DVCS at HERA II

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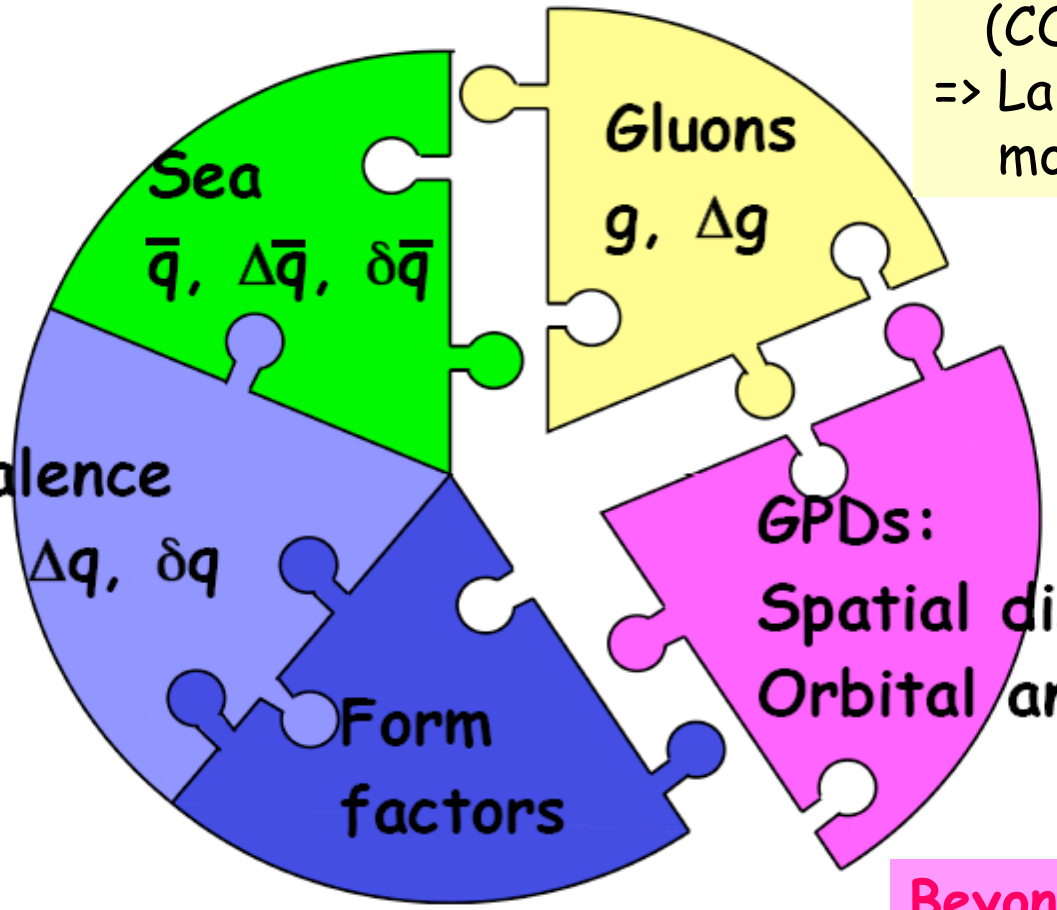
DIS 2007 – Munich

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



TRIBUTE of HERA to LHC

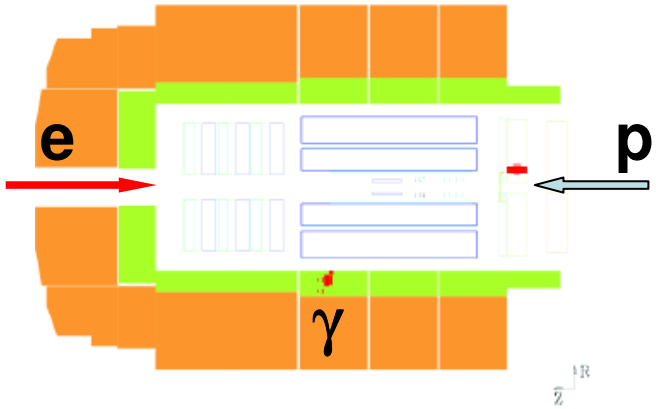
Δg rather low (COMPASS)
=> Large orbital momentum ?

DVCS

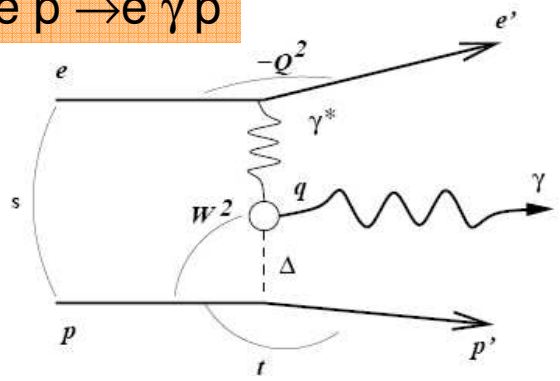
Beyond the tribute :
Nucleon tomography

The DVCS process

DVCS reaction : QCD exclusive prod. of a real γ

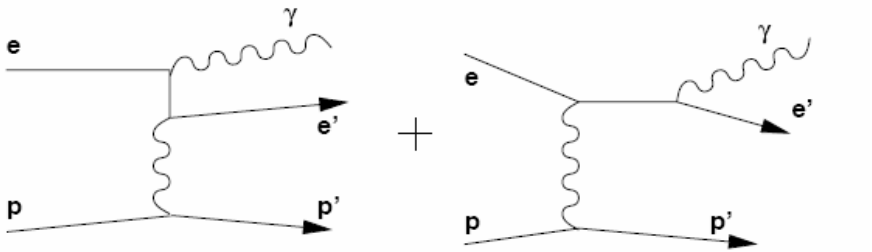


e p →e γ p



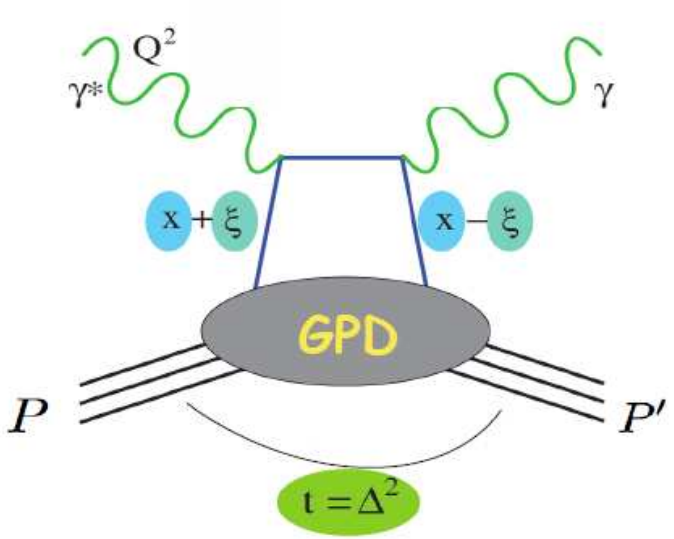
$$s = (e+p)^2$$
$$Q^2 = -q^2 = -(e-e')^2$$
$$W^2 = (q+p)^2$$
$$t = \Delta^2 = (p-p')^2 \approx -p_T'^2$$

Identical final state : QED Bethe-Heitler process



=> Interference DVCS & BH (Beam Charge Asymmetry)

The DVCS process in QCD

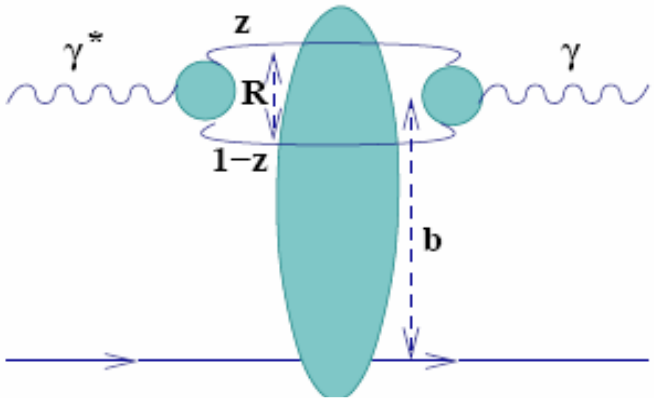


- x: average quark momentum frac^n
- ξ: "skewing parameter" = $x_1 - x_2$
- t: 4-momentum transfer^2

DVCS cross section ~
$| \int dx \; Coef \otimes GPD |^2$

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

- Dipole model interpretation :



DVCS cross section ~
$| \int dR dz \; \psi_{ini}^{\gamma^*} \; \sigma_{dip} \; \psi_{out}^{\gamma} |^2$

σ_{dip} universal (F2, DVCS) ?

Nucleon tomography with DVCS

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

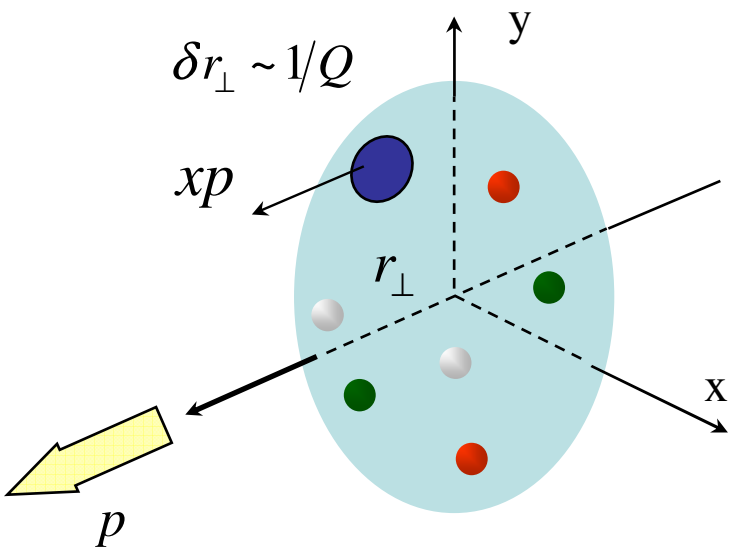
$$q(x,\mathbf{r}_\perp,Q^2)=\int\frac{d^2\Delta_\perp}{(2\pi)^2}\,e^{-i\mathbf{r}_\perp\cdot\Delta_\perp}\,GPD_q(x,Q^2,t=-\Delta_\perp^2)$$

$r_\perp$ & $\Delta_\perp$ are conjugate variables :

$\langle r_T^2\rangle = 4\ d/dt[GPD(x,t)]/GPD(x,0)$

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

$\Rightarrow \langle r_T^2\rangle = 2b = 0.46\ fm^2$



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

=> spatial distribution of sea and glue

Experimental conditions

Kinematic domain

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

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

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

The DVCS cross section is extracted by subtracting the BH contribution + proton dissociation bckg *(note : the interference contribution is estimated < 1% -integration over ϕ_{Bel}-)*

Dominant systematic uncertainties

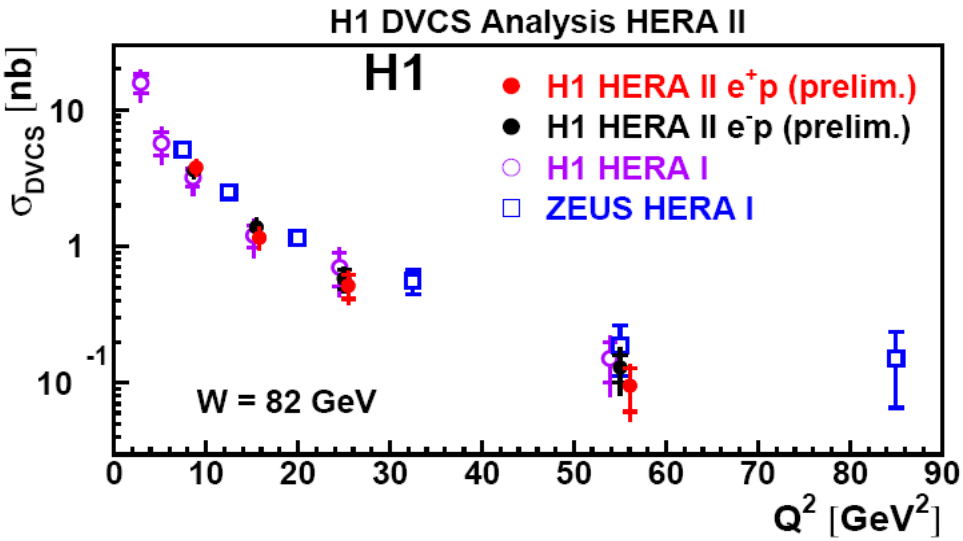
-Acceptance (t-slope parameter b variation by 7.5%) : $d\sigma/\sigma$ ~10%

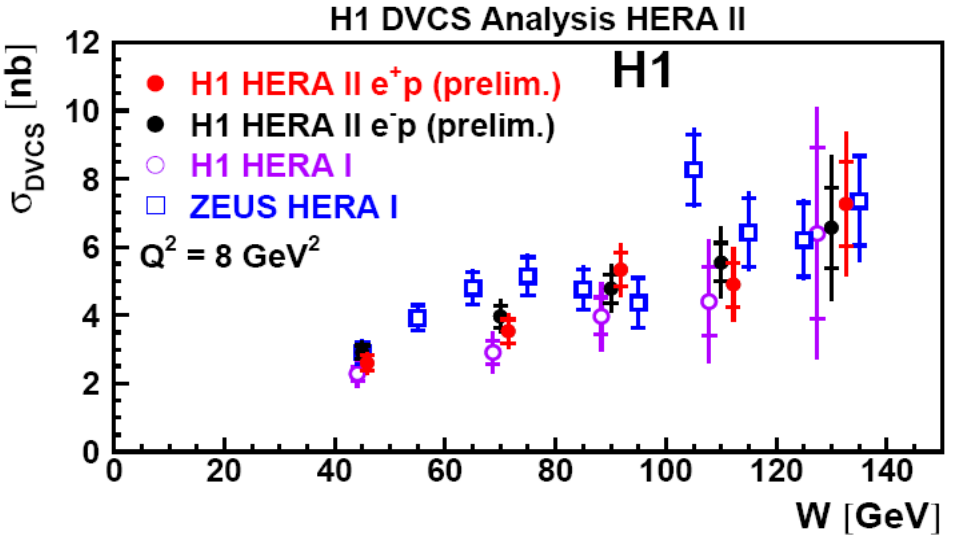
-Proton dissociation bckg (25% uncertainty on the contribution) : $d\sigma/\sigma$ ~ 5%

-Uncertainty on θe (1mrad) & $\theta\gamma$ (3mrad) : $d\sigma/\sigma$ ~ 5%

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

Analysis samples





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

L = 145 pb^{-1}

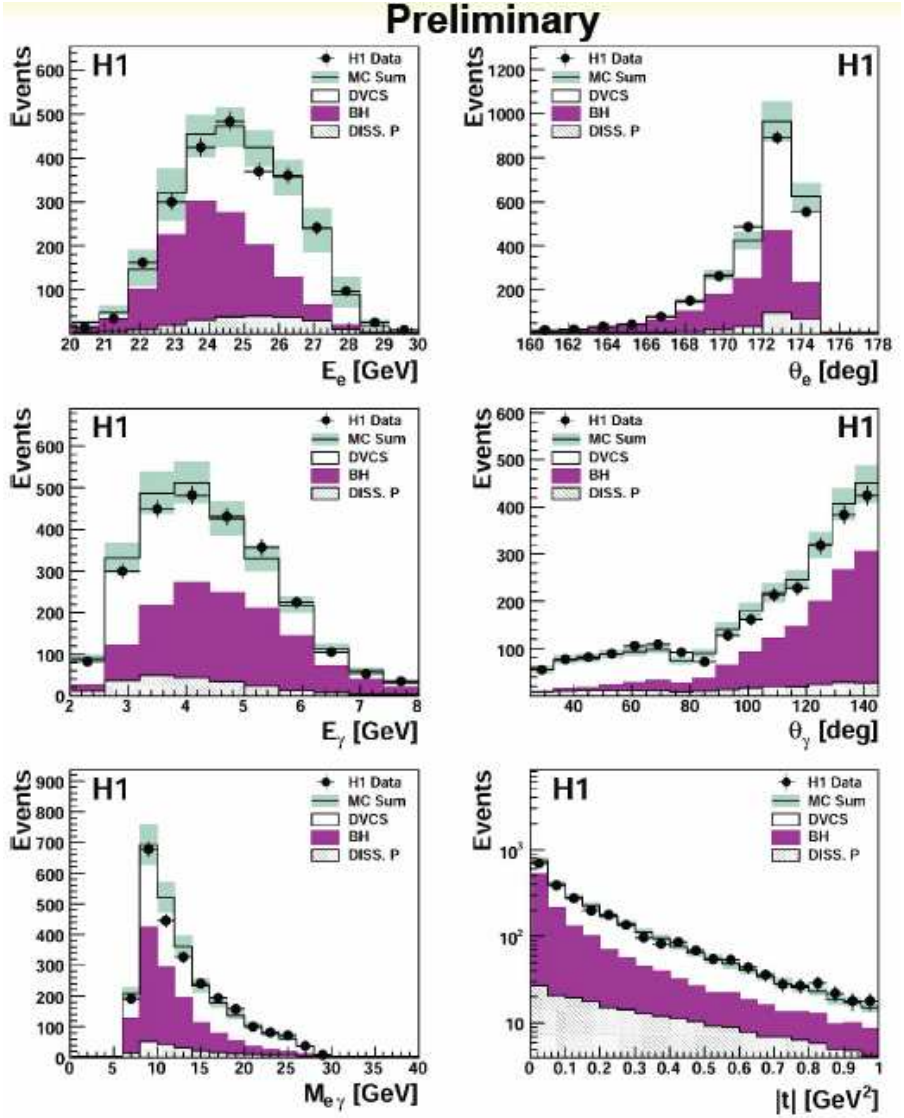
2005;<mid-2006

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

L = 146 pb^{-1}

2004;>mid-2006;2007

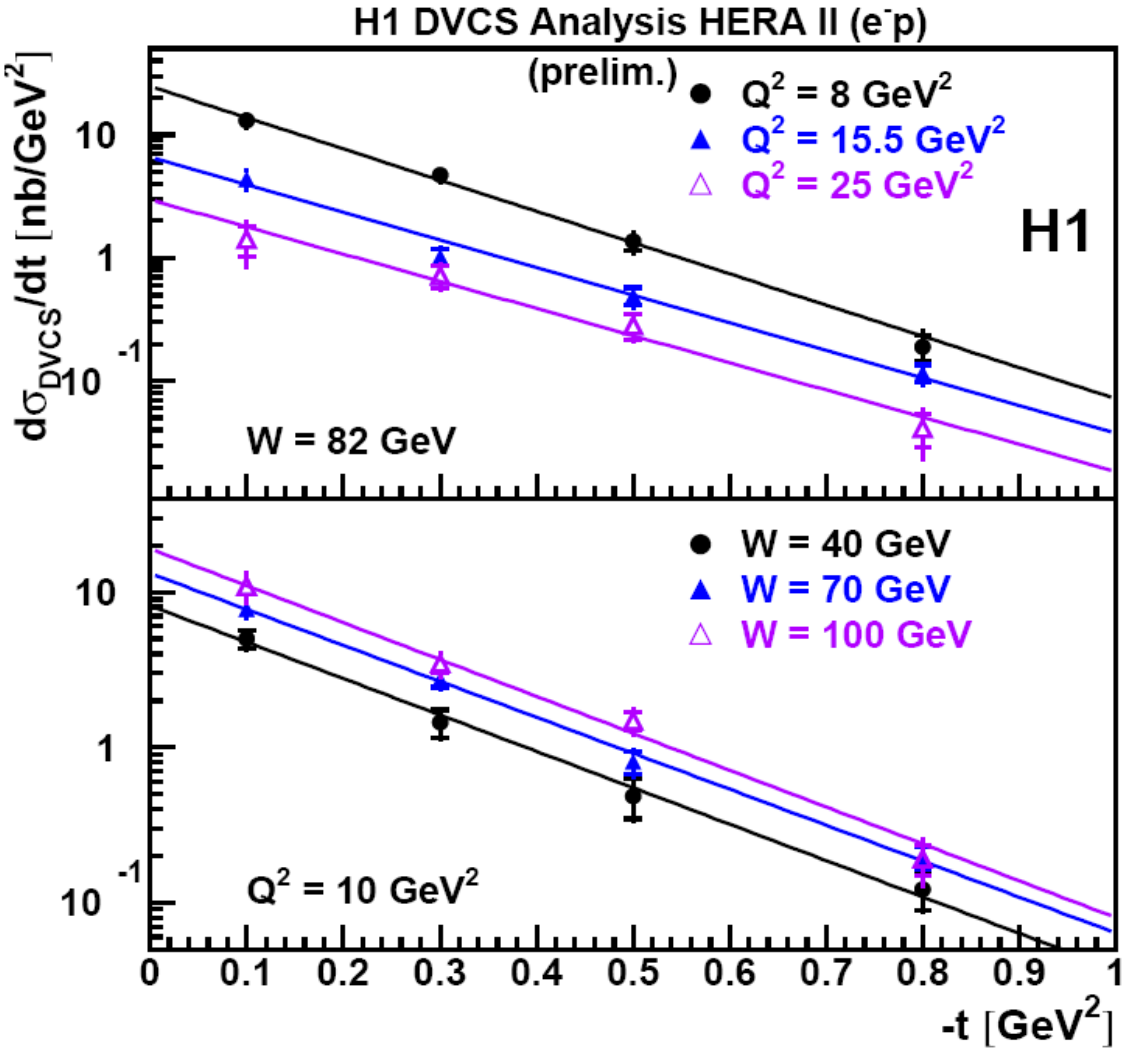
Control plots for the e- sample



DVCS data sample compared to
The sum of MC expectations :

BH (elastic + inelastic components)
+ DVCS (elastic)
+ DVCS (inelastic : DISS. P)

New H1 results on dσ/dt

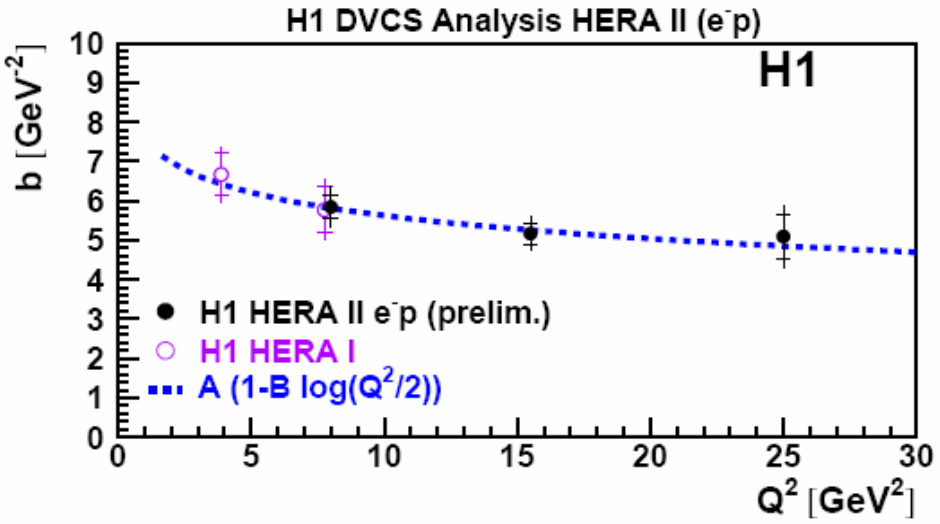


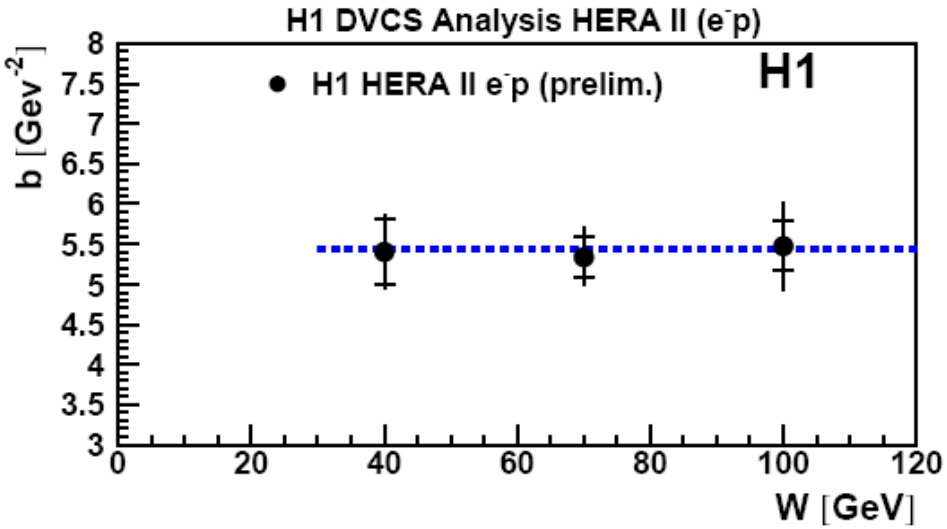
Measurement @ various Q^2 and W values

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

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

New H1 results on dσ/dt





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

A = 6.98 +/- 0.98 GeV^{-2}
B = 0.12 +/- 0.03

no W dependence!

Global value :

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

=> $\sqrt{\langle r_T^2 \rangle}$=0.65 fm
>> valence quarks value

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

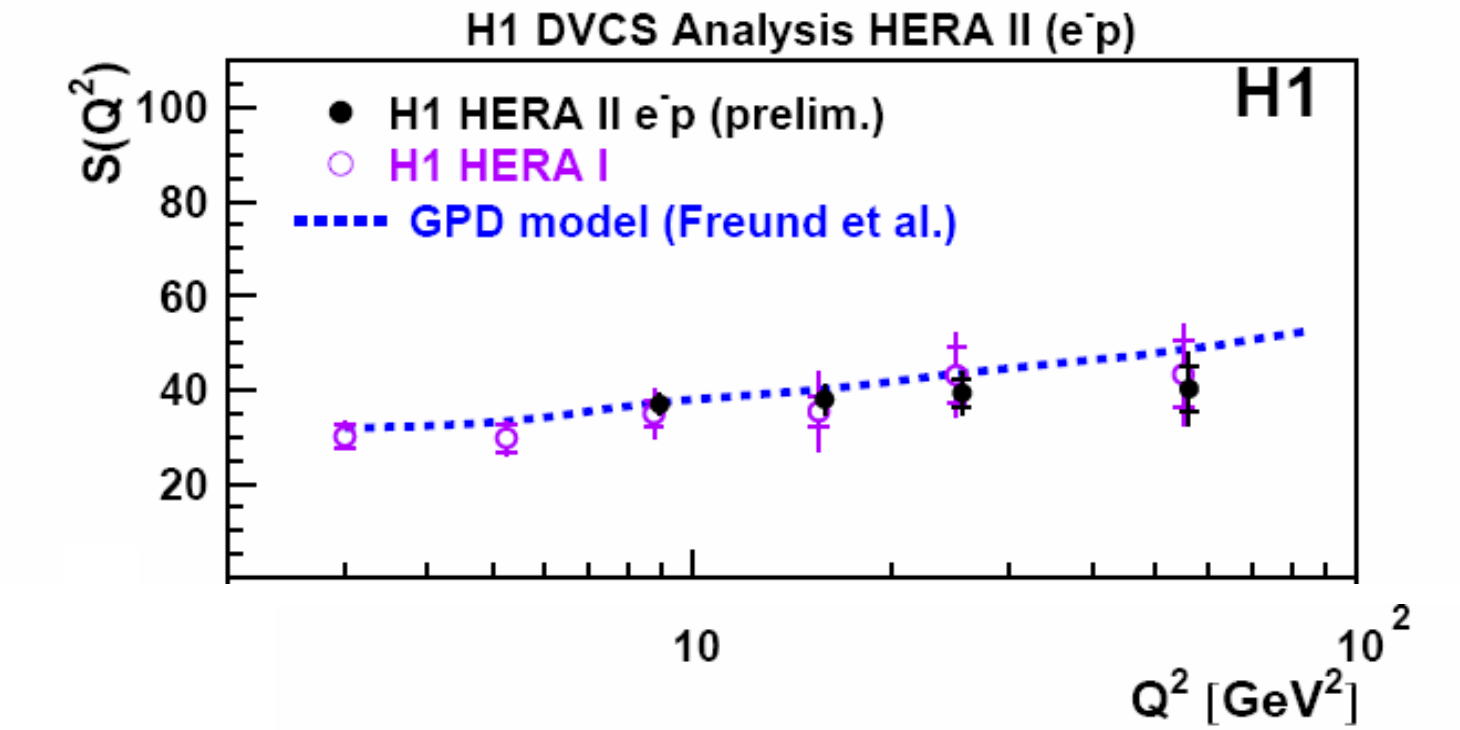
GPD approach

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

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

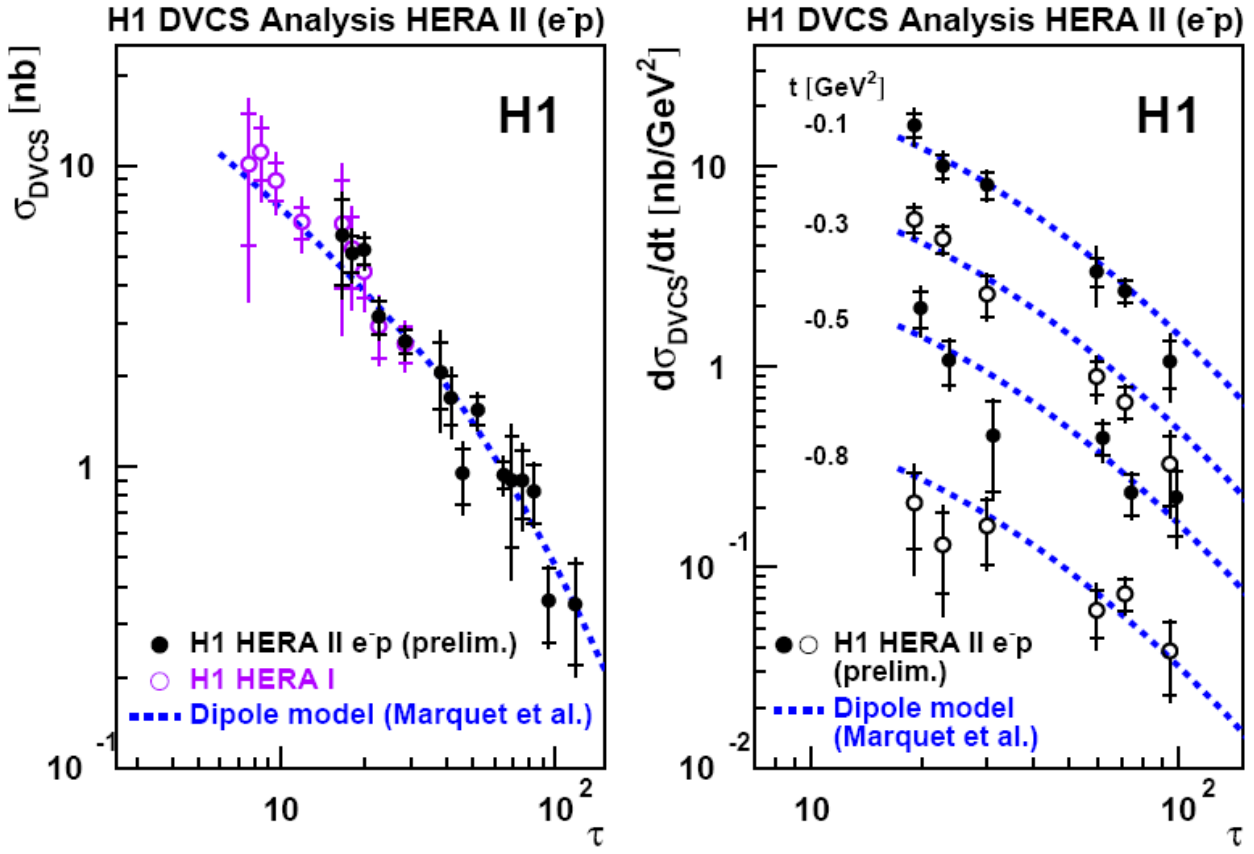
@ LO we can write : $S(Q^2) = 4\pi^2\alpha/W^2 \ \langle e \rangle^2 \ GPD^S(\xi,\xi,Q^2)$ $\quad \xi \sim x_{bj}/2$

=> 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
=> we get σ_{DVCS} from the dipole model
Reminder from the Geometric Scaling for DVCS (Marquet et al.)
$\sigma_{DVCS}(x,Q^2)=\sigma_{DVCS}(\tau=Q^2/Q_s^2)$ *with* $Q_s=Q_0\,(x_0/x)^{\lambda/2}$ *(not dependent on t)*



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

A step further : Beam Charge Asymmetry

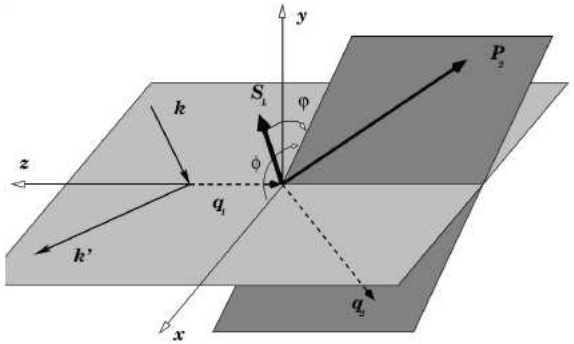
Let's neglect beam polarisation effects

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

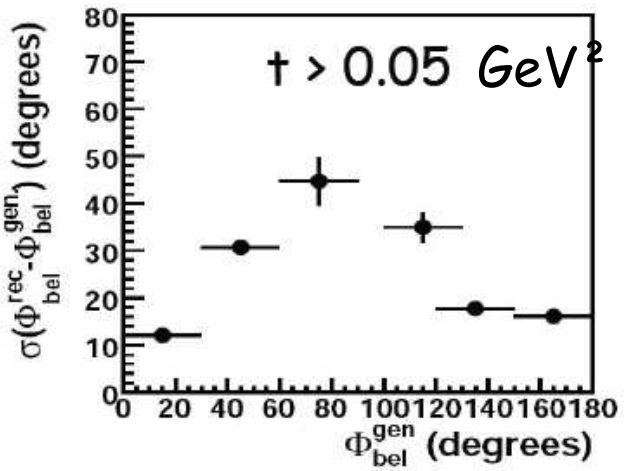
with $a^{BH}\ Re\ A^{DVCS} \approx$ **+/-** { $\mathbf{Re(M^{11})\ cos(\phi)}$ + $Re(M^{01})\cos(2\phi)$ + $Re(M^{-11})\cos(3\phi)$ }

+/- == incident lepton charge

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



=> direct access to GPDs



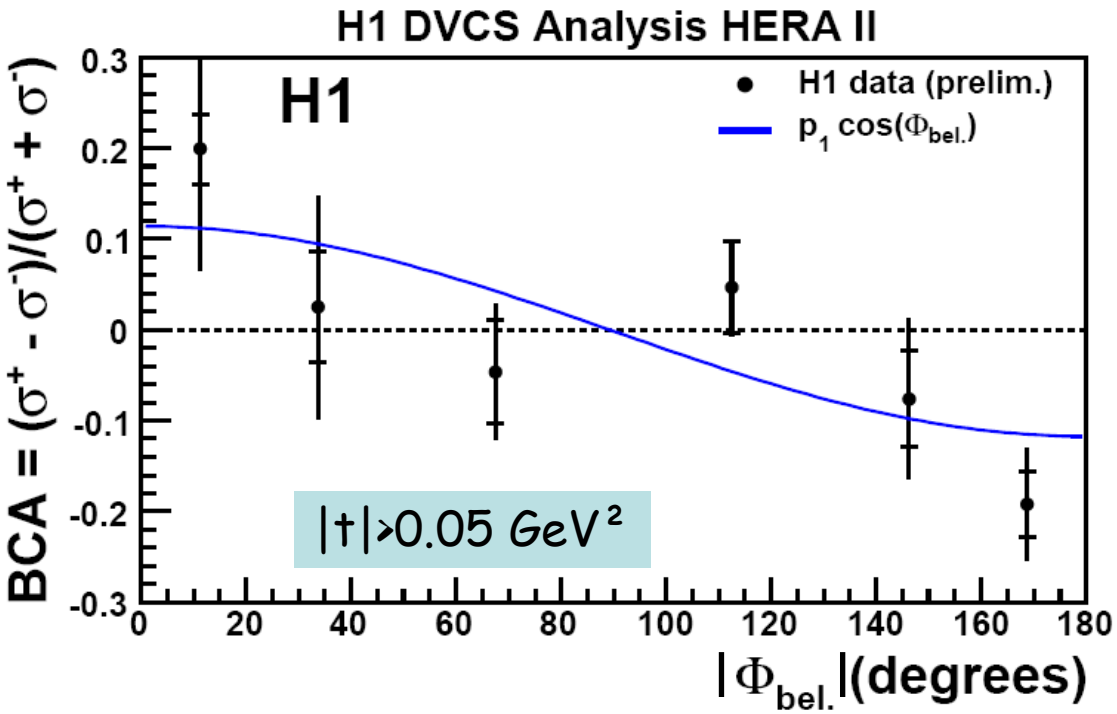
Large sensitivity to GPD models,
in particular to (x,t) correlations
(Freund '03 ; Guzey '05)

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

Beam Charge Asymmetry

HERA II data with 291 pb^{-1} analysed
(equally shared in the e+ & e- samples)

BCA = $\sigma^+ - \sigma^- / \sigma^+ + \sigma^- \sim$ p1 cos(ϕ)+…



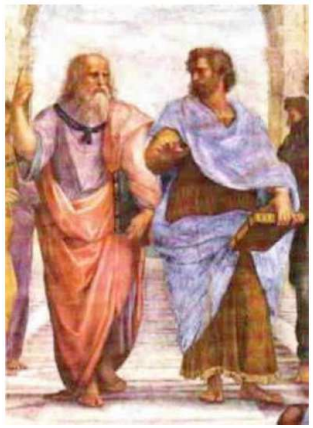
p1 is found well > 0
(a first indication of
a non factorised (x,t)
model ?!)

Large potential to
examine the GPD(x,t)
(via p1 and p3 coefs
-p2 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(ϕ)) (H1 @ low x)**