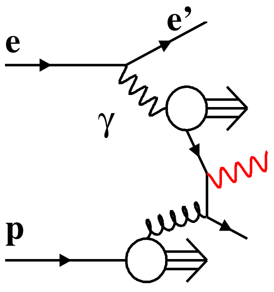
Prompt Photons
and
Deeply Virtual Compton Scattering
at HERA

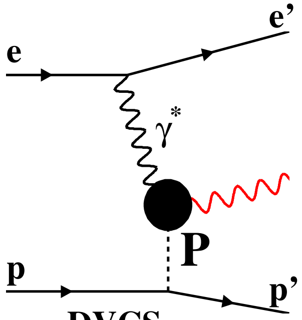
IWONA GRABOWSKA-BOŁD, UMM-CRACOW
on behalf of the H1 and ZEUS Collaborations



Prompt Photon

OUTLINE

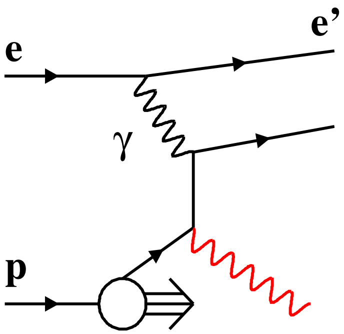
- Introduction
- Prompt Photons (ZEUS)
- DVCS (H1, ZEUS)
- Summary and Outlook



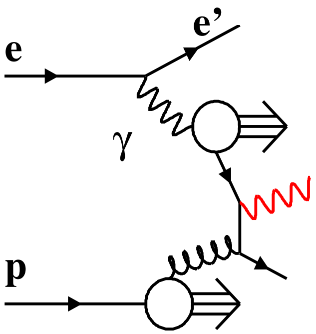
DVCS

Prompt Photons

At LO the diagrams are of the following kinds (examples)



Direct Process



Resolved Process

- $Q^2 \approx 0$
- Sensitive to parton level interactions
- Study parton density of photon
- Compare with NLO pQCD calculations

♣ Possible to extract $\langle k_T \rangle$ - effective parton momentum in the proton - from direct events, by measuring the p_T balance of the photon and a jet

Prompt Photons - Events Selection

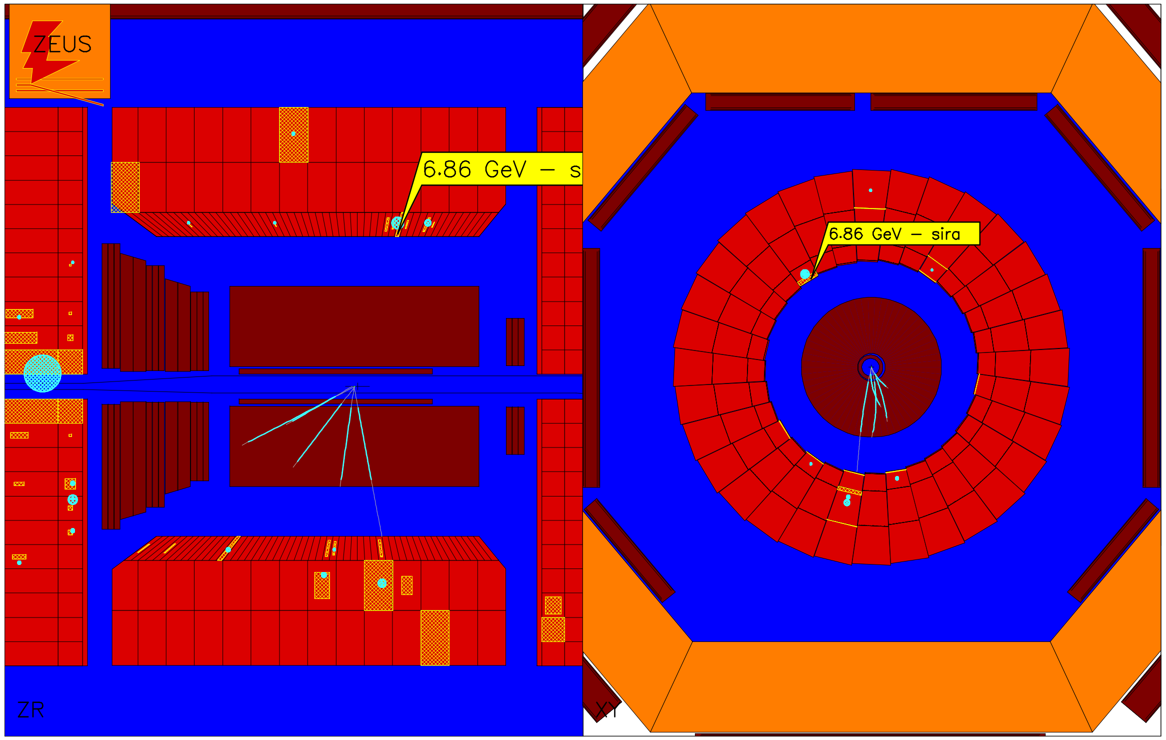
$\gamma q \leftarrow \gamma q$

photon + jet

- $Q^2 \approx 0$ no e^+ observed
- $E_T^{\gamma} > 5\ GeV$, $-0.7 < \eta^{\gamma} < 0.9$
- $E_T^{jet} > 5\ GeV$, $-1.5 < \eta^{jet} < 1.8$
- $134 < W < 251\ GeV$

Background study

- shower shape variables to separate γ from π^0 and η^0
- isolation criterion in (η, ϕ) for a photon



A prompt photon event measured in ZEUS

Prompt Photons - Measurement of $\langle k_T \rangle$

Fraction of the incoming photon energy that takes part in the QCD subprocess

$$x_\gamma^{meas} = \frac{1}{2E_e y_{JB}} \sum (E - p_z)$$

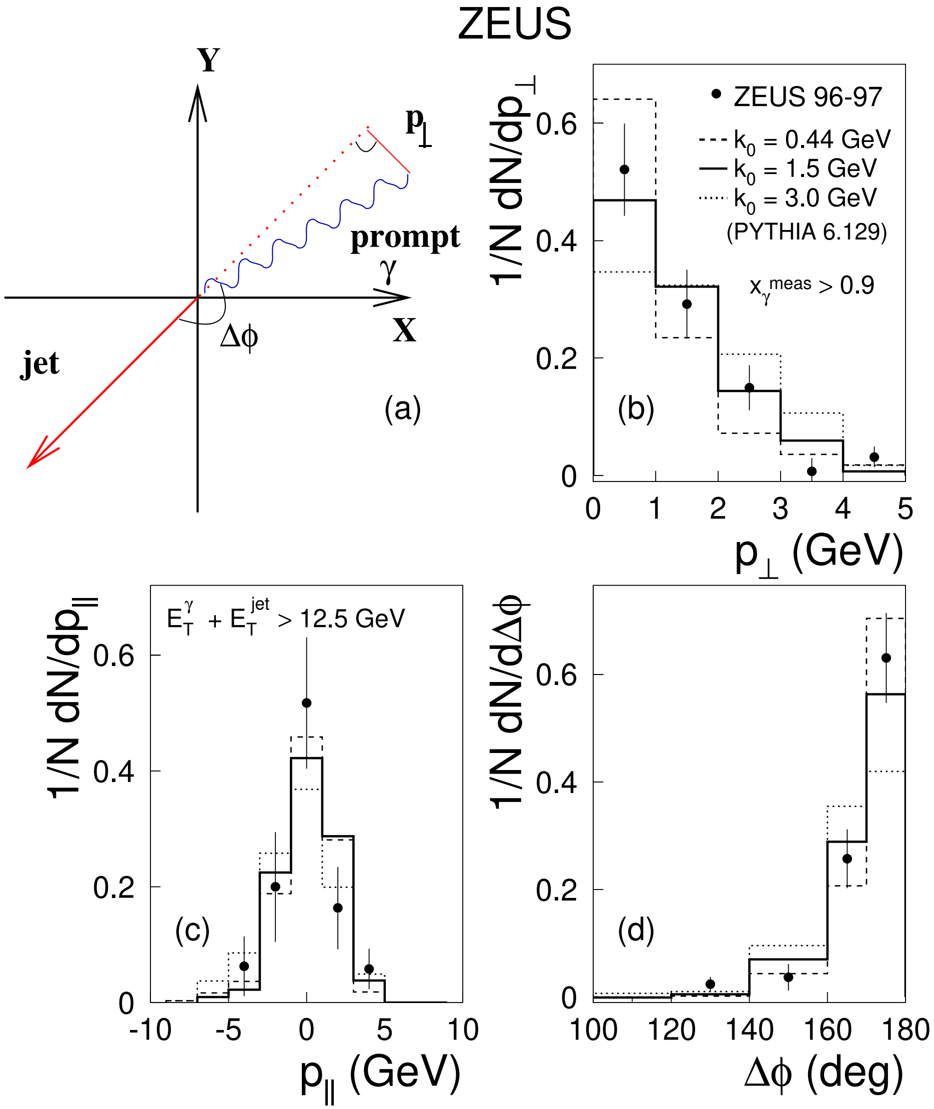
- $x_\gamma^{meas} > 0.9 \rightarrow$ direct process
- Choose variables sensitive to $\langle k_T \rangle$ ($p_\perp$, $\Delta\phi$)
- Vary k_0 in PYTHIA

$$k_0 = \sqrt{\frac{4}{\pi}} \langle k_T^{intr} \rangle$$

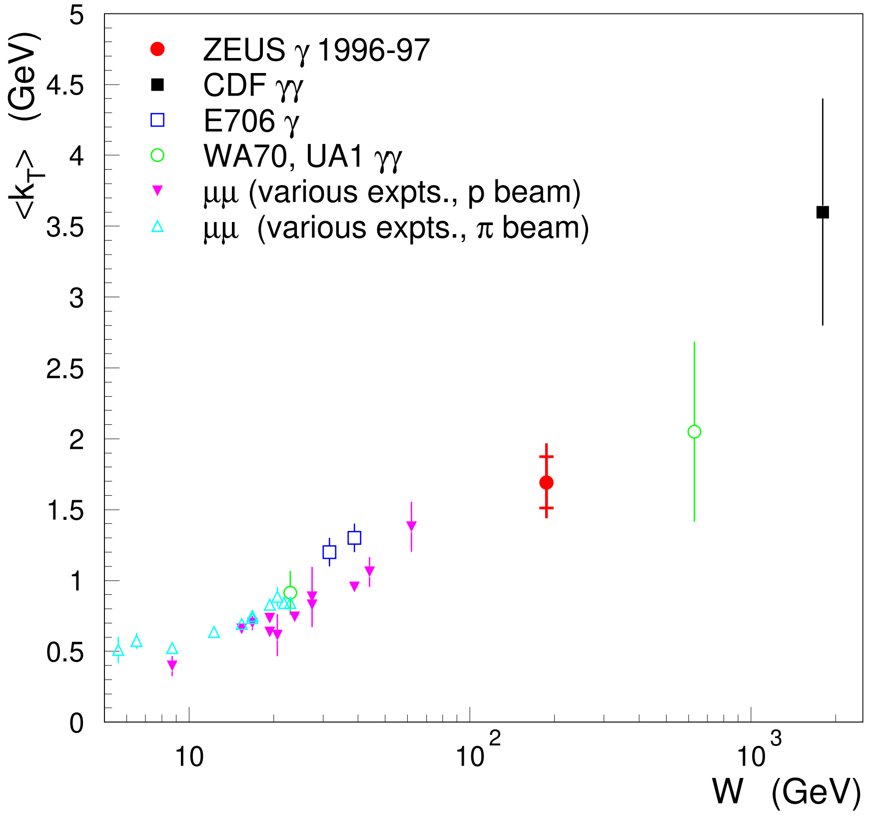
- Determine $\langle k_T^{intr} \rangle$ from fit
- Add parton shower distribution in PYTHIA

Effective transverse parton momentum $\langle k_T \rangle$ = intrinsic + parton shower

$$\boxed{\langle k_T \rangle = 1.69 \pm 0.18^{+0.18}_{-0.20} \text{ GeV}}$$



Prompt Photons - $\langle k_T \rangle (W)$



Two groups of measurements

→ direct ($\mu\mu$, $\gamma\gamma$)

→ model-dependent (prompt photons)

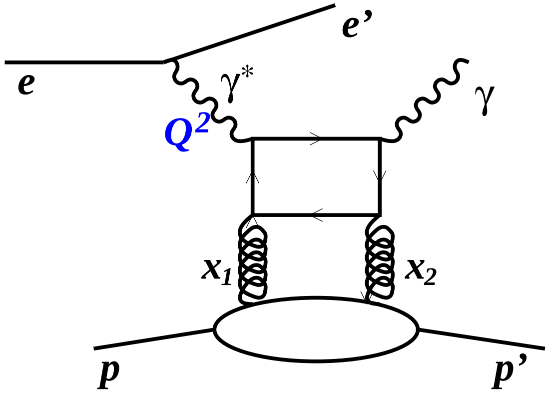
ZEUS result is consistent with the rising trend seen in the other experiments

ZEUS Collaboration, Phys. Lett. B511 (2001) 19

MOTIVATION FOR DVCS STUDY

Deeply **V**irtual **C**ompton **S**cattering (**DVCS**)

$\rightarrow$ diffractive scattering of the virtual photon off a proton

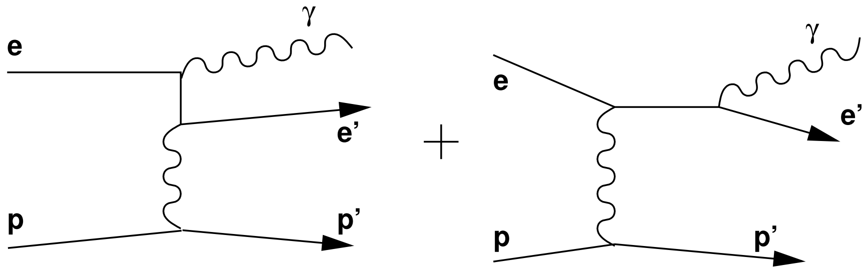


$\leftarrow$ Modelled as (Frankfurt, Freund, Strikman)

$$\boxed{x_1 \neq x_2}$$

- New possibility to study diffraction at HERA
- Proven QCD factorization formula
- Interference between DVCS and BH
  $\rightarrow$ Real part of QCD amplitude
- Sensitive to SPD

♣ **Focus on cross section measurements**



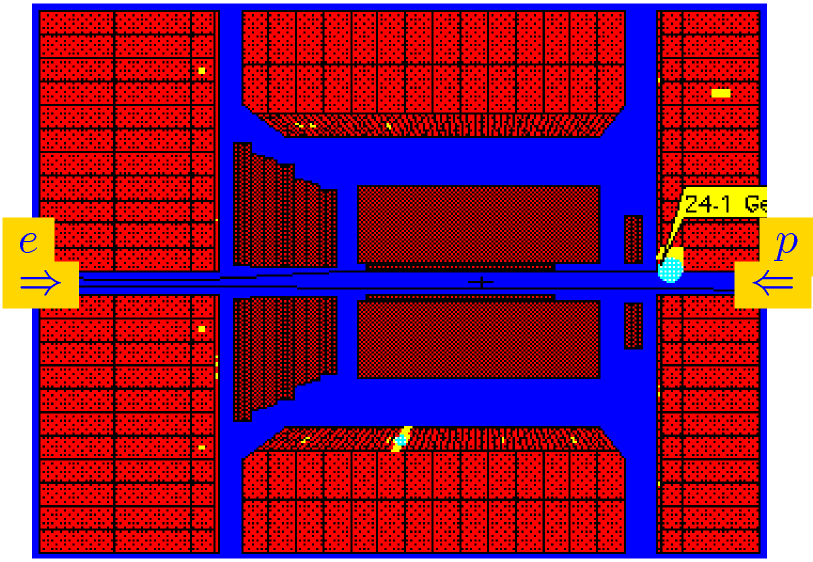
$$d\sigma^{total} = d\sigma^{BH} + \underset{\sim e^{-b|t|}}{\underset{\uparrow}{d\sigma^{DVCS}}} + \underset{\sim cos\phi_r}{\underset{\uparrow}{d\sigma^{interf}}}$$

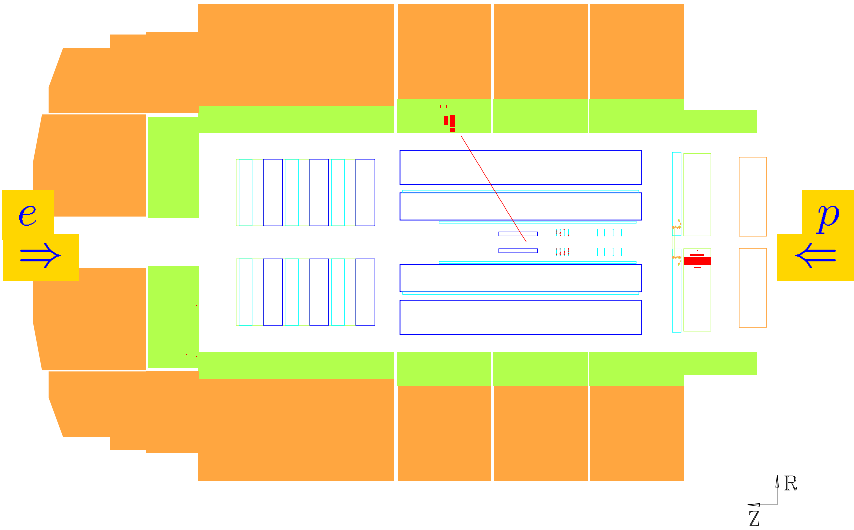
DVCS - Events Topology

The same topology for both ZEUS and H1

Case 1 γ SAMPLE
(ENRICHED DVCS)
Both BH and DVCS contribute

Case 2 e^+ SAMPLE
(CONTROL SAMPLE)
Only BH contributes





If BH MC describes data in case 2, use it to subtract BH contribution in case 1

DVCS - H1 and ZEUS comparison

H1	ZEUS

Main selection requirements

2 EM clusters

H1	ZEUS
$E_1 > 15\ GeV$	$E_1 > 10\ GeV$
$p_{T2} > 1\ GeV$	$E_{T2} > 3\ GeV$

0 or 1 track pointing to the cluster

No other activity in the calorimeter (elastic, diffractive sample)

Number of events

H1	ZEUS
338(e^+) + 172(γ)	1059(e^+) + 537(γ)
97 e^+p data 8 pb^{-1}	96-97 e^+p data 37 pb^{-1}

Cross section definition

H1	ZEUS
$2 < Q^2 < 20\ GeV^2$	$5 < Q^2 < 100\ GeV^2$
$30 < W < 120\ GeV$	$40 < W < 140\ GeV$
$\vert t\vert < 1\ GeV^2$	$E_T^\gamma > 3\ GeV$
	$-0.6 < \eta_\gamma < 1.0$

DVCS - H1 CONTROL PLOTS

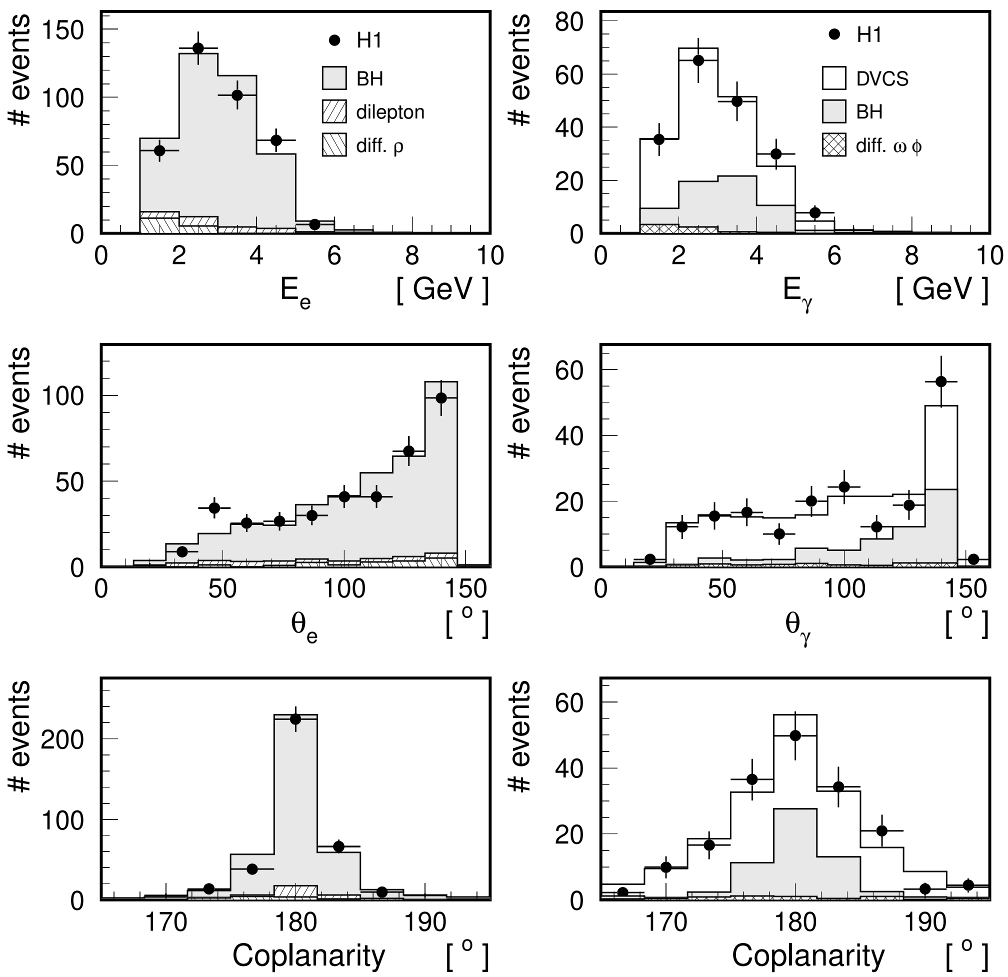
Control sample

- Photon backwards
- e^+ track in the central region

DVCS background negligible

BH events well described by MC

- Detector well understood
- Possibility to extract cross section



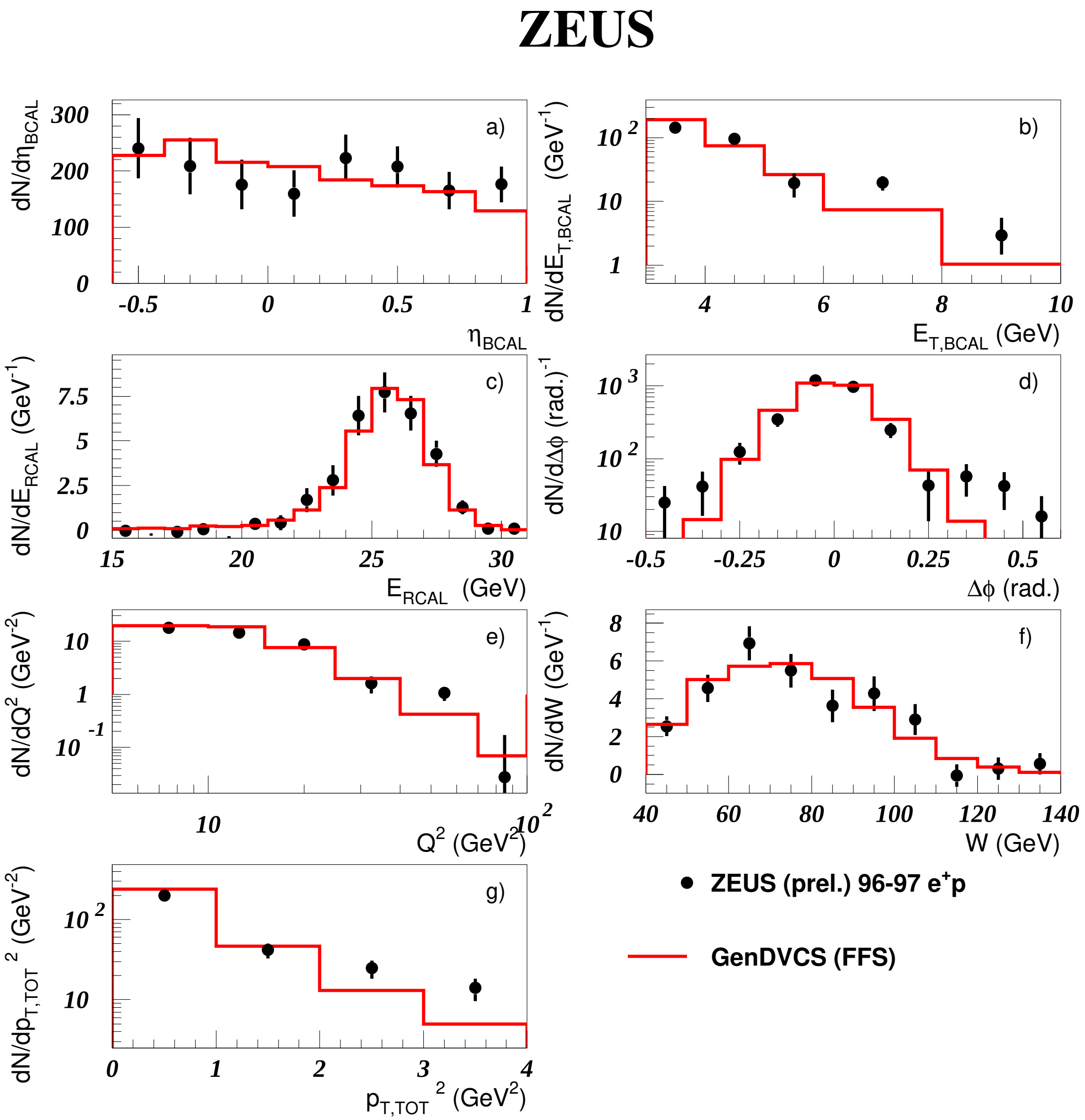
Enriched DVCS sample

Large excess of events above BH prediction
$\rightarrow$ clear DVCS signal

- flatter t-dependence
- less balanced p_T
- different coplanarity distribution

Good agreement
between data and MC

DVCS - ZEUS γ SAMPLE



After BH subtraction

DVCS MC based on **FFS** predictions normalised to data

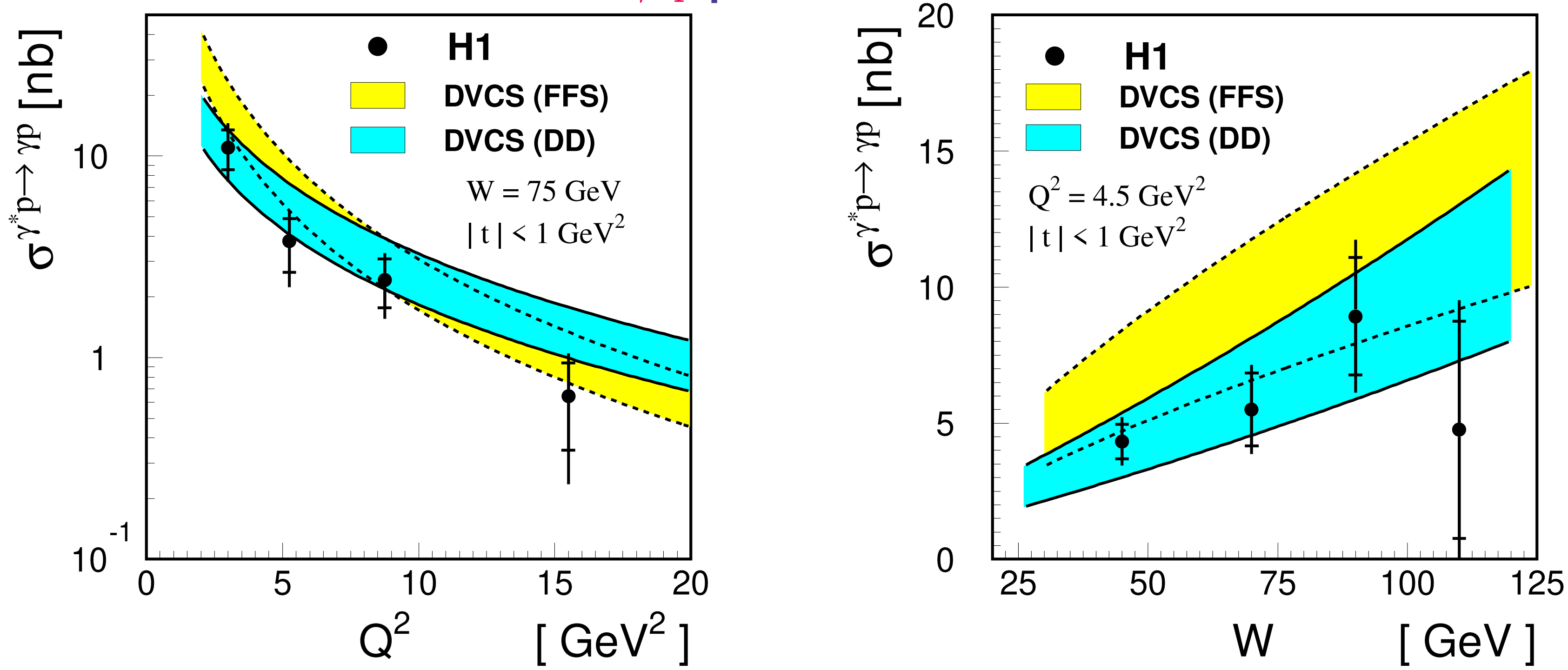
Good agreement found

$\Downarrow$

Possibility to use GenDVCS to unfold to cross section

DVCS - H1 Cross Sections

Elastic DVCS cross sections for $\gamma^* p$ process



The data are compared to the theoretical predictions of **FFS** and **DD**

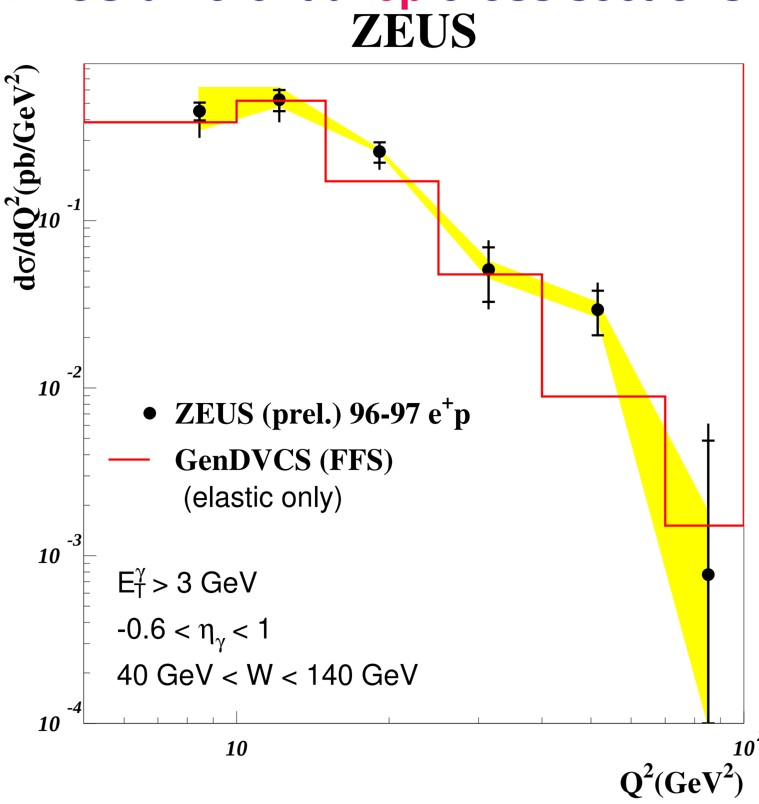
The band associated to each prediction corresponds to a variation of the assumed t-slope from 5 GeV^{-2} to 9 GeV^{-2}

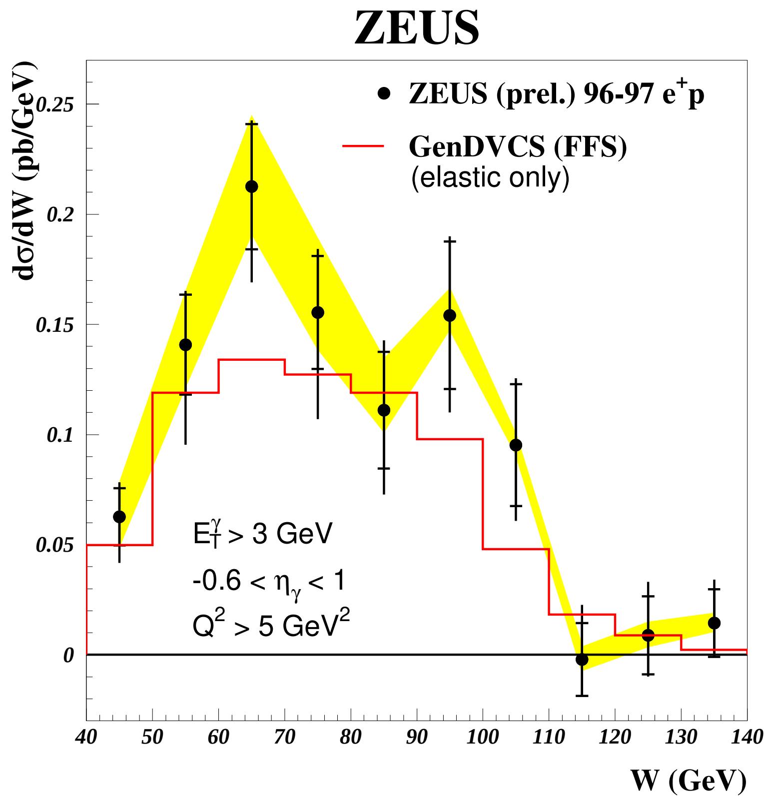
Good agreement found

H1 Collaboration, Phys. Lett. B517 (2001) 47

DVCS - ZEUS Cross Sections

DVCS differential ep cross sections





Data are compared to the theoretical predictions of **FFS**

pQCD framework of describing DVCS works well

Data aren't corrected for proton-dissociation (20 %)

b-slope can affect normalisation (b = 4.5 GeV^{-2})

Summary and Outlook

Prompt Photons

- ZEUS has measured the production of prompt photons in photoproduction
- New determination of $\langle k_T \rangle$ for the parton at HERA gives

$$\boxed{\langle k_T \rangle = 1.69 \pm 0.18^{+0.18}_{-0.20}\ \text{GeV}}$$

which is consistent with the rising trend in the function of W

DVCS

- Signals for DVCS have been seen by H1 and ZEUS
- Cross sections in reasonable agreement with predictions by Frankfurt, Freund and Strikman (H1, ZEUS) and Donnachie, Dosch (H1)

⋆ Interference between DVCS and BH will be investigated

⋆ Better statistics after the HERA upgrade