

DVCS at HERA II

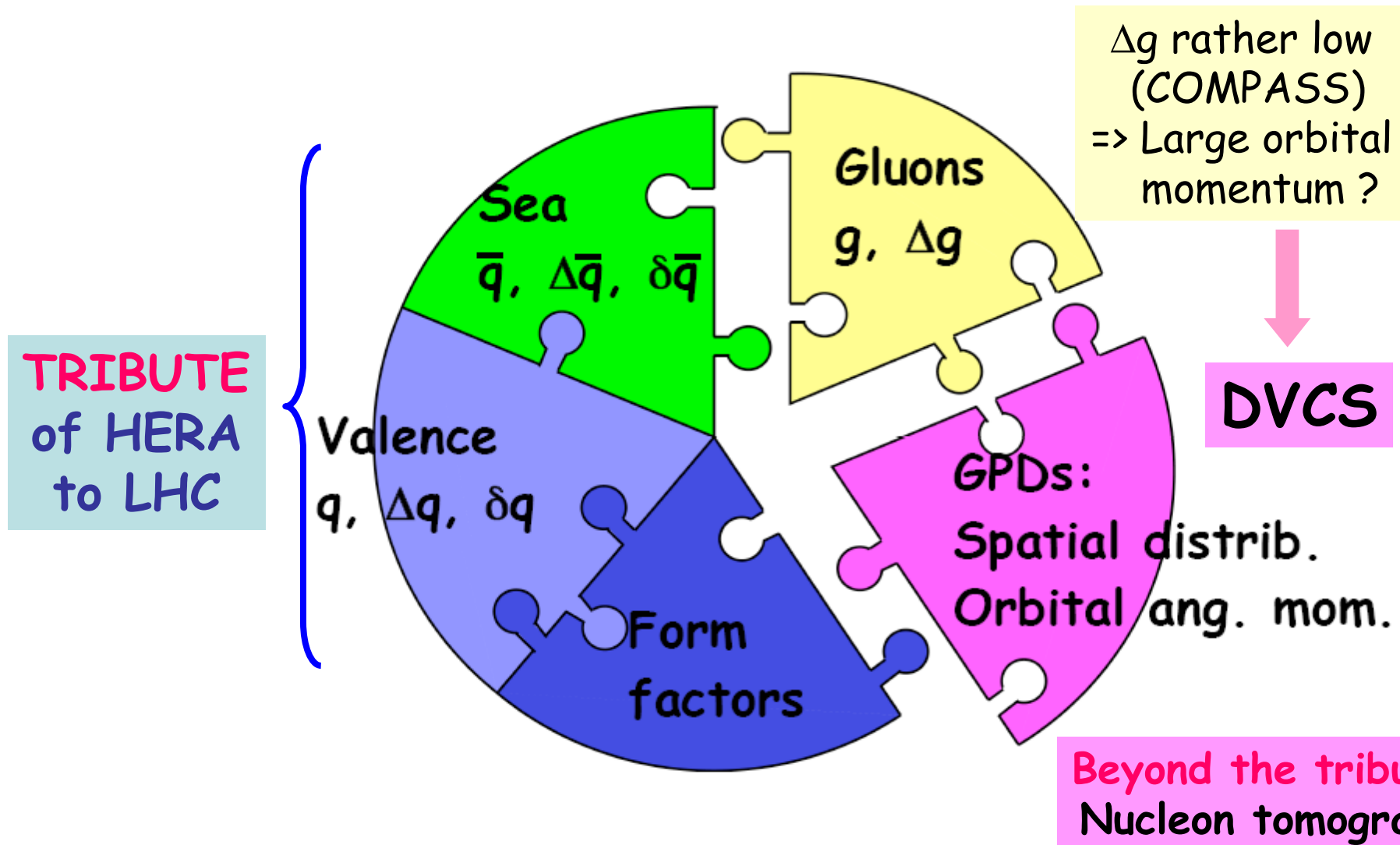
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DIS 2007 - Munich

On behalf of the
H1 collaboration

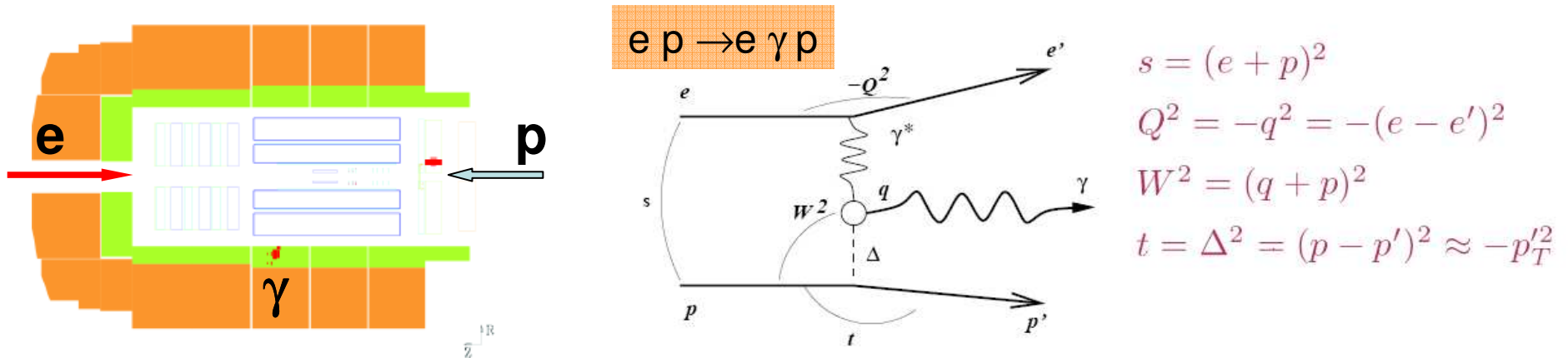
1. Basics of Deeply Virtual Compton Scattering (DVCS)
2. New H1 results on the t dependence
3. QCD approaches
4. **First measurement of the Beam Charge Asymmetry @ collider**

The nucleon map

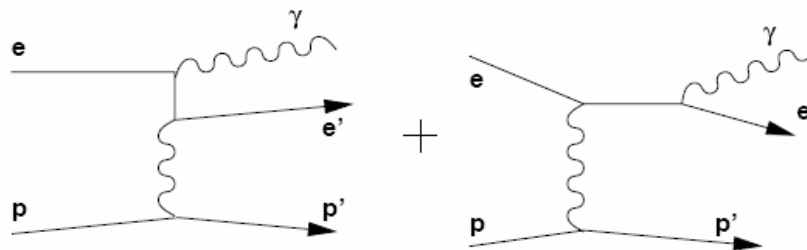


The DVCS process

DVCS reaction : QCD exclusive prod. of a real γ

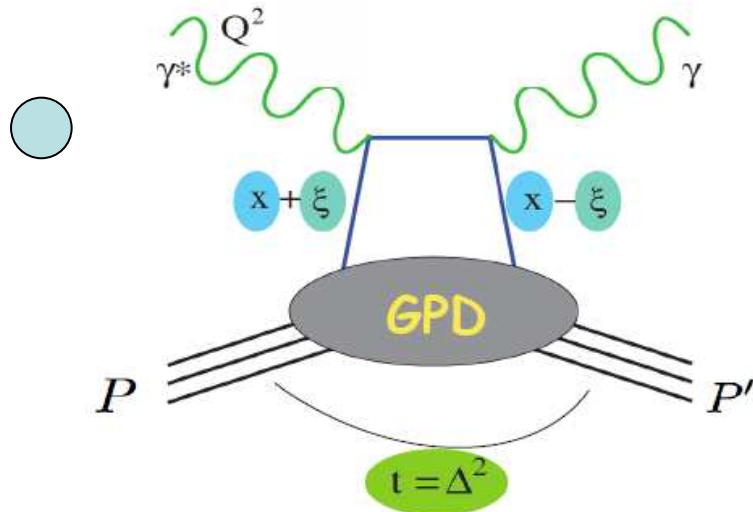


Identical final state : QED Bethe-Heitler process



=> Interference DVCS & BH (Beam Charge Asymmetry)

The DVCS process in QCD

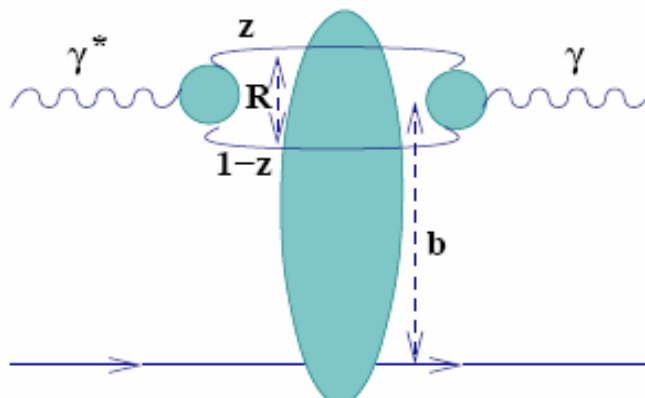


- x : average quark momentum fracⁿ
- ξ : "skewing parameter" = $x_1 - x_2$
- t : 4-momentum transfer²

$$\text{DVCS cross section} \sim \left| \int dx \text{ Coef} \otimes \text{GPD} \right|^2$$

$$\xi \sim x_{bj}/2 \sim 10^{-3} \text{ (this analysis)}$$

● Dipole model interpretation :



$$\text{DVCS cross section} \sim \left| \int dR dz \psi_{\text{ini}}^{\gamma^*} \sigma_{\text{dip}} \psi_{\text{out}}^{\gamma} \right|^2$$

σ_{dip} universal (F2, DVCS) ?

Nucleon tomography with DVCS

PDF (transverse plane) \equiv F.T. { $GPD[\Delta_{\perp}]$ }

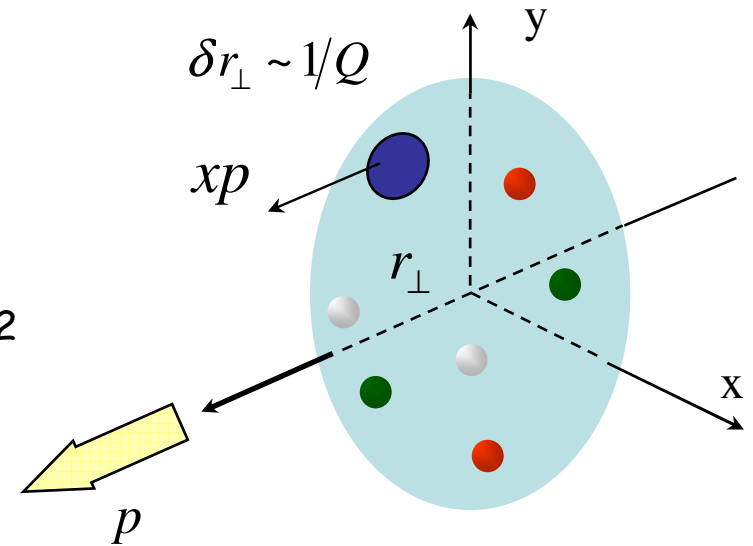
$$q(x, \mathbf{r}_{\perp}, Q^2) = \int \frac{d^2 \Delta_{\perp}}{(2\pi)^2} e^{-i\mathbf{r}_{\perp} \cdot \Delta_{\perp}} GPD_q(x, Q^2, t = -\Delta_{\perp}^2)$$

\mathbf{r}_{\perp} & Δ_{\perp} are conjugate variables :

$$\langle r_{\perp}^2 \rangle = 4 \frac{d/dt[GPD(x, t)]}{GPD(x, 0)}$$

with $d\sigma/dt = A \exp(bt)$ & $b = 6 \text{ GeV}^{-2}$

$$\Rightarrow \langle r_{\perp}^2 \rangle = 2b = 0.46 \text{ fm}^2$$



H1 : measurement of $d\sigma/dt$ [DVCS]

\Rightarrow spatial distribution of sea and glue

Experimental conditions

Kinematic domain

$$6.5 < Q^2 < 80 \text{ GeV}^2$$

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

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

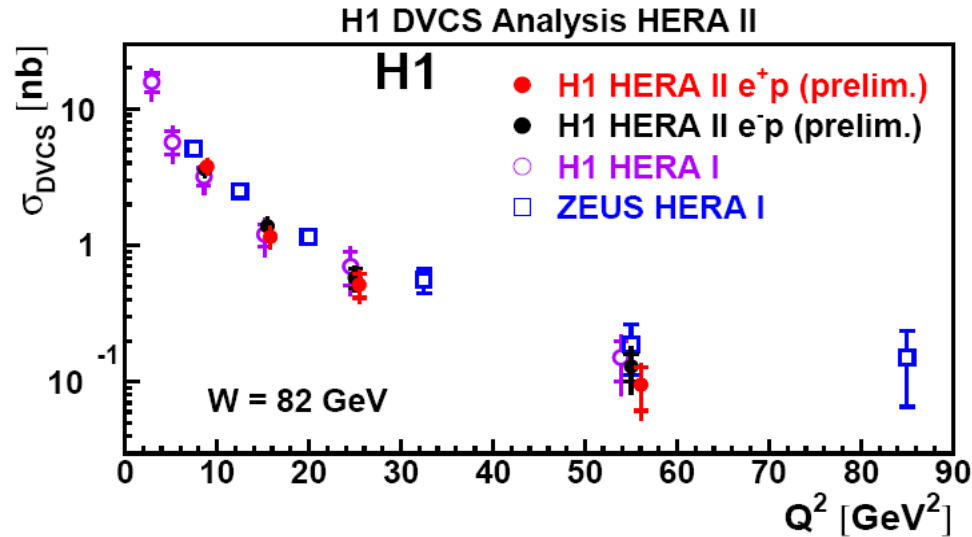
The DVCS cross section is extracted by subtracting the BH contribution + proton dissociation bckg (*note : the interference contribution is estimated < 1% -integration over $\phi_{Be\Gamma^-}$*)

Dominant systematic uncertainties

- Acceptance (t-slope parameter b variation by 7.5%) : $d\sigma/\sigma \sim 10\%$
- Proton dissociation bckg (25% uncertainty on the contribution) : $d\sigma/\sigma \sim 5\%$
- Uncertainty on θ_e (1mrad) & θ_γ (3mrad) : $d\sigma/\sigma \sim 5\%$

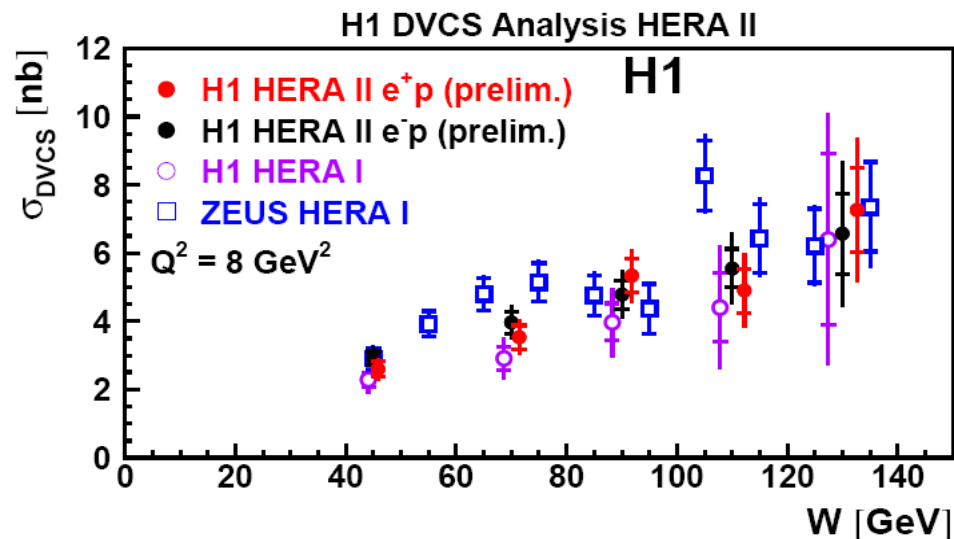
Finally, <stat error> $\sim 10\%$ and <total syst> $\sim 15\%$
using the e^- sample : $e^- p \rightarrow e^- \gamma p$

Analysis samples



e^- sample : $e^- p \rightarrow e^- \gamma p$

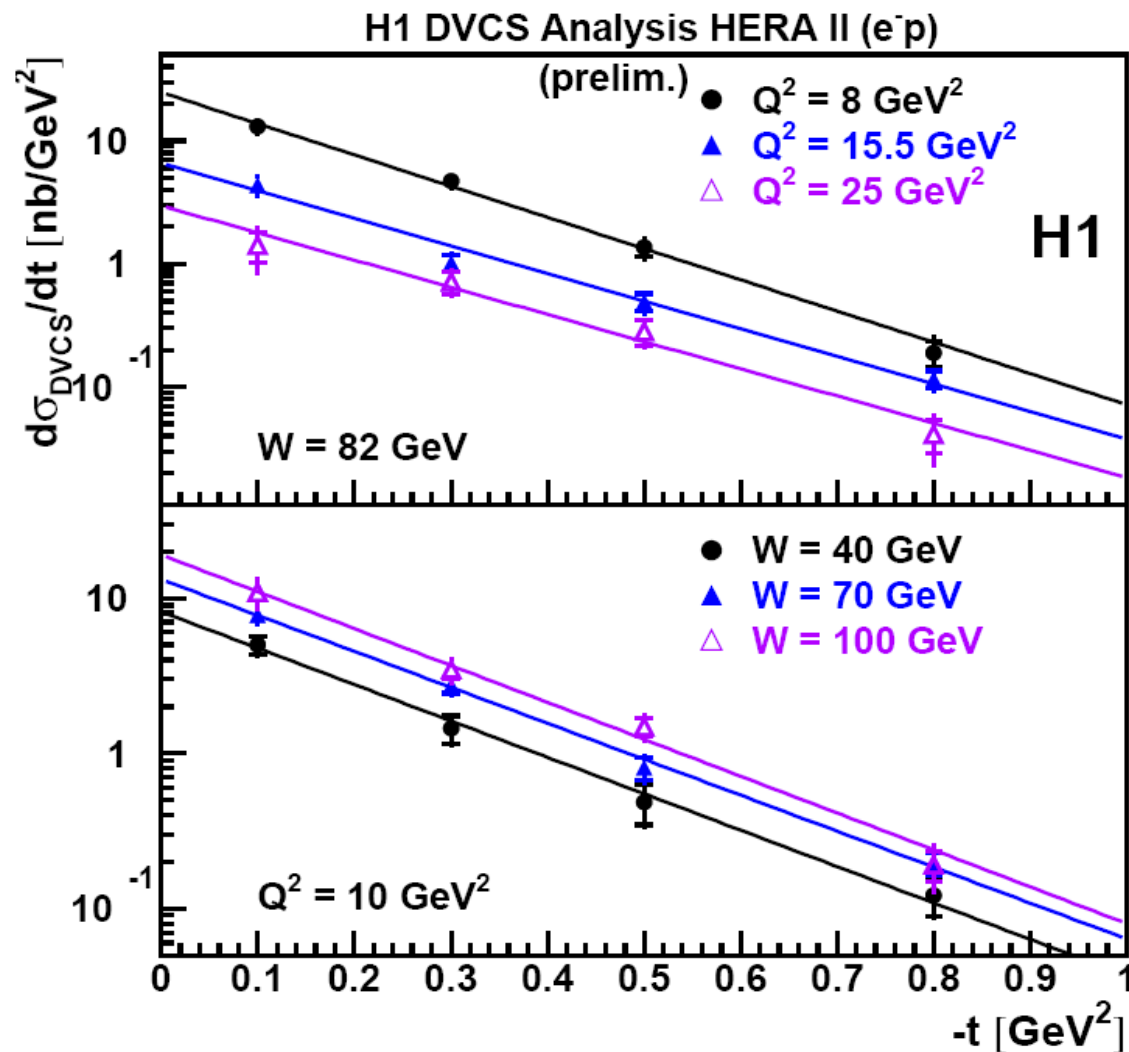
$L = 145 \text{ pb}^{-1}$
2005; <mid-2006



e^+ sample : $e^+ p \rightarrow e^+ \gamma p$

$L = 146 \text{ pb}^{-1}$
2004; >mid-2006; 2007

New H1 results on $d\sigma/dt$

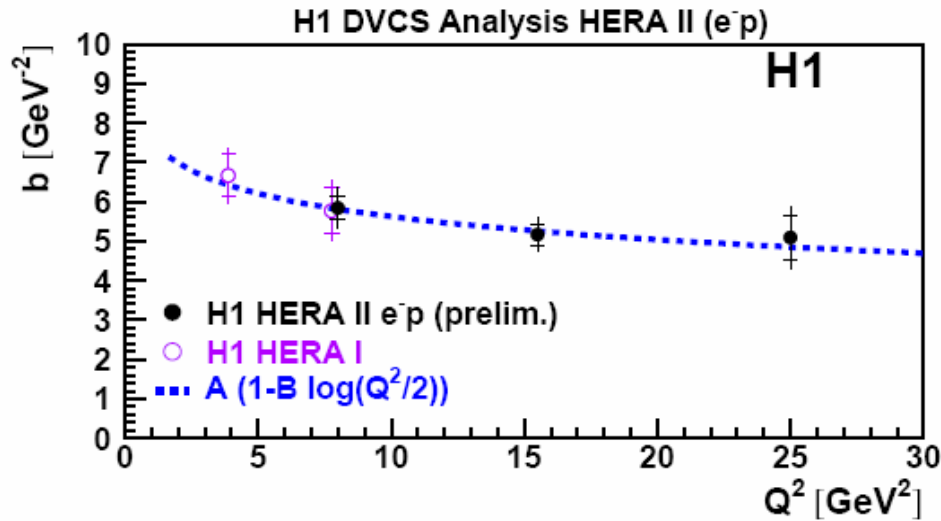


Measurement @
various Q^2 and W values

Best description with an
exponential fit of the
form : $d\sigma/dt \sim \exp(bt)$
 \Rightarrow t -slope parameter $b()$

(with $\langle r_T^2 \rangle := 2b$)

New H1 results on $d\sigma/dt$



$$b(Q^2) = A * (1 - B * \log(Q^2/2))$$

$$A = 6.98 \pm 0.98 \text{ GeV}^{-2}$$

$$B = 0.12 \pm 0.03$$

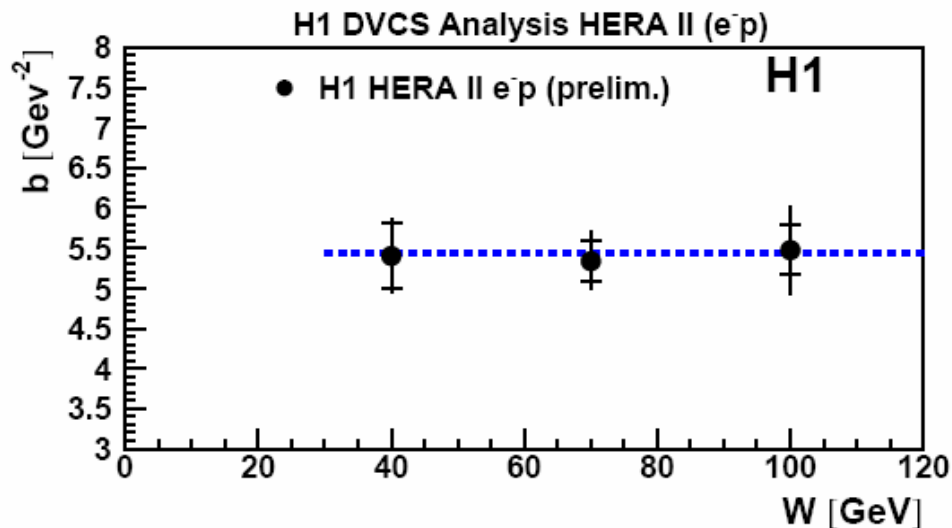
no W dependence!

Global value :

$$b = 5.45 \pm 0.19 \pm 0.34 \text{ GeV}^{-2}$$

$$\Rightarrow \sqrt{\langle r_T^2 \rangle} = 0.65 \text{ fm}$$

\gg valence quarks value



$b()$ measurements @ H1 (low x):
dominated by glue and sea quarks
// exclusive production of light
states (ρ, ϕ)

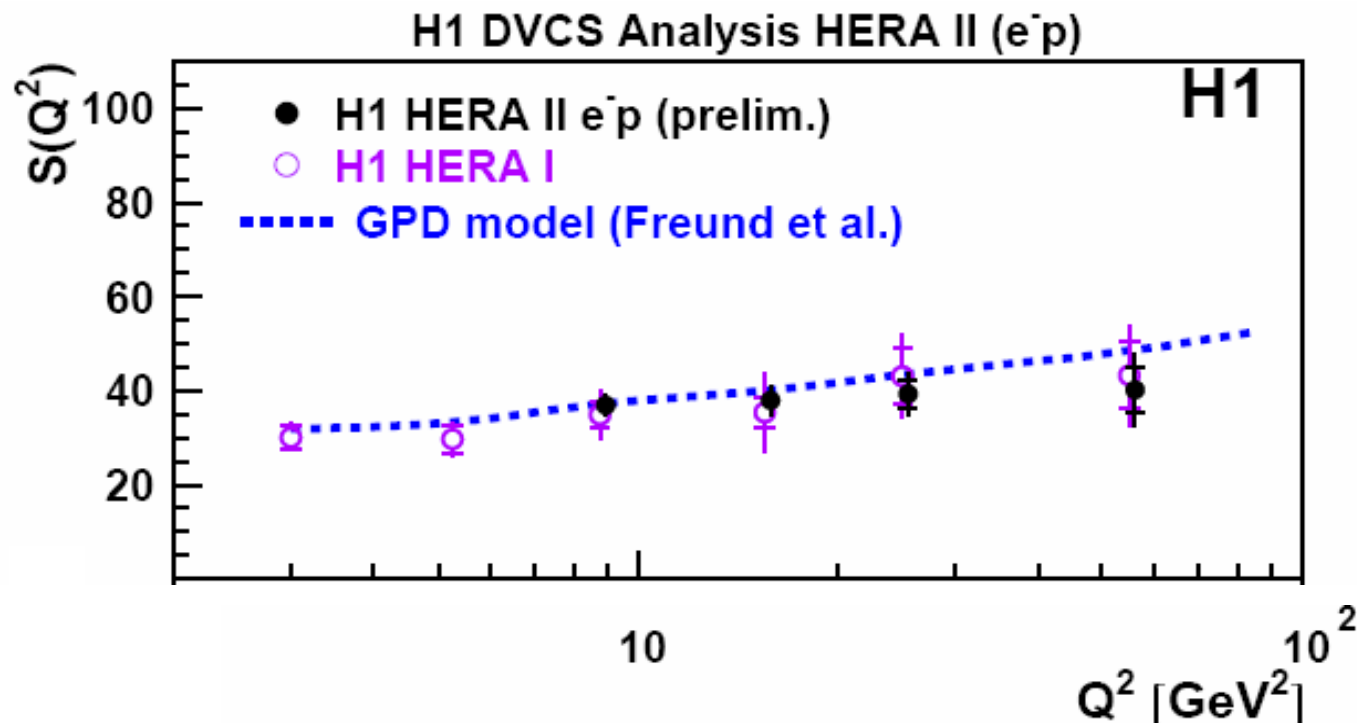
GPD approach

$$\sigma_{\text{DVCS}}(Q^2, W) = [\text{Im}A_{\text{DVCS}}(Q^2, W)]^2 (1+\rho^2) / [16 \pi b(Q^2, W)]$$

We define $S(Q^2) := \text{Im}(A(\gamma^*p \rightarrow \gamma p)) = [16\pi b(Q^2) \sigma_{\text{DVCS}}(Q^2, W)/(1+\rho^2)]^{1/2}$

@ LO we can write : $S(Q^2) = 4\pi^2 \alpha/W^2 \langle e \rangle^2 \text{GPD}^S(\xi, \xi, Q^2) \quad \xi \sim x_{bj}/2$

=> Direct sensitivity to the weak QCD evolution[Q^2] of the GPDs

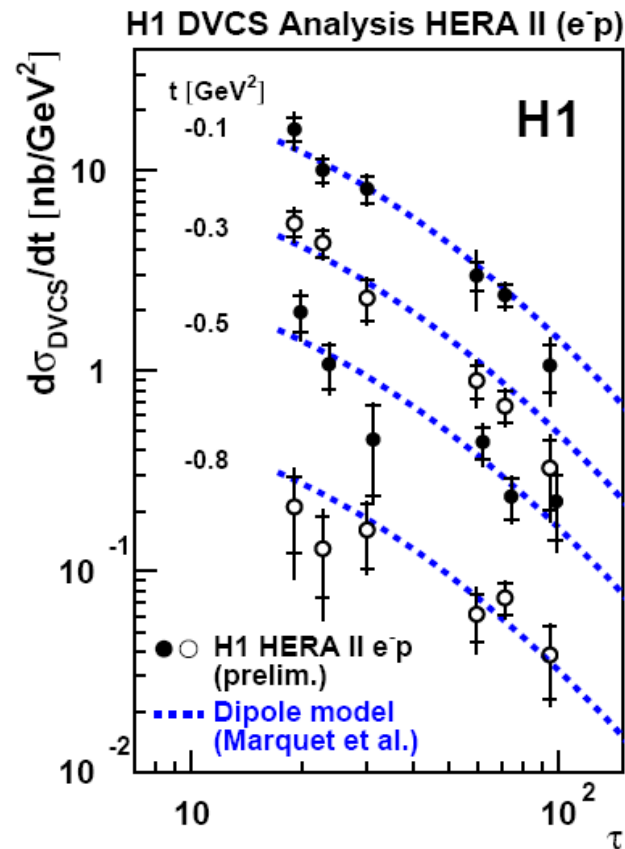
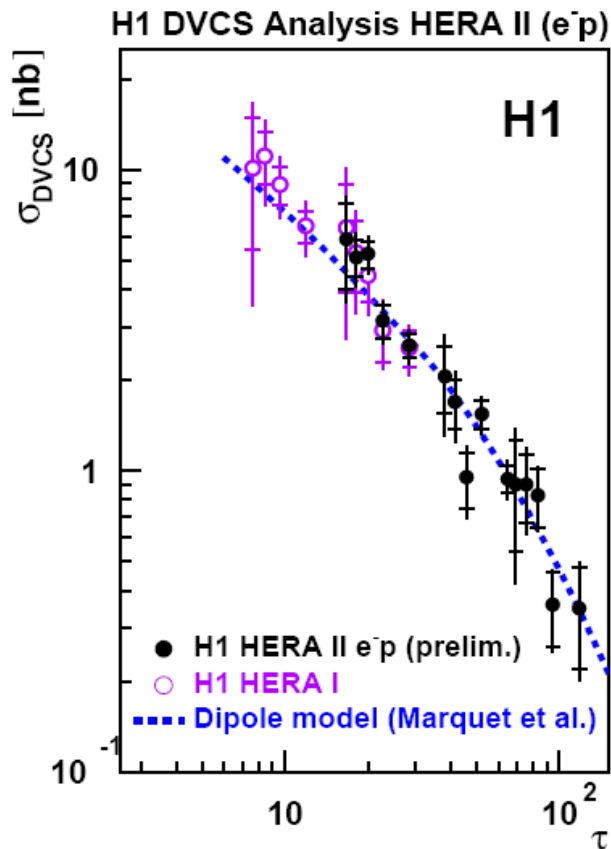


Dipole approach

With the measured b value & the dipole σ from Itakura-Iancu-Munier
 \Rightarrow we get σ_{DVCS} from the dipole model

Reminder from the Geometric Scaling for DVCS (Marquet et al.)

$\sigma_{\text{DVCS}}(x, Q^2) = \sigma_{\text{DVCS}}(\tau = Q^2/Q_s^2)$ with $Q_s = Q_0 (x_0/x)^{1/2}$ (not dependent on t)



$$\tau = Q^2 / Q_s^2$$

A step further : Beam Charge Asymmetry

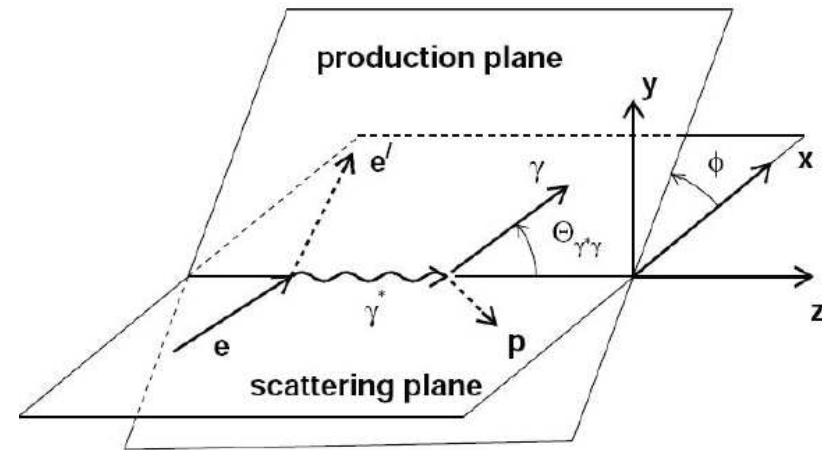
Let's neglect beam polarisation effects

$$d\sigma_{(ep \rightarrow ep\gamma)} \approx d\sigma^{\text{BH}} + d\sigma^{\text{DVCS}}_{\text{unpol}} + a^{\text{BH}} \text{Re} A^{\text{DVCS}} \text{ (interference term)}$$

with $a^{\text{BH}} \text{Re} A^{\text{DVCS}} \approx +/- \{ \text{Re}(M^{11}) \cos(\phi) + \text{Re}(M^{01})\cos(2\phi) + \text{Re}(M^{-11})\cos(3\phi) \}$
 $+/- == \text{incident lepton charge}$

$$\text{Re}(M^{11}) = P \int_{-1}^{+1} dx \frac{\text{GPD}(x, \xi, t)}{x - \xi + i\epsilon} + c.t.$$

=> direct access to GPDs



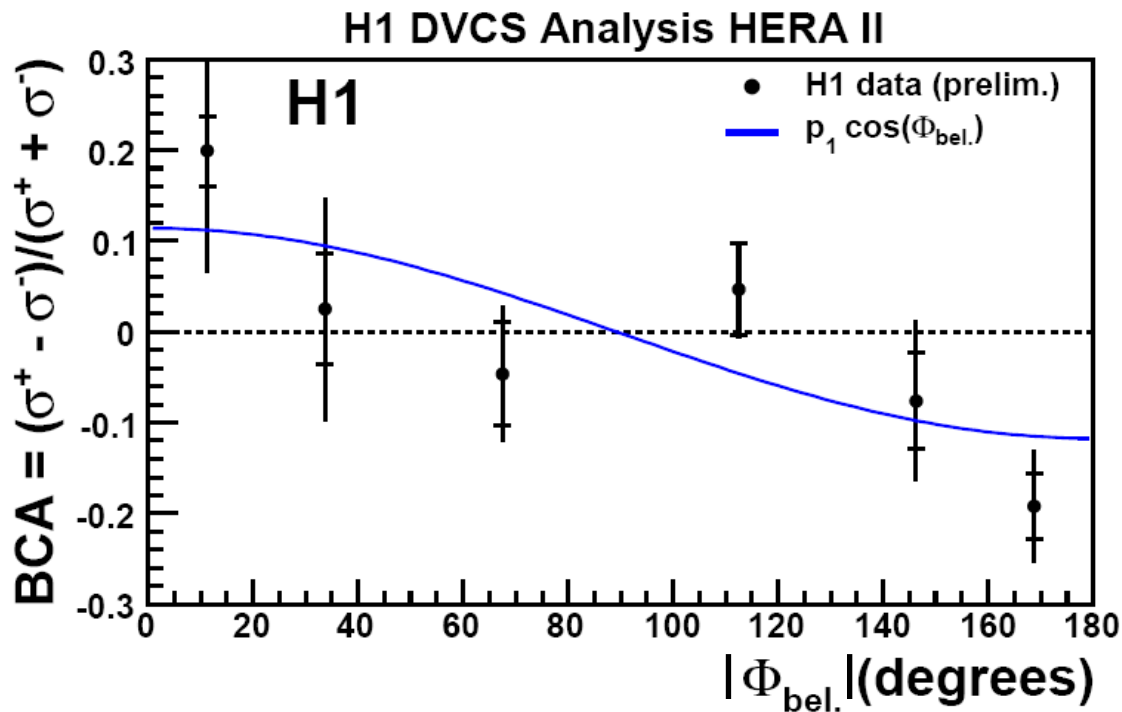
Large sensitivity to GPD models, in particular to (x,t) correlations
 (Freund '03 ; Guzey '05)

Complementarity with cross-section measurements, which are mainly sensitive to the GPD @ one point : $x=\xi$

Beam Charge Asymmetry

HERA II data with 291 pb⁻¹ analysed
(equally shared in the e⁺ & e⁻ samples)

$$BCA = \sigma^+ - \sigma^- / \sigma^+ + \sigma^- \sim p_1 \cos(\phi) + \dots$$



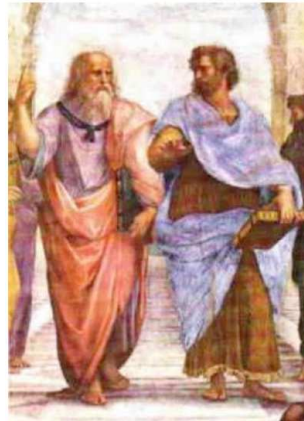
p_1 is found well > 0
(a first indication of
a non factorised (x,t)
model ?!)

Large potential to
examine the $GPD(x,t)$
(via p_1 and p_3 coeffs
- p_2 negligible-)

Conclusions & outlook

New DVCS analysis : e^- & e^+ samples : 291 pb^{-1} (all HERA II data)
New insights on the t dependence of the DVCS reaction (e^- sample)

GPDs
& QCD evolution
(weak Q^2 dependence)



Dipole model
& saturation
(see also talk of
R.Peschanski)

Measurement of the BCA :

This is a FIRST ANALYSIS @ colliders of the interference BH/DVCS

BCA can be a trigger of the possible GPDs models : new insights in nucleon tomography : **first indication for a significant >0 $BCA(\cos(\phi))$ (H1 @ low x)**