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Deeply Virtual Compton Scattering at H1 and ZEUS on HERA

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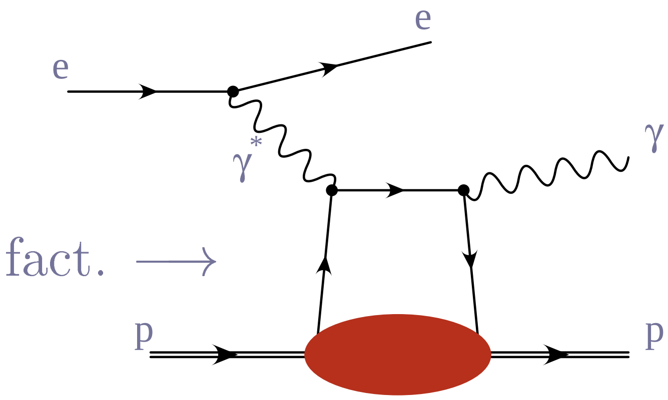
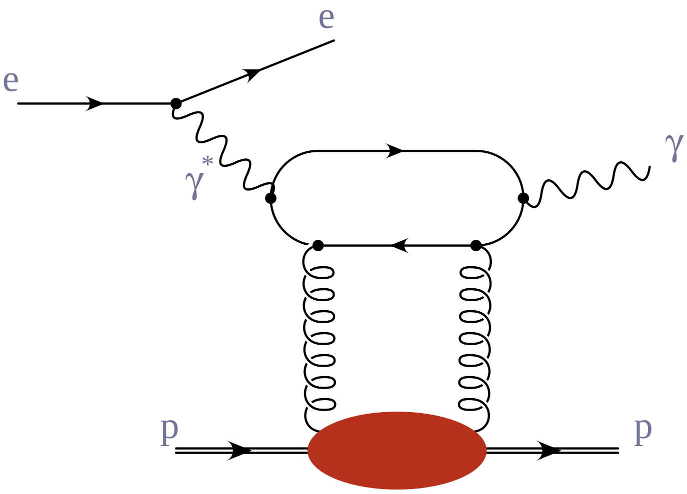
DVCS - Introduction

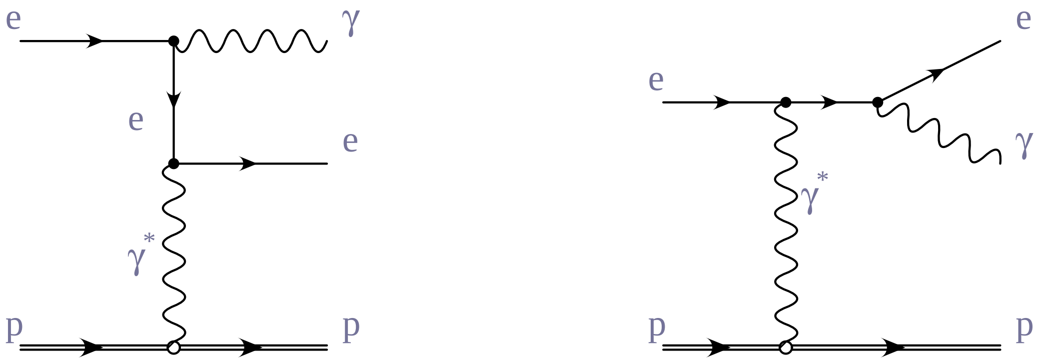


H1, ZEUS
HERMES, CLAS



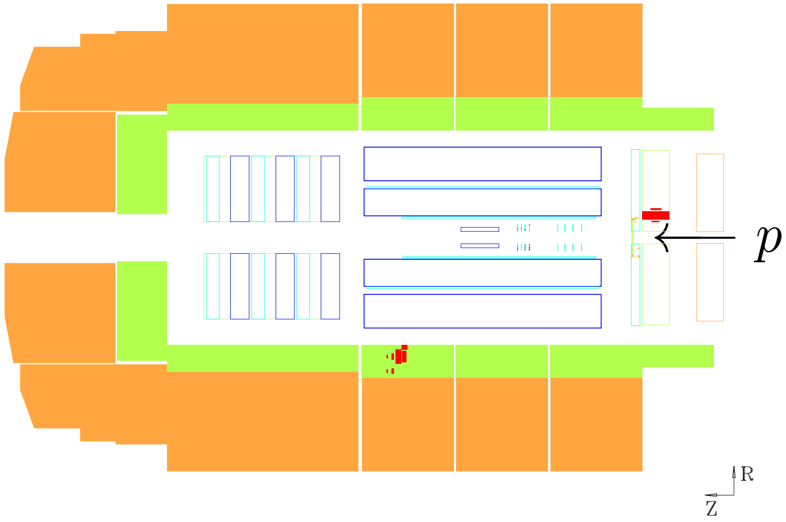
H1, ZEUS
COMPASS

- Bethe-Heitler Process (Background + Interference)



- HERA (ep): wide range in Q^2, W and t accessible
  at high Q^2 and low x
- Sensitivity to GPD
- interference term $\rightarrow$ $Re\ \mathcal{A}_{DVCS}$

Analysis strategy

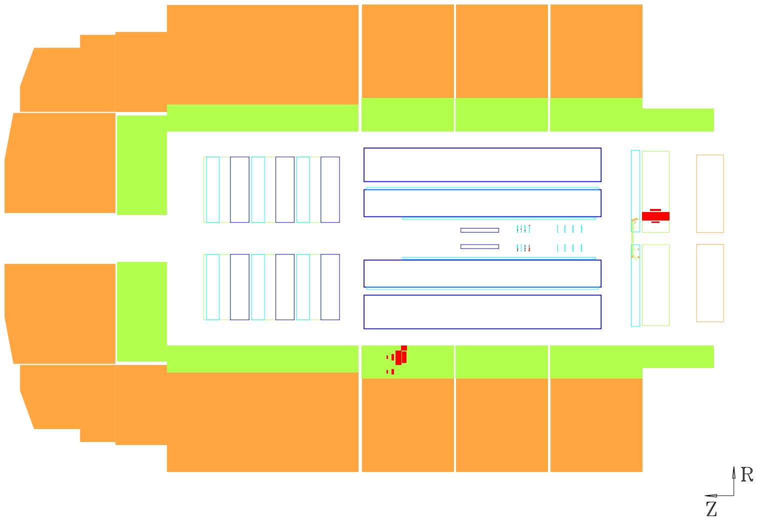
- DVCS $e^+ \longrightarrow$  $\longleftarrow p$

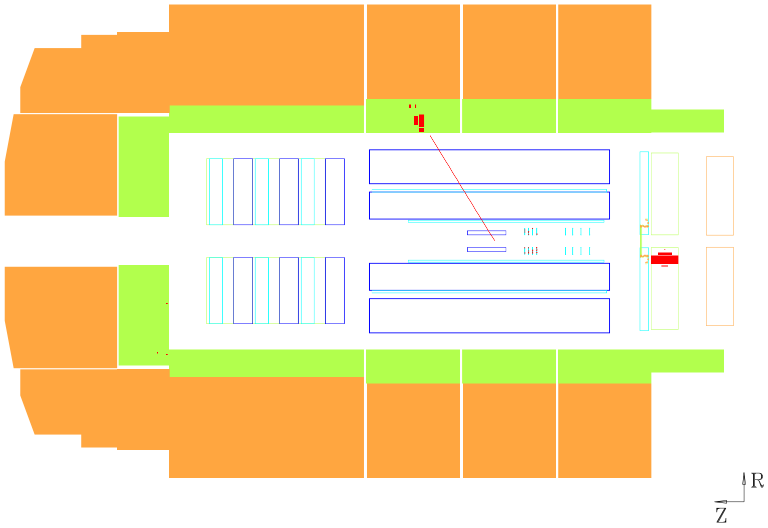
	H1	ZEUS
$E_1 >$	15 GeV	10 GeV
$p_{T_2} >$	1 GeV	
$E_2 >$		3 GeV
$E_3 <$	0.5 GeV	0.2 GeV
elast.	no track, Fwd	no track

γ–sample

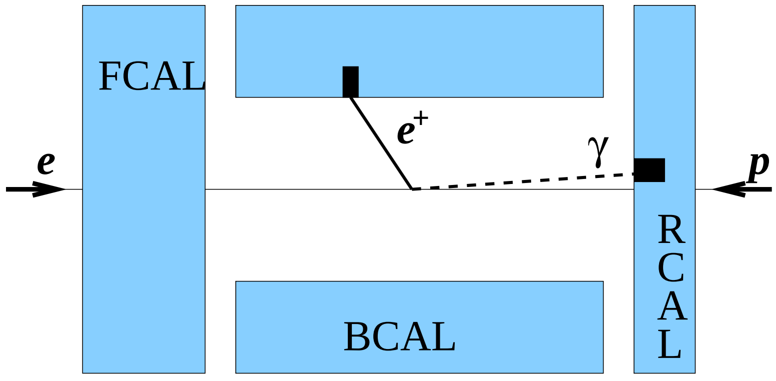
e^+–sample

- Bethe-Heitler





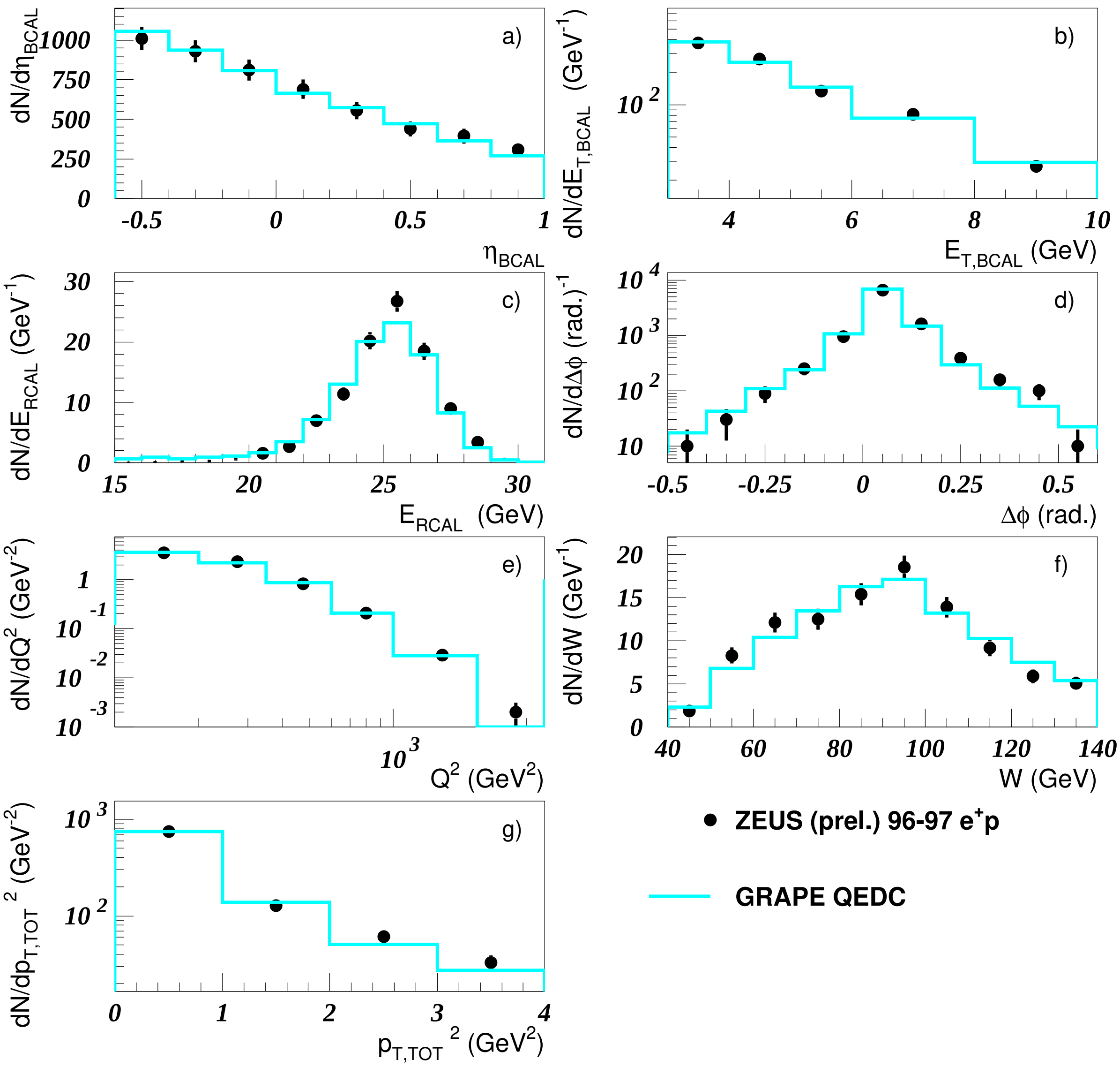
ZEUS Control Sample



$\theta_1 > 160^0, \; E_1 > 10$ GeV
$\theta_2 < 137^0, \; E_2 > 3$ GeV
$|\theta_2 - \theta_1| > 45^0$
$-0.6 < \eta_\gamma < 1.0$

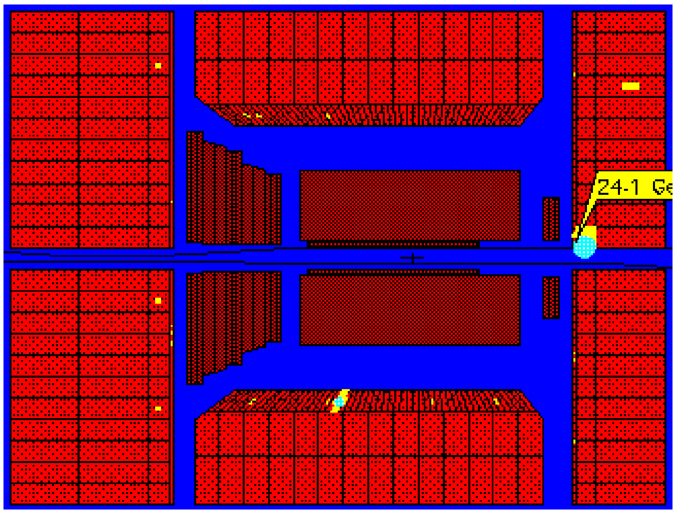
$\int L = 37\text{pb}^{-1}$

ZEUS



Detector response well understood

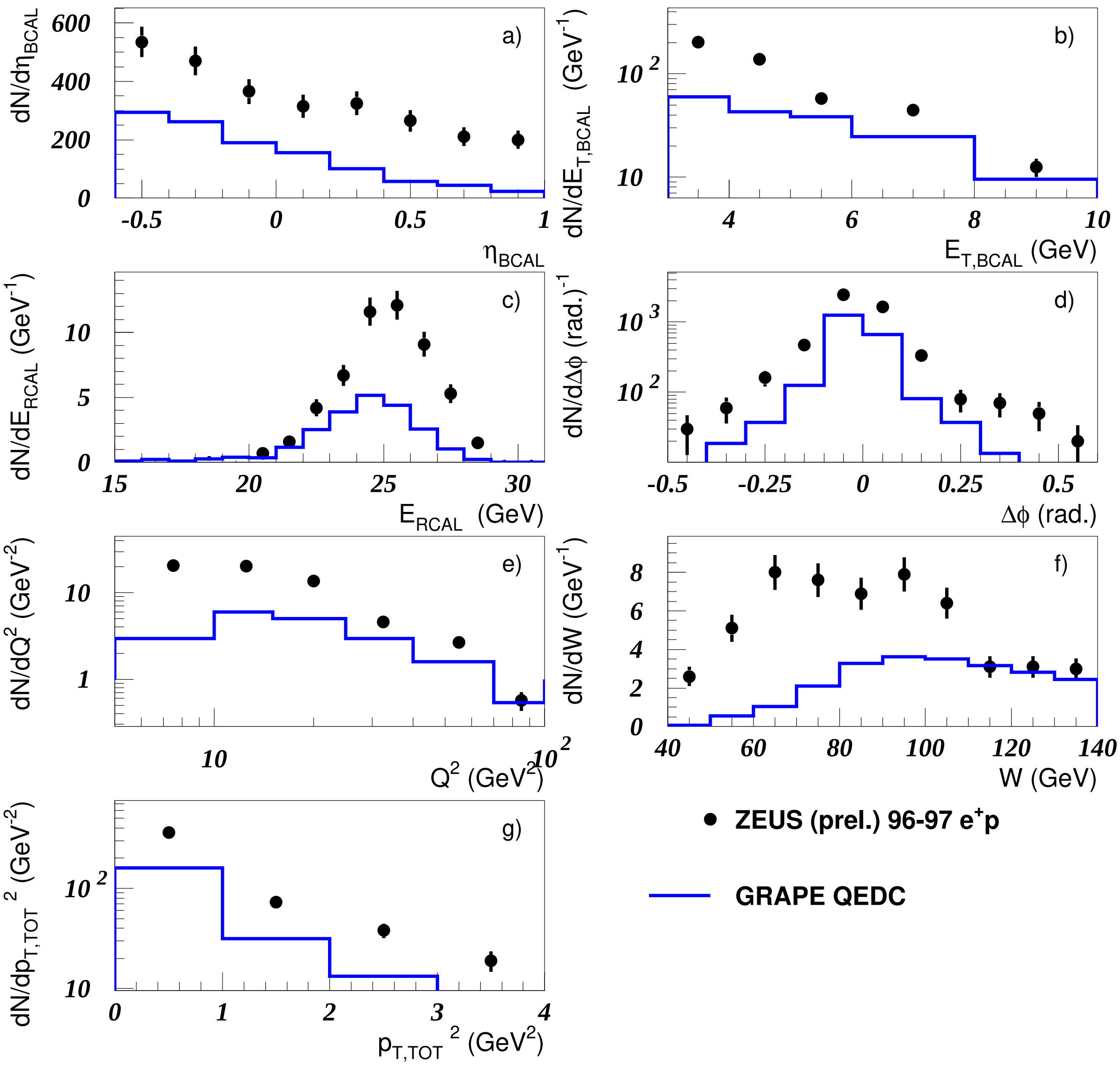
ZEUS: γ Sample



$5 < Q^2 < 100$ GeV^2

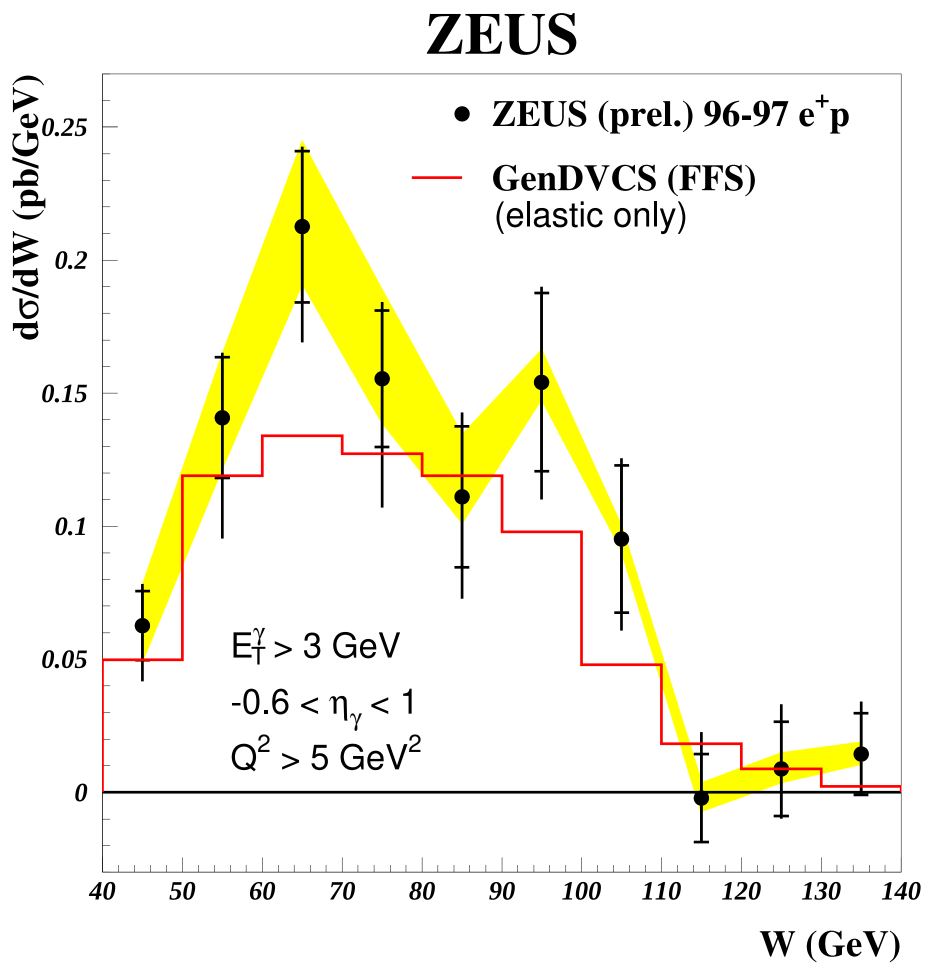
$40 < W < 140$ GeV

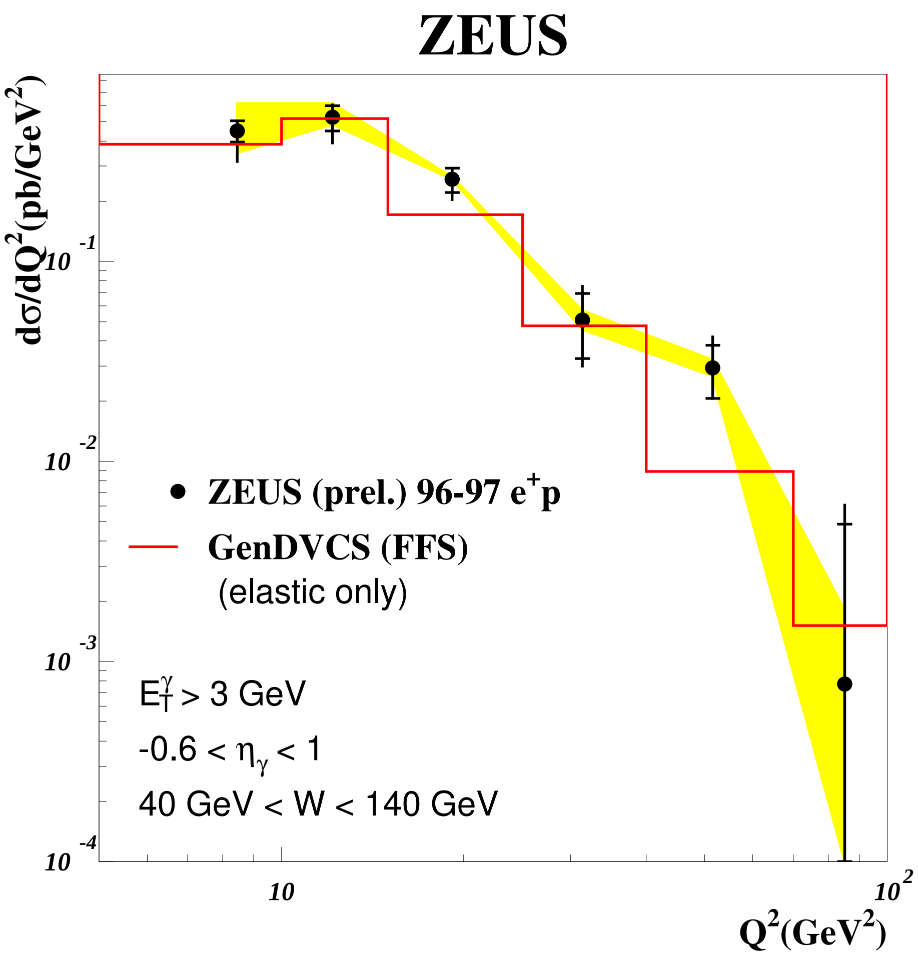
$-0.6 < \eta_\gamma < 1.0$



Signal above the Bethe-Heitler

Total Cross Section $ep \to e\gamma p$





- No proton dissociation background soustraction (20%)
- Cuts in η and E_T^γ
- MC : $b = 4.5\ GeV^{-2}$

H1 Cross Section Measurement

- Cross Section extraction

$$\frac{\mathrm{d}\sigma_{bin}}{\mathrm{d}Q^2} = \frac{(N_{bin} - N_{backg.} - N_{p.dis.})}{\epsilon \cdot A \cdot \Delta Q^2 \cdot \mathcal{L}} \cdot (1 + \delta_{rad})$$

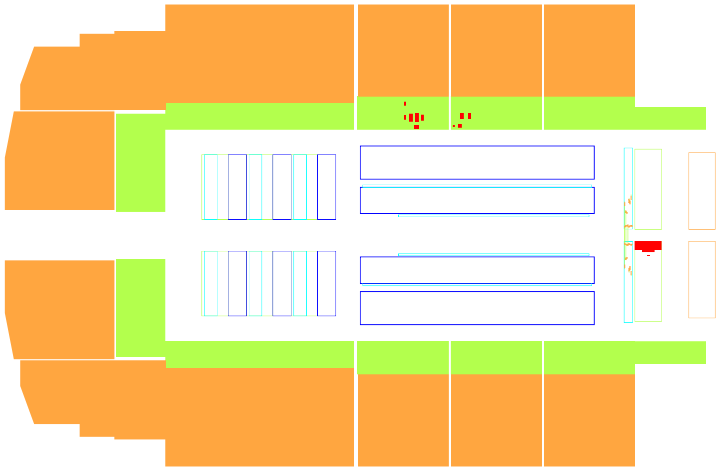
$$\frac{\mathrm{d}\sigma_{bin}}{\mathrm{d}W} = \frac{(N_{bin} - N_{backg.} - N_{p.dis.})}{\epsilon \cdot A \cdot \Delta W \cdot \mathcal{L}} \cdot (1 + \delta_{rad})$$

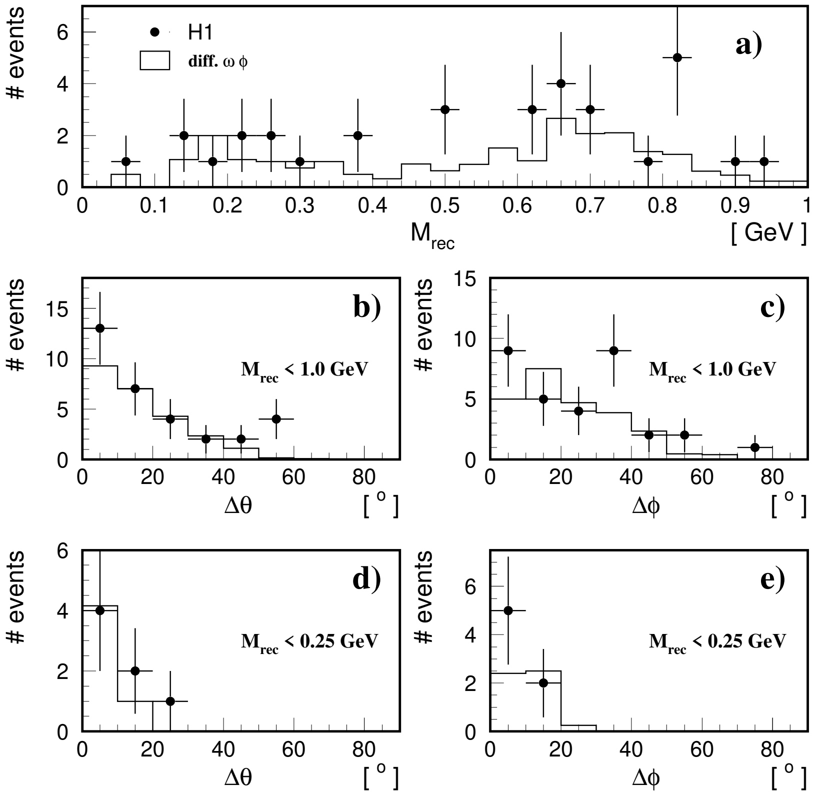
  - ω and ϕ background: $N_{backg.} \sim 3.5\,\%$
  - Proton dissociation background: $N_{p.dis.} \sim 16\,\%$
  - Trigger efficiency: $\epsilon \sim 100\,\%$
  - Geometrical acceptance: $A \sim 25\,\%$
  - QED radiative corrections: $(1 + \delta_{rad}) \sim 3\,\%$
  - Luminosity: $\mathcal{L} \sim 8\,\mathrm{pb}^{-1}$

- Dominating systematic uncertainties
  - Proton dissociation background: $8\,\%$
  - Scattering angle uncertainty of the electron ($1.3\,\mathrm{mrad}$): $2 - 15\,\%$

H1 Data Analysis: Background Study

- Study low multyplicity events: e. g.
  $ep \longrightarrow ep\pi^0 \ldots \qquad \pi^0 \longrightarrow \gamma\gamma$
- Investigate events with two cluster in the LAr calorimeter E_1, $E_2 > 0.5\,\mathrm{GeV}$:

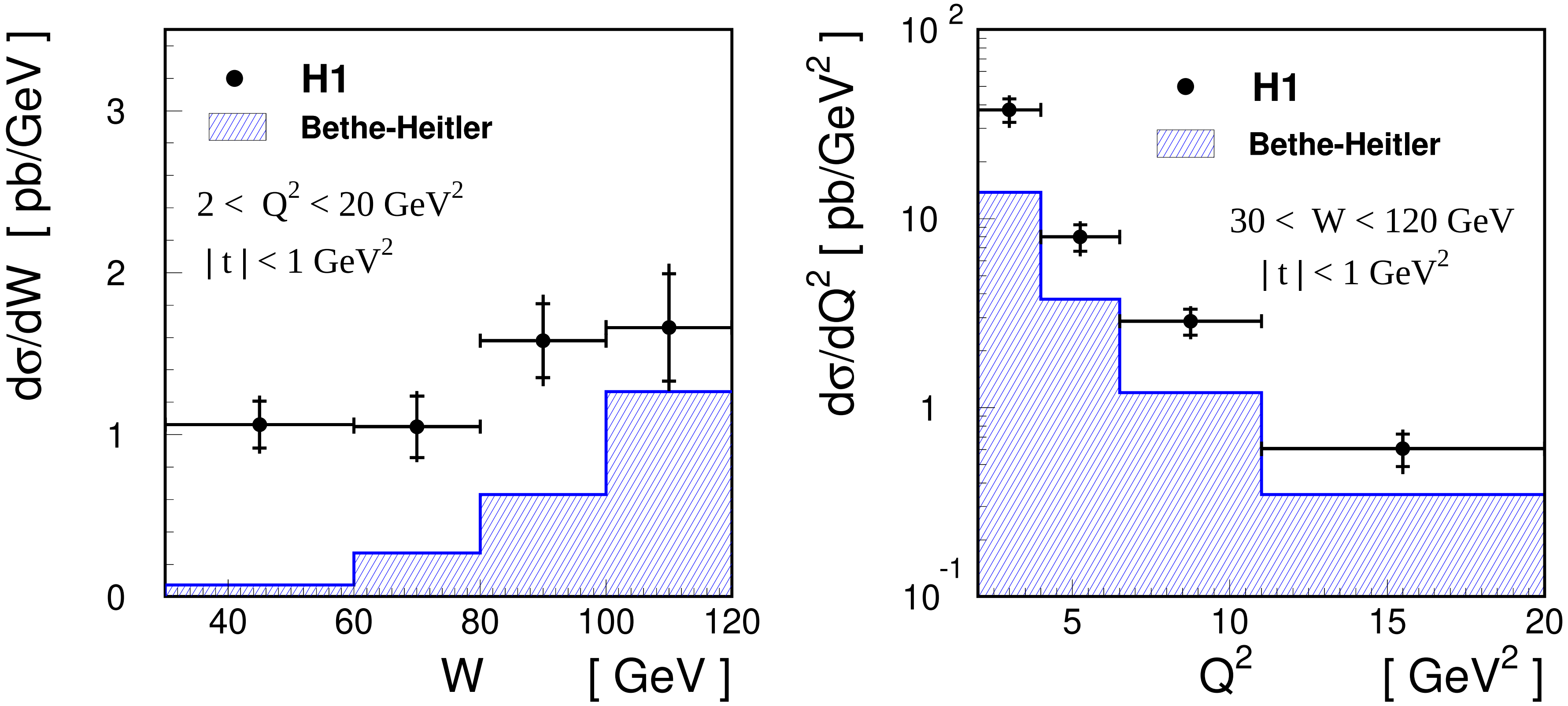




- Data are well described by ω and ϕ production

$\Longrightarrow$ Observed signal is not induced by processes with additional π^0's

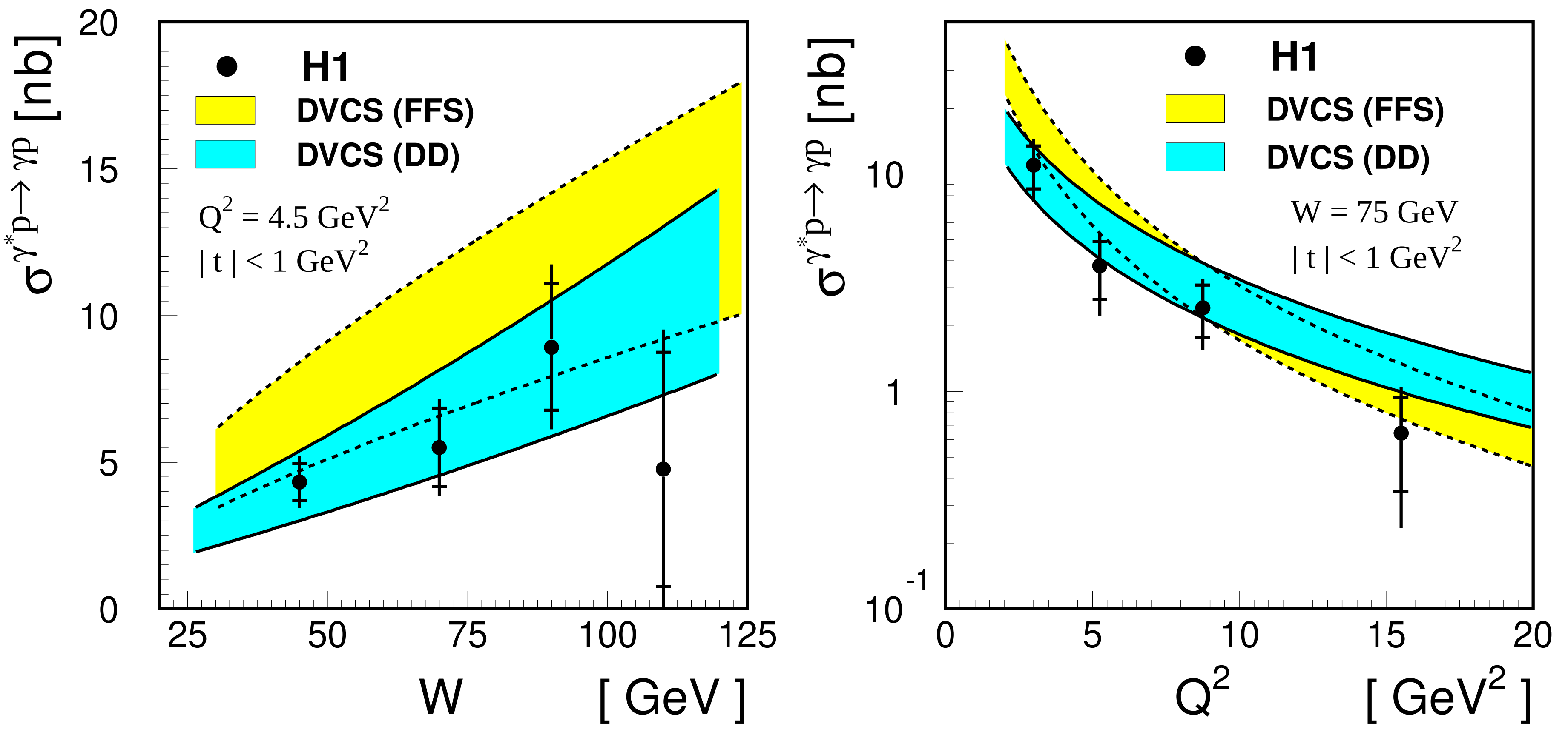
H1 Cross Section Measurement: $ep \to e\gamma p$



- Cross Section is larger than the Bethe–Heitler prediction
- Shape is different
- Excess can be attributed to Deeply Virtual Compton Scattering

H1 Results

- Subtraction of the Bethe Heitler contribution from the measured cross section
- $\frac{d\sigma^{ep\to e\gamma p}}{dQ^2 dy}\left(Q^2,y\right) = \Gamma\left(Q^2,y\right)\cdot\sigma^{\gamma^* p\to\gamma p}\left(Q^2,y\right)$



$\Longrightarrow$ Good description by both, QCD based calculations as well as semiclassical dipole models assuming a slope in t of $5 < b < 9\,\mathrm{GeV}^{-2}$

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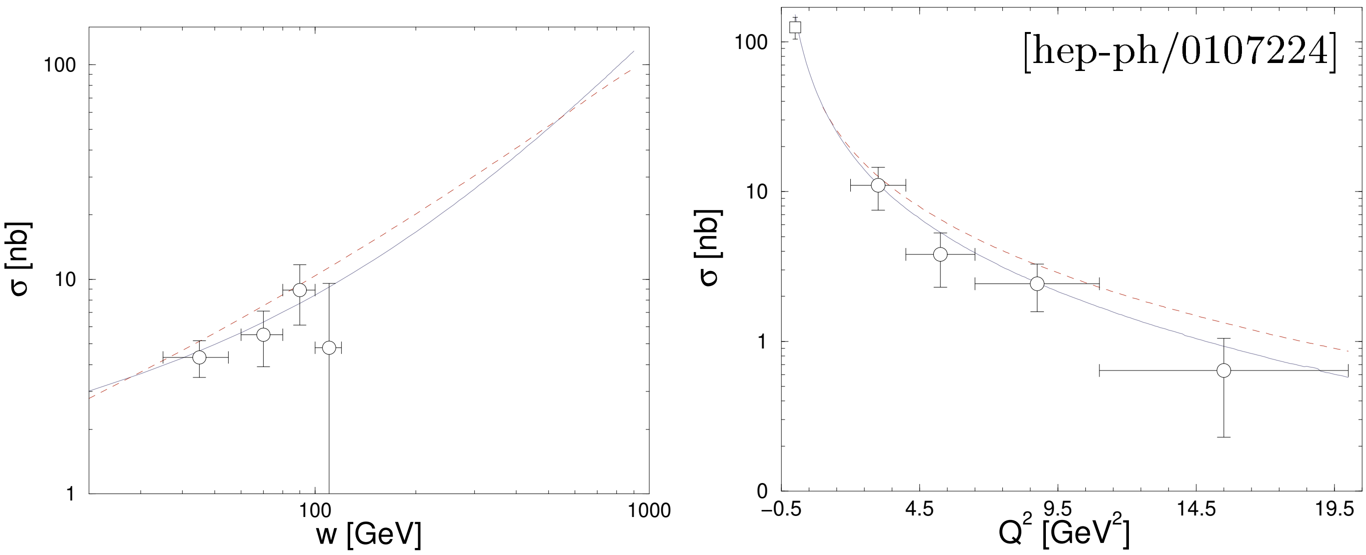
Cross section predictions

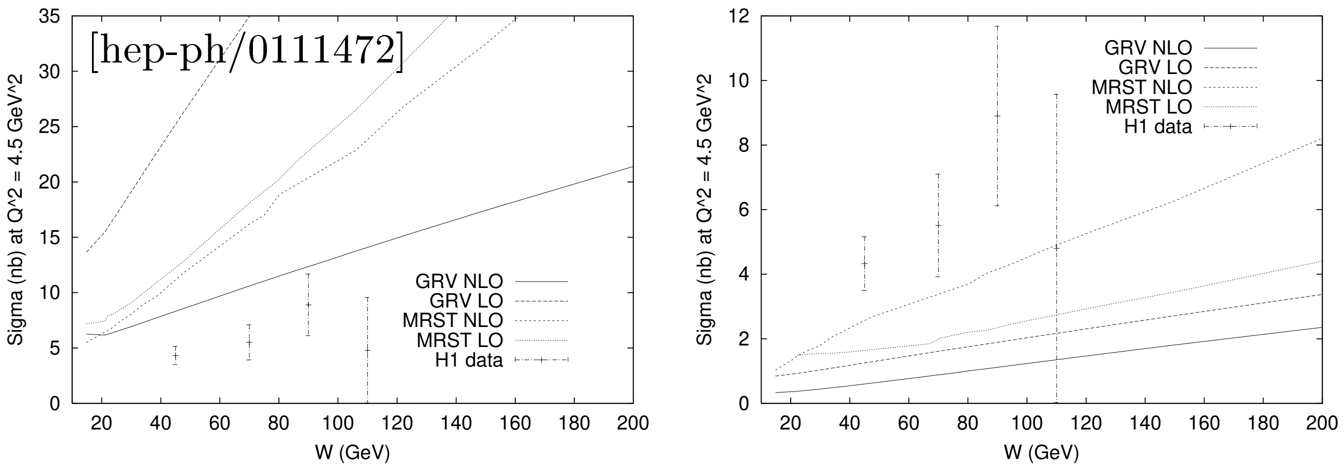
Dipole Model predictions:



- Forshaw, Kerley and Shaw (full line) - fit of σ_{dipole}
- McDermott, Frankfurt, Guzey and Strikman (dashed line) - 2 gluon exch.
- Donnachie and Dosch (DD) (previous plot) - soft et hard pomeron

Pure QCD prediction:

- A.V. Belitsky, et al. [hep-ph/0112108] - beyond LO/twist 3 (not shown).
- A. Freund, M. McDermott [hep-ph/0111472] NLO/leading twist



Lim $x \to 0$ - no saturation

Limited to $x = x_B$

Sensitivity to the ERBL region ?

Future: Possibilities at HERA II

HERA II: High Luminosity regime starting now

- factor five Lumi increase $\rightarrow \sim 1\ \mathrm{fb}^{-1}$
- long. polarised e^+/e^- beam

- Helicity Asymetry

long. polarised $\overrightarrow{e}$ and $\overleftarrow{e}$ beams

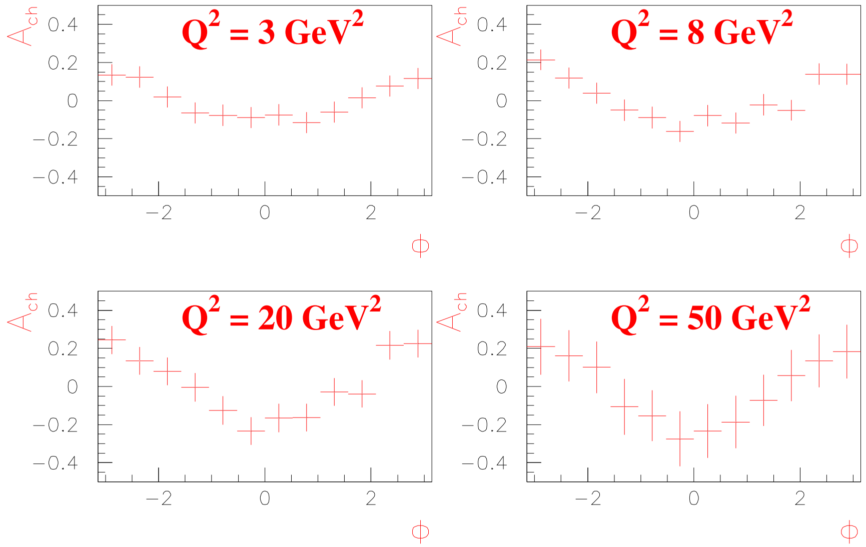
$$\Delta\sigma_{LU} \sim \sin(\phi) \times Im\ \mathcal{A}_{DVCS}(\xi, x = \xi, t, Q^2)$$

no estimate yet

- Charge Asymetry

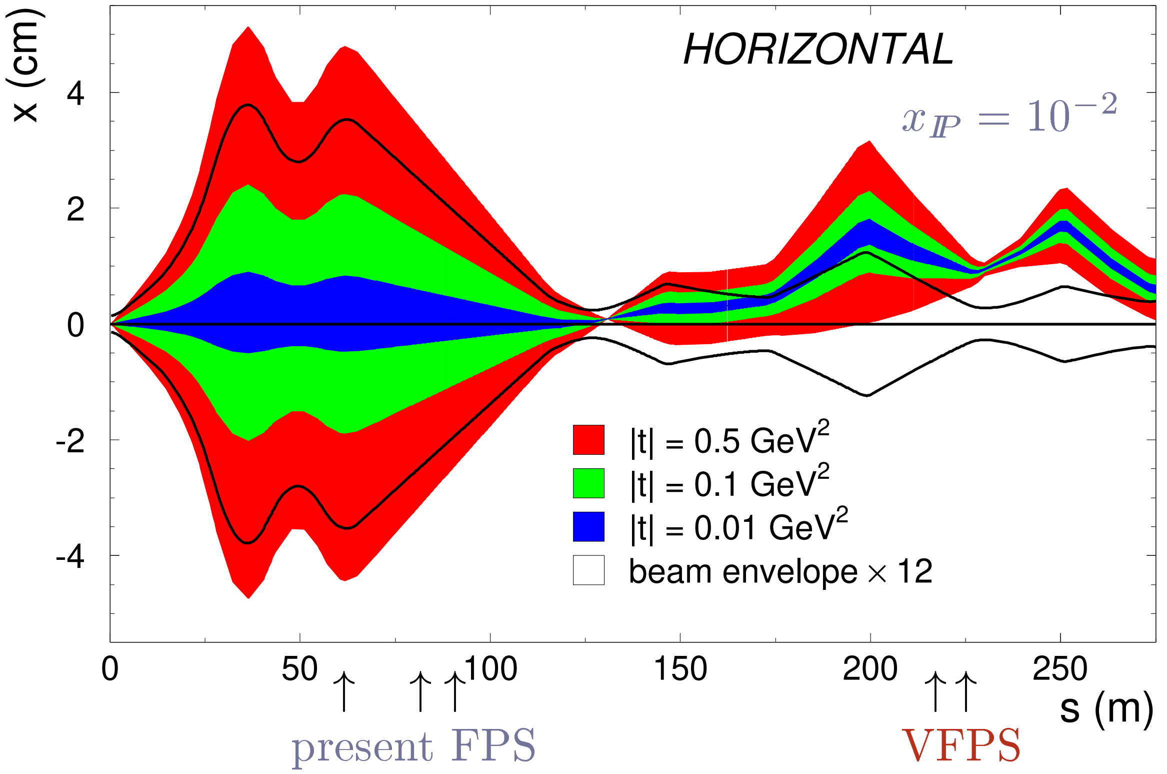
e^+ and e^- beams

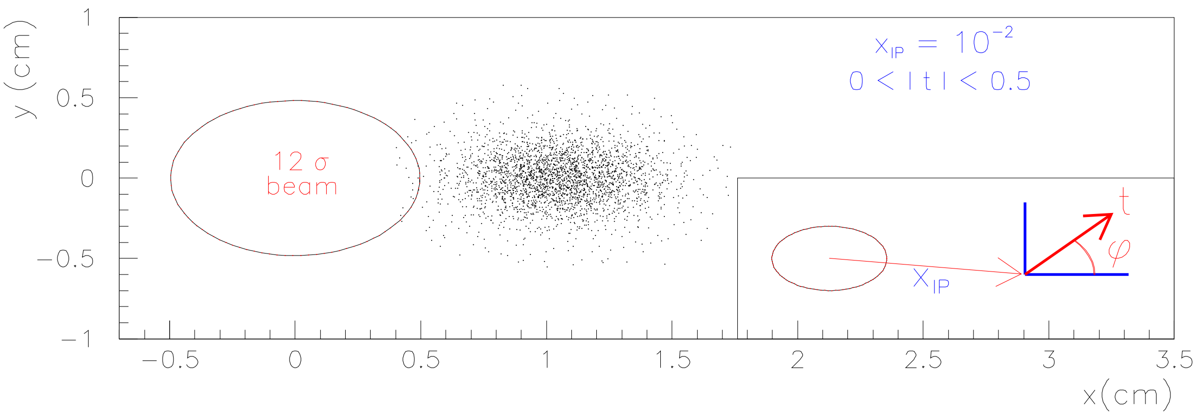
$$\Delta\sigma_{ch} \sim \cos(\phi) \times Re\ \mathcal{A}_{DVCS}(\xi, x, t, Q^2)$$



H1 detector ($10 < W < 120$ GeV). Lumi assumed: 150 $\mathrm{pb}^{-1} e^+$, 150 $\mathrm{pb}^{-1} e^-$, based on FFS prediction.

VFPS: New Roman Pots for H1





- Two Roman Pots equiped of two detectors each

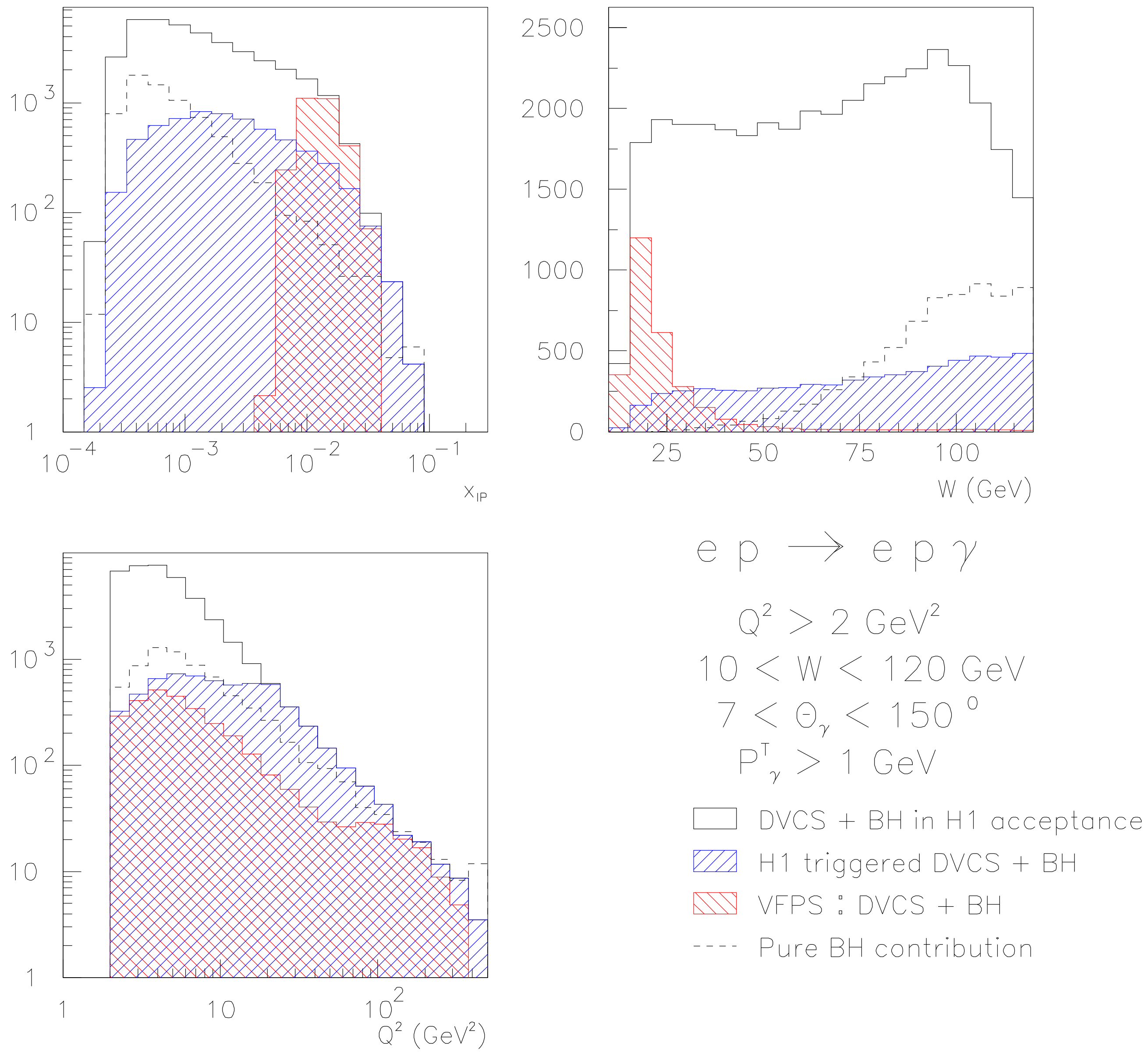
$$(x, y, x', y') \rightarrow t, x_{I\!P}, \phi$$

⇒ High Acceptance (> 80%) : $5.10^{-3} < x_{I\!P} <\sim 3.10^{-2}$
$0 < |t| <\sim 0.5\ \text{GeV}^2$

⇒ proton tagging
4-5 bins in t
5-6 bins in ϕ

To be install during the winter 2002-2003

VFPS Acceptance and DVCS



HERA II: $\sim 350\ \mathrm{pb}^{-1}$ in VFPS

Minimum Q^2 (GeV^2)	DVCS (BH) Produced in H1	DVCS: H1 triggered	DVCS: VFPS triggered	combined
2	29900 (7080)	5052	8732	12010
8	5566 (2318)	2707	2046	3636
20	828 (762)	828	487	828
40	172 (326)	172	128	172

Conclusion

• HERA using colliding beams is a very favorable place to study DVCS :

  • as a diffractive process in terms of pQCD
  • to access to GPD (in part. gluons)
  • wide kinematic range.

• Cross sections, $\frac{d\sigma}{dQ^2}$ and $\frac{d\sigma}{dW}$, have been measured for the first time.

• Measurements are in agreement with different dipole model and QCD predictions and exhibit sensitivity to GPDs (ERBL?).

• HERA II: much more data to come, and higher precision (proton tagging) and asymetry measurements (charge and helicity).