DVCS and prompt photon production at HERA

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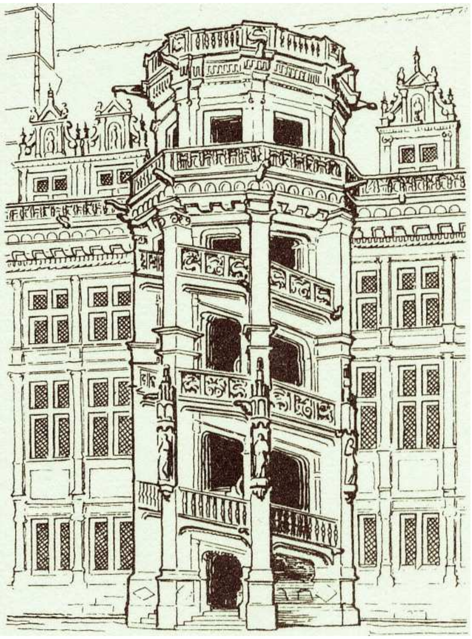


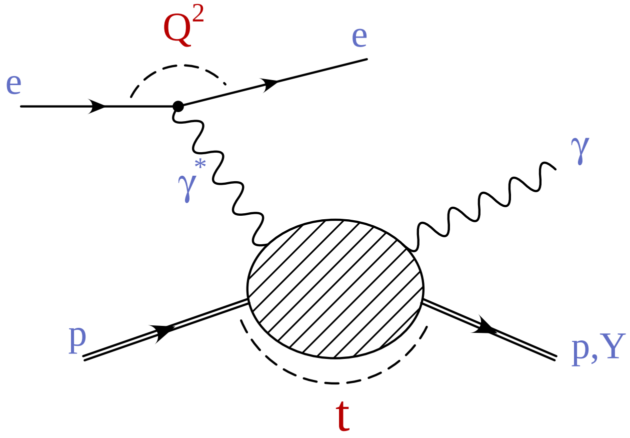
XIth Int. Conf. on Elastic and Diffractive Scattering

XVIIth Rencontres de Blois

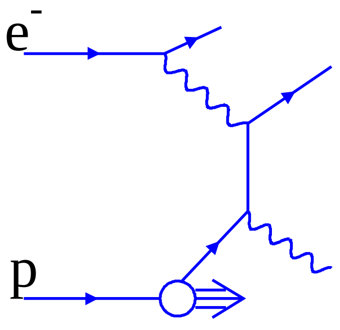
EDS05 - Blois - 15-20th of May 2005

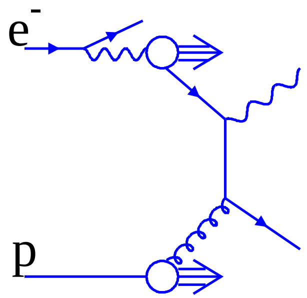
Introduction

DVCS



Prompt Photon





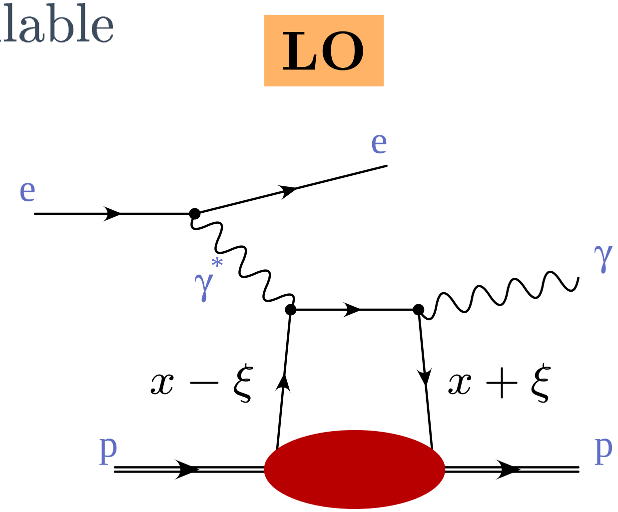
- First QCD absolute prediction in Diffraction
- No VM wave function uncertainty
- Access to GPDs
- Interference with Bethe-Heitler (purely QED process) - Access to full process amplitude

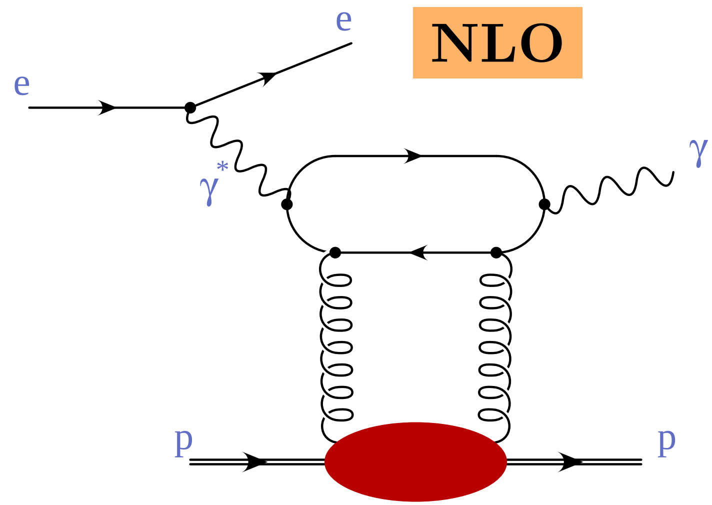
- Direct probe of the hard process - interesting test of QCD
- Small hadronisation uncertainty
- Good energy measurement
- Two signatures: w/wo jet

(→) sensitivity to proton and photon PDFs

DVCS - QCD predictions

- Fully calculable in QCD





- NLO leading twist (+ twist three) calc. by A. Freund and M. McDermott Eur.Phys.J. **C23** (2002) 651. Input: GPDs

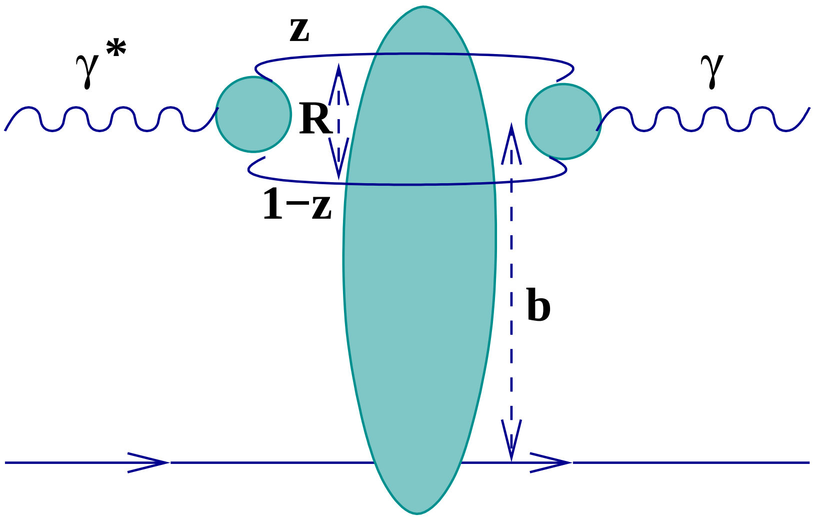
DGLAP region: $\vert x\vert > \xi$		ERBL region: $\vert x\vert < \xi$
$\mathcal{H}^q(x,\xi,t;\mu^2) = q(x;\mu^2)\, e^{-b\vert t\vert}$	q singlet	simple analytic function
$\mathcal{H}^g(x,\xi,t;\mu^2) = x\ g(x;\mu^2)\, e^{-b\vert t\vert}$	gluons	
MRST2001 and CTEQ6		

$\rightarrow$ Q^2 and ξ generated dynamically

b from the data

Colour Dipole Models

In the proton rest frame



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

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

- ψ^{in} and ψ^{out} calculable
- σ_{d} is modeled

Donnachie-Dosch: hard + soft $I\!P$

Phys.Lett. B502 (2001) 74

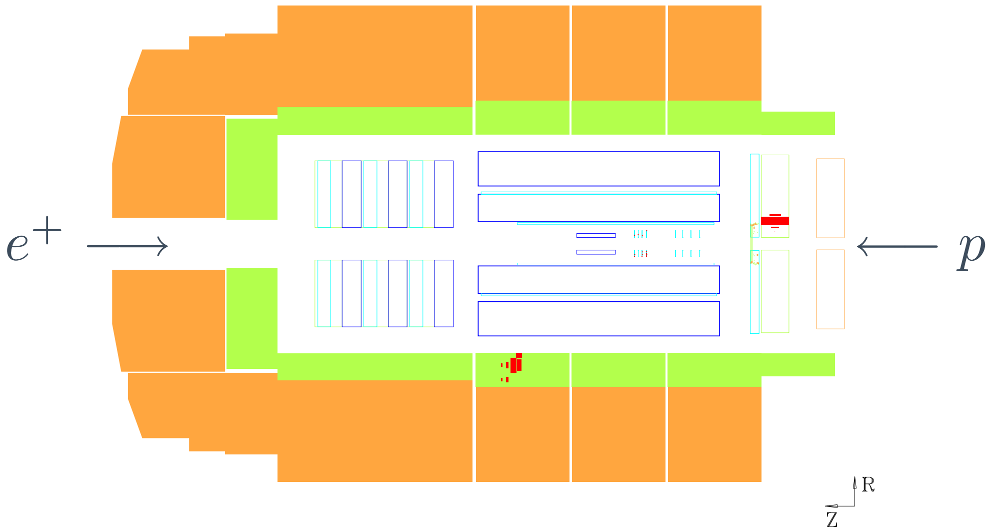
Favart-Machado: GBW saturation model applied to DVCS (with and without DGLAP evolution: BGBK)

Eur.Phys.J. C29, 365 (2003)

-Complemantary to pure QCD (Breit frame) approach, to test non-pert → pert. transition and staturation models.

Analysis strategy

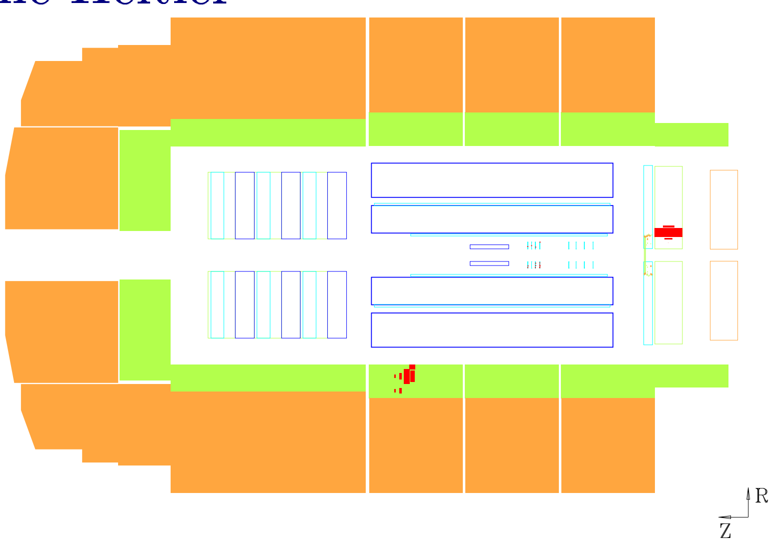
- DVCS



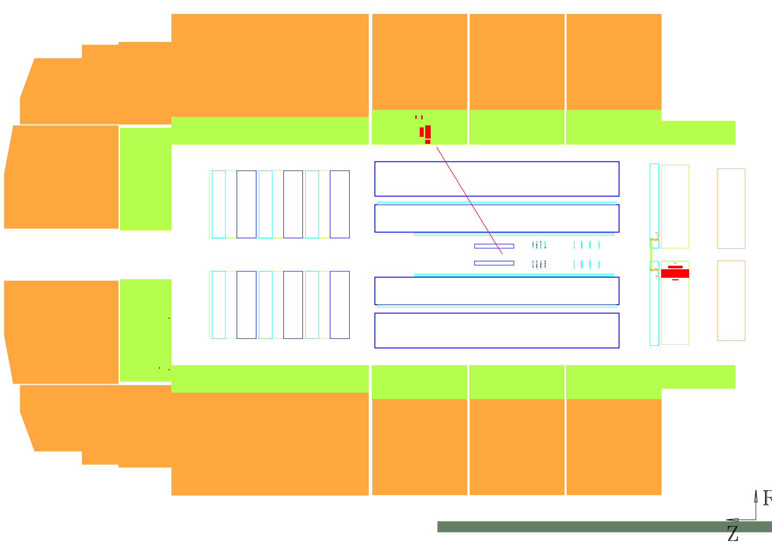
	H1	ZEUS
$E_1 >$	15 GeV	10 GeV
$p_{T_2} >$	1 GeV	
$E_2 >$		3 GeV
$E_3 <$	0.5 GeV	0.2 GeV
elast.	no track, Fwd	no track
Lumi	46.5 pb^{-1} (e$^+$)	95 (e$^+$) pb^{-1}
		16.7 (e$^-$) pb^{-1}

- Bethe-Heitler

γ–sample



control–sample



ZEUS - Control and Signal samples

Control-sample $\Leftarrow$

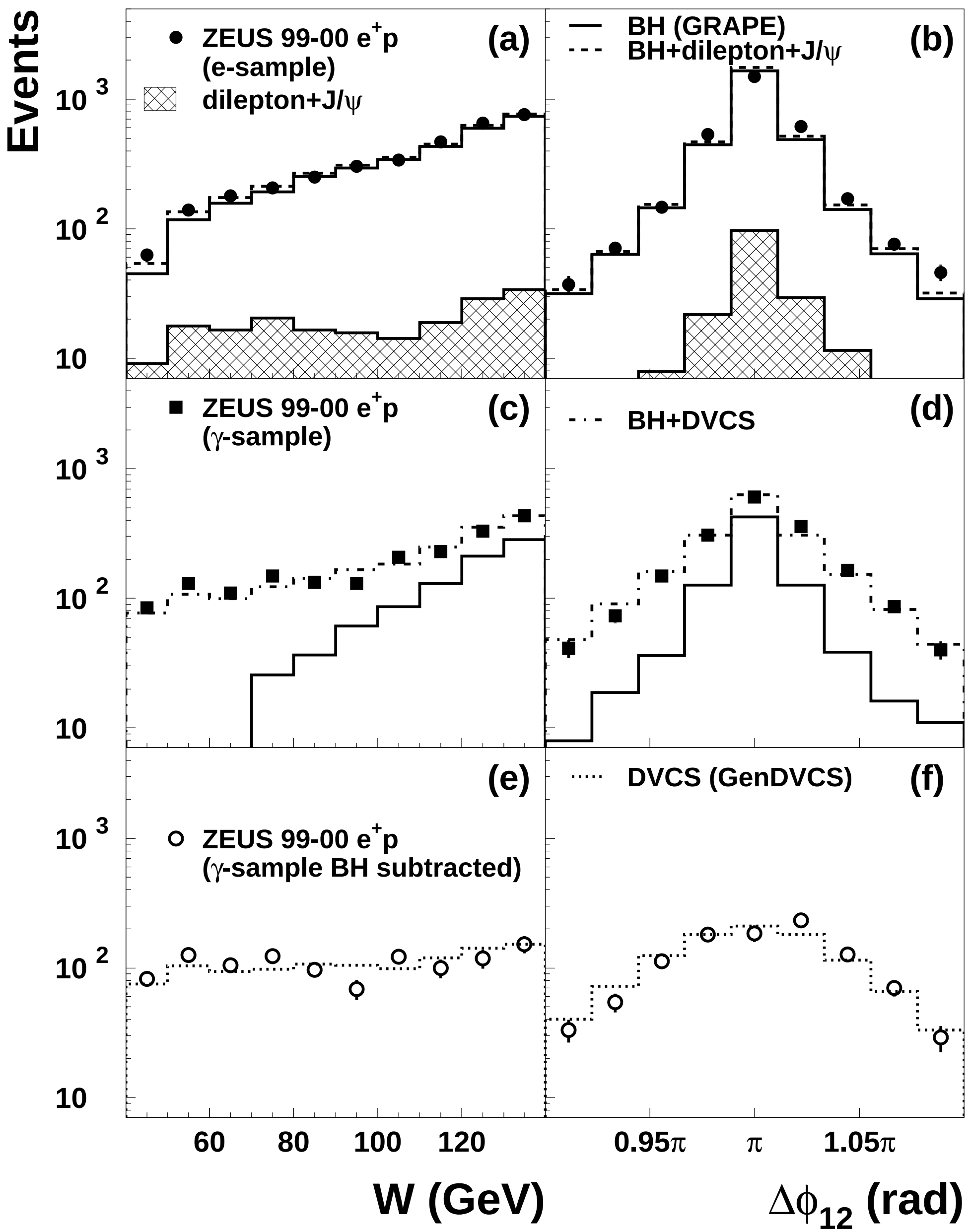
Well known cross section
$\Rightarrow$ detector response is understood

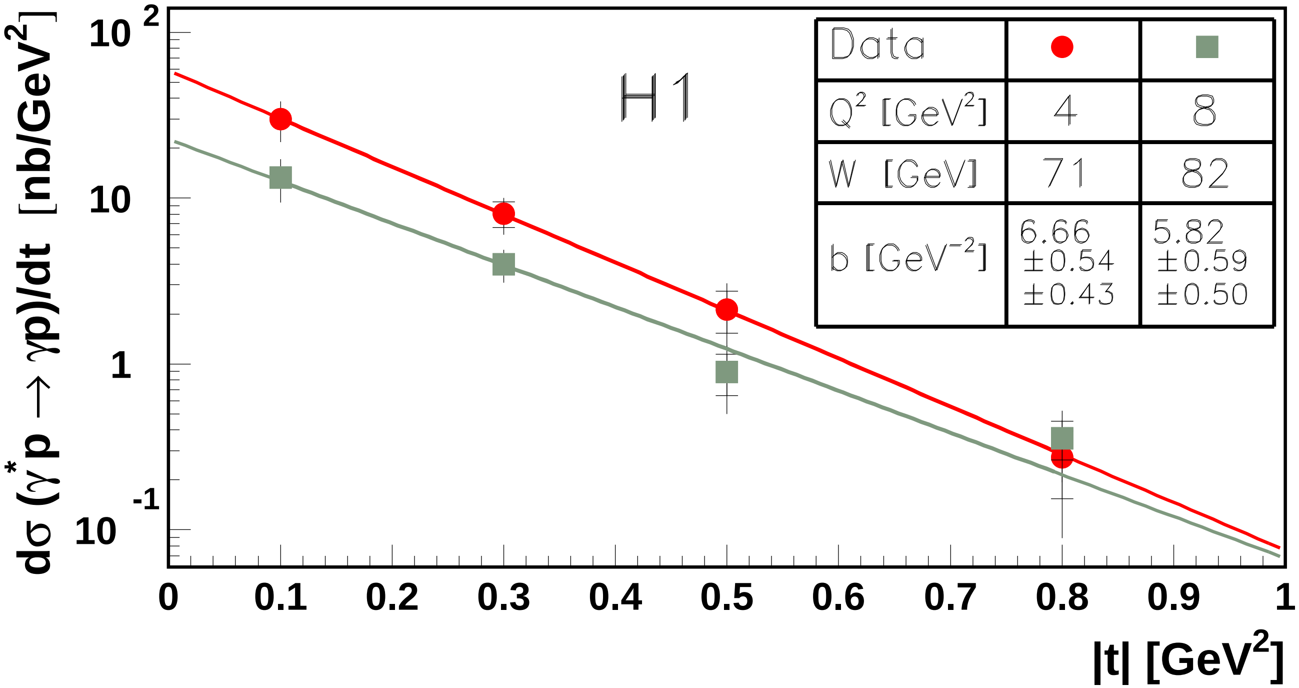
γ-sample $\Leftarrow$

BH + DVCS (MC) good description

DVCS $\Leftarrow$

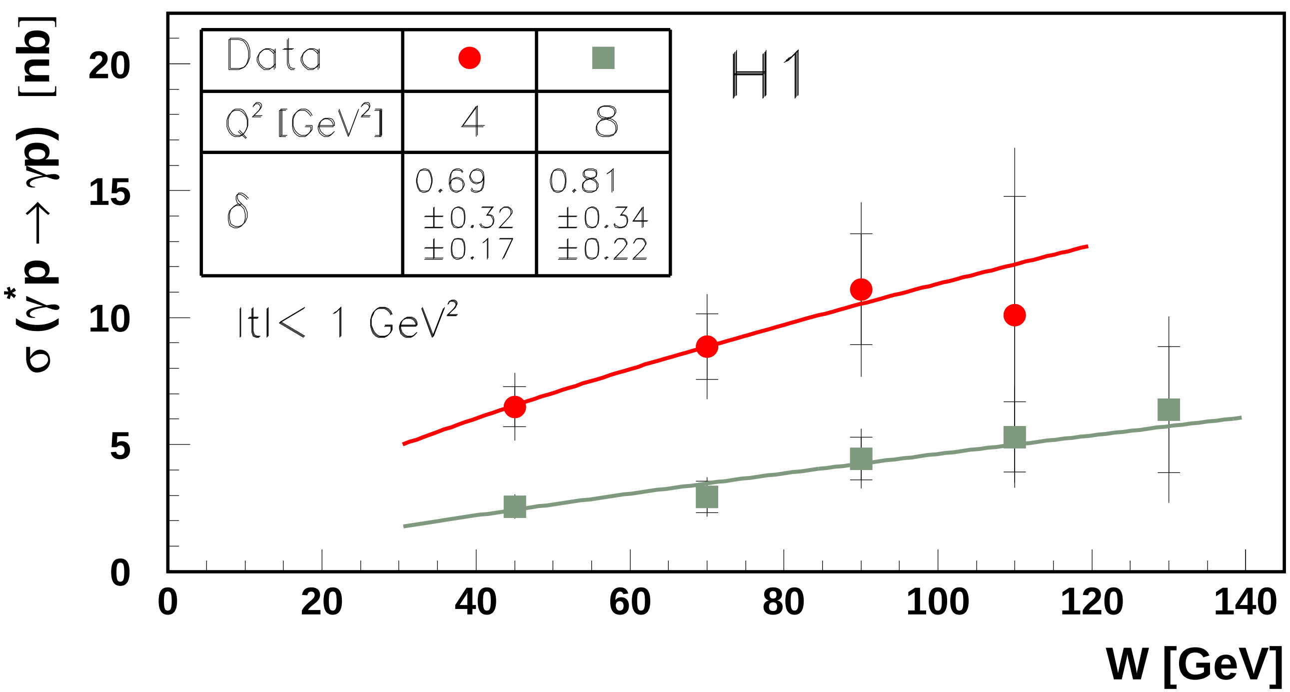
After BH subtraction: pure DVCS
$\sigma_{ep} \rightarrow \sigma_{\gamma^* p}$ correcting by the flux factor.





→ First measurement of the t slope

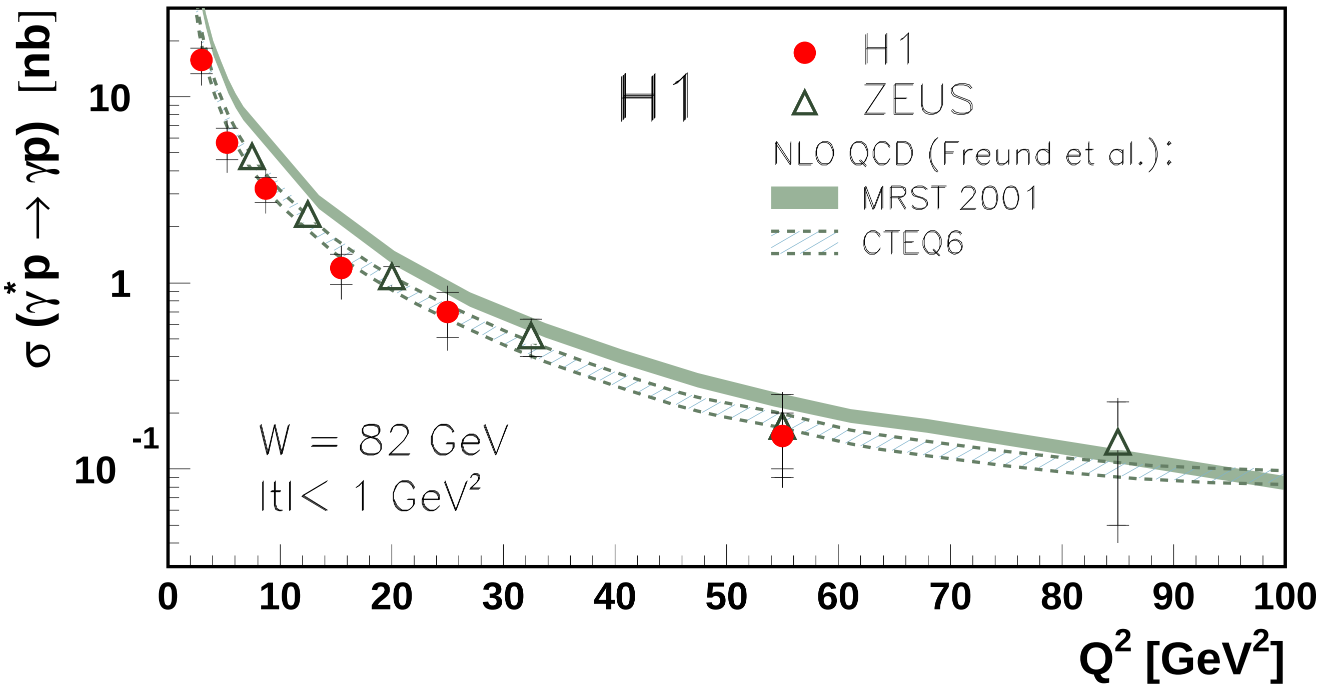
combined samples:
$b = 6.02 \pm 0.35 \pm 0.39$ GeV^{-2}

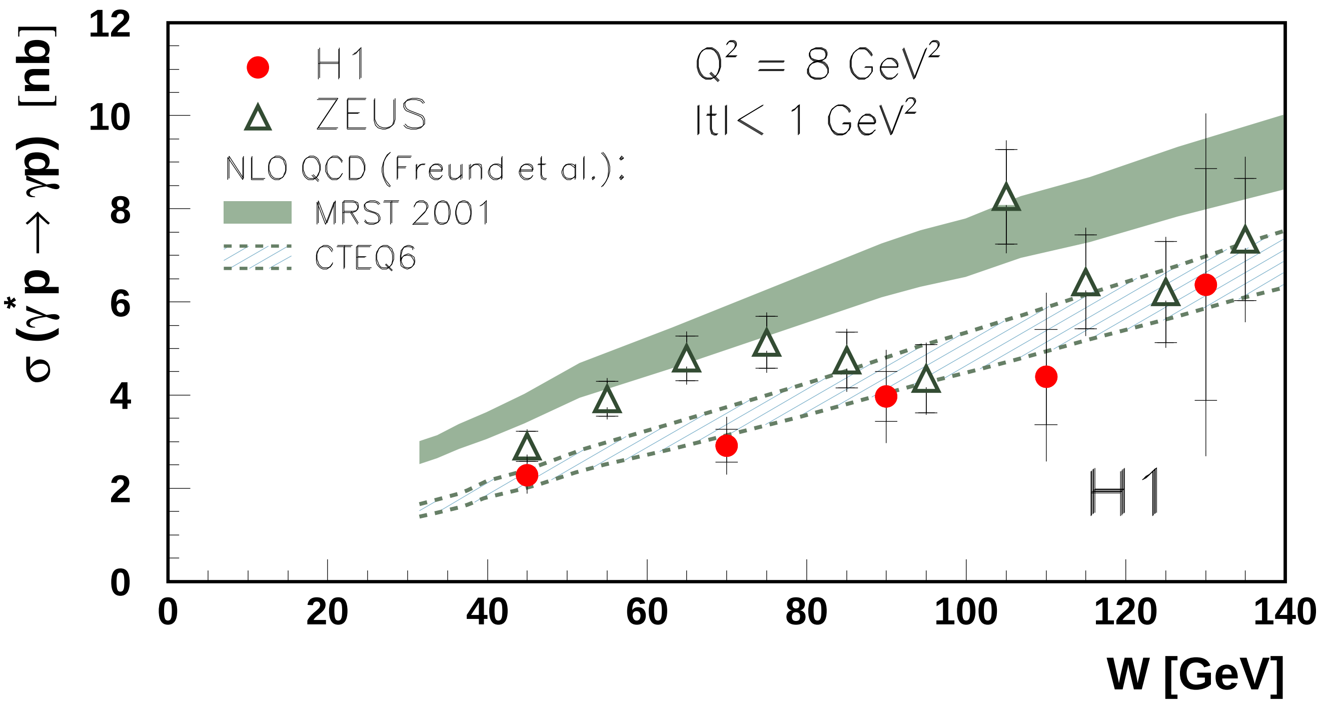


→ W dependence for two Q^2 values

→ Fit W^δ:

→ indication of a hard regime (comparable to J/Ψ)





H1-ZEUS Comparison

→ Agreement

Fit in Q^2: $(Q^2)^{-n}$

→ $n = 1.54 \pm 0.09 \pm 0.04$

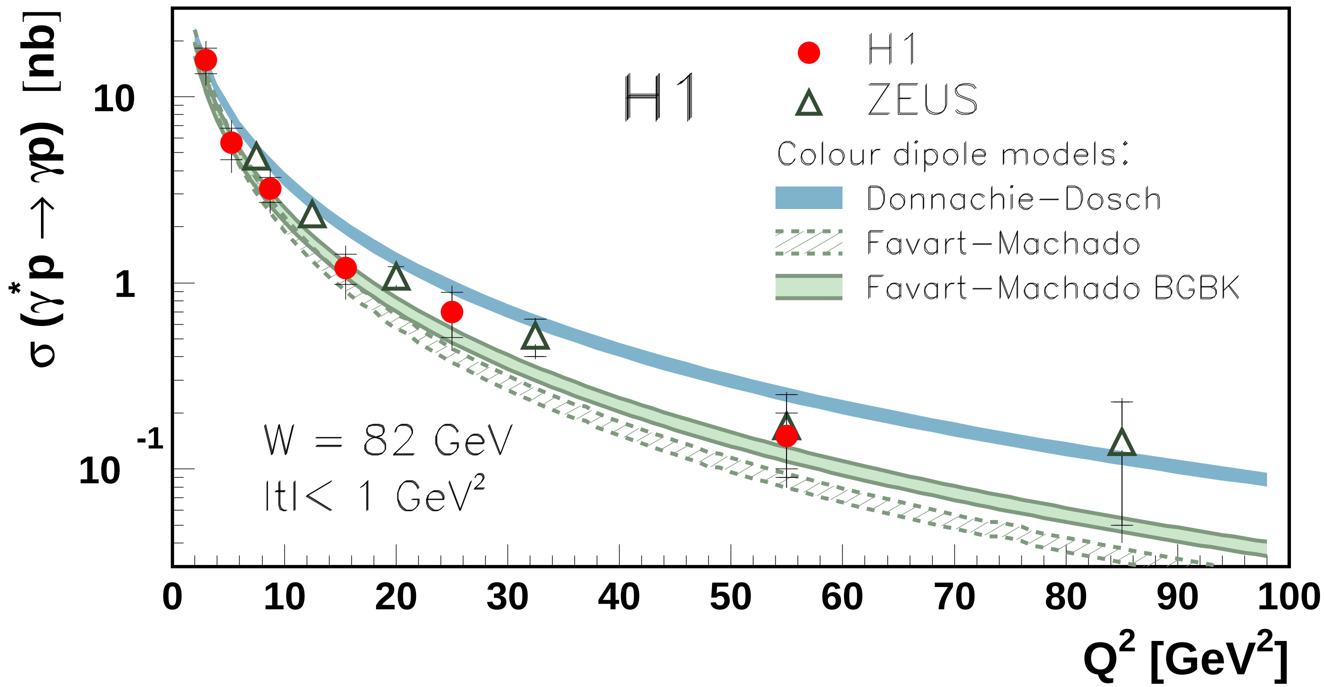
→ n smaller than for VM $(n(\rho) = 2.60 \pm 0.04)$

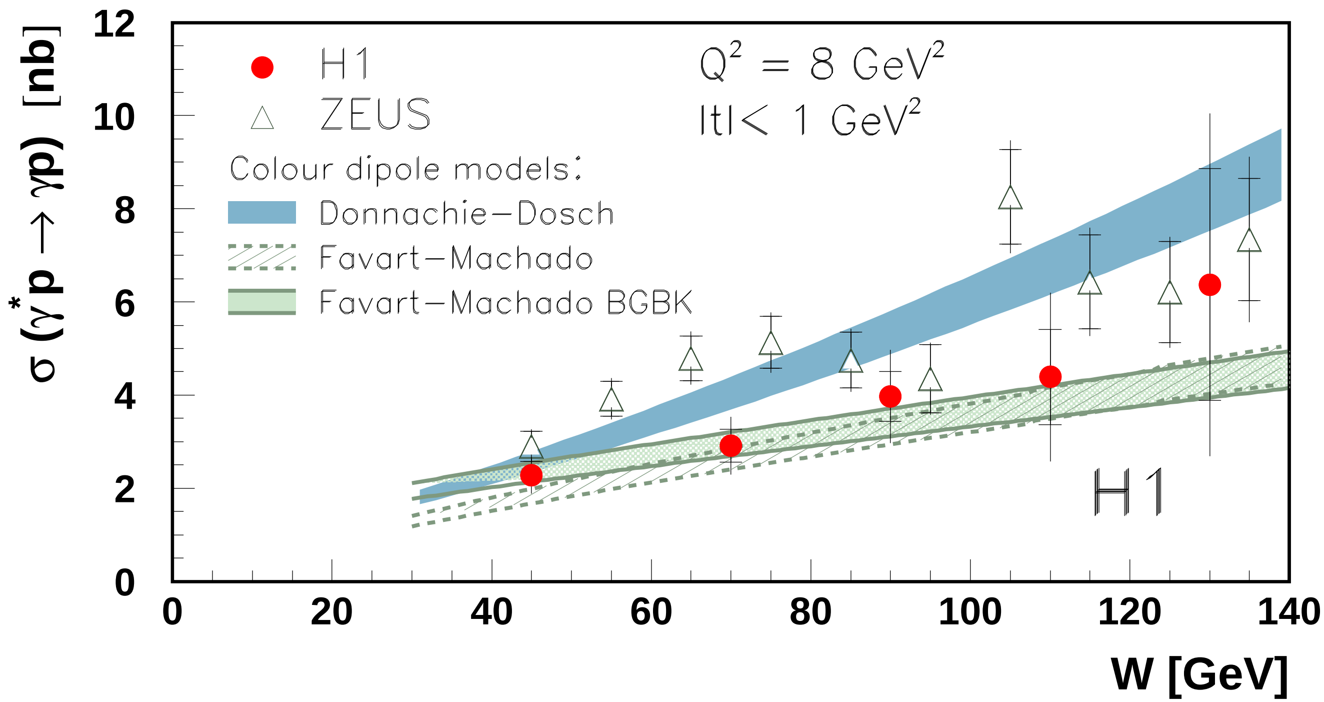
Comparison to NLO QCD:

- Band width provided by b measurement.

→Good description by QCD-NLO calculations

→No need for intrinsic skewing





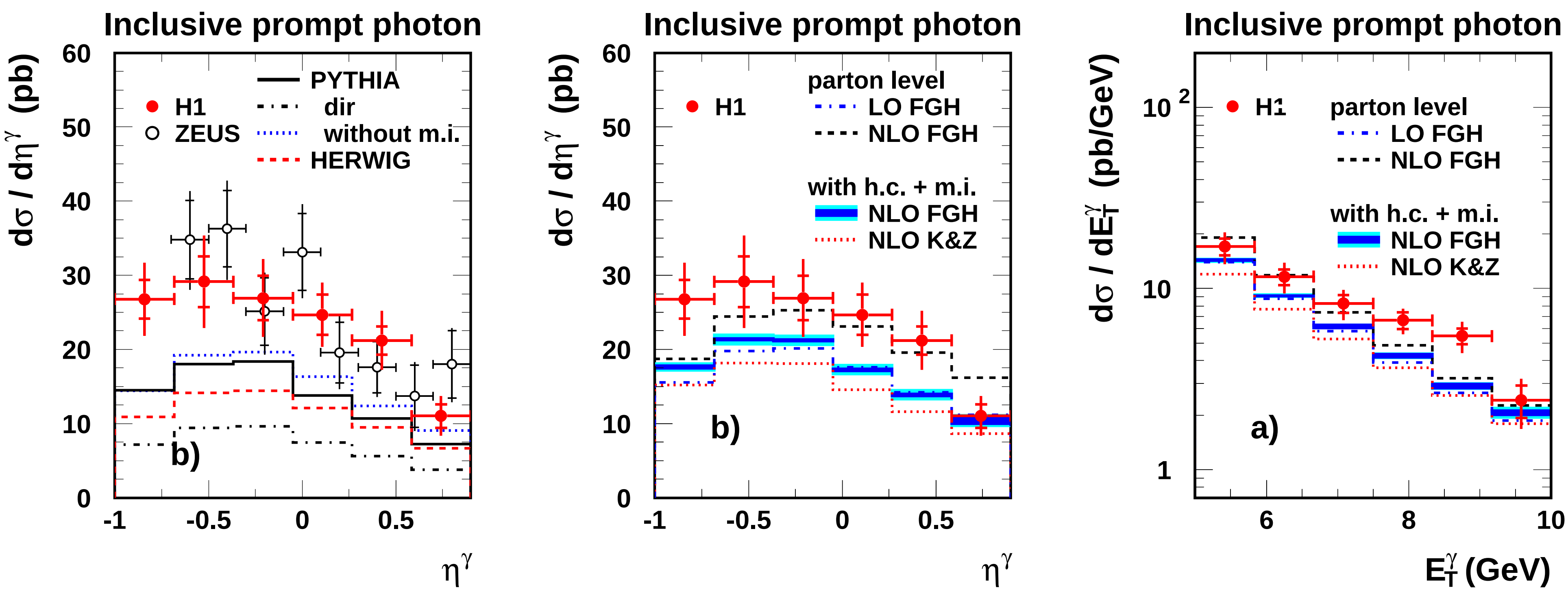
Comparison to Dipole Models

- Good normalisation and shape description

- Improvement in FM when DGLAP evol. included

- Still improved if $b(Q^2)$ used as observed for ρ

Inclusive Prompt Photon in Photoproduction

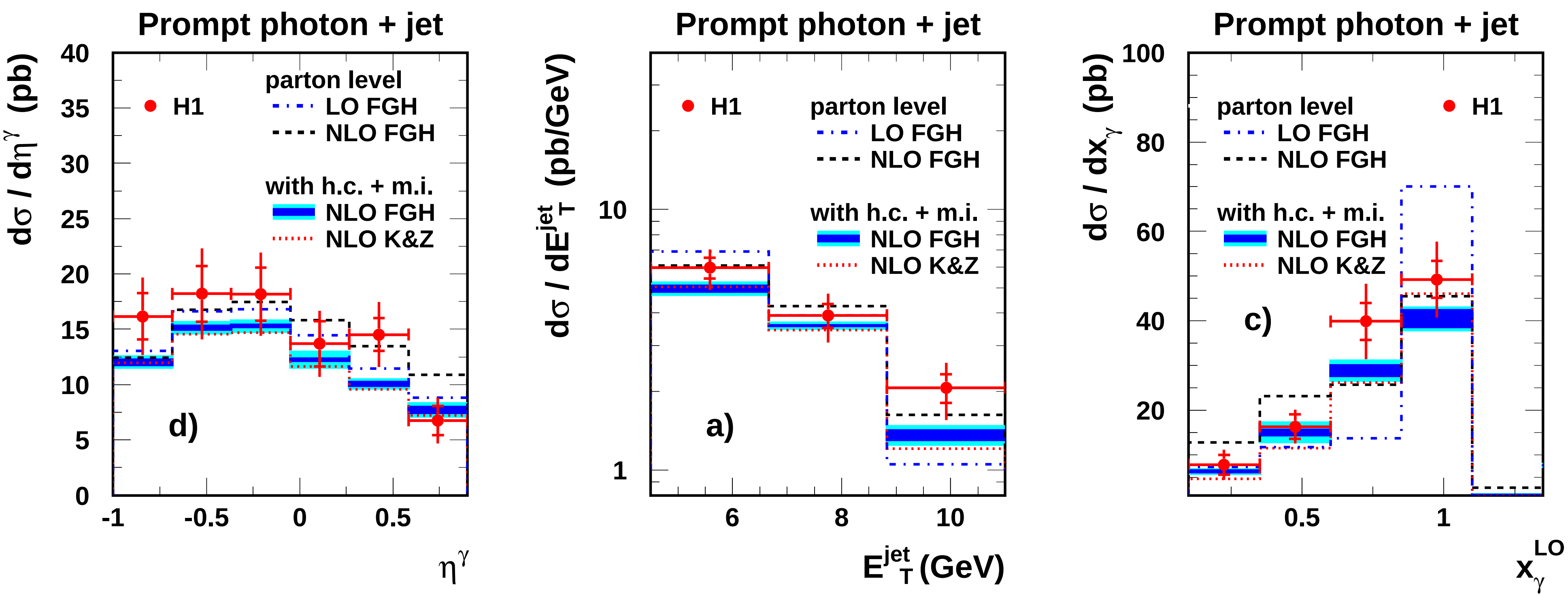


- Agreement H1 and ZEUS (Phys.Lett.B472(2000)175)
- direct $\simeq$ resolved contribution
- Multiple int. spoil isolation cut $\rightarrow$ reduced σ.

$142 < W < 266$ **GeV**
$Q^2 < 1$ **GeV**^{2}
$\mathcal{L} = 105$ **pb**$^{-1}$

- NLO pQCD (Fontanaz, Guillet, Heinrich / Krawczyk, Zembruski): good shape desc. but Norm. too low 30-40%
- MC: shape OK but Normalisation to low by 40-50%

Prompt Photon with Jet in Photoproduction



→ NLO pQCD: good description of shapes and better descrip. of Normalisation.

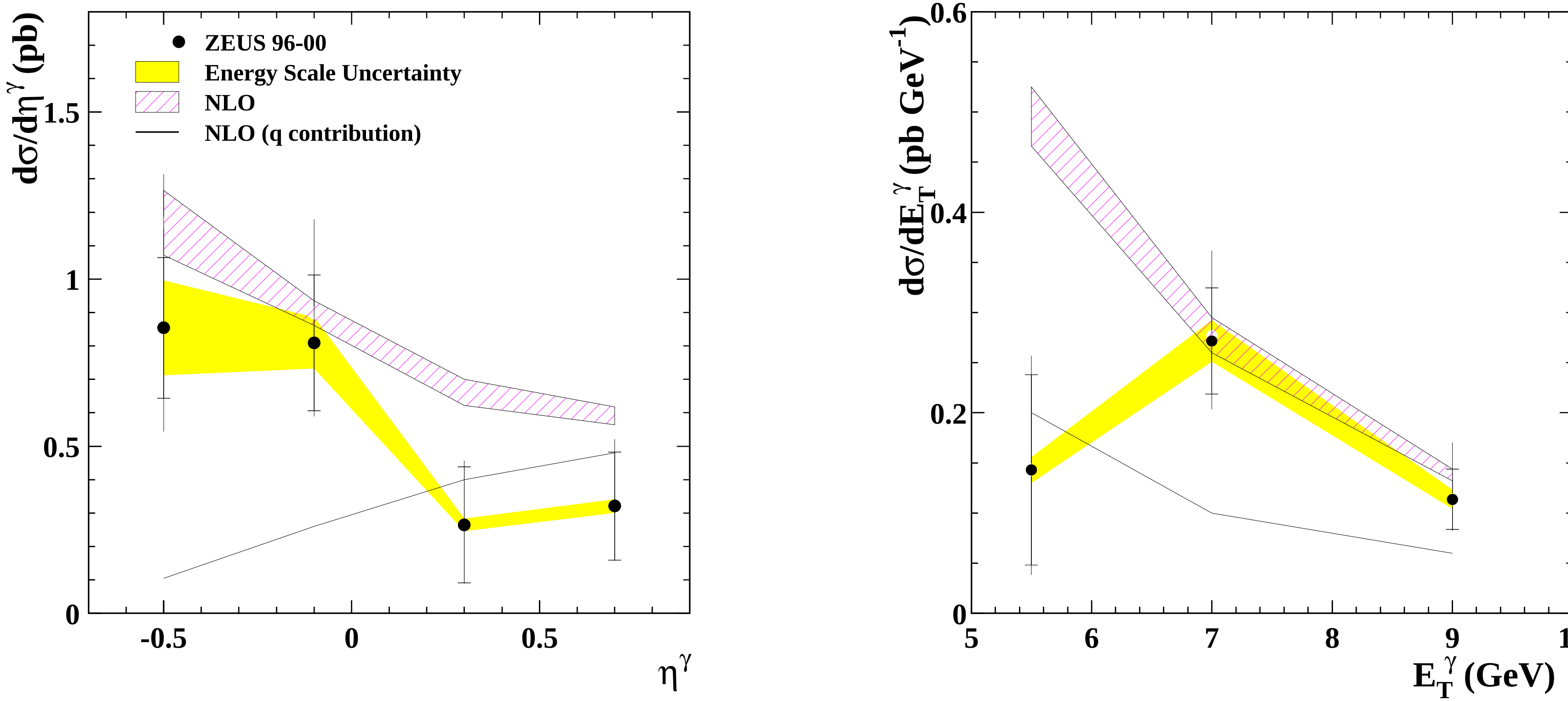
→ Multiple interactions more important at low x_γ (resolved contribution).

→ NLO less important then for inclusive.

Same cuts +
$E_T^{jet} > 4.5$ **GeV**

DESY-04-118

Prompt Photon with Jet in DIS



- MC PYTHIA and HERWIG factor 2 and 8 too low (not shown).
- 65% of photon emitted by electron (low rapidity)
- Hadronisation corrections expected to be 30-40%.
- NLO pQCD (Kramer, Spiesberger): at parton level good description except at low E_T^γ (large stat error) and in most forward direction.

$$Q^2 > 35\ \mathbf{GeV}^2$$
$$E_T^{jet} > 6\ \mathbf{GeV}$$
$$-1.5 < \eta_{jet} < 1.8$$
$$\mathcal{L} = 121\ \mathbf{pb}^{-1}$$

Phys.Lett.B 595(2004) 86

Conclusions

Prompt Photon: study of pQCD

- no hadronisation of the photon, good energy measurement.
- NLO QCD calculation in reasonable agreement but a bit too low Norm. except in jet case in photoproduction.
- PYTHIA and HERWIG MC always undershoot the data.
- Higher order needed ? Non-pert effects ? Not clear situation.

DVCS cross sections as a function of Q^2, W and t have been measured.

- First t slope mesurement. Allows absolute theoretical prediction.
- in good agreement with NLO QCD predictions, based on GPD model: no intrinsic skewing.
- set constrains on gluon and sea GPDs.
- in agreement with different dipole model predictions.

Compl. Prompt Photon MC and PDFs

			Photon PDF	Proton PDF
Photoprod.	ZEUS publ 2000	PYTHIA 5.7	GRV	MRSA
		HERWIG 5.9	GRV	MRSA
		K&Z	GRV/GS	MRSA
		LG	GRV/GS	MRSA
	H1 publ 2004	PYTHIA 6.2	GRV	GRV
		HERWIG 6.1	GRV	GRV
		FGH	AFG	MRST2
		KZ	AFG	MRTS2
DIS	ZEUS publ 2004	PYTHIA 6.206		CTEQ3M
		HERWIG 6.1		CTEQ4L
		KS		MRST

DVCS - Cross Section Measurement

- $e - p$ Cross Section extraction

$$\frac{\mathrm{d}^3\sigma_{bin}[ep \to e\gamma p]}{\mathrm{d}Q^2\,\mathrm{d}W\,\mathrm{d}t} = \frac{(N_{bin} - N_{BH} - N_{p.dis.})}{\epsilon \cdot A \cdot \Delta Q^2 \cdot \Delta W \cdot \Delta t \cdot \mathcal{L}} \cdot (1 + \delta_{rad})$$

- $ep \to \gamma p$ Cross Section (BH substraction and photon flux factor)

$$\frac{\mathrm{d}^3\sigma[ep \to e\gamma p]}{\mathrm{d}y\,\mathrm{d}Q^2\,\mathrm{d}t}(Q^2, y, t) = \Gamma\,(Q^2, y)\;\frac{\mathrm{d}\sigma[\gamma^* p \to \gamma p]}{\mathrm{d}t}(Q^2, y, t),$$

- Main corrections and systematics (up to):

	H1	ZEUS
• Proton diss background:	$16 \pm 8\%$	$22 \pm 4\%$
• Δ acceptance & bin cent. corr, cuts:	7 %	10%
• Energy scale uncertainty:	5 %	5 %