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on Deep Inelastic Scattering

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# Deeply Virtual Compton Scattering at HERA II (H1 results)

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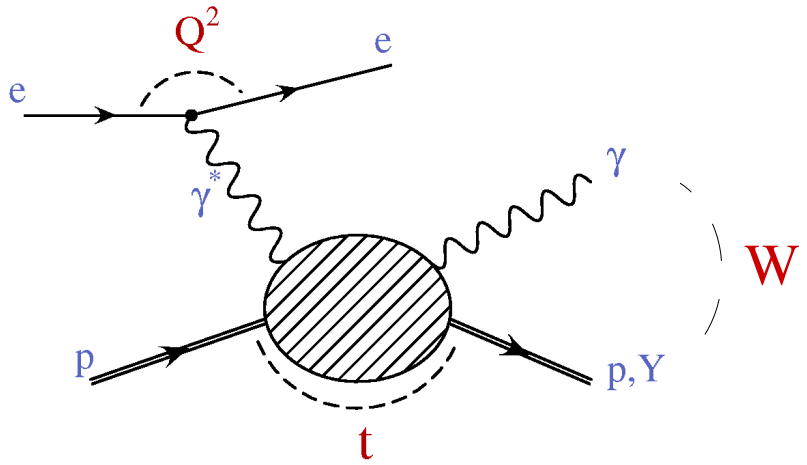
On behalf of the

**H1 Collaboration**

# Introduction

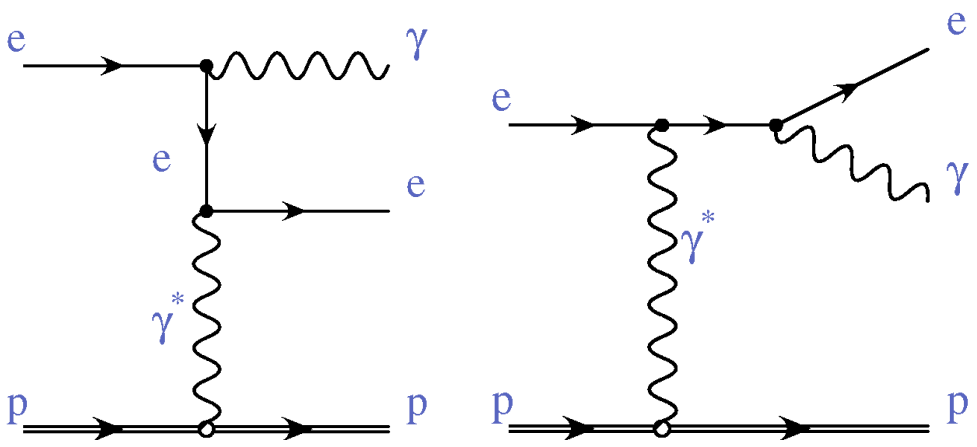



$Q^2$: virtuality at which the proton is probed

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

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

Same final state as the BH process:




BH is a purely QED process involving only proton elastic form factors → precise knowledge of this background

→ use it to study the detector response

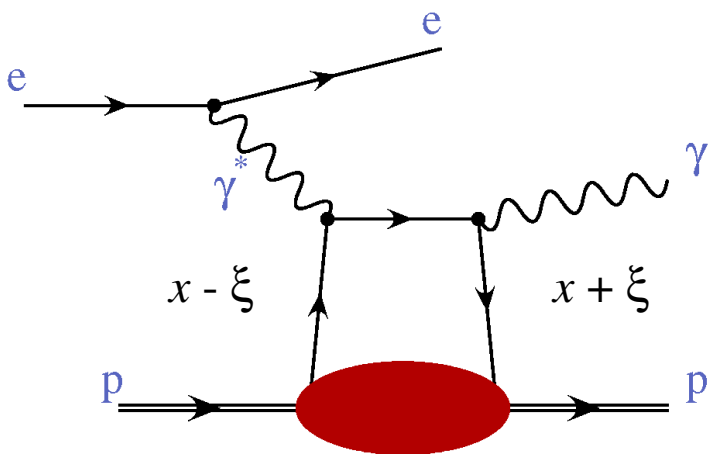
DVCS and BH processes interfere

→ interference term vanishes because of integration over the azimuthal angle

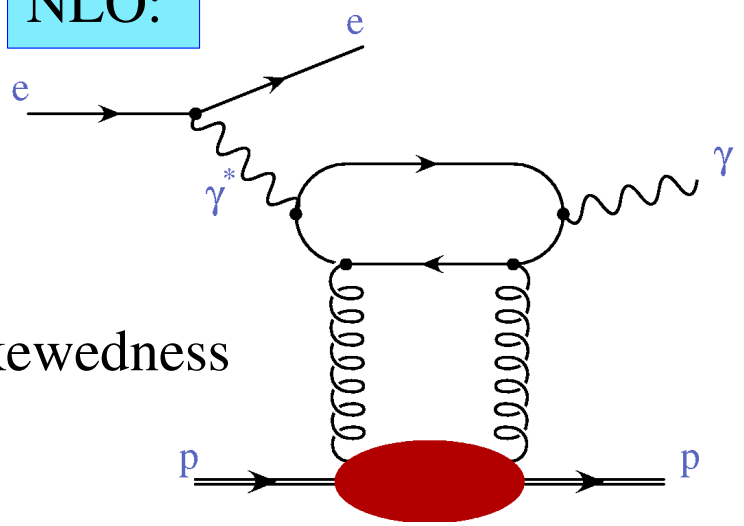
# QCD predictions

$Q^2 >> 1\ GeV^2$, $-t << Q^2$: factorization of the DVCS process amplitude into a hard scattering at parton level, fully calculable in pQCD and a non-perturbative part describing the internal dynamics of the proton.

LO:




NLO:




ξ: skewedness

Emitted and absorbed partons carry different longitudinal momentum fractions

→ new formalism to describe the dynamics inside of the proton:

Generalized Parton Distributions: GPD = f ($x$, $\xi$, t; $\mu^2$)

→ distribution of the partons in the transverse plane

correlation between longitudinal and transverse distributions

# 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 | $\widetilde{H}^{q,g}(x, \xi, t; \mu^2)$ | $\widetilde{E}^{q,g}(x, \xi, t; \mu^2)$ |

DVCS: sensitivity to NLO processes and dominant contribution from $H^g(x, \xi, t; \mu^2)$

**NLO leading twist (+ twist three) QCD predictions**

by A. Freund and M. McDermott (Eur.Phys.J. C23 (2002) 651)

**DGLAP region:** $|x| > \xi$ **ERBL region:** $|x| < \xi$

quark singlet: $H^q(x, \xi, t; \mu^2) = q(x; \mu^2)\, e^{- b |t|}$

gluon: $H^g(x, \xi, t; \mu^2) = x\, g(x; \mu^2)\, e^{- b |t|}$

input: usual pdfs from MRST2001 and CTEQ6 at a starting scale

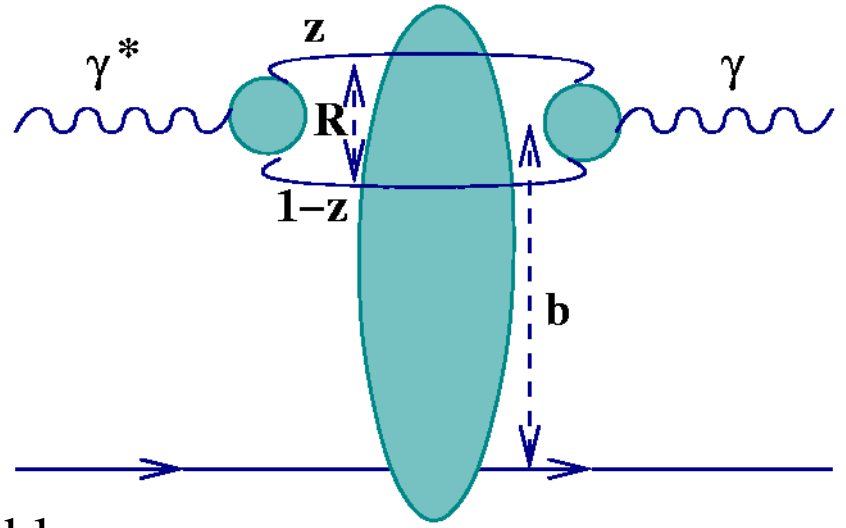
quark singlet and gluon distributions are parametrized by simple analytic functions

**$Q^2$ and $\xi$ dependence:** generated dynamically by the evolution equations.

# Color Dipole Model

In proton rest frame, DVCS process can be seen as 3 subprocesses factorized in time:

1. $\gamma^*$ fluctuates into a $q\bar{q}$ pair
2. color dipole interacts with the proton
3. $q\bar{q}$ pair annihilates in a real $\gamma$




$$A = \int d^2R\, dz\, \Psi_{\gamma^*}^{in} \quad \sigma_{\text{dipole}} \quad \Psi_{\gamma}^{out}$$

$\Psi_{\gamma^*}^{in}$, $\Psi_{\gamma}^{out}$ : photon wave function calculable

$\sigma_{\text{dipole}}$ : model dependent

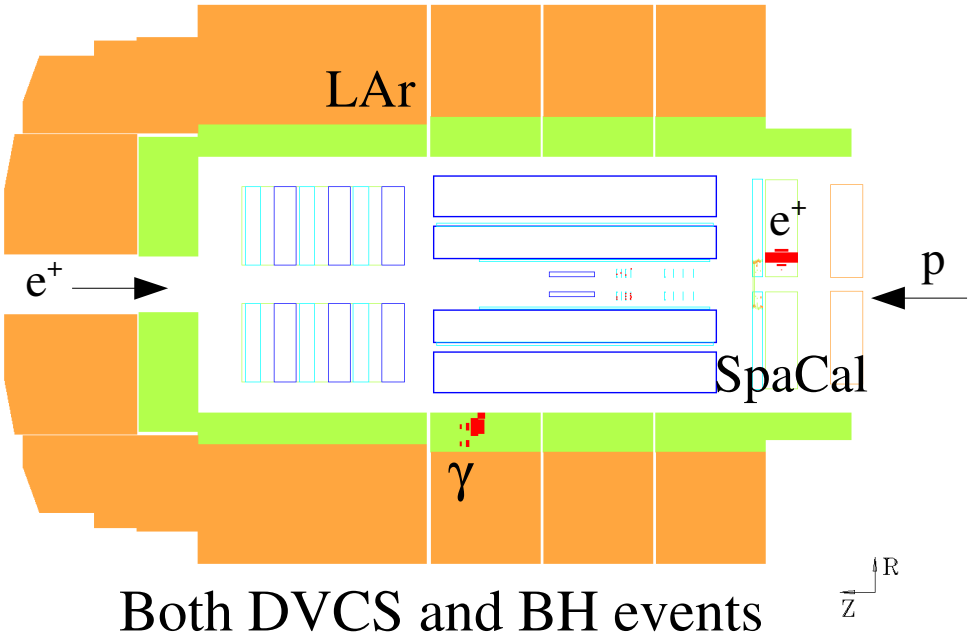
GBW saturation model applied to DVCS with DGLAP evolution (BGBK)

by L. Favart and M.V.T. Machado

Eur.Phys.J C29, 365 (2003)

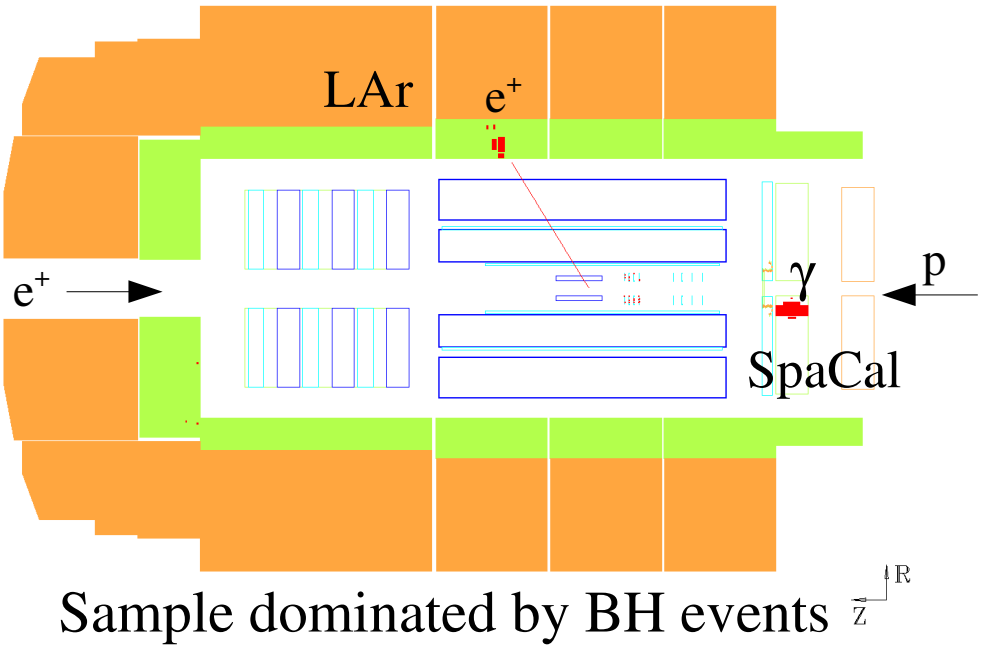
# Analysis strategy & events selection

DVCS enriched sample




Both DVCS and BH events contribute to this sample

BH control sample




Sample dominated by BH events

Particle in SpaCal: $E_1 > 15$ GeV, $153° < \theta_1 < 175°$

Particle in LAr: $P_{T\,2} > 2$ GeV, $25° < \theta_2 < 145°$

Elastic selection: no other cluster with $E > 0.5$ GeV in LAr

fwd detectors used as veto

# Control Plots DVCS enriched sample

H1 data 2004

L = 39.7 $pb^{-1}$

Data : 859

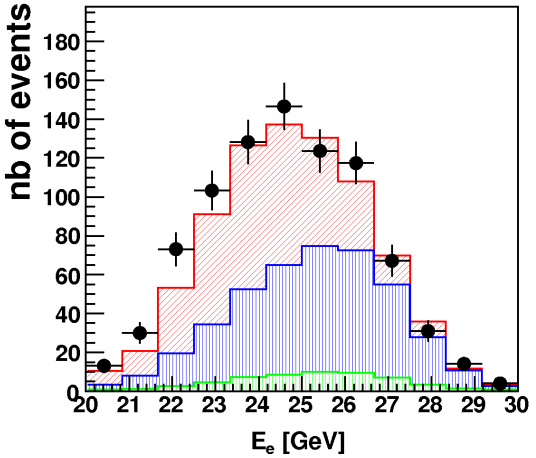
MC : 800.739

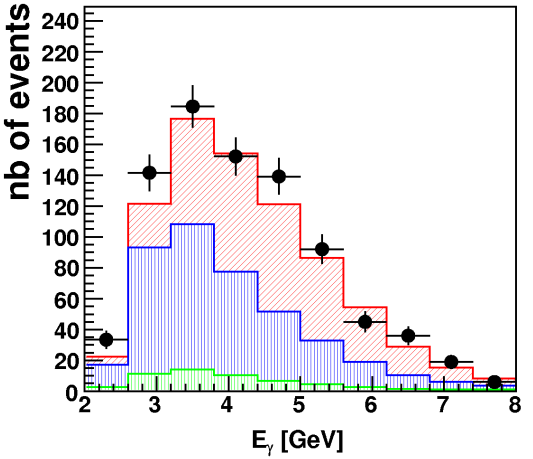
DVCSPdis: 56.390

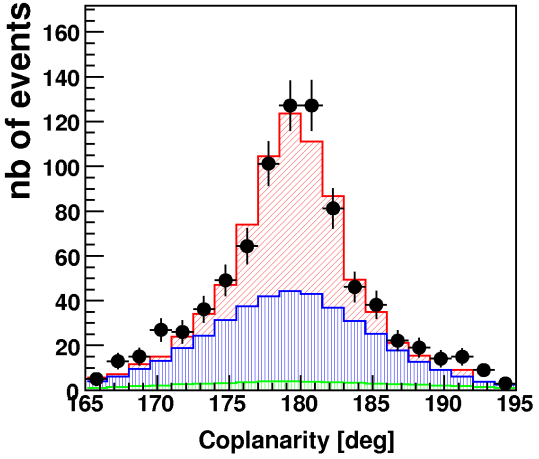
DVCSEla: 371.760

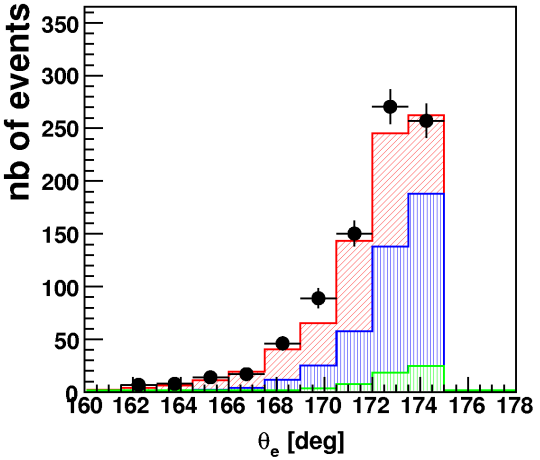
Compton: 372.589

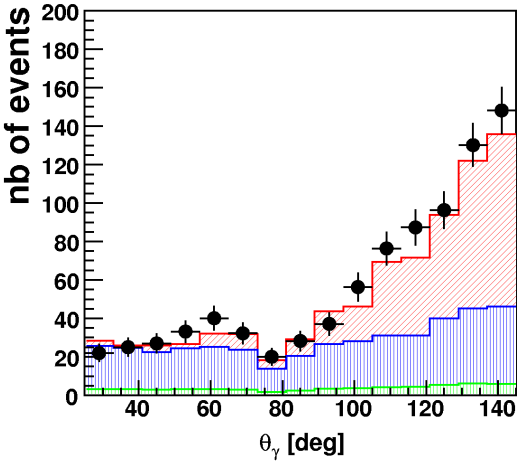
**H1 Preliminary**




MC Simulation: Milou generator for DVCS el. & inel. contributions
(NLO QCD cross-section + radiative corrections)
Compton20 for the BH el. & inel. contributions

# Cross Section Measurement

Kinematics range: $6.5 < Q^2 < 80\ \mathrm{GeV}^2$

$30 < W < 140\ \mathrm{GeV}$

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

extraction of the $e\,p \longrightarrow e\,p\,\gamma$ cross section:

bin by bin subtraction of the background
(elastic and inelastic BH, inelastic DVCS)
correction for acceptance, efficiency and radiative corrections

extraction of the $\gamma^* p \longrightarrow \gamma\,p$ cross section: photon flux factor

Main contributions to systematics uncertainties

Proton dissociation background subtraction: 8 to 14 %

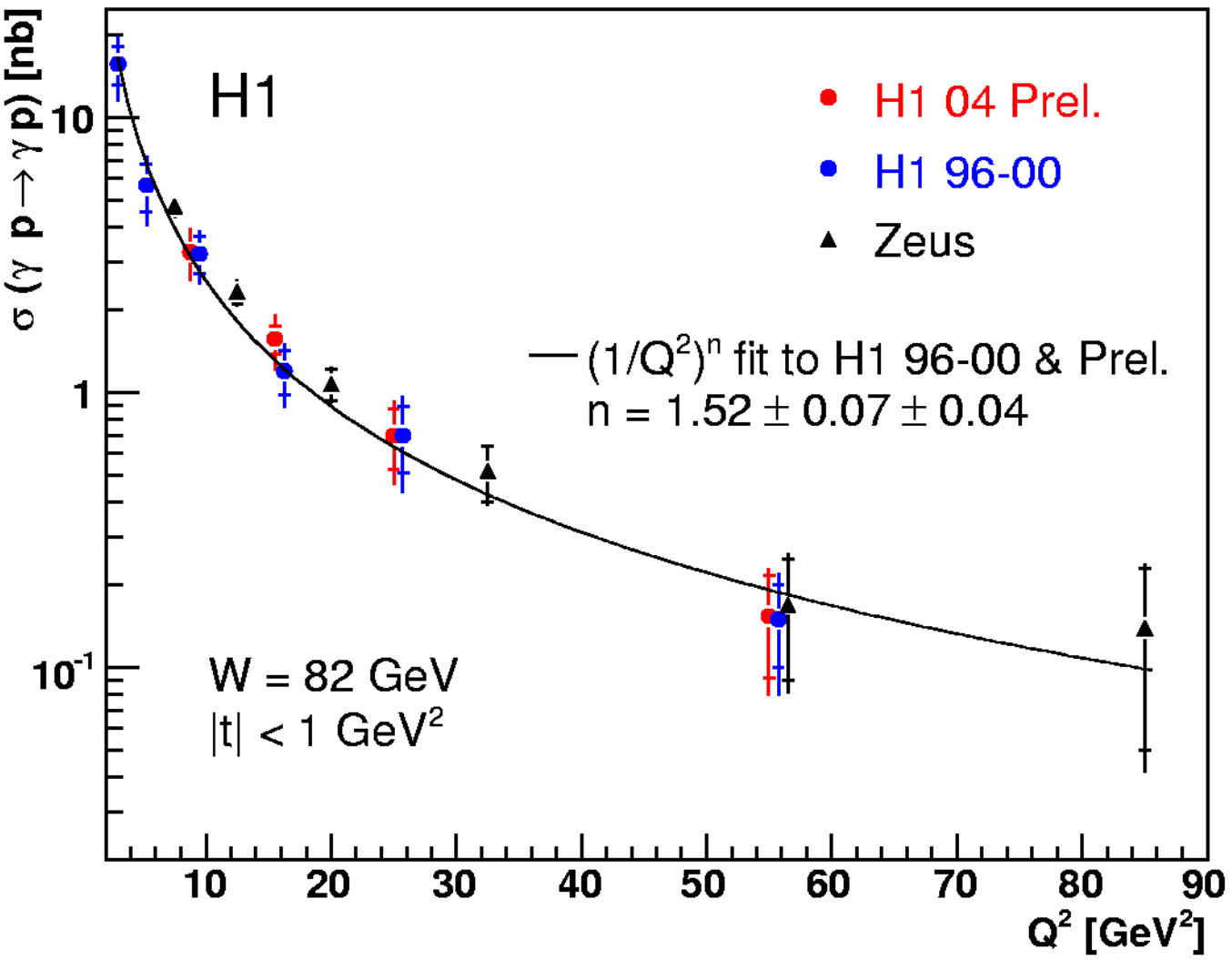
Correction for the acceptance ( t dependence): 2 to 6 % in the highest t bin

Bin center correction for the W and $Q^2$ dependence: 3 to 6 %

$\Delta\theta_e$ , $\Delta\theta_\gamma$ (1/3mrad): 4 to 6 %

uncertainty on the energy scale: 2 to 5 %

# $Q^2$ dependence




Good agreement between H1 results

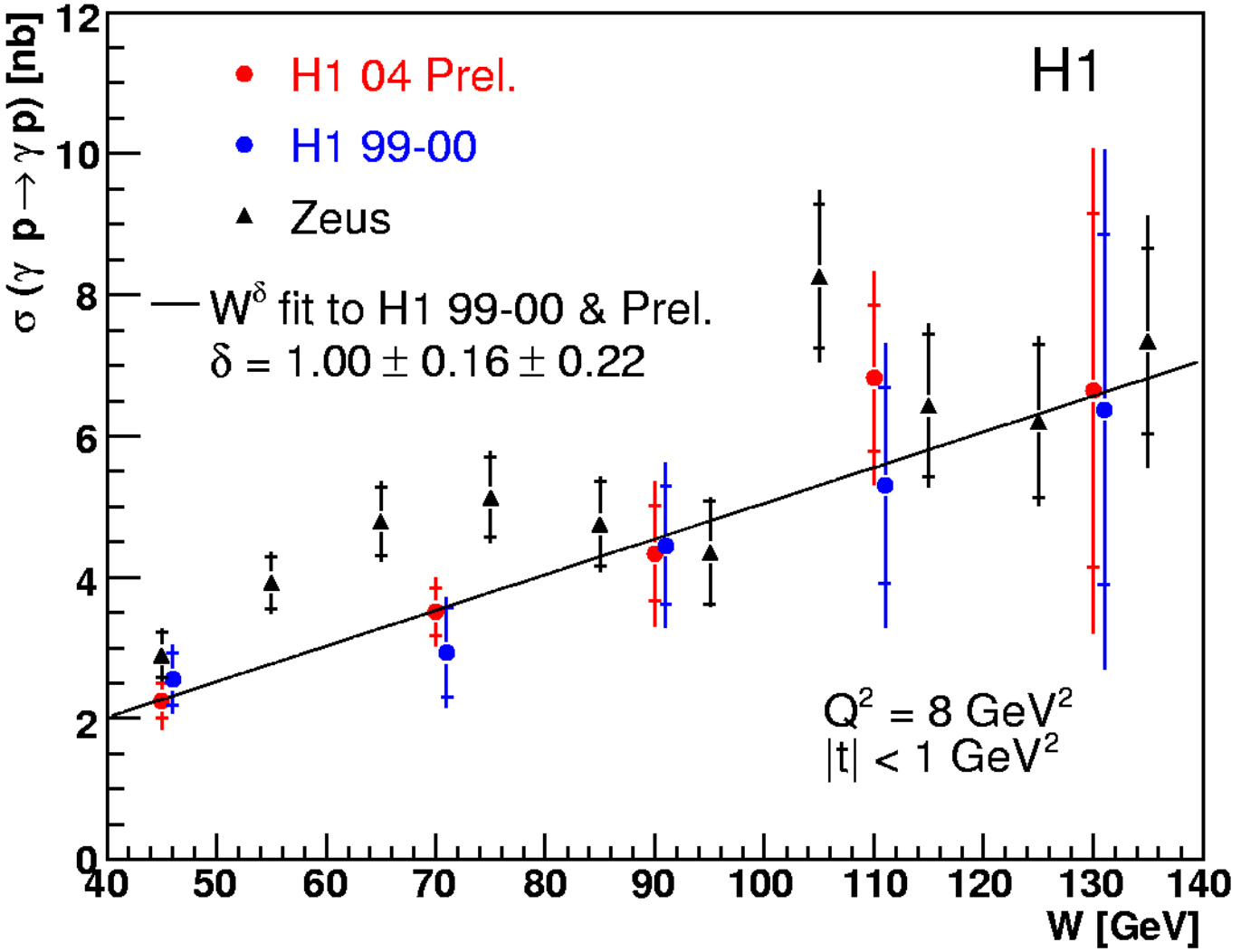
Combined fit to the H1 96-00 and H1 04 Prel. data using the parametrization:

$$\sigma(Q^2) = A \cdot (1/Q^2)^n$$

statistical error on n parameter decreased

# W dependence

δ value indicates presence of a hard scale

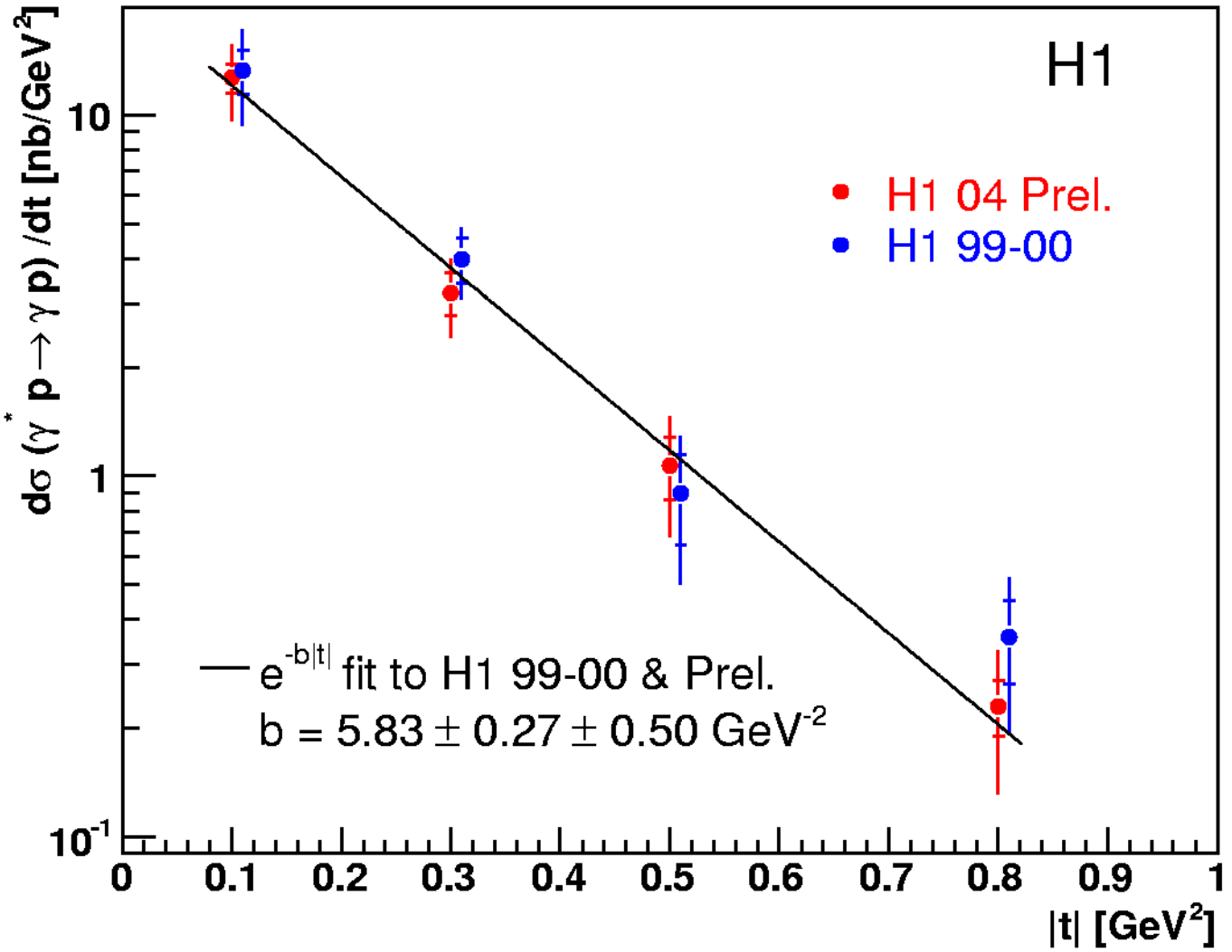



Combined fit to the H1 99-00 and H1 04 Prel. data using the parametrization:

$$\sigma(W) = A \cdot W^{\delta}$$

statistical error on δ parameter decreased

# t dependence

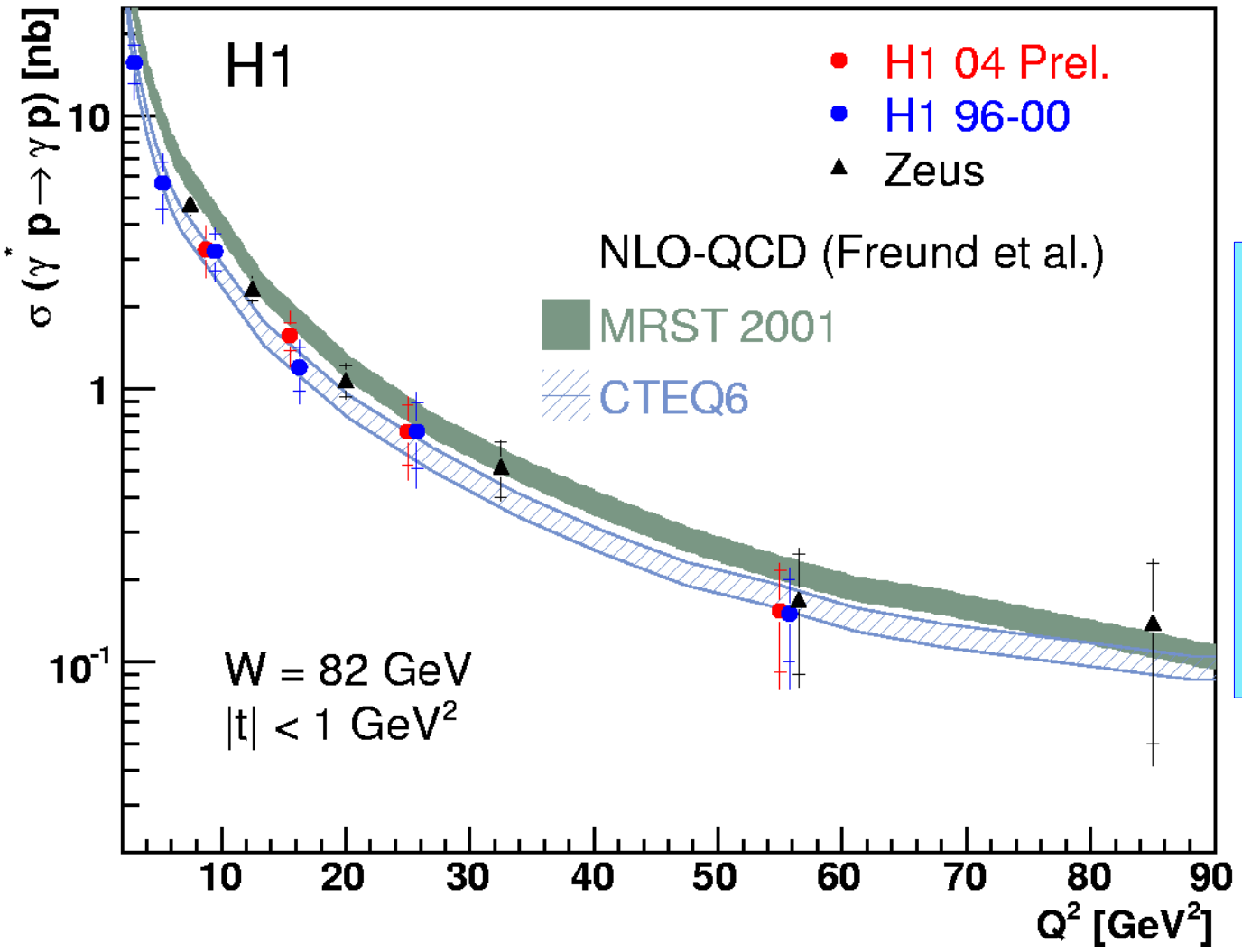



Combined fit to the H1 99-00 and H1 04 Prel. data using the parametrization:

$$d\sigma/dt\ (t) = d\sigma/dt_{|\,t=0}\ e^{-b\,|t|}$$

statistical error on t slope b decreased

# $Q^2$ dependence: NLO predictions



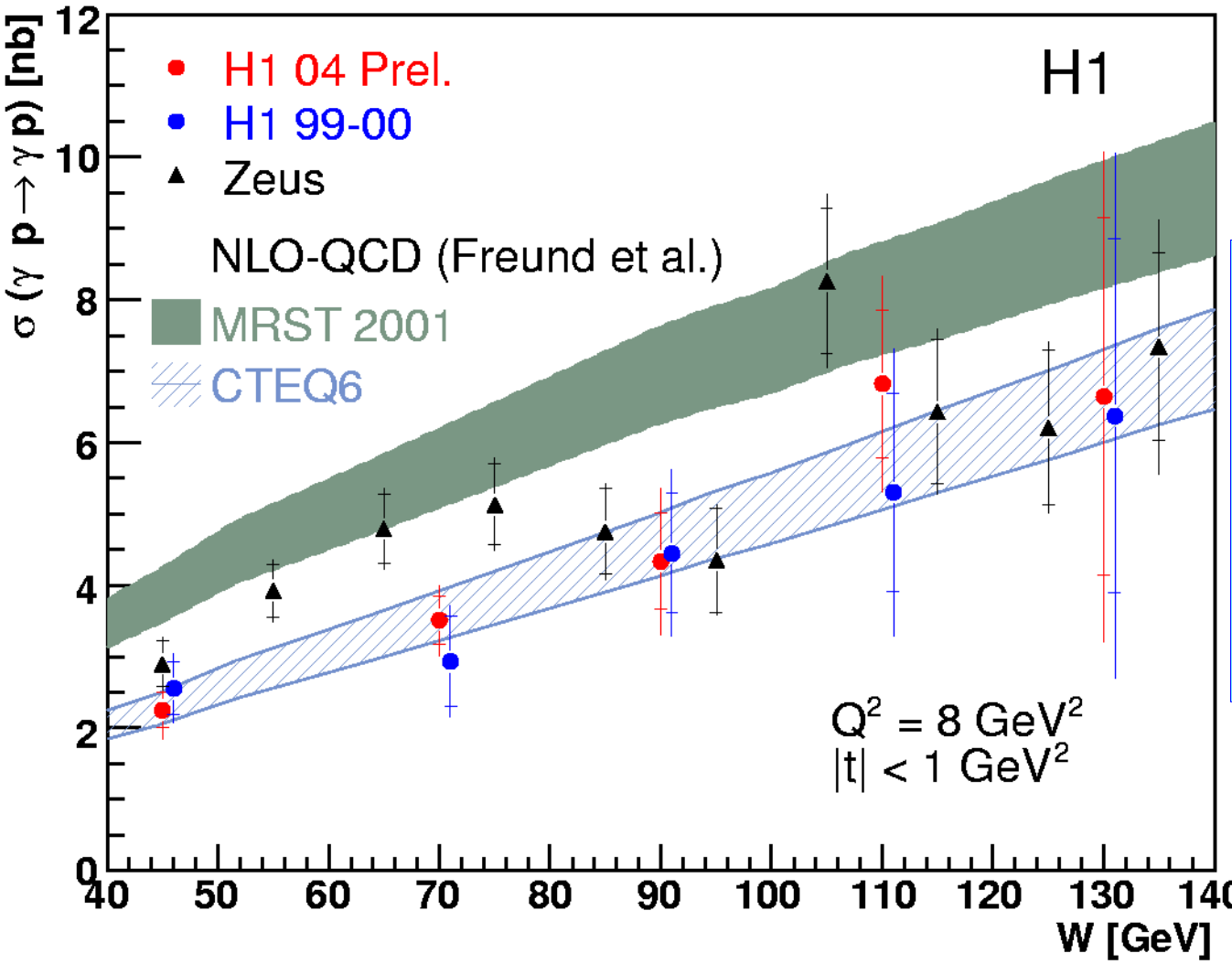

Nice description of the data by NLO QCD predictions (CTEQ6)

Band width includes experimental error on b: $5.26 < b < 6.40$

b kept constant, no dependence on $Q^2$ considered

No need for intrinsic skewing

# W dependence: NLO predictions

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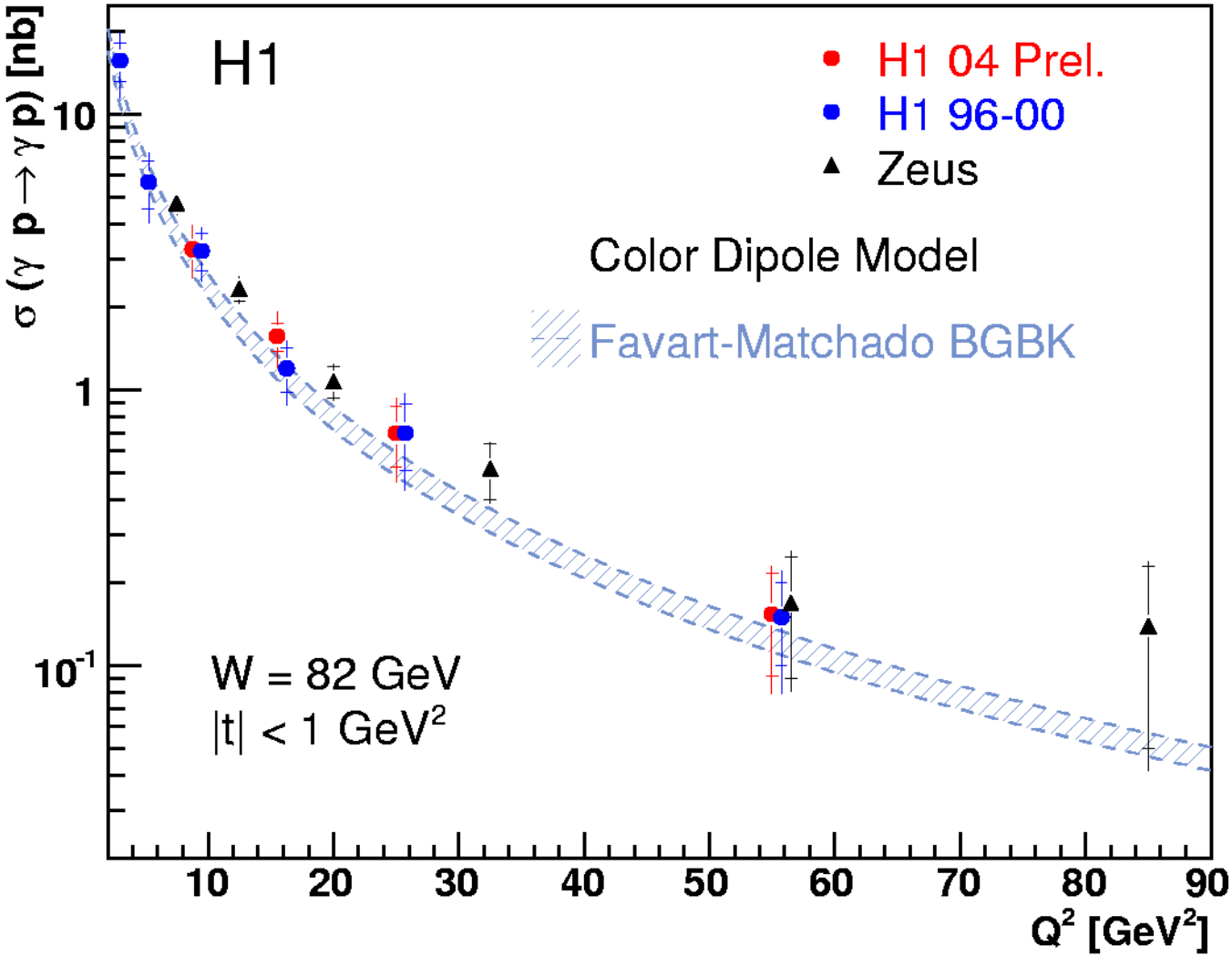


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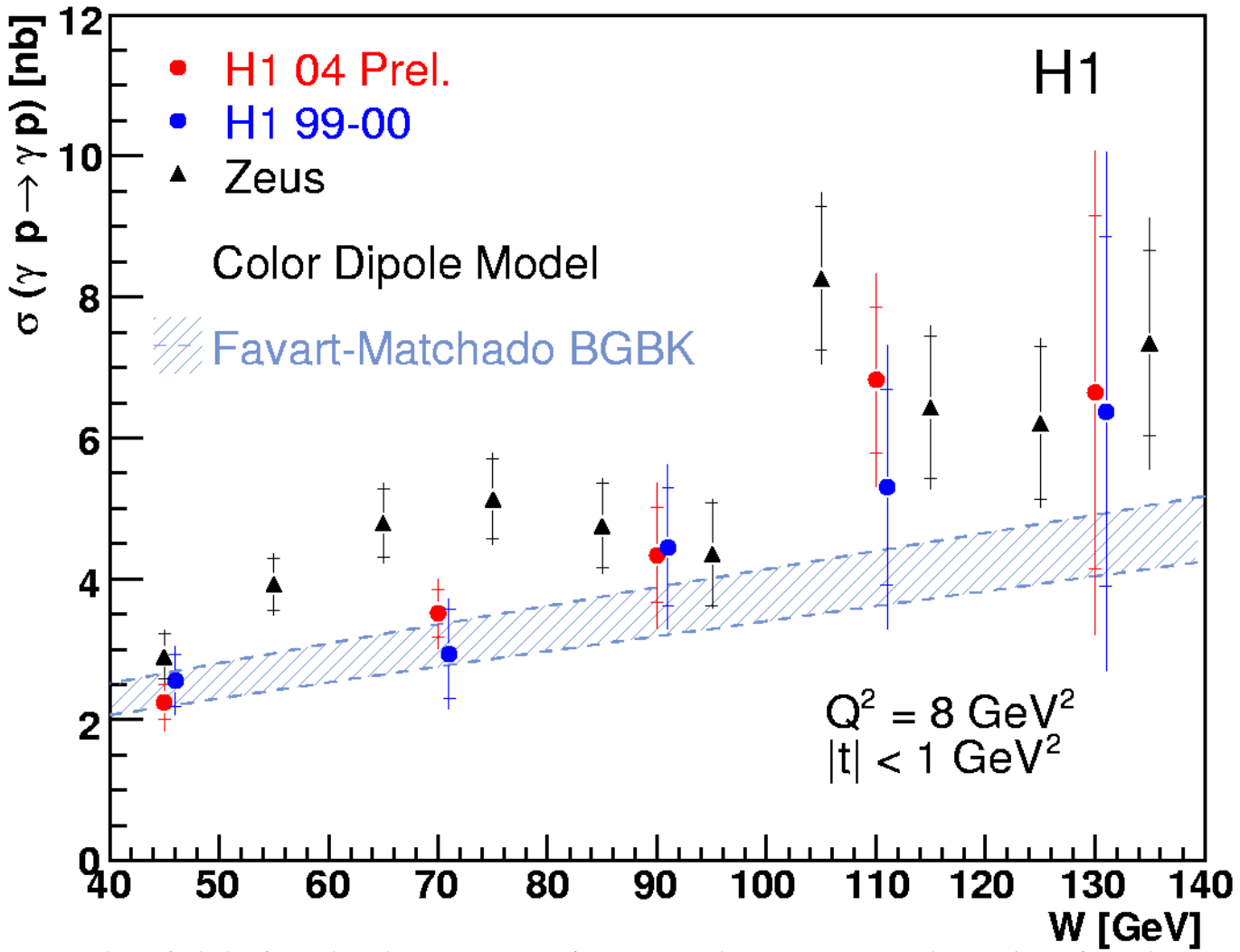
Reasonable description by FM model applying GBW saturation model with DGLAP evolution (BGBK)

# W dependence: Dipole Model

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# Conclusions and outlook

First HERAII measurement of DVCS cross sections

Preliminary results are in agreement with previous H1 results, QCD predictions and dipole model

Statistical errors on n, b and $\delta$ slopes have decreased