Asymmetries)



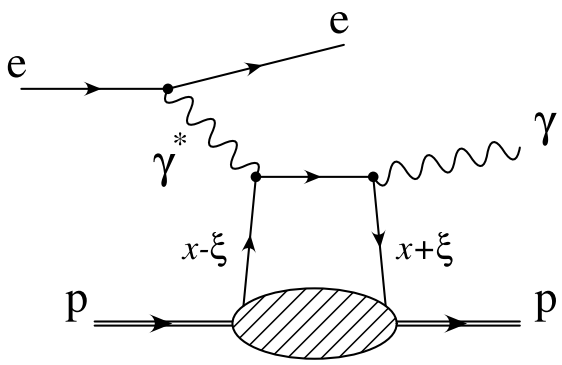
DVCS - QCD predictions

$Q^2 >> 1\mathrm{GeV}^2$

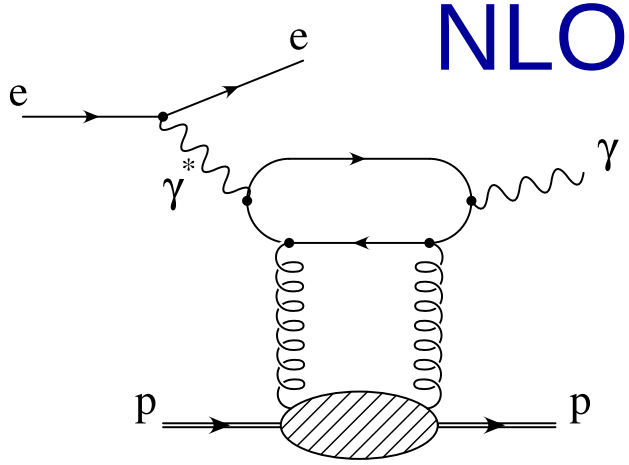
$-t << Q^2$

$\Rightarrow$ DVCS amplitude factorise in a pQCD calculable hard scattering part and a non-peturbative part describing the internal dynamics of the proton

LO



NLO



ξ - “Skewedness", i.e. momemtum difference between emitted and absorbed parton

$\longrightarrow$ need to use the GPD formalism to describe DVCS

(GPDs encodes info about transverse motion of partons and about their correlations)

DVCS - QCD predictions

4 types of GPD:

	proton helicity conserved	allow proton helicity flip
unpolarized	$H^{q,g}(x,\xi,t;\mu^2)$	$E^{q,g}(x,\xi,t;\mu^2)$
polarized	$\tilde{H}^{q,g}(x,\xi,t;\mu^2)$	$\tilde{E}^{q,g}(x,\xi,t;\mu^2)$

At low x, DVCS is mainly sensitive to $H^g(x,\xi,t;\mu^2)$

NLO leading twist calcl. by A. Freund and M. McDermott
Eur. Phys. J. C23 (2002) 651

DGLAP region ($|x| > \xi$):

$$H^{q,g}(x,\xi,t;\mu^2) \xrightarrow[\xi\to 0]{t\to 0} q(x), g(x)$$
$$\tilde{H}^{q,g}(x,\xi,t;\mu^2) \xrightarrow[\xi\to 0]{t\to 0} \Delta q(x), \Delta g(x)$$

ERBL region ($|x| < \xi$):

Simple analytic functions

t dependence: parametrised as e^{-t}

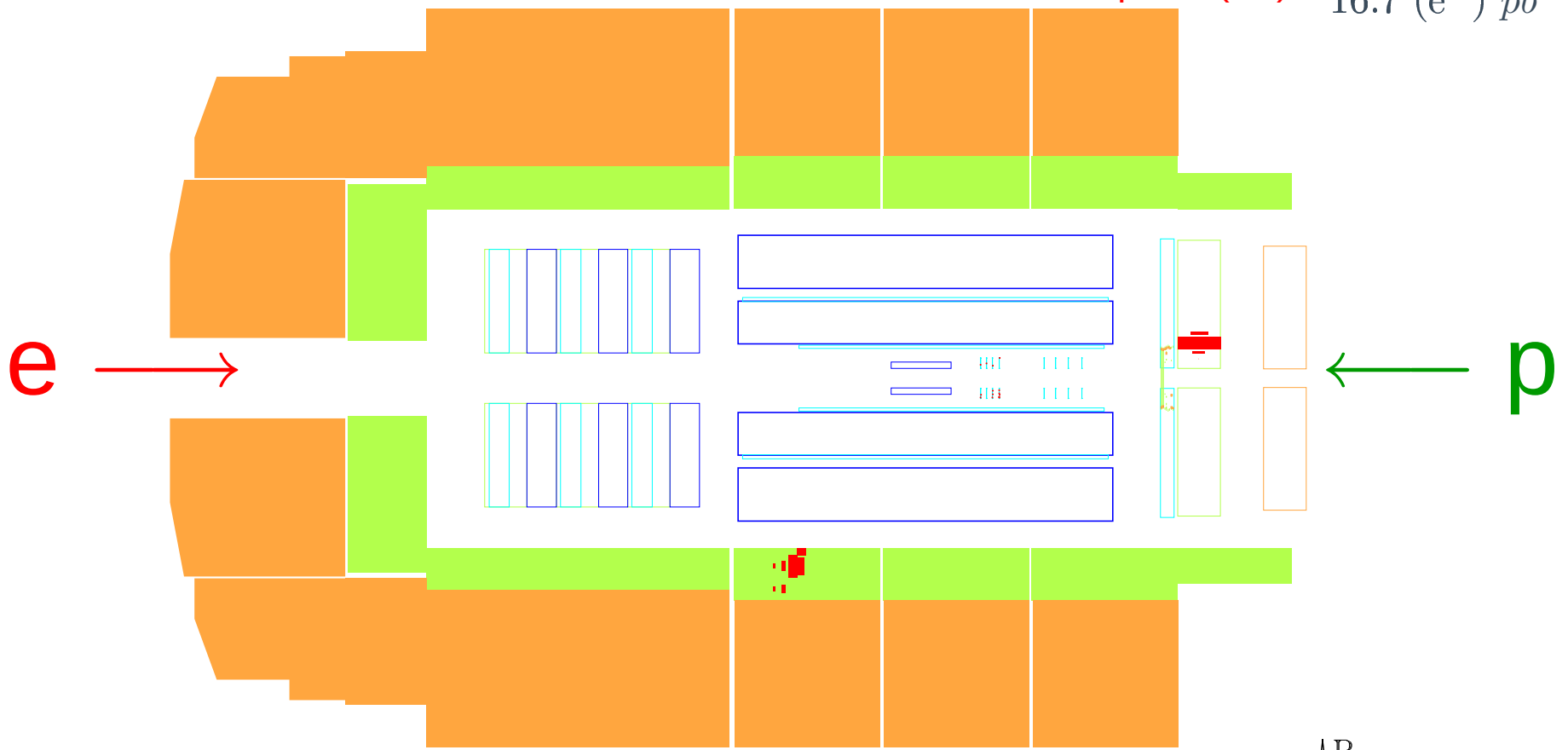
ξ and Q^2 dependence: generated dynamically by the evolution equations

DVCS - Data Selection

γ sample

DVCS + Bethe-Heitler

	H1	ZEUS
$E_1 >$	15 GeV	10 GeV
$p_{T_2} >$	1 GeV (2 GeV)	
$E_2 >$		3 GeV
$E_3 <$	0.5 GeV	0.2 GeV
elast.	no track, Fwd	no track
Lumi	46.5 pb^{-1} (e^+)	95 (e^+) pb^{-1}
+ 2004:	39.7 pb^{-1} (e^+)	16.7 (e^-) pb^{-1}

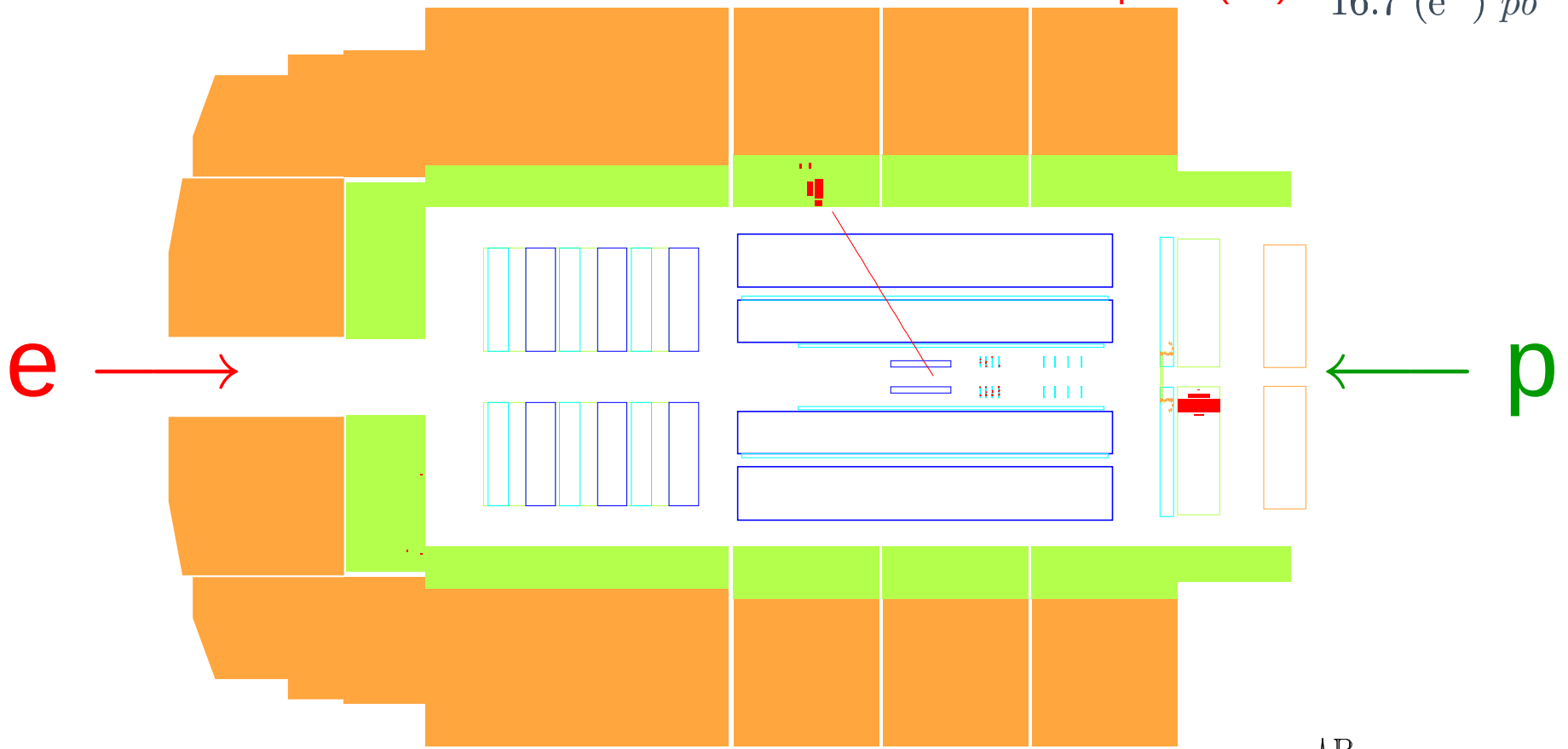


DVCS - Data Selection

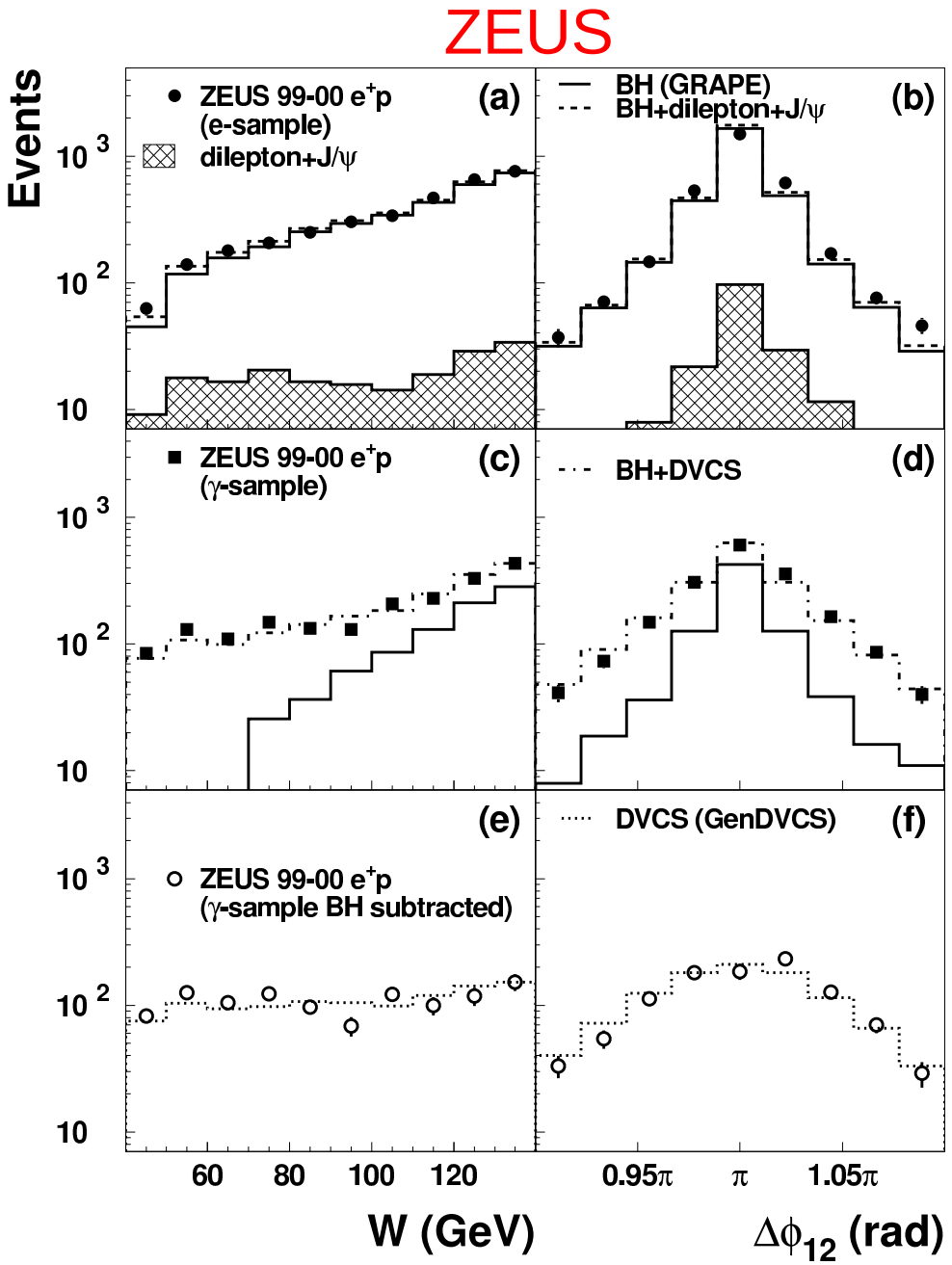
Control sample

Mainly Bethe-Heitler

	H1	ZEUS
$E_1 >$	15 GeV	10 GeV
$p_{T_2} >$	1 GeV (2 GeV)	
$E_2 >$		3 GeV
$E_3 <$	0.5 GeV	0.2 GeV
elast.	no track, Fwd	no track
Lumi	46.5 pb^{-1} (e^+)	95 (e^+) pb^{-1}
+ 2004:	39.7 pb^{-1} (e^+)	16.7 (e^-) pb^{-1}



DVCS - Control Plots



- Control sample:

  Well described by MC

  $\rightarrow$ Detector understood

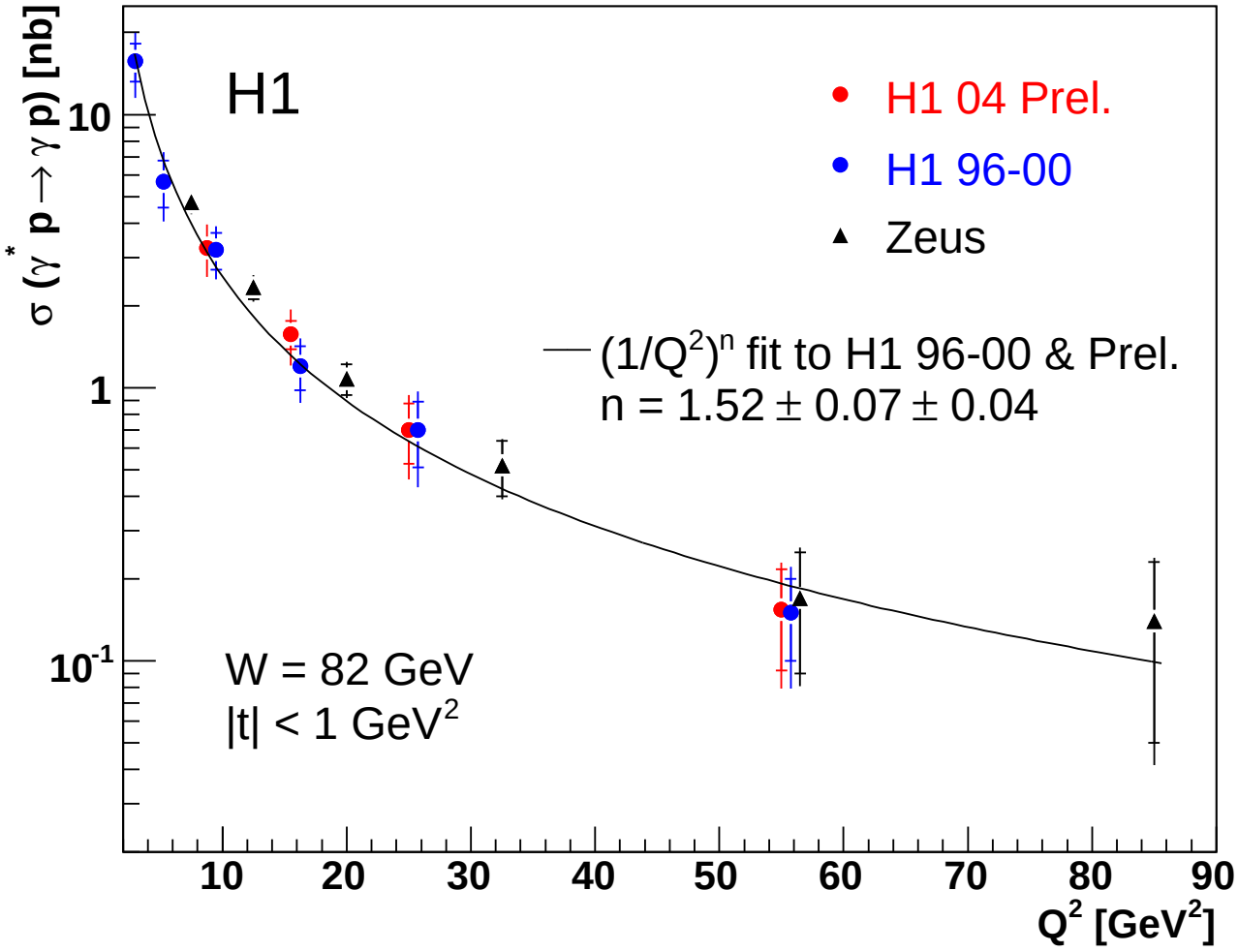
- γ sample:

  Good description by BH + DVCS MC

$\Longrightarrow$ DVCS cross section:

1. Subtract Bethe-Heitler ($\int d\phi$ Interf. = 0)
2. $\sigma_{ep} \longrightarrow \sigma_{\gamma^* p}$ (/ flux factor)

DVCS - Q^2 dependence

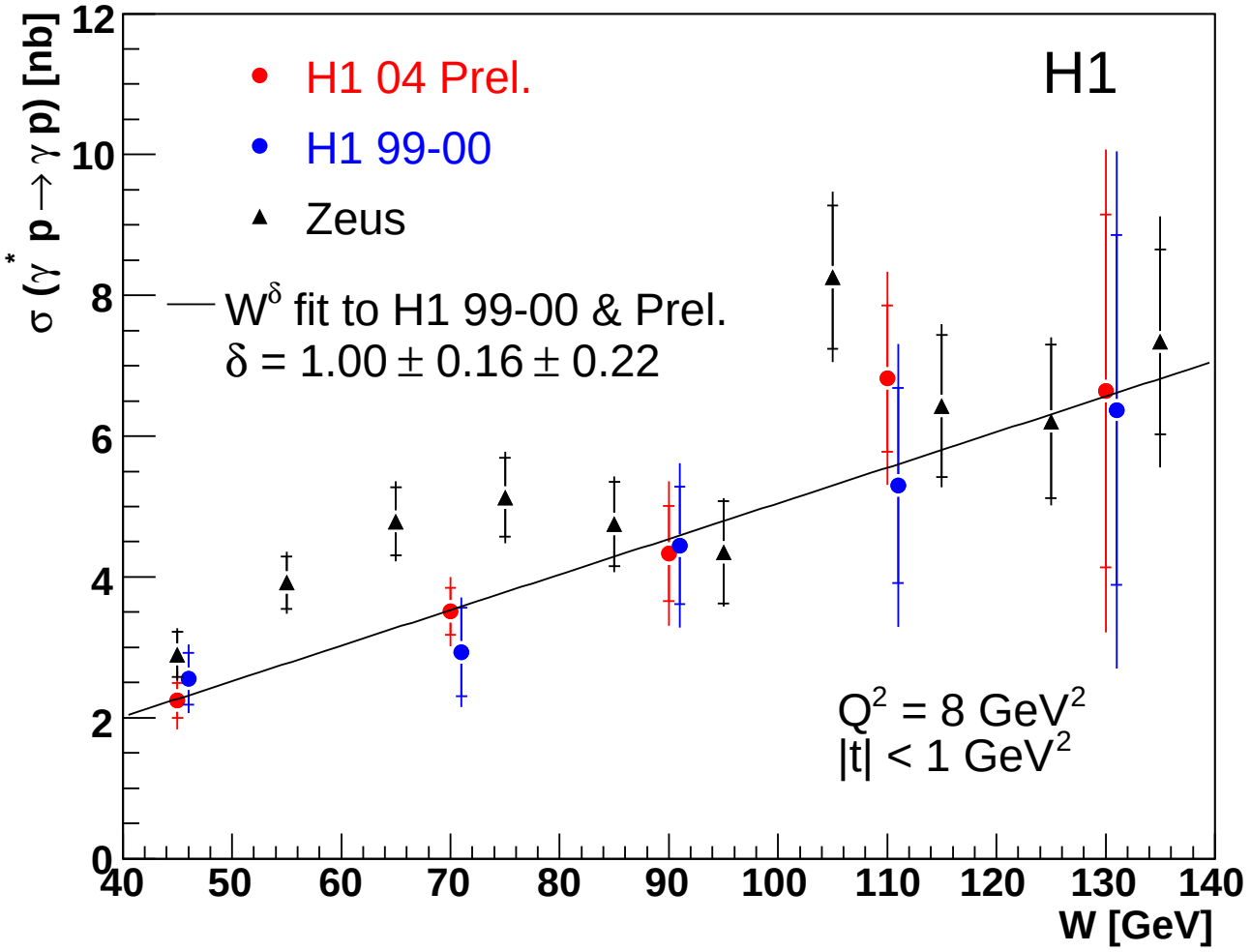


Good agreement with previous results

Combined fit to H1 99-00 and H1 2004 data : $\sigma(Q^2) \propto (1/Q^2)^n$

$\longrightarrow$ statistical error on n parameter decreased

DVCS - W dependence



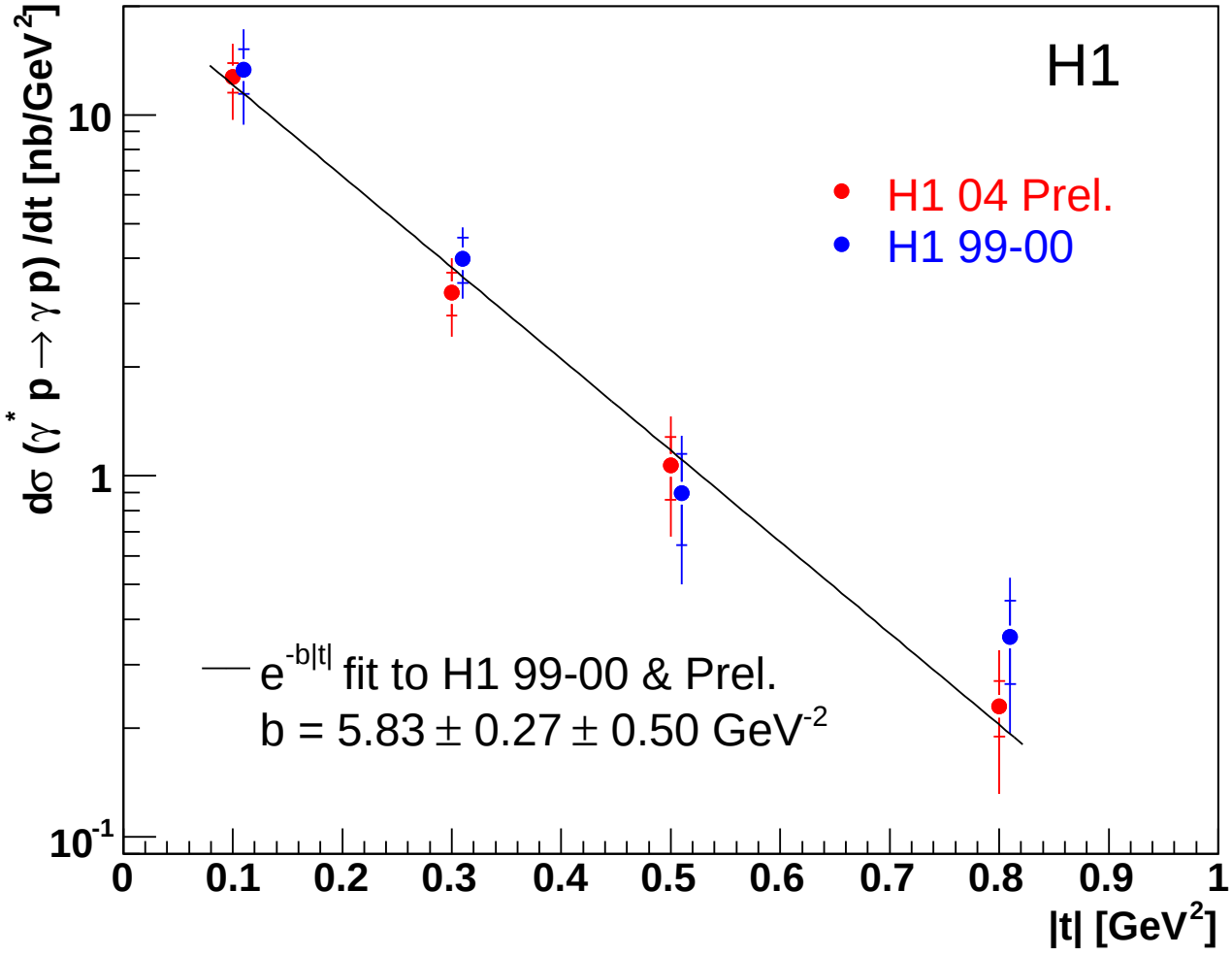
δ value indicates hard regime

cf. J/ψ production

Combined fit to H1 99-00 and H1 2004 data : $\sigma(W) \propto W^{\delta}$

$\longrightarrow$ statistical error on δ parameter decreased

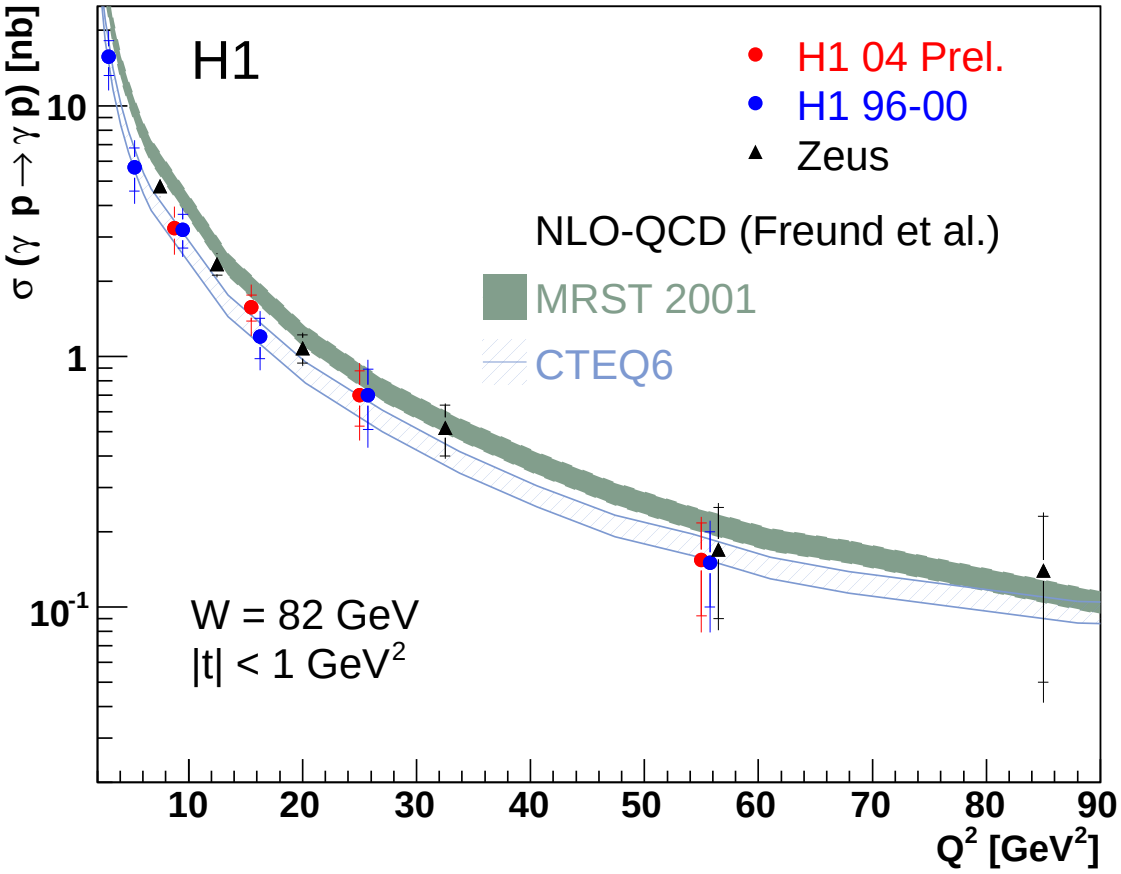
DVCS - t dependence



Combined fit to H1 99-00 and H1 2004 data : $\mathrm{d}\sigma/\mathrm{d}t \propto \exp(-bt)$

$\longrightarrow$ statistical error on t slope b decreased

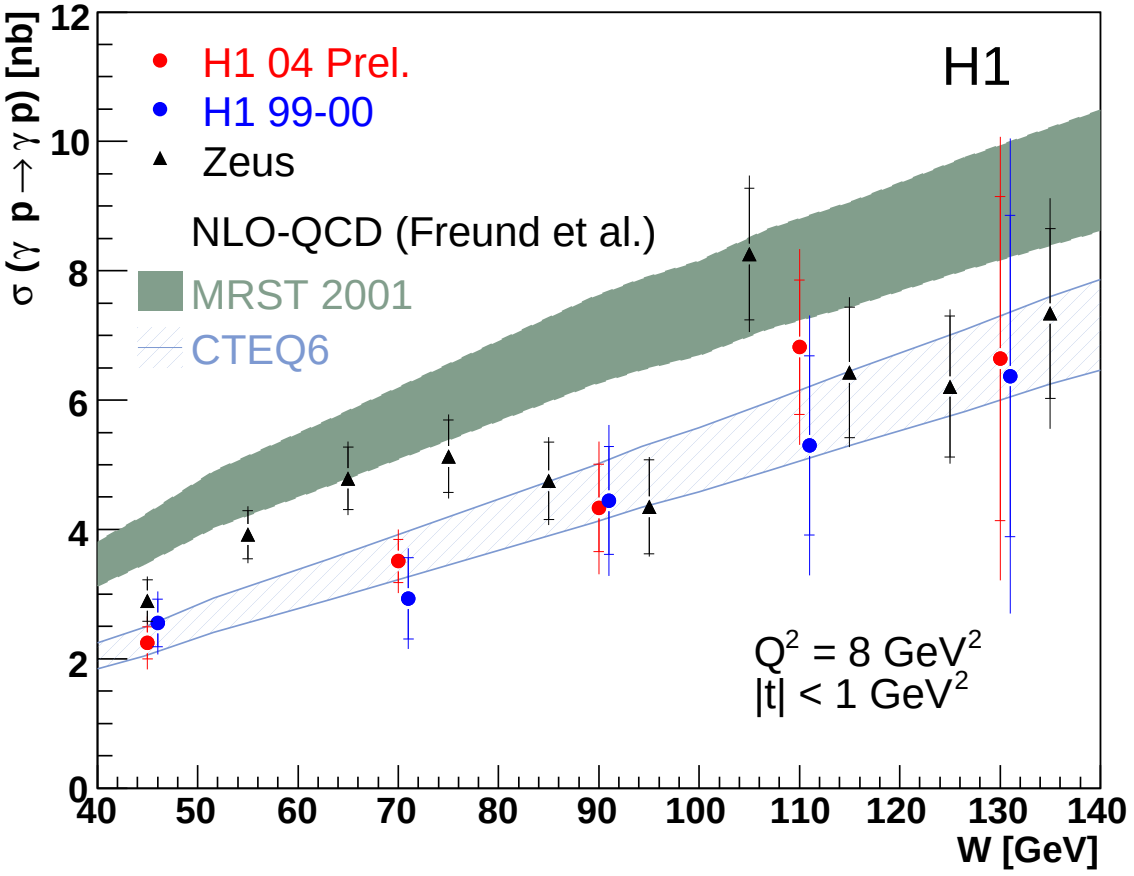
DVCS - Comparison to QCD predictions



Comparison to NLO QCD:

- **Band width reduced by b slope measurement**
- **Good description by NLO QCD calculations.**
- **Sensitivity to GPDs parametrization**
- **b kept constant with Q^2**
- **no need for intrinsic skewing**

DVCS - Comparison to QCD predictions

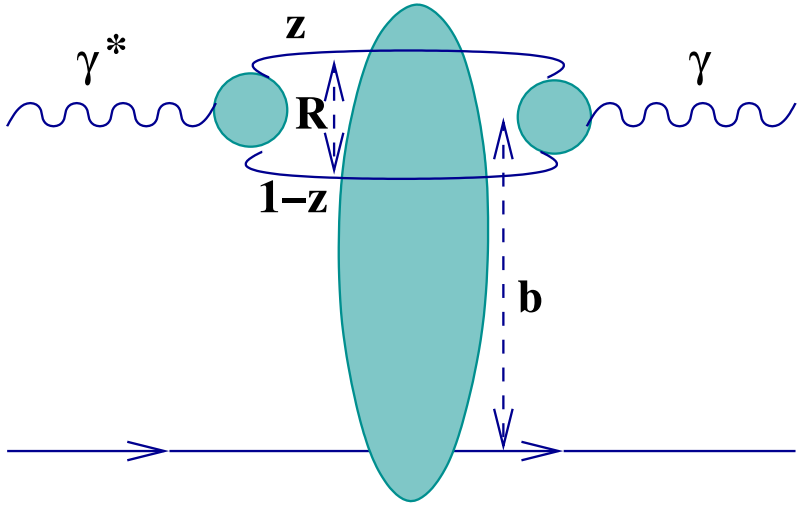


Comparison to NLO QCD:

- **Band width reduced by b slope measurement**
- **Good description by NLO QCD calculations.**
- **Sensitivity to GPDs parametrization**
- **b kept constant with Q^2**
- **no need for intrinsic skewing**

DVCS - ... and to Color Dipole Models

In proton rest frame:



- γ^* fluctuates in $q\bar{q}$ + $q\bar{q}g$ + ...

$$\mathcal{A} = \int dR^2\, dz\, \Psi^{in}\, \sigma_{dipole}\, \Psi^{out}$$

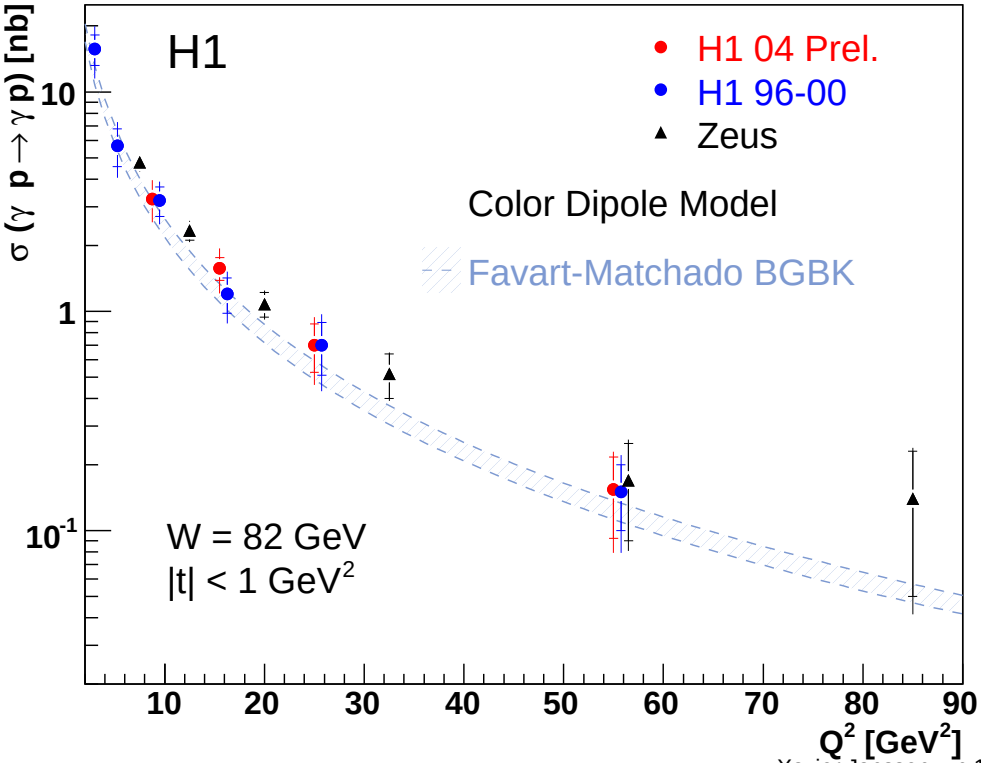
- Ψ^{in} and Ψ^{out} calculable
- σ_{dipole} modeled

Favart-Machado:

GBW Saturation model

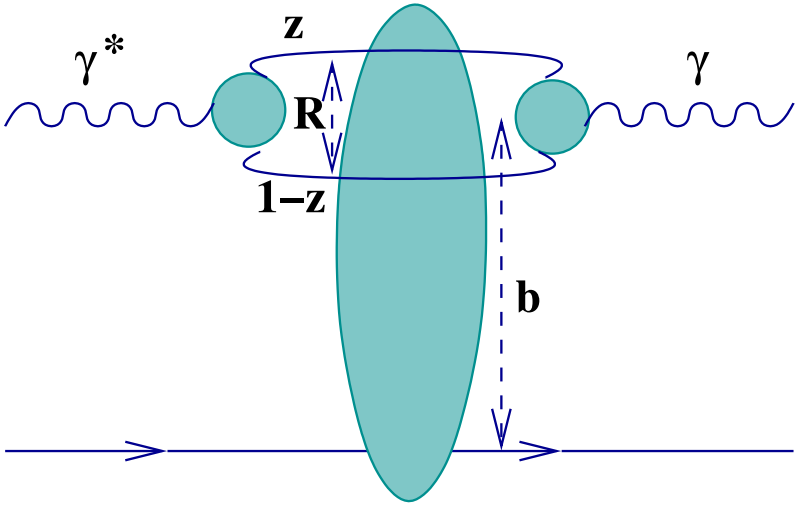
Eur. Phys. J. C29 (2003) 365

⟶ Describe shape and norm. when including DGLAP evolution (BGBK)



DVCS - ... and to Color Dipole Models

In proton rest frame:



- γ^* fluctuates in $q\bar{q}$ + $q\bar{q}g$ + ...

$$\mathcal{A} = \int dR^2\, dz\, \Psi^{in}\, \sigma_{dipole}\, \Psi^{out}$$

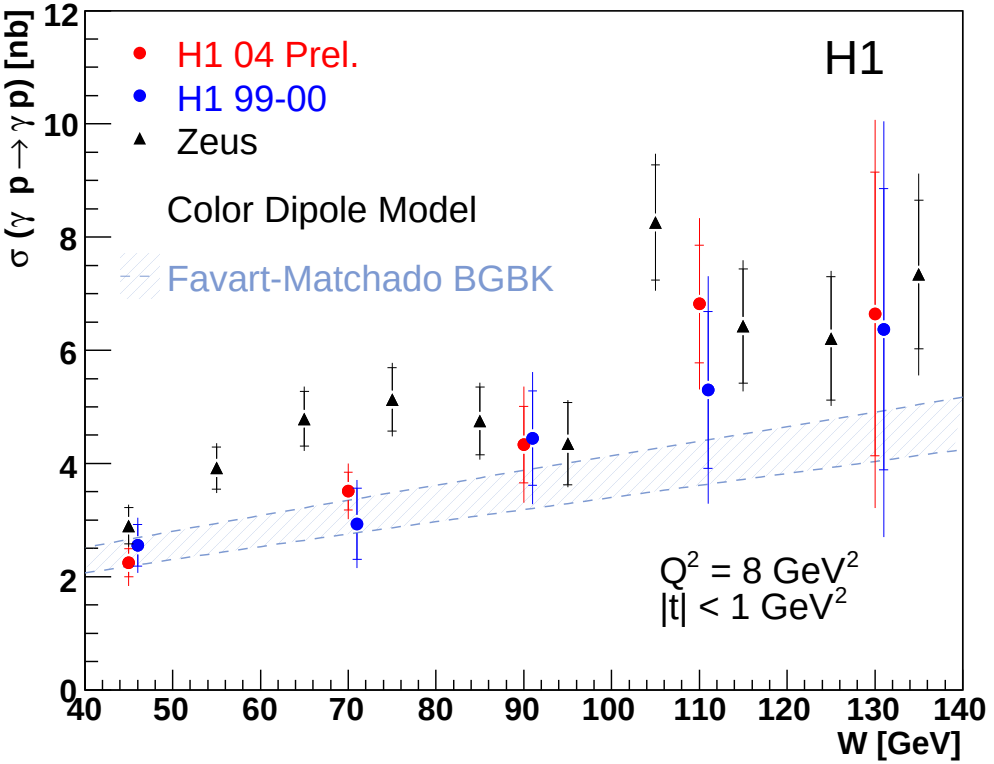
- Ψ^{in} and Ψ^{out} calculable
- σ_{dipole} modeled

Favart-Machado:

GBW Saturation model

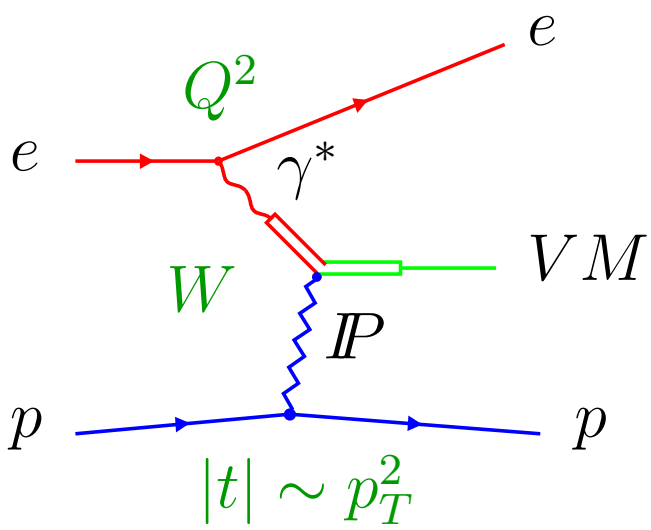
Eur. Phys. J. C29 (2003) 365

⟶ Describe shape and norm. when including DGLAP evolution (BGBK)



VECTOR MESON PRODUCTION

$$e + p \to e + VM + p \,(\text{or } Y)$$



ρ	$u\bar{u} + d\bar{d}$	771 MeV
ω	$u\bar{u} + d\bar{d}$	782 MeV
ϕ	$s\bar{s}$	1019 MeV
J/ψ	$c\bar{c}$	3097 MeV
$\psi(2S)$	$c\bar{c}$	3686 MeV

Regge Theory

= Soft $I\!P$omeron exchange

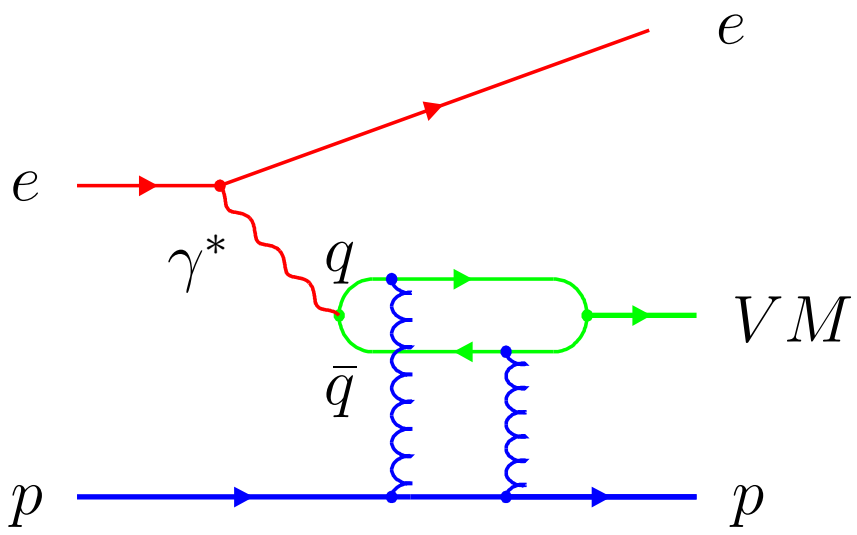
$$\sigma \propto \left(\frac{W}{W_0}\right)^{4(\alpha_{I\!P}(t)-1)}$$

$$\alpha_{I\!P}(t) = 1.08 - 0.25|t|$$

Works for light VM

at low Q^2 (and low t)

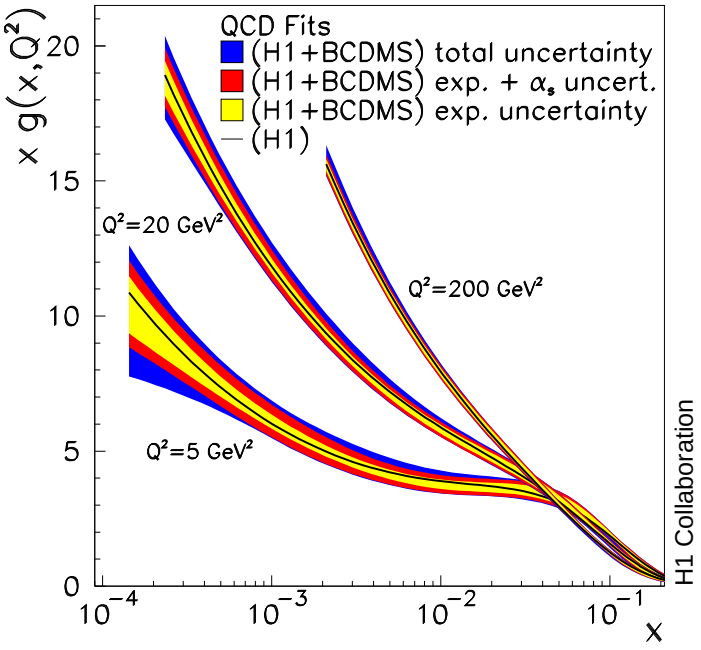
Vector Mesons: Perturbative QCD Models



Assume Factorization

$\Longleftrightarrow$ Requires hard scale:
Q^2, m_q or t

$\Longleftrightarrow$ Requires endpoints cancellation mechanism to avoid divergence



Exchange of ≥ 2 gluons:

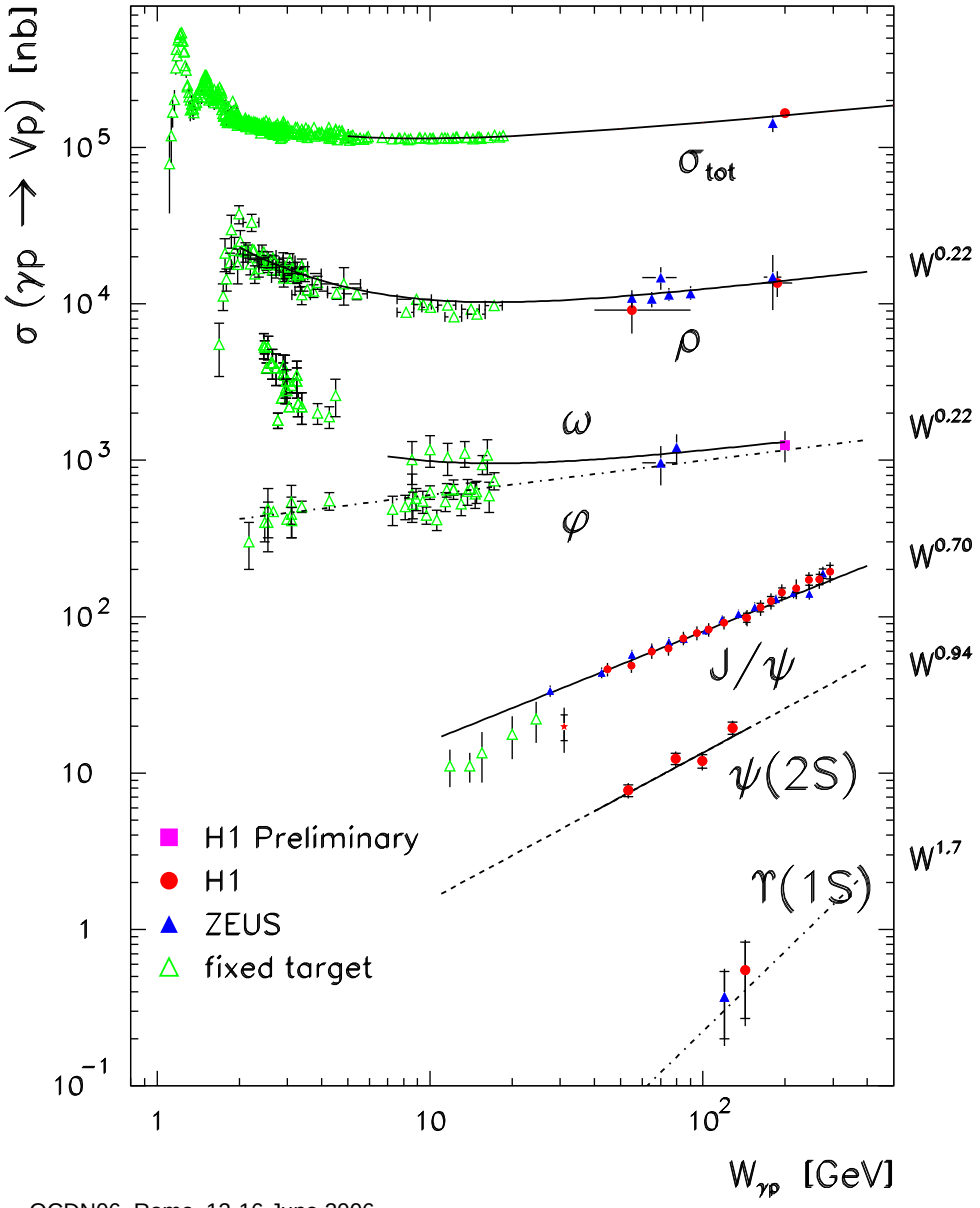
$\sigma \propto (xG(x, Q^2))^2$

Steep rise of $xG(x, Q^2)$

No (or little) shrinkage

Vector Mesons : Photoproduction Overview

Photoproduction ($Q^2 = 0\ \mathrm{GeV}^2$)



Light vector meson(ρ, ω, ϕ):

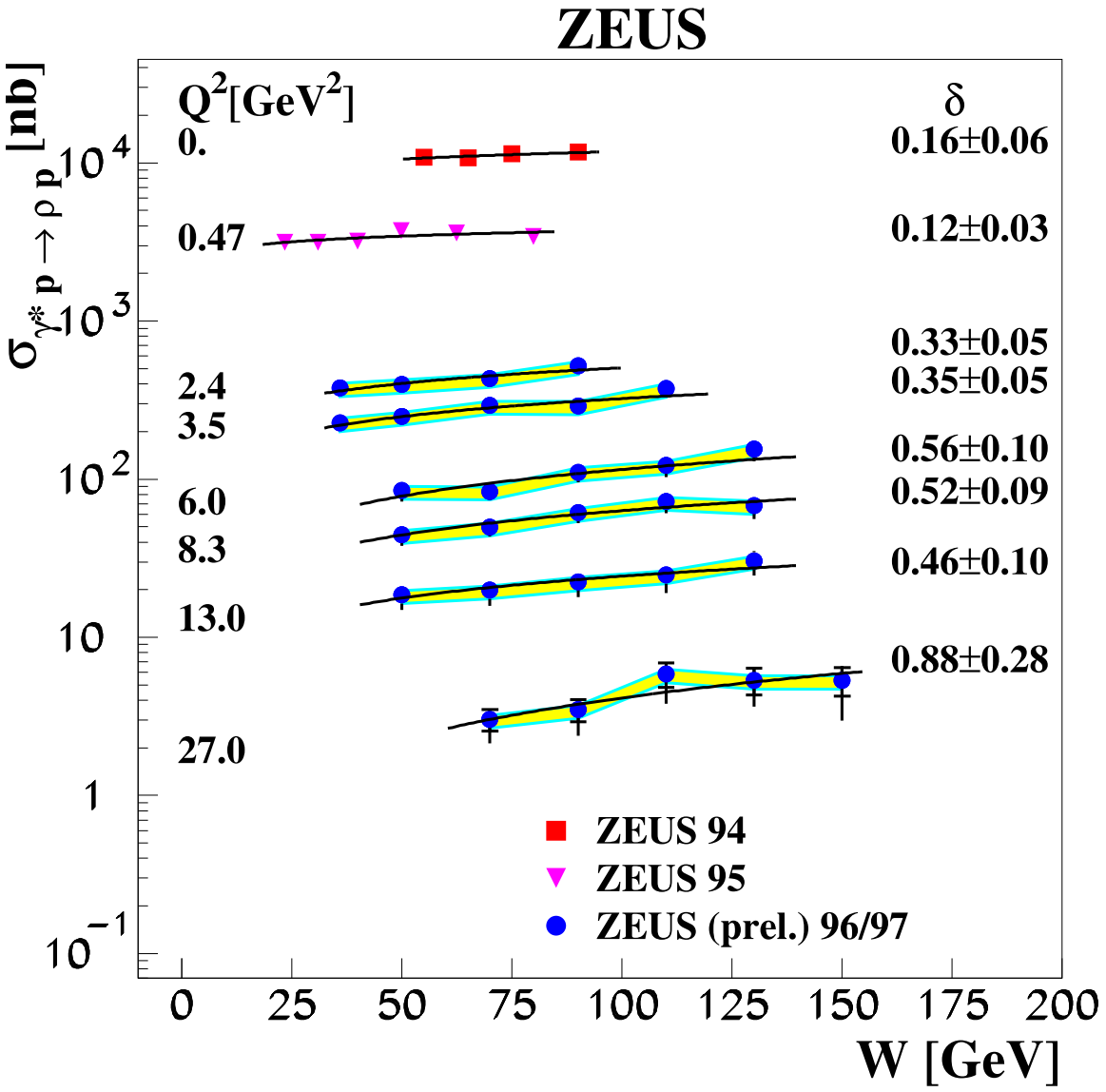
Soft energy dependence

J/ψ :

Hard energy dependence

$\Longrightarrow$ Quark mass (m_c)
= hard scale

Vector Mesons : Elastic Rho Production



Transition with Q^2 to a hard dependence in W

$\longrightarrow$ Q^2 = hard scale

Exclusive ρ^0 Photoproduction

- electron not detected:

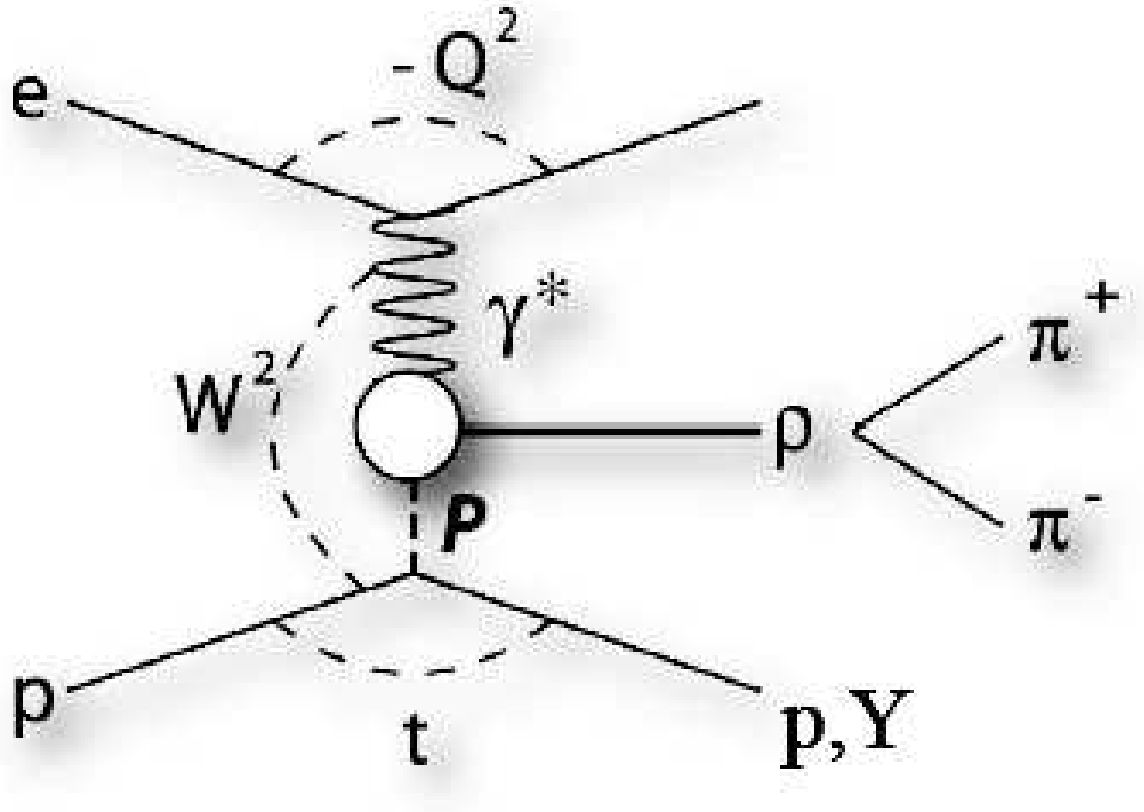
$$Q^2 < 4 \text{ GeV}^2$$

$$< Q^2 >= 0.01 \text{ GeV}^2$$

- $W = \sqrt{2E_p(E_\rho - P_{z,\rho})}$

$$20 < W < 90 \text{ GeV}$$

- $t = -P^2_{t,\rho} \quad |t| < 3 \text{ GeV}^2$



- Previous HERA measurements:
  - H1: 93 data, 358 events, 20 nb^{-1} $\longrightarrow$ new measurement needed
  - ZEUS: no level arm in W, combined fit with fix target data

$$\longrightarrow \alpha(t) = (1.096 \pm 0.021) + (0.125 \pm 0.038)\, t$$

ρ^0 Photoproduction - Data Selection

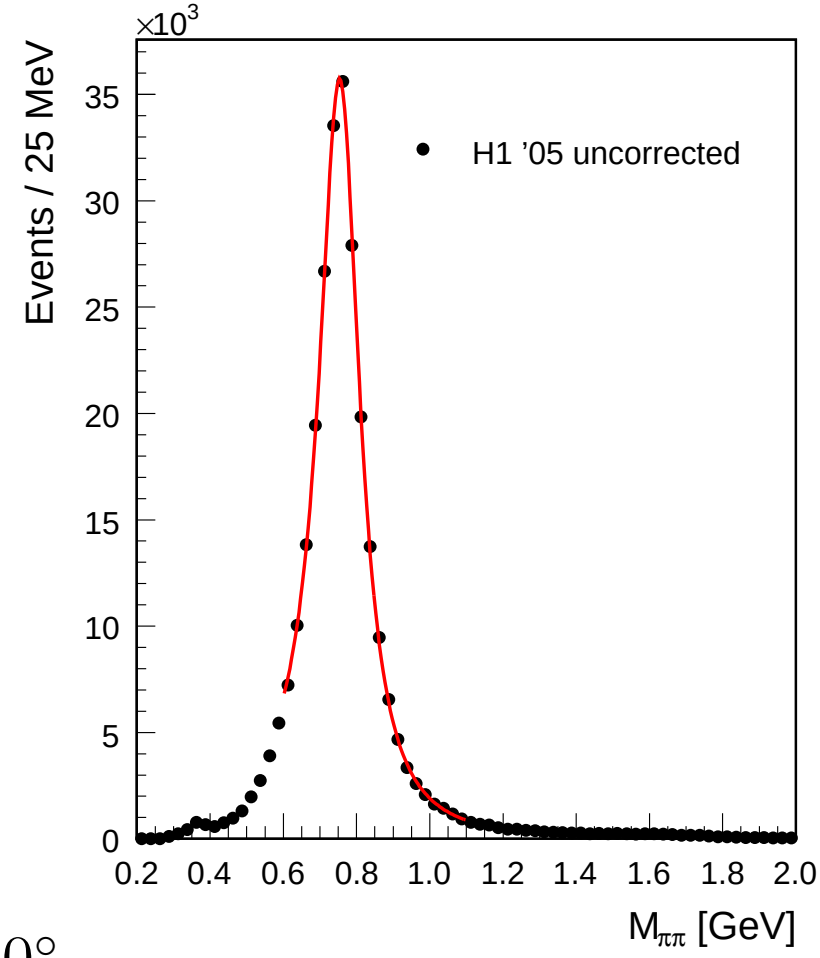
H1 Fast Track Trigger at HERA-II:

- Threshold: $p_t > 100$ MeV
- Selection on nr of tracks, charge

$\rightarrow$ 1 Million triggered events in 2005 (570 pb^{-1})

Offline Event Selection:

- Vertex within 25 cm of nominal IP
- 2 tracks, opposite charge
- tracks: $p_t > 200$ MeV, $20° < \theta < 160°$
- No electron detected
- No other particles

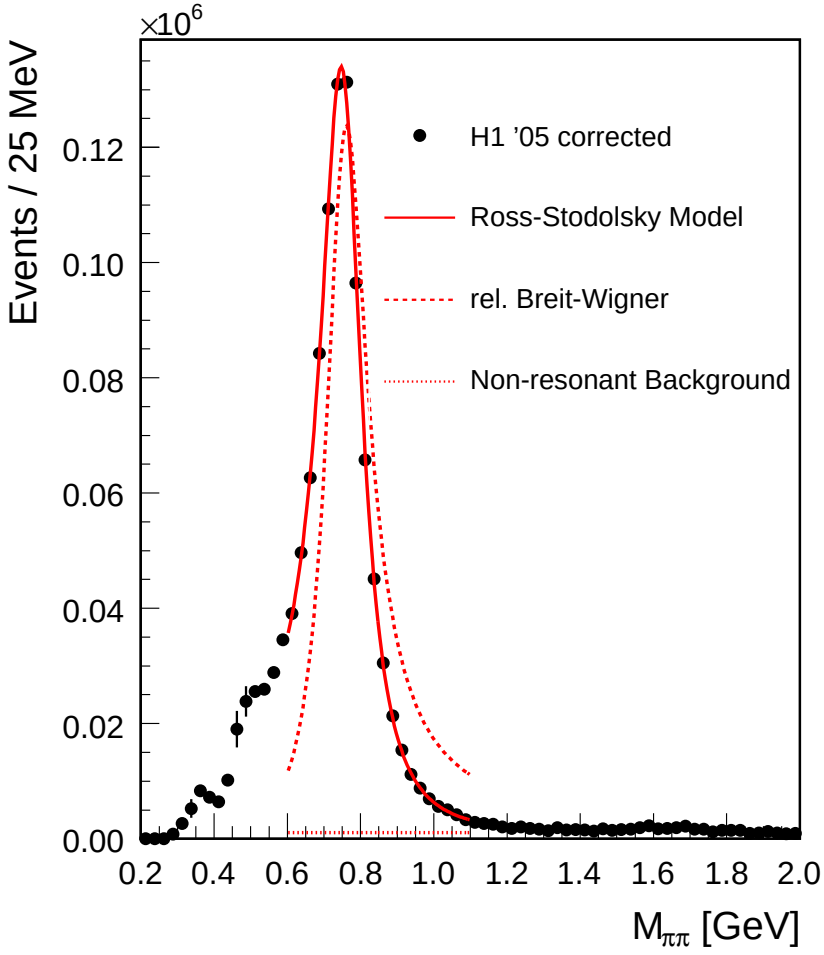


$\longrightarrow$ 267785 selected ρ^0

$\longrightarrow$ 12 bins in $|t|$
5-10 bins in W

ρ^0 PhP - Corrected Mass Distribution

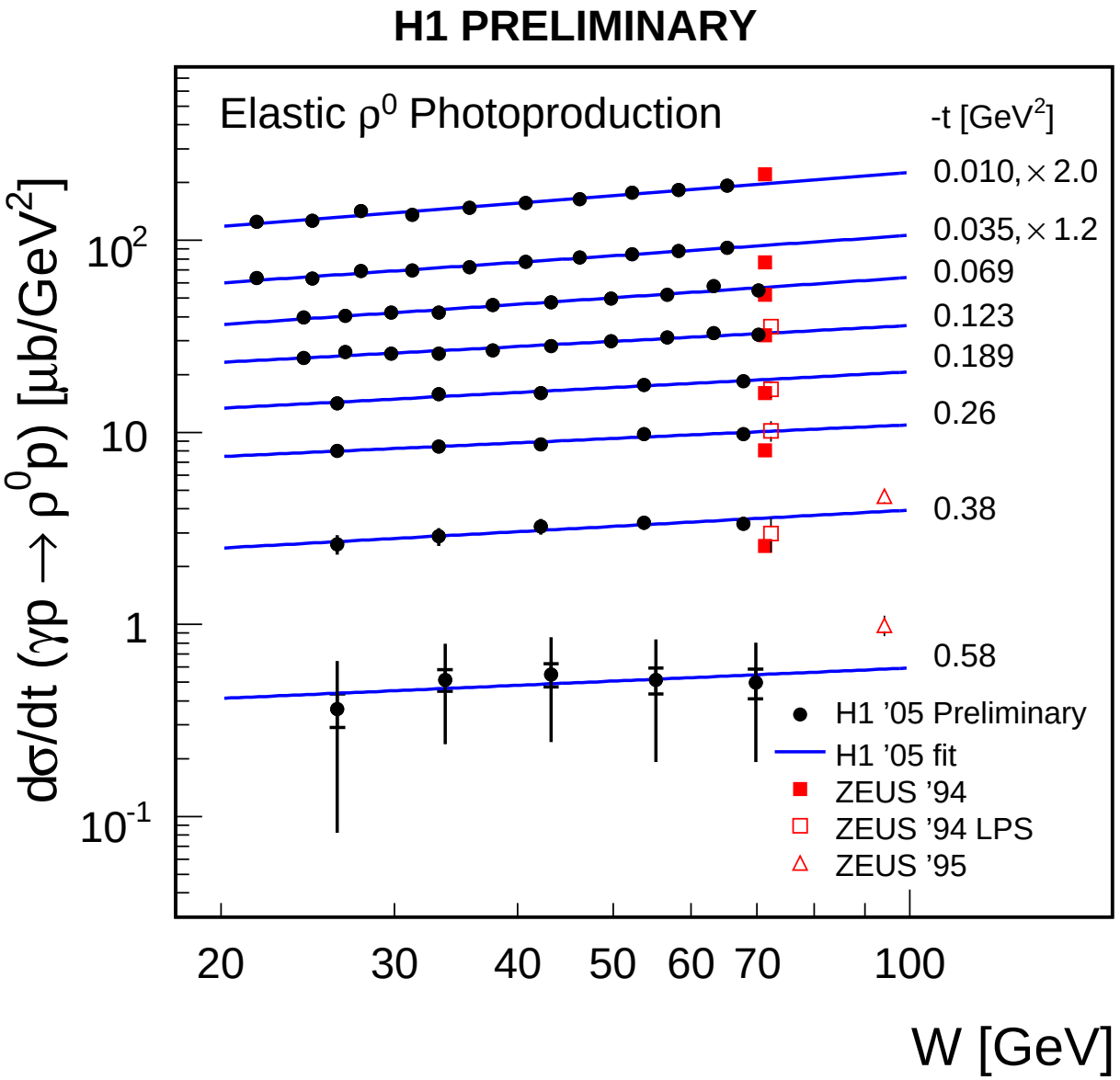
- Mass distribution distorded, due to non-resonant $\pi^+\pi^-$ production
- Fit rel. Breit-Wigner, including a skewing factor (Ross-Stodolsky):
  - $m_\rho = 766.4$ MeV (PDG: 768 MeV)
  - $\Gamma_\rho = 145$ MeV (PDG: 150 ± 3 MeV)
- Perform fit in each $W - t$ bin with fixed ρ^0 mass and width to average values above



$\longrightarrow$ Obtain number of ρ^0 in each $W - t$ bin (for $2m_\pi < M_{\pi\pi} < m_\rho + 5\Gamma_\rho$)

$\longrightarrow$ Extract σ_{gp} cross sections in each $W - t$ bin

ρ^0 PhP - Elastic Cross Section



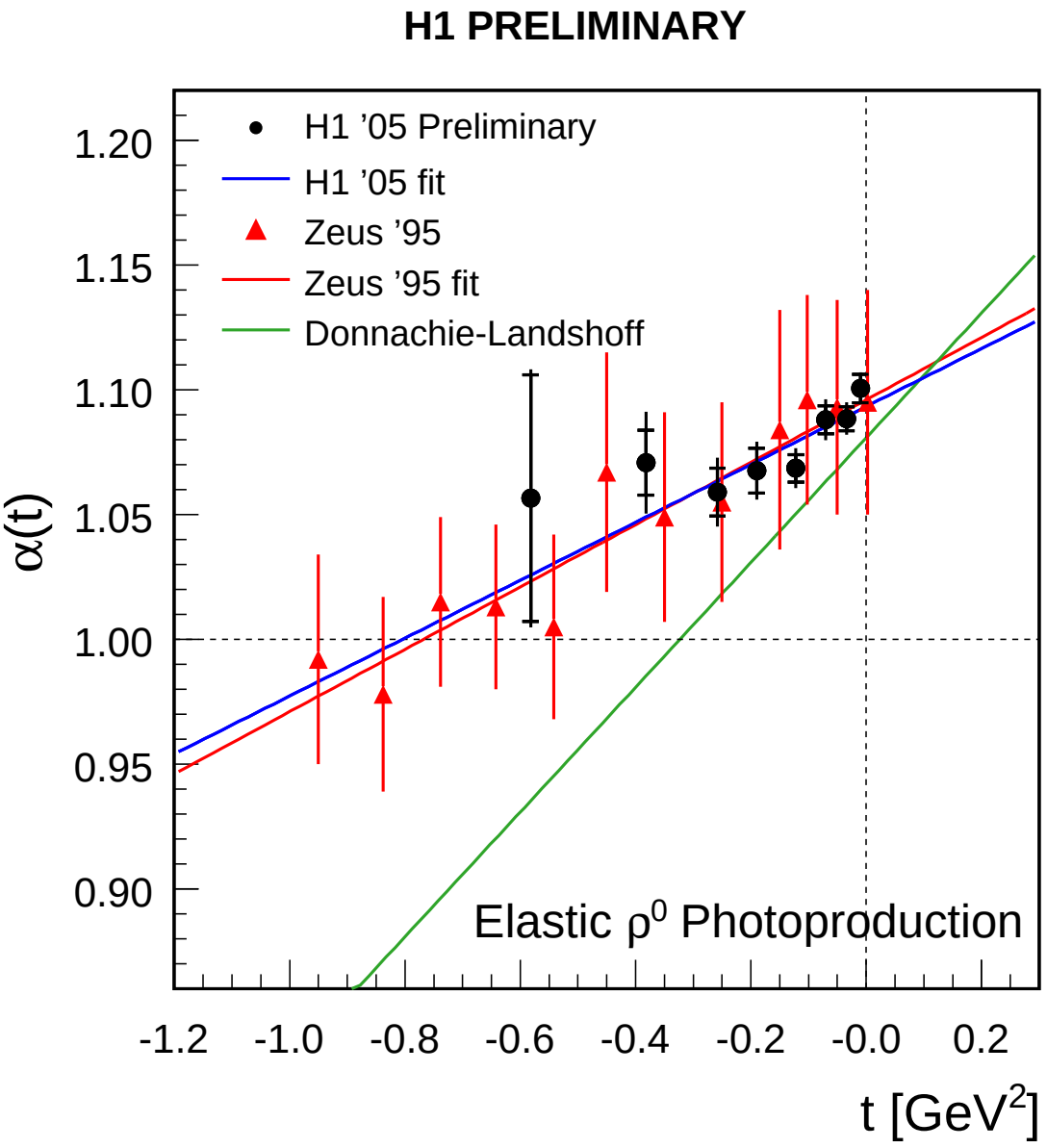
Good agreement with previous results from H1, ZEUS and OMEGA (not shown)

Fit to H1 data:

$$\frac{\mathrm{d}\sigma}{\mathrm{dt}} \propto \frac{W}{W_0}^{4\,(\alpha(t)-1)}$$

$\rightarrow$ Pomeron trajectory

Elastic ρ^0 PhP - Pomeron trajectory



$$\alpha(t) = \alpha_0 + \alpha' t$$

$$\rightarrow \alpha_0 = 1.093 \pm 0.003\,^{+0.008}_{-0.007}$$

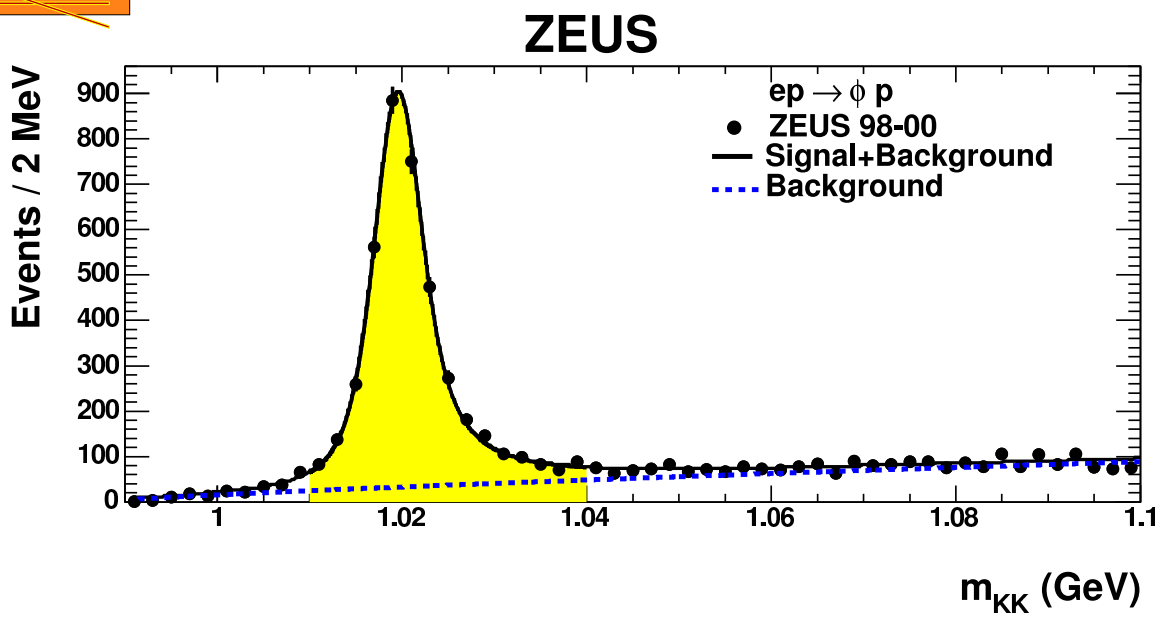
$$\rightarrow \alpha' = 0.116 \pm 0.027\,^{+0.036}_{-0.046}\ \text{GeV}^{-2}$$

- α' smaller than 0.25 GeV^{-2}
- Good agreement with fit to ZEUS and fix target data:

$$\alpha_0 = 1.096 \pm 0.021$$
$$\alpha' = 0.125 \pm 0.038\ \text{GeV}^{-2}$$

Exclusive ϕ Production in DIS

Nucl. Phys. B 718 (2005) 3-31



98-2000 data:

- $\mathcal{L} = 65.1$ pb^{-1}
- Select $\phi \longrightarrow K^+ K^-$
- 3642 events in range $1.01 < M_{KK} < 1.04$ GeV

Kinematic range:

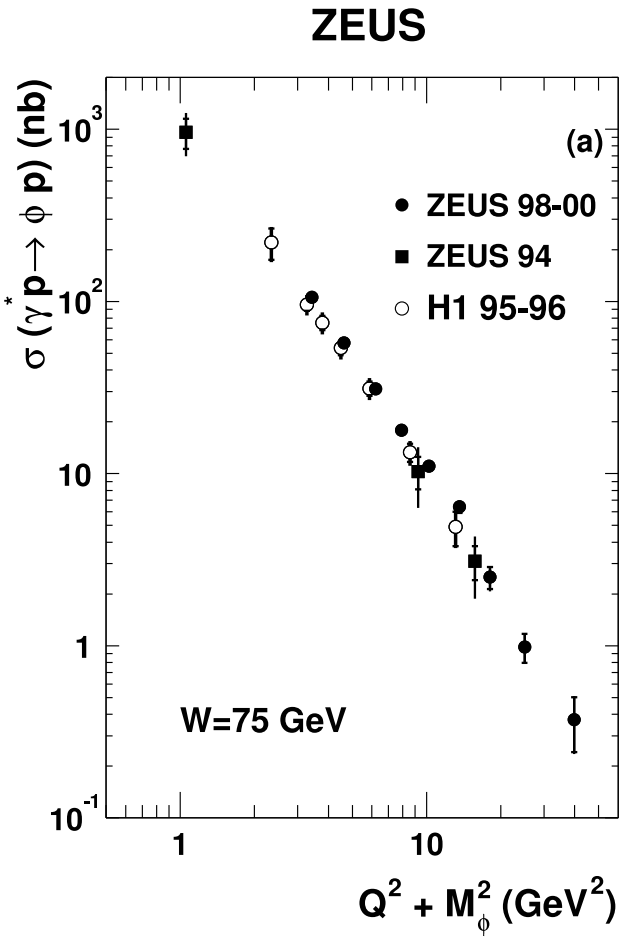
- $2 < Q^2 < 70$ GeV^2
- $35 < W < 145$ GeV ($\rightarrow Q^2$ dependent)
- $|t| < 0.6$ GeV^2

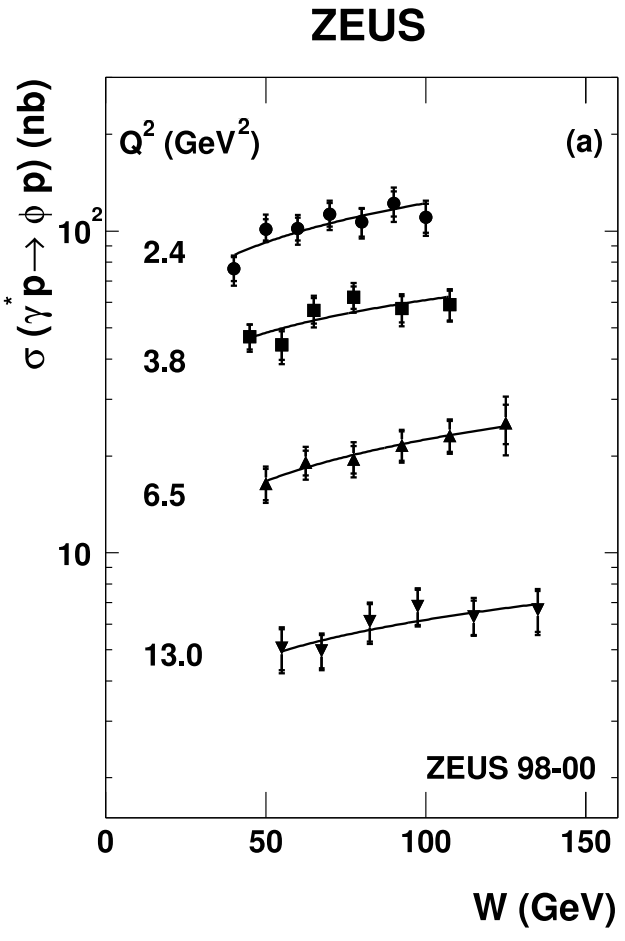
Substracted backgrounds:

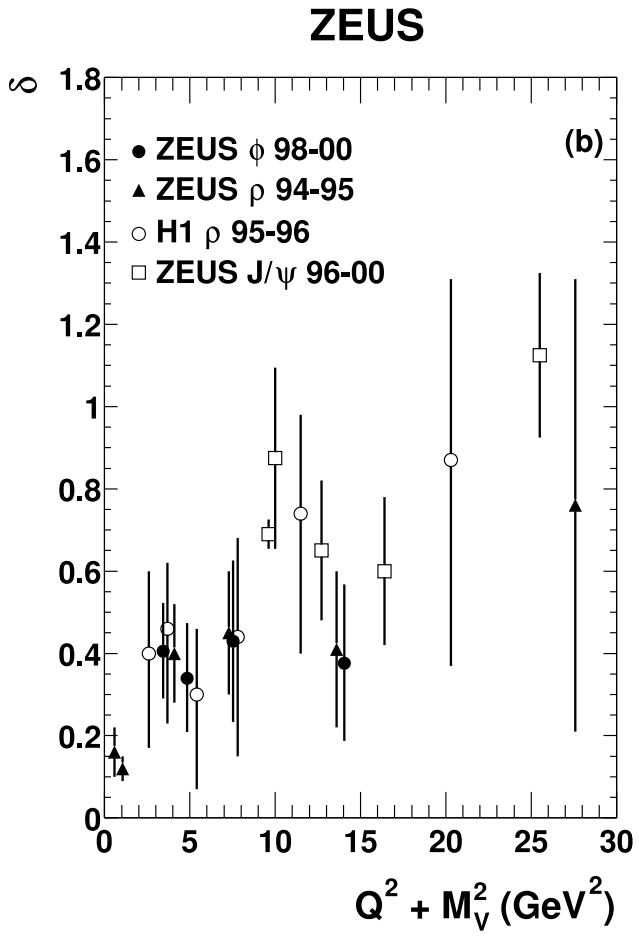
- non-resonant decreasing from 18 % at $Q^2 = 2.4$ GeV^2 to 5 % at $Q^2 = 13$ GeV^2
- Proton dissociation: $(7 \pm 0.4\,^{+4.2}_{-2.8})$%

ϕ in DIS - Q^2 and W dependence

- Fit $\sigma_\phi \propto W^\delta \longrightarrow \delta \sim 0.4 \longrightarrow$ no Q^2 dependance of δ
- rise of δ with $Q^2 + M_{VM}^2$ observed in global VM picture
- ρ,ϕ: tansition from soft to hard regime observed

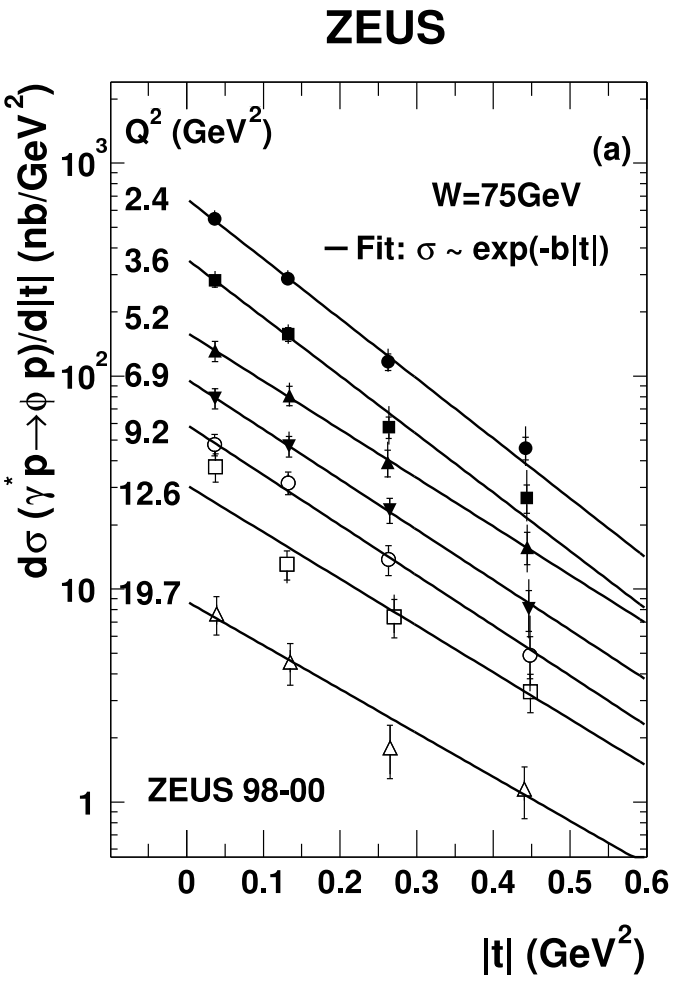


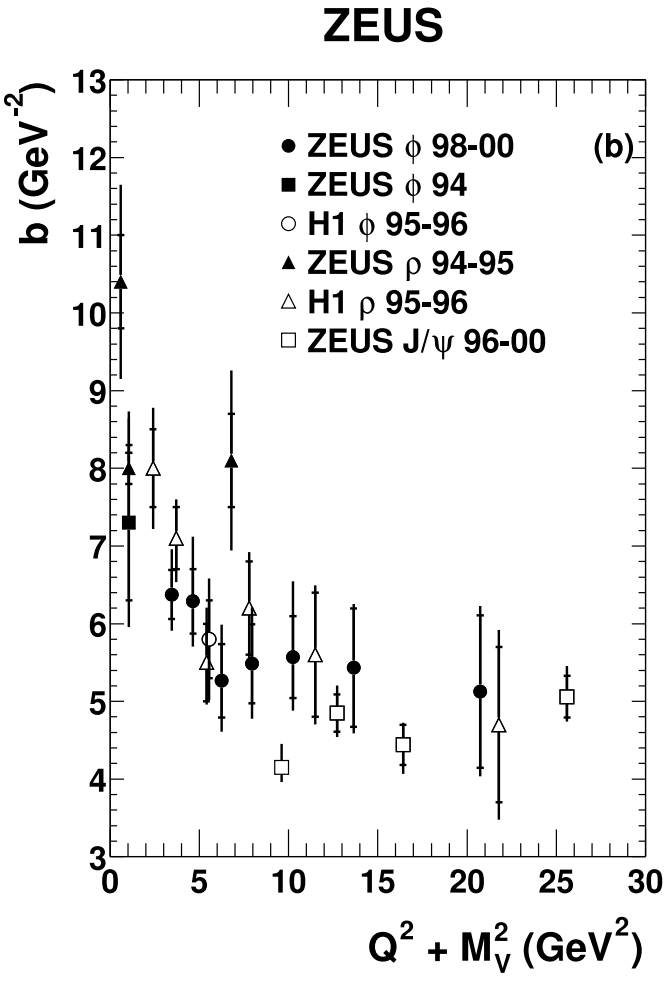




ϕ in DIS - t dependence

- Fit $\mathrm{d}\sigma/\mathrm{dt} \propto \exp(-\mathrm{b}|\mathrm{t}|)$ for $W = 75\,\mathrm{GeV}$
- No Q^2 dependence of b observed within errors
- Data suggest scaling with $Q^2 + M_{VM}^2$ in global VM picture





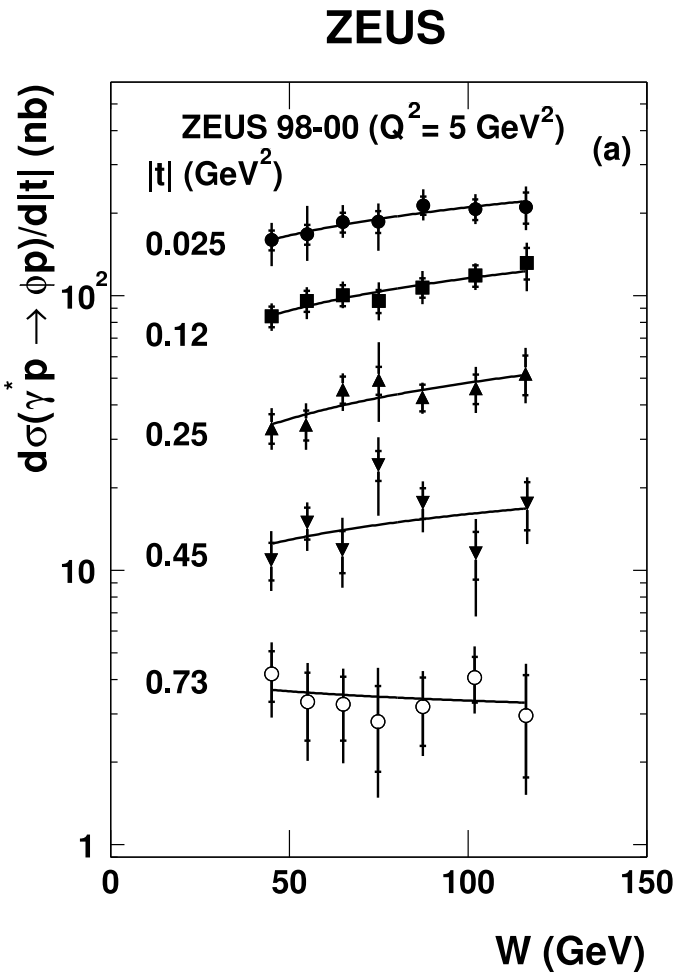
ϕ in DIS - Pomeron trajectory

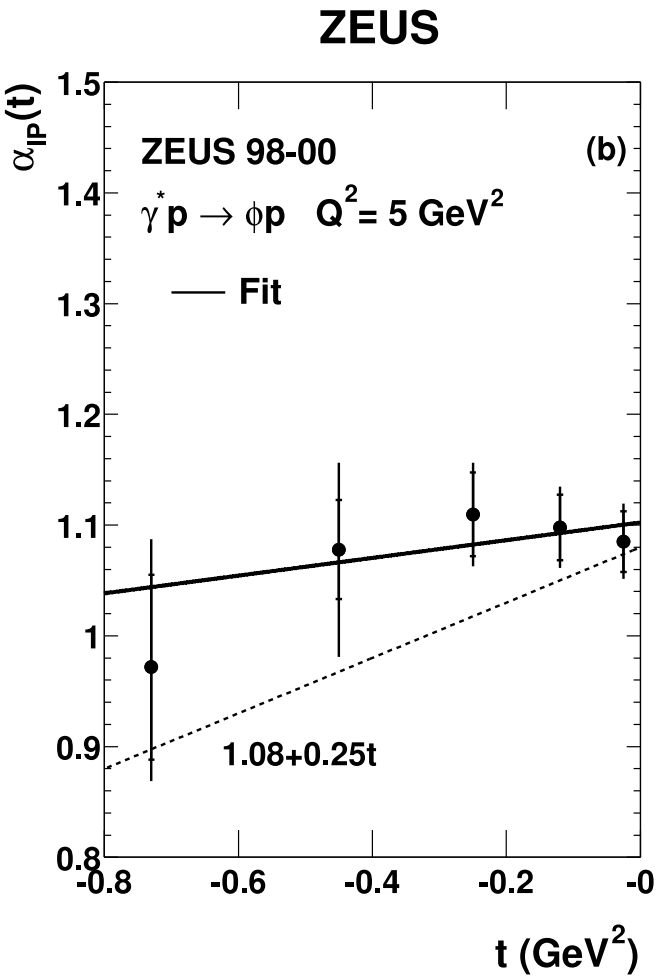
- Fit $\frac{\mathrm{d}\sigma}{\mathrm{dt}} \propto \frac{W}{W_0}^{4\,(\alpha(t)-1)}$

$\rightarrow \alpha_0 = 1.10 \pm 0.02$ (stat.) ± 0.2 (syst.)

$\rightarrow \alpha' = 0.09 \pm 0.02$ (stat.) ± 0.8 (syst.) GeV^{-2}

$\longrightarrow$ Data compatible with $\alpha' = 0$ (no shrinkage)

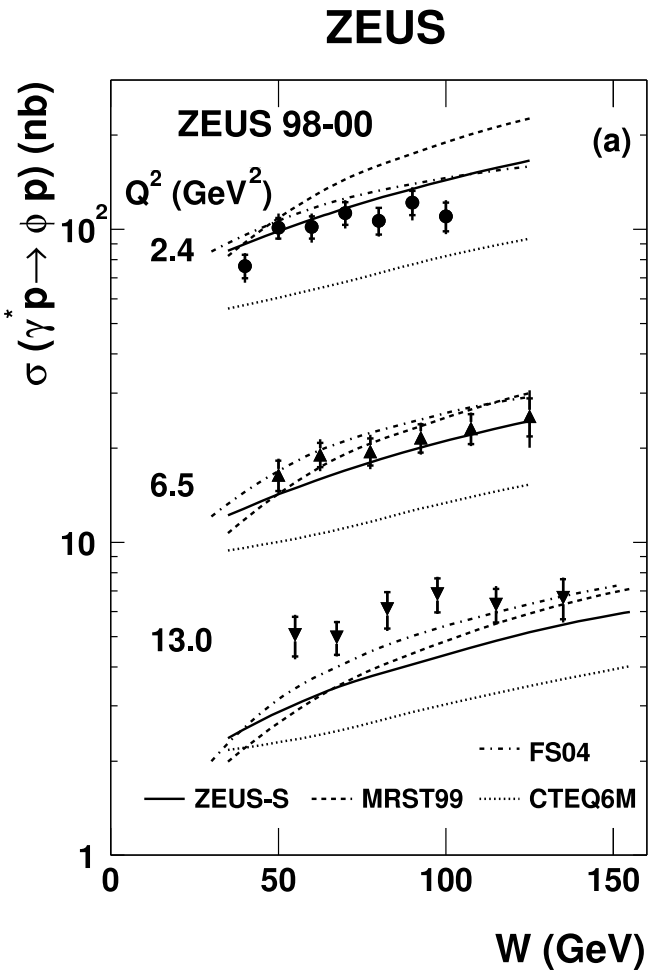


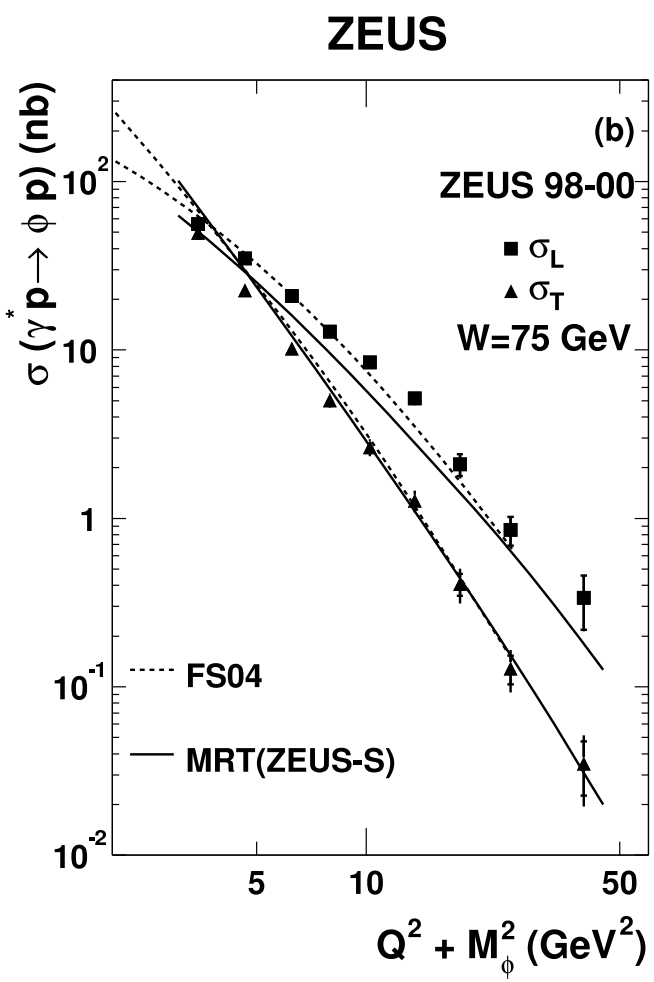


ϕ in DIS - Comparison with pQCD models

- comaparison with MRT and FS04 pQCD models
  - different assumptions on gluon densities
- $\sigma(\gamma p \to \phi p) = \sigma_T + \epsilon\,\sigma_L$

JHEP 0412, 052 (2004)
Phys. Rev. D62, 14022 (2000)

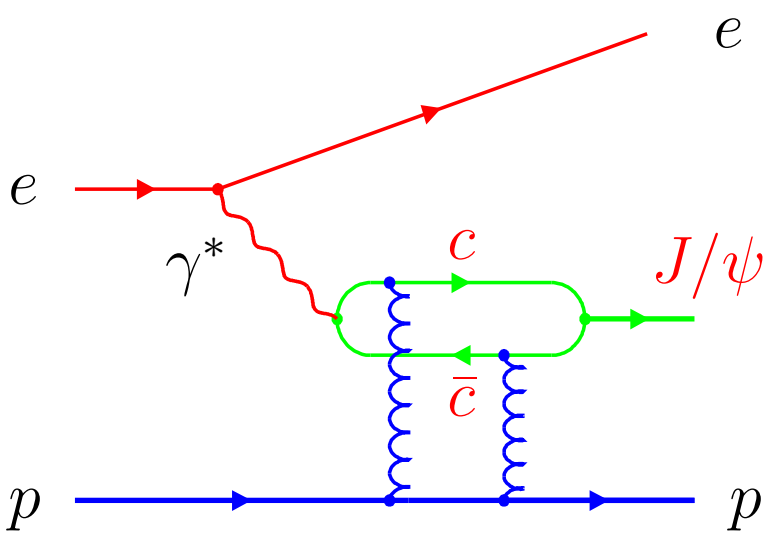




$\longrightarrow$ models describe qualitatively data; best description by FS04

Elastic J/ψ Production

hep-ex/0510016



- Charm q mass as hard scale
  $\longrightarrow$ pQCD valid in photoproduction
- Interplay with second hard scale Q^2 ?
- Sensitivity to GPDs at low x
  $\longrightarrow$ constrain on gluon density ?

Photoproduction $< Q^2 >= 0.05\ \mathrm{GeV}^2$

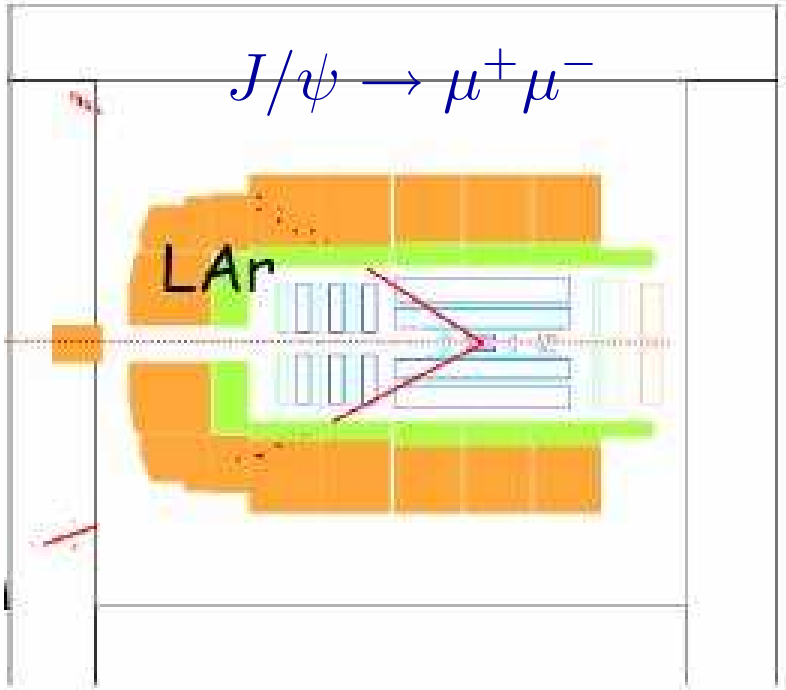
$\rightarrow$ $J/\psi \rightarrow \mu^+\mu^-$ for $40 < W < 160$ GeV

$\rightarrow$ Dedicated $J/\psi \rightarrow e^+e^-$ high W analysis

$\rightarrow$ $40 < W < 305$ GeV

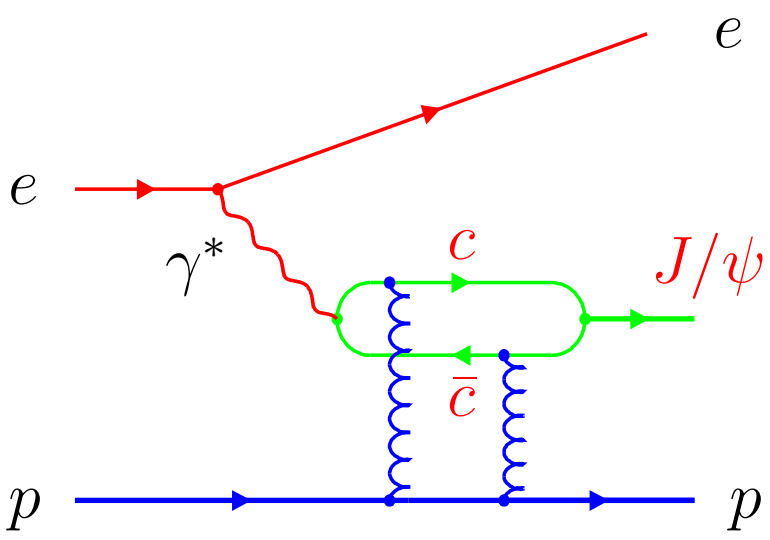
Electroproduction ($J/\psi \rightarrow \mu^+\mu^-$ Only)

- $2 < Q^2 < 80\ \mathrm{GeV}^2$
- $40 < W < 160$ GeV



Elastic J/ψ Production

hep-ex/0510016



- Charm q mass as hard scale

  $\longrightarrow$ pQCD valid in photoproduction
- Interplay with second hard scale Q^2 ?
- Sensitivity to GPDs at low x

  $\longrightarrow$ constrain on gluon density ?

Photoproduction $< Q^2 >= 0.05\ \mathrm{GeV}^2$

$\rightarrow$ $J/\psi \rightarrow \mu^+\mu^-$ for $40 < W < 160$ GeV

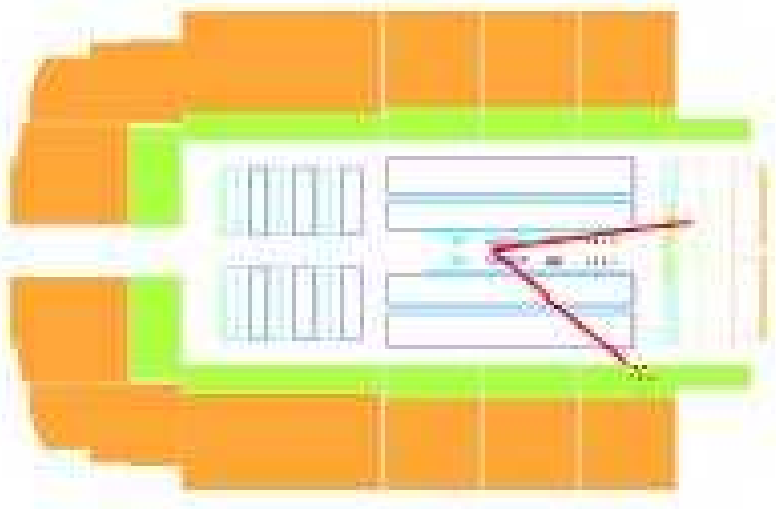
$\rightarrow$ Dedicated $J/\psi \rightarrow e^+e^-$ high W analysis

$\rightarrow$ $40 < W < 305$ GeV

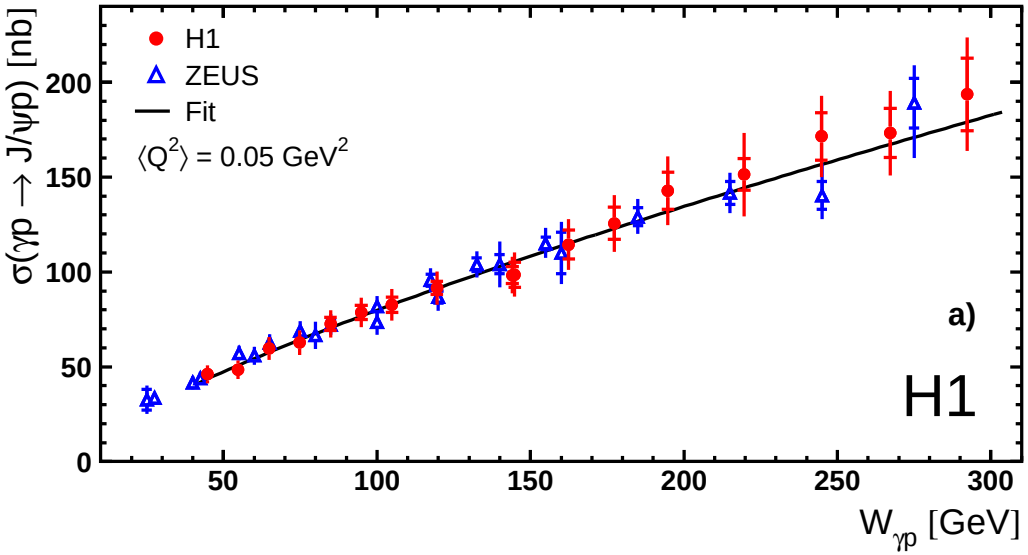
Electroproduction ($J/\psi \rightarrow \mu^+\mu^-$ Only)

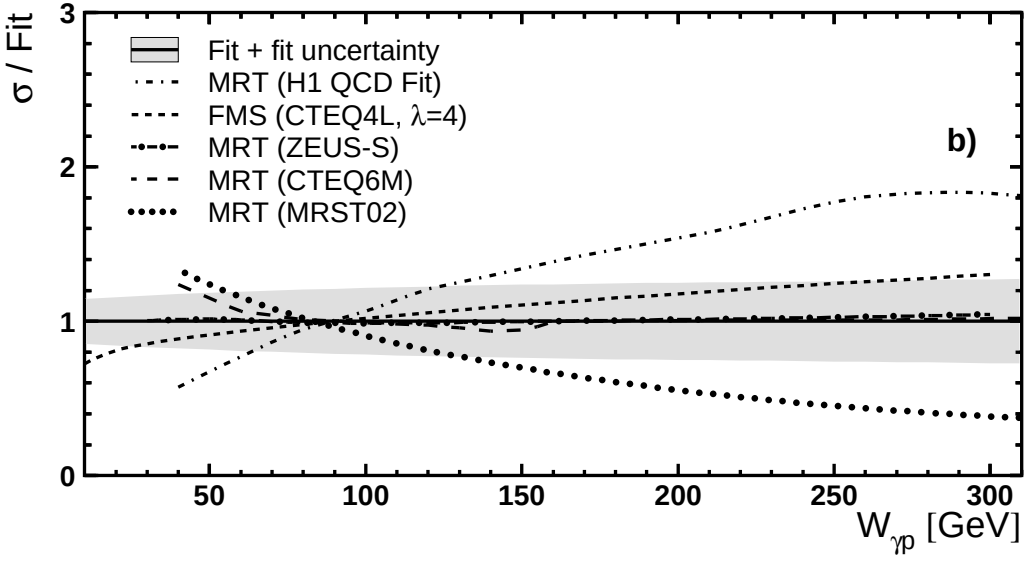
- $2 < Q^2 < 80\ \mathrm{GeV}^2$
- $40 < W < 160$ GeV

$J/\psi \rightarrow e^+e^-$



Elastic J/ψ - W dependence in PhP





- H1 and ZEUS data agree
- Fit $\sigma \propto W^{\delta}$ (H1 only):

$$\delta = 0.75 \pm 0.03 \pm 0.03$$

Martin, Ryskin, Teubner :

Phys Rev D62 (2000) 014033

$$A = \int_0^{oo} \frac{\mathrm{dl}_\mathrm{T}^2}{l_T^4}\, \alpha_s(l_T^2)\, f(x, x', l_T^2)\, \Phi^{L,T}(..., l_T^2)$$

$x \neq x' \longrightarrow$ need GPDs

$$f(x = x', l_T^2) = \frac{\partial[(xg(x,q_o^2)T(q_o^2,\mu^2)]}{\partial q_o^2} \|_{q_o^2 = l_T^2}$$

+ skewing ansatz

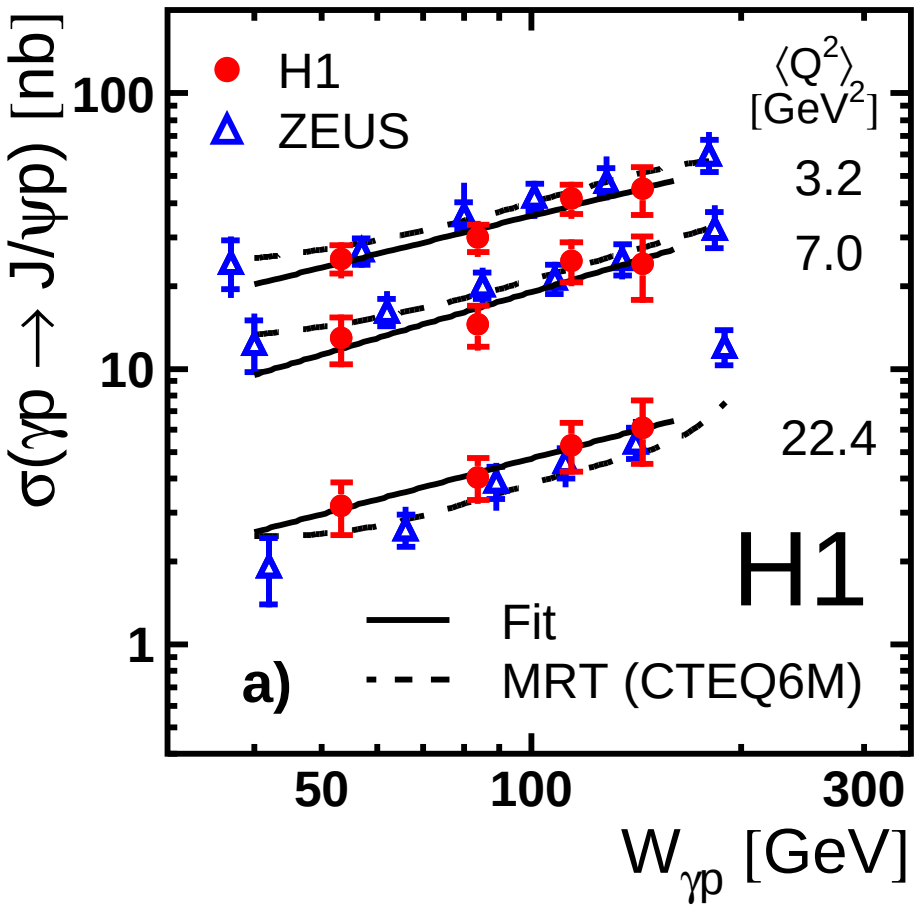
$\rightarrow$ Sensitivity to gluon at low x (?)

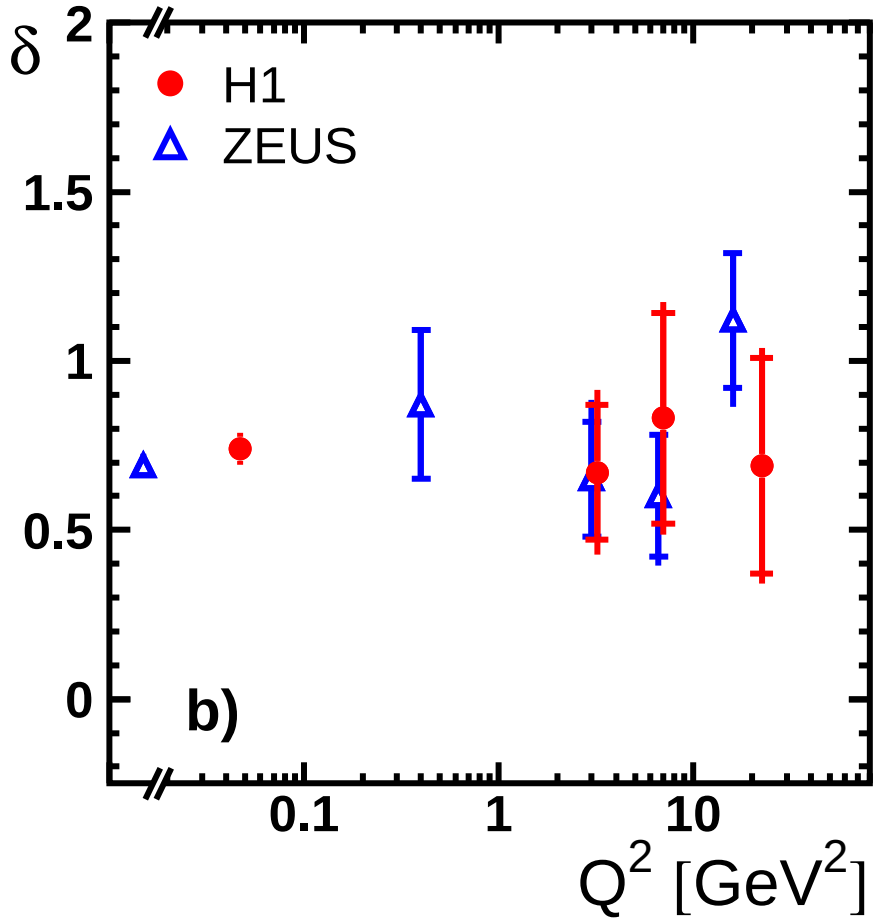
FMS: dipole model $\longrightarrow$ OK

JHEP 0103 (201) 045

Elastic J/ψ - W dependence in DIS

Fit $\sigma \propto W^{\delta}$

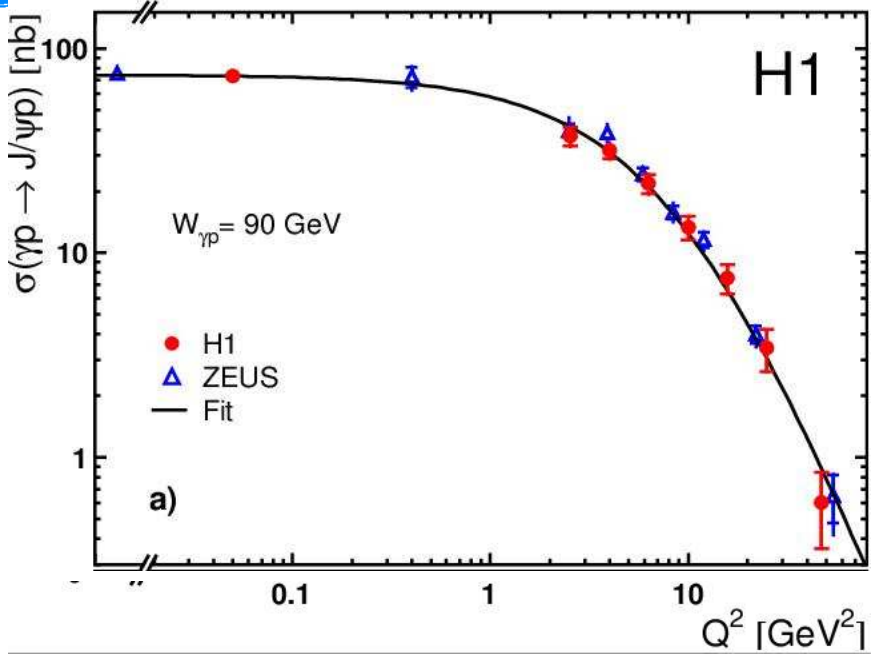




- No Q2 dependence of δ within errors

$\longrightarrow$ "Scale" is already hard, set by the charm quark mass

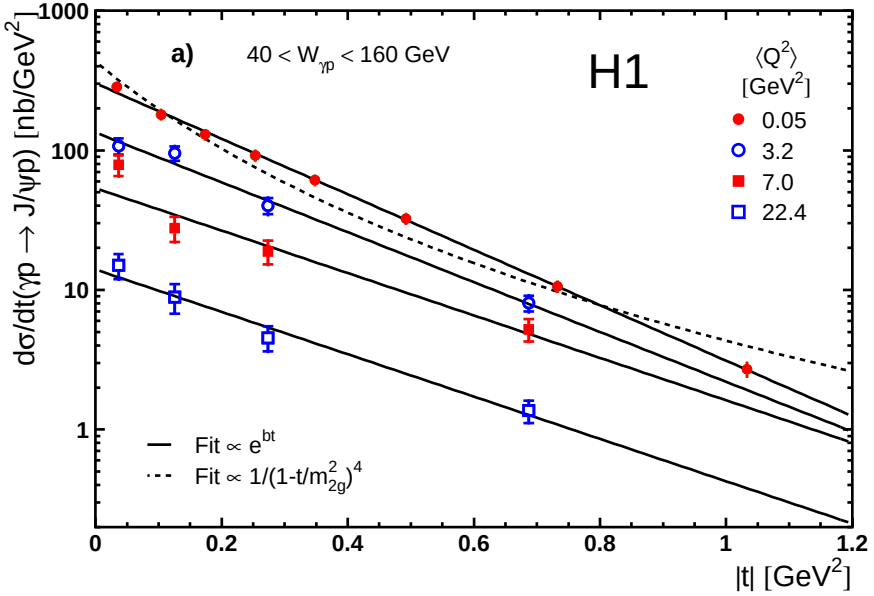
Elastic J/ψ - Q^2 and t dependences



Fit: $\sigma \propto (Q^2 + M^2_{J/\psi})^{-n}$

$\rightarrow n = 2.486 \pm 0.080 \pm 0.068$

$\rightarrow$ in agreement with ZEUS



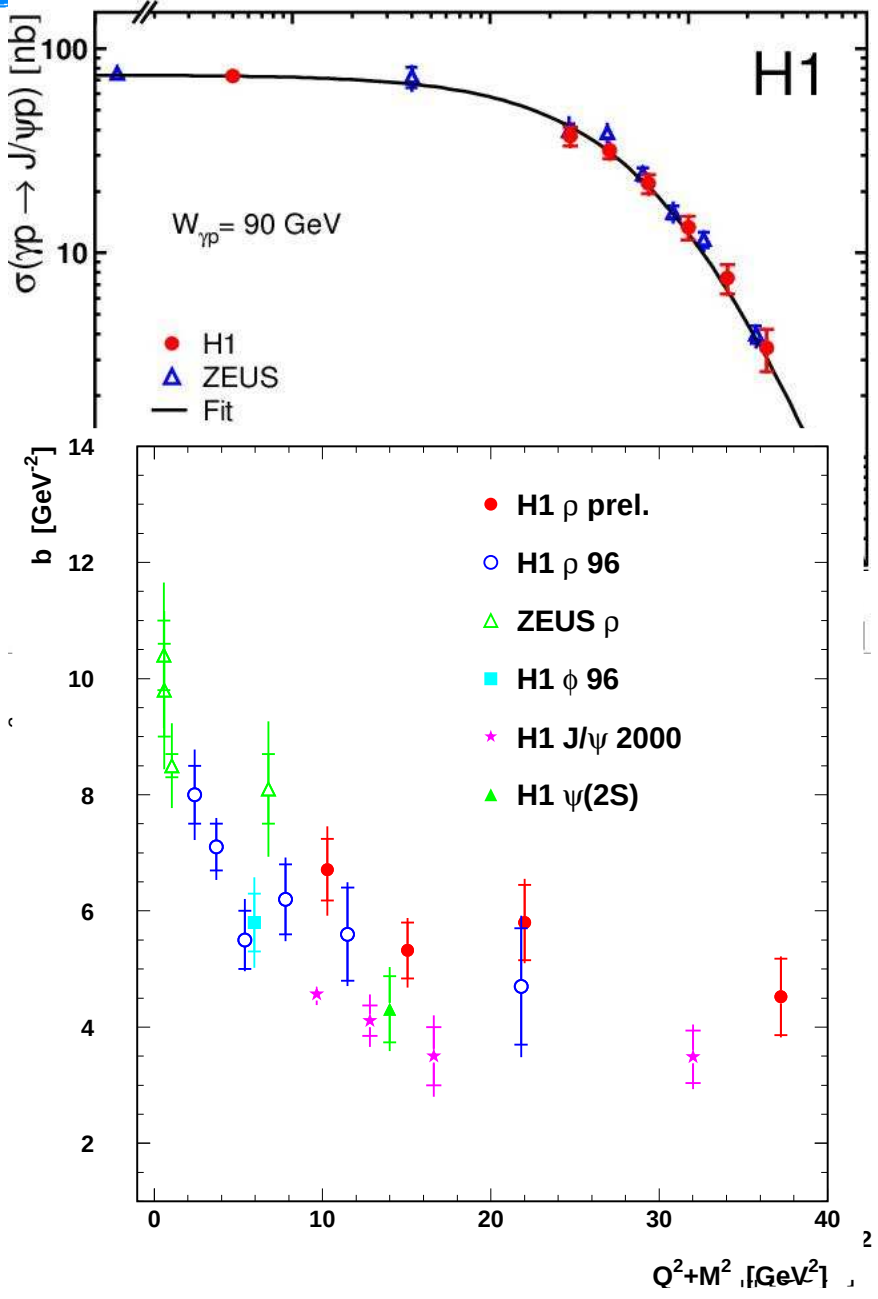
Fits: $\mathrm{d}\sigma/\mathrm{dt} \propto \exp(-\mathrm{b}|\mathrm{t}|)$

$Q^2 = 0.05 \quad b = 4.57 \pm 0.06^{+.11}_{-.18}$

$Q^2 = 22.4 \quad b = 3.49 \pm 0.45^{+.49}_{-.33}$

$\rightarrow$ no Q^2 dependence within errors

Elastic J/ψ - Q^2 and t dependences



Fit: $\sigma \propto (Q^2 + M^2_{J/\psi})^{-n}$

$\rightarrow n = 2.486 \pm 0.080 \pm 0.068$

$\rightarrow$ in agreement with ZEUS

Fits: $\mathrm{d}\sigma/\mathrm{dt} \propto \exp(-b|t|)$

$Q^2 = 0.05 \quad b = 4.57 \pm 0.06^{+.11}_{-.18}$

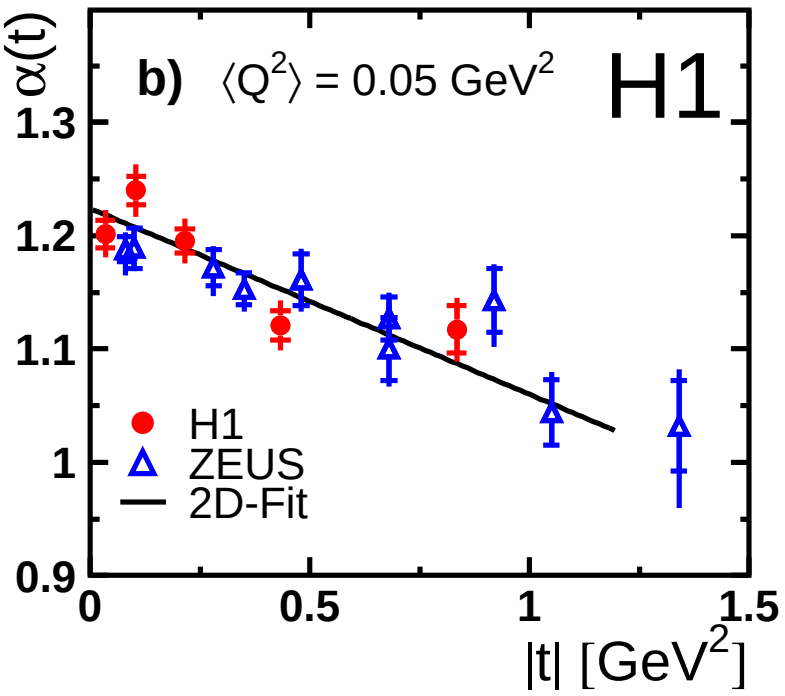
$Q^2 = 22.4 \quad b = 3.49 \pm 0.45^{+.49}_{-.33}$

$\rightarrow$ no Q^2 dependence within errors

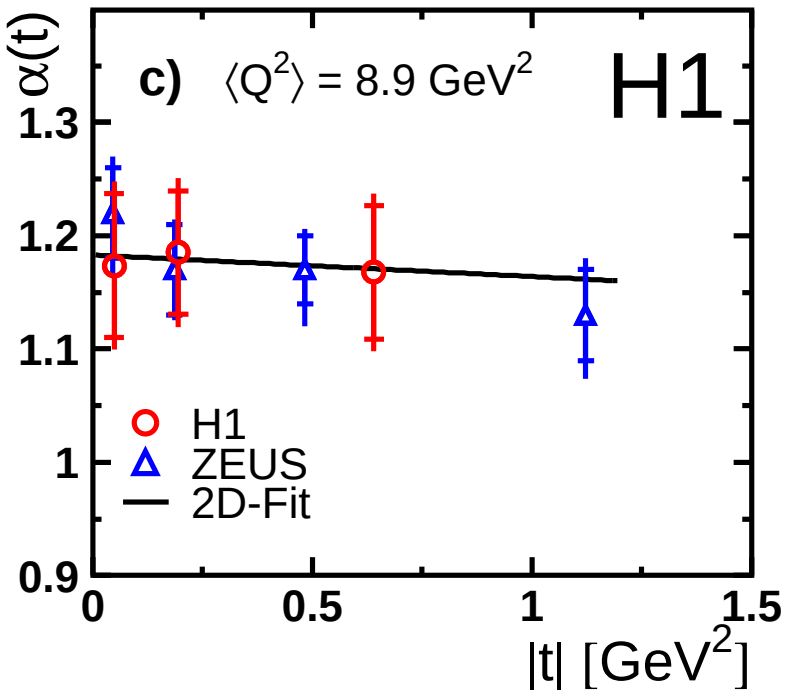
$\rightarrow$ Universality with $Q^2 + M^2_{VM}$

Elastic J/ψ - Pomeron trajectory

Photoproduction



Electroproduction



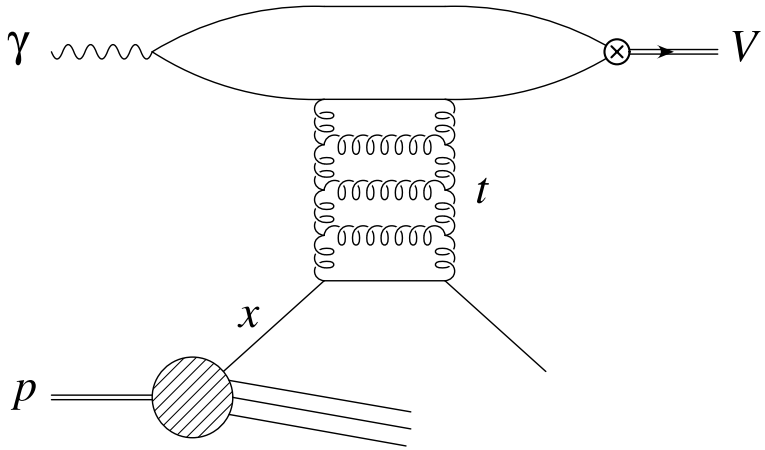
- PhP: $\alpha(t) = (1.224 \pm 0.010 \pm 0.012) + (0.164 \pm 0.028 \pm 0.030)\ \mathrm{GeV}^{-2}\ t$
- DIS: $\alpha(t) = (1.183 \pm 0.054 \pm 0.030) + (0.019 \pm 0.139 \pm 0.076)\ \mathrm{GeV}^{-2}\ t$

$\longrightarrow$ Similar trajectories within errors in PhP and DIS

$\longrightarrow$ PhP: $0 << \alpha' << 0.25\ \mathrm{GeV}^{-2}$

Vector Mesons at Large $|t|$

VM photoproduction at large $|t|$ proposed as test of BFKL



- Need $W^2 > |t| \rightarrow \sum_n \alpha_s^n \ln^n W^2/|t|$
- BFKL model by Forshaw *et al.*:
  - Free parameters: α_s^{BFKL}, Λ^2
  - Power like t dependence
  - Challenge is to describe both the t dependence and the helicity structure

JHEP 0309 (2003) 008 and JHEP 0312 (2003) 002

H1: ρ^0 PhP at large $|t|$

- 2000 data: $\mathcal{L} = 20\text{pb}^{-1}$
- $75 < W < 95$ GeV
- $1.5 < |t| < 10$ GeV^2
- $M_Y < 5$ GeV (Y=proton remnant)

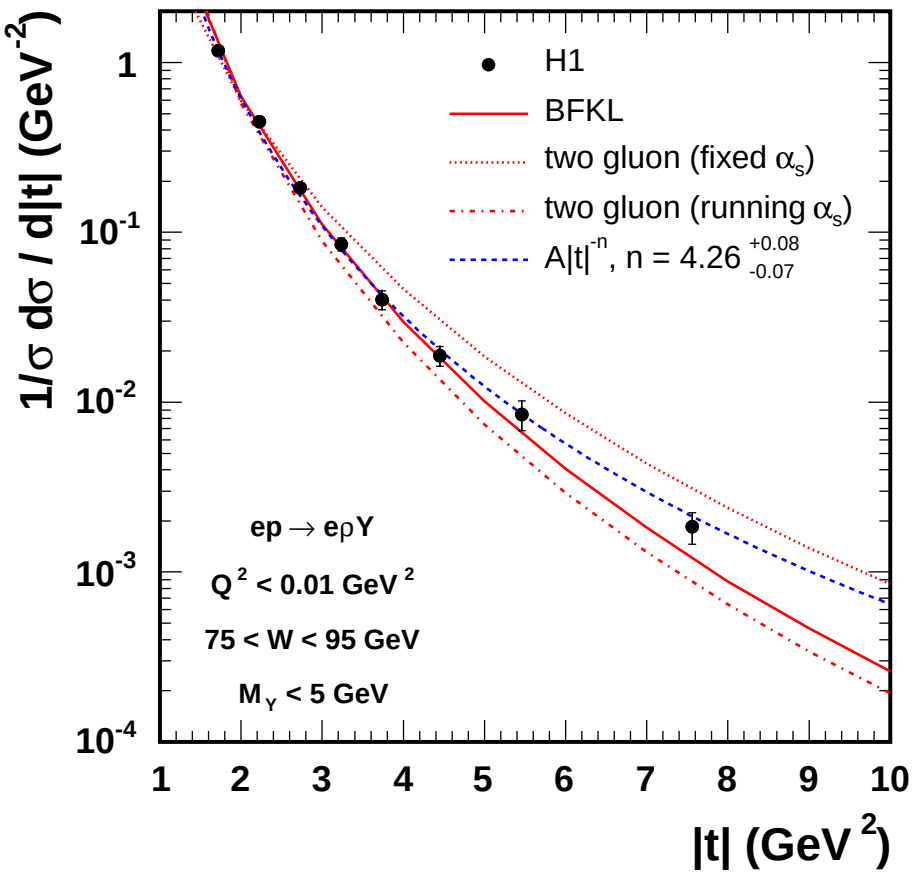
Acc by Phys. Lett. B [hep-ex/0603038]

ZEUS: J/ψ PhP at large $|t|$

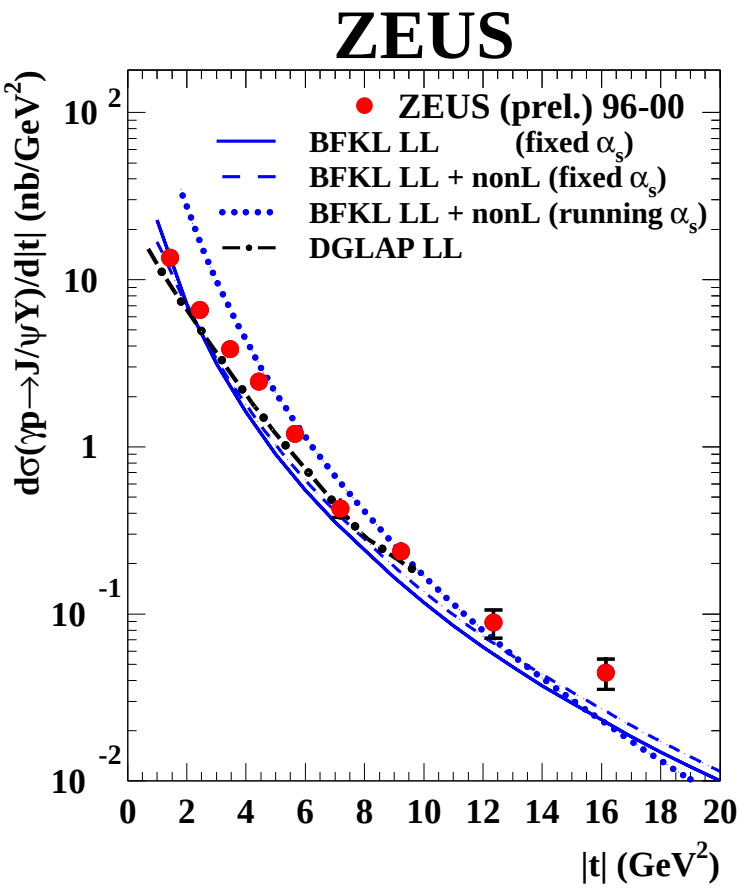
- 96-2000 data: $\mathcal{L} = 112\text{pb}^{-1}$
- $50 < W < 150$ GeV
- $1 < |t| < 20$ GeV^2
- $M_Y < 30$ GeV

VM at Large $|t|$ - t dependence

ρ^0 PhP at large $|t|$

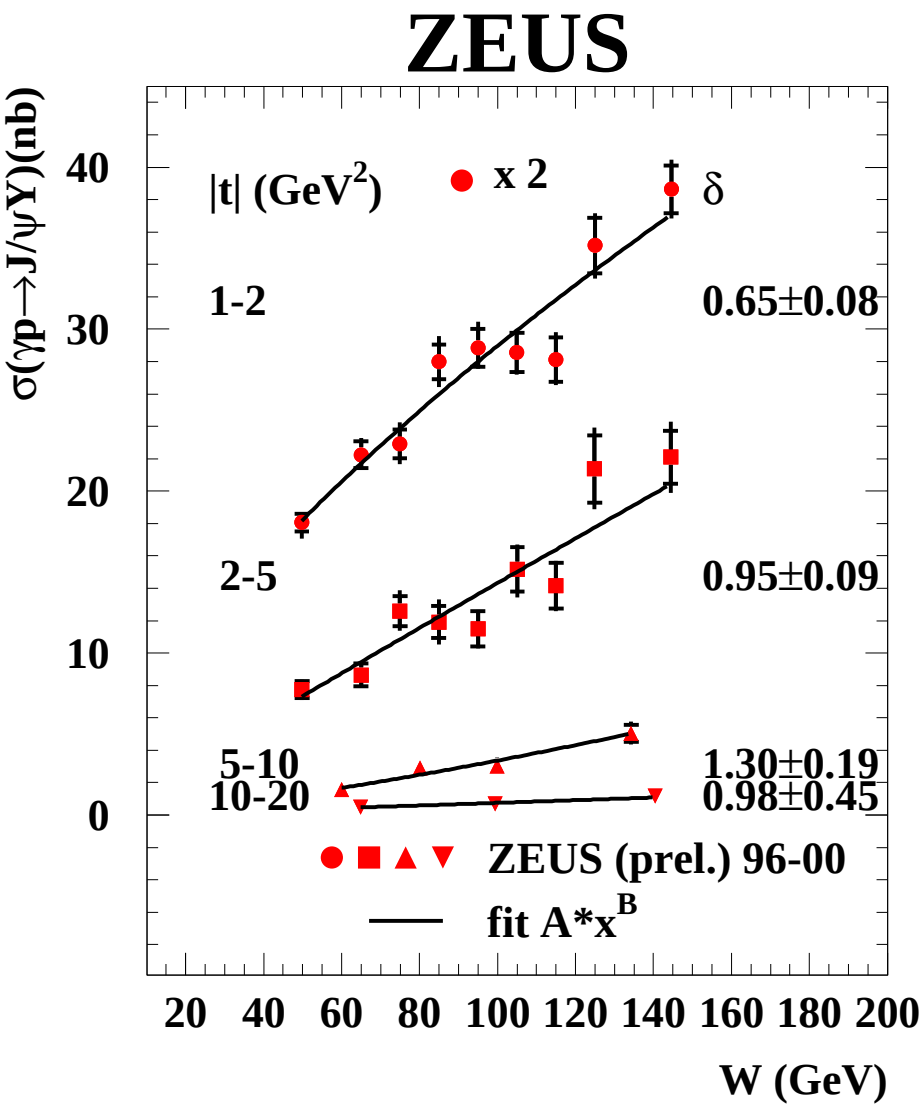


J/ψ PhP at large $|t|$



- Approx. power-like behaviour supported by data
- BFKL predictions (with fixed α_s) describe reasonably the data

VM at Large $|t|$ - W dependence



J/ψ PhP at large $|t|$

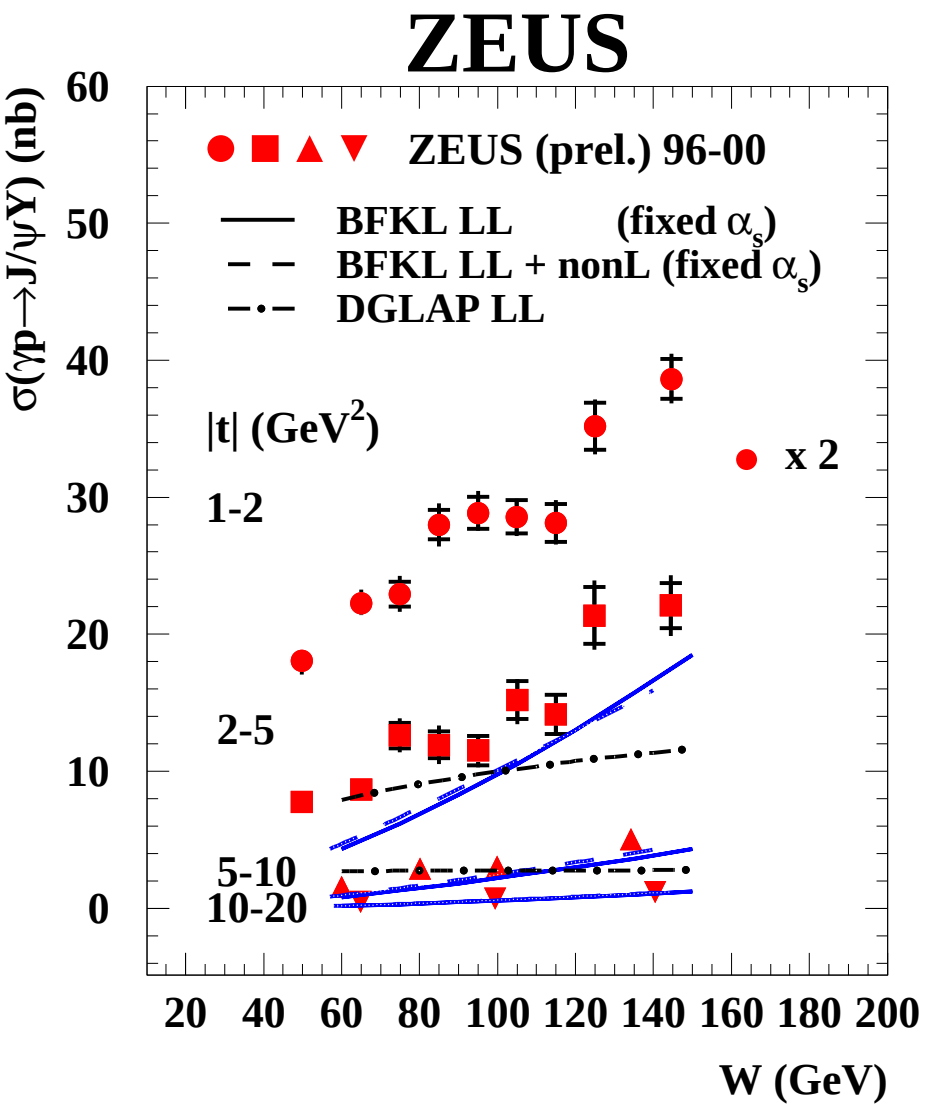
- Fit $\sigma \propto W^{\delta}$; $\delta = 4(\alpha_{I\!P}(t) - 1)$

$\rightarrow$ δ rise with $|t|$

$\rightarrow$ effective Pomeron trajectory:

$$\alpha(0) = 1.153 \pm 0.048 \pm 0.039$$
$$\alpha' = -0.020 \pm 0.014 \pm 0.010 \ \mathrm{GeV}^{-2}$$

VM at Large $|t|$ - W dependence



J/ψ PhP at large $|t|$

- Fit $\sigma \propto W^{\delta}$; $\delta = 4(\alpha_{I\!P}(t) - 1)$

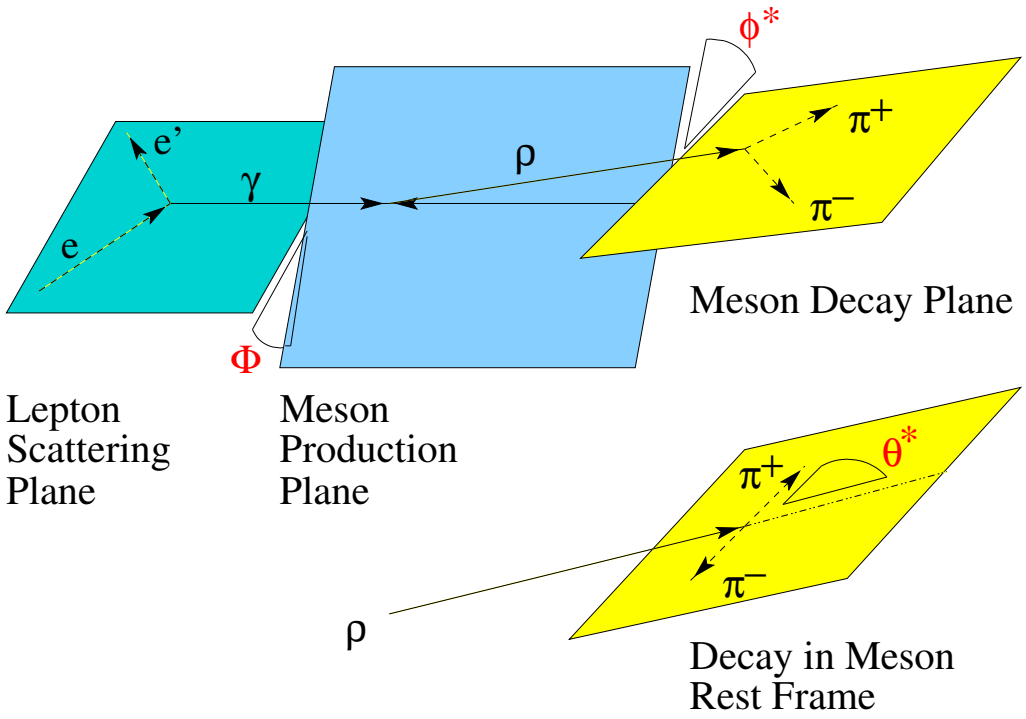
$\rightarrow$ δ rise with $|t|$

$\rightarrow$ effective Pomeron trajectory:

$$\alpha(0) = 1.153 \pm 0.048 \pm 0.039$$
$$\alpha' = -0.020 \pm 0.014 \pm 0.010 \ \mathrm{GeV}^{-2}$$

- DGLAP does not describe rise with W
- BFKL reproduces general behaviour of data

VM at Large $|t|$ - Spin Density Matrix Elements



- Production & decay angles

→ 15 spin density matrix elements (SDME)

But only 3 accessible in PhP

- SDMEs = bilinear combinations on the helicity amplitudes

$$r^{ij}_{kl} \propto M_{\lambda_{VM}\lambda_\gamma} M_{\lambda'_{VM}\lambda'_\gamma}$$

  - No helicity flip: M_{++} / M_{--}
  - Single flip: M_{+0} / M_{-0}
  - Double flip: M_{+-} / M_{-+}

- s-channel helicity conservation (SCHC), i.e. $\lambda_{VM} = \lambda_\gamma$

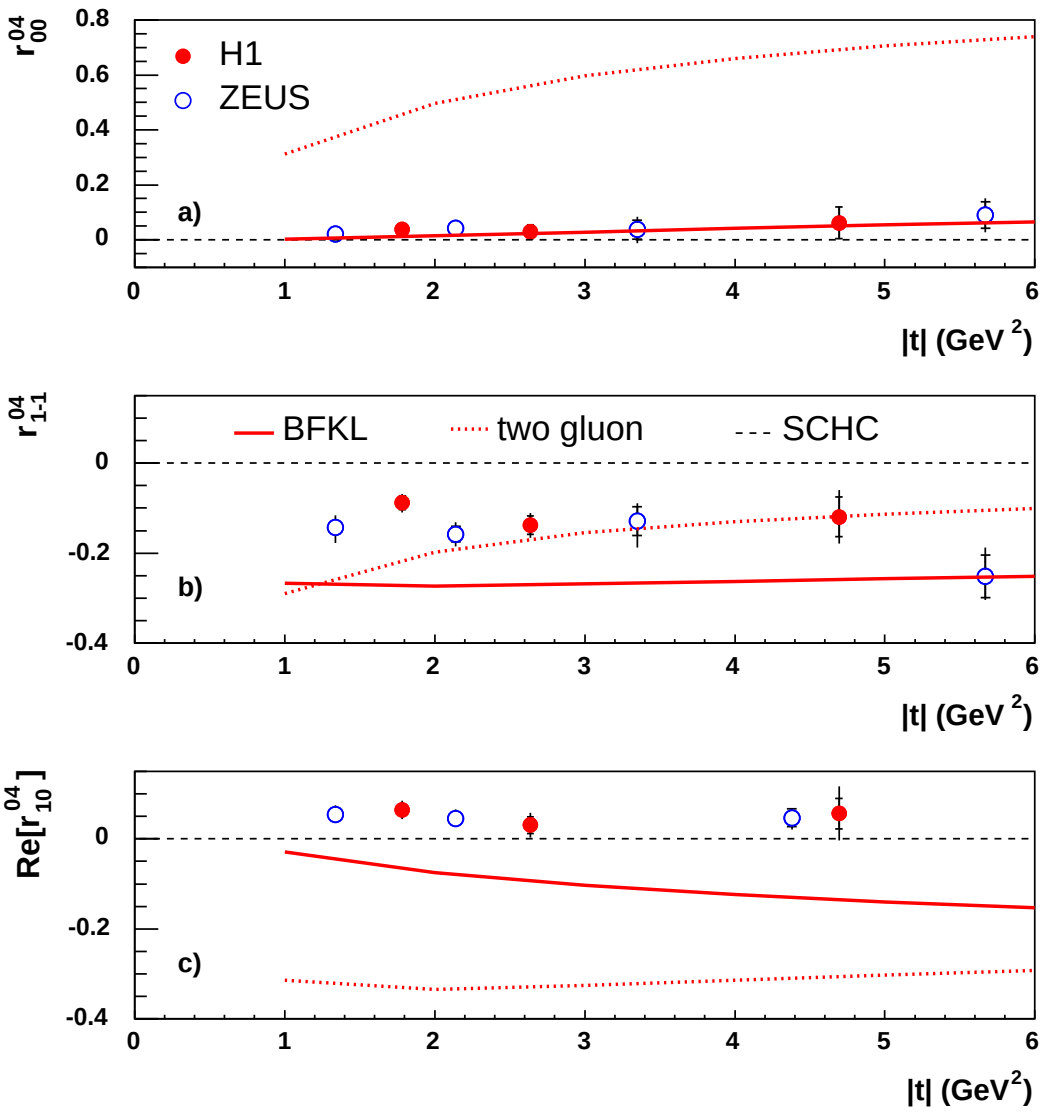
⟶ All 3 SDMEs to be zero

$$r^{04}_{00} = \frac{|M_{+0}|^2}{|M_{++}|^2+|M_{+0}|^2+|M_{+-}|^2}$$

$$r^{04}_{10} = \frac{1}{2}\frac{M_{++}M^*_{+0}-M_{+-}M^*_{+0}}{|M_{++}|^2+|M_{+0}|^2+|M_{+-}|^2}$$

$$r^{04}_{1-1} = \frac{1}{2}\frac{M_{++}M^*_{+-}-M_{+-}M^*_{++}}{|M_{++}|^2+|M_{+0}|^2+|M_{+-}|^2}$$

VM at Large $|t|$ - Dependence of SDMEs on $|t|$



- Small r^{04}_{00} value ($\sim 5\%$) $\rightarrow$ ρ meson mainly transverse
- Two-gluon model hugely overestimates r^{04}_{00} but BFKL gives a good description
- $r^{04}_{1-1} << 0 \rightarrow$ SCHC violation with double flip contribution
- $r^{04}_{10} > 0 \rightarrow$ SCHC violation with single flip contribution
- BFKL model fails to describe r^{04}_{10} (as well as Two-gluon)

CONCLUSION

First HERA-II DVCS cross sections versus Q^2, W and t:

- H1 prelimary results in agreement with previous results
- t slope measurement $\longrightarrow$ Constraint theory normalisation
- NLO QCD predictions based on GPDs in agreement with data
  $\longrightarrow$ Sensitivity to different GPD models

Elastic ρ^0 photoproduction using the H1 Fast Track Trigger:

- Pomeron trajectory determined using data within one experiment
- α' significantly smaller than 0.25 GeV^{-2}

Elastic ϕ and J/ψ production:

- ϕ: $\sigma \propto W^{\delta}$; $\delta \sim 0.4 \rightarrow$ between soft and hard regime
- J/ψ: $\sigma \propto W^{\delta}$; $\delta \sim 0.7 \rightarrow$ charm provide hard scale (at all Q^2)
- High sensitivity of elastic J/ψ to gluon at low x ?

Vector mesons photoproduction at large $|t|$

- W and t dependences are described by pQCD BFKL model
- BFKL model however fails to describe fully the helicity structure