DVCS at HERA

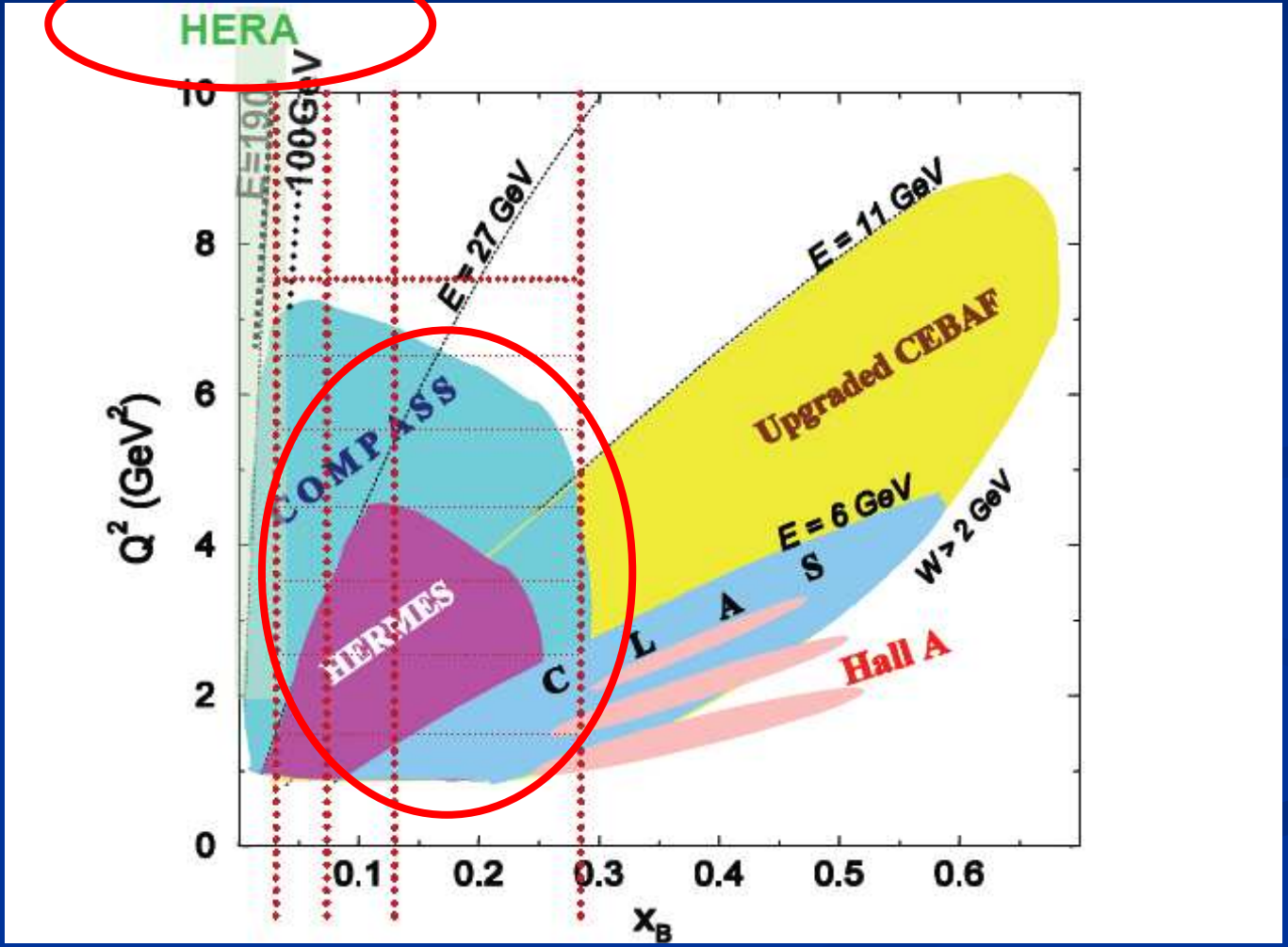
Laurent Schoeffel

CEA Saclay

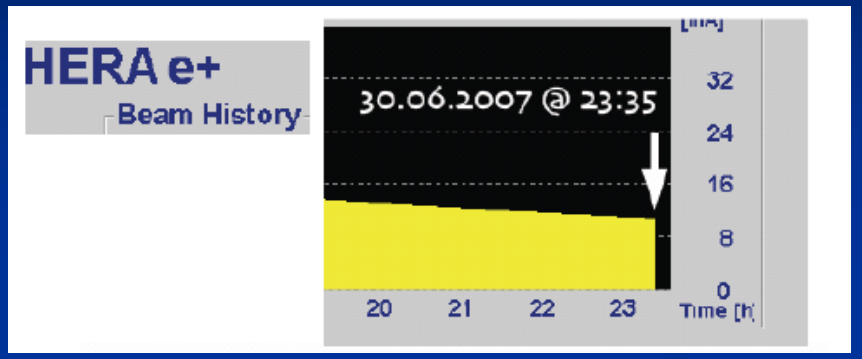
On behalf of **H1 & ZEUS** collaborations

Trento – 10/06/2008

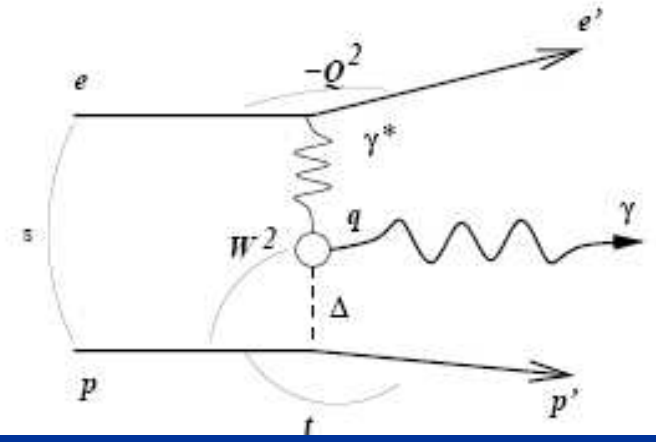
DVCS around the word present & future



DVCS kinematics @ HERA



DVCS: QCD process



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

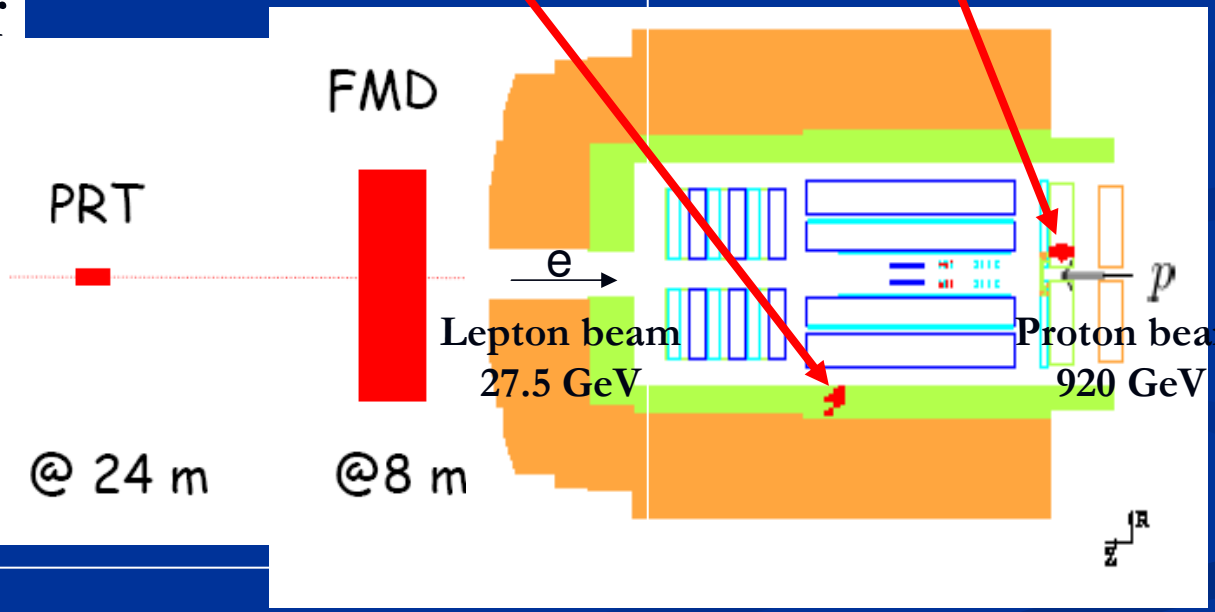
DVCS at HERA (H1/ZEUS)
some basic characteristics

- Low x kinematics ($x<0.01$) : large gluon density, saturation effects?!
- Large Q^2 range: from 2 GeV^2 till 100 GeV^2 : possibility to test scaling violations in Skewed PDFs (or GPDs) dynamics
- At low x & medium Q^2, DVCS cross section is larger than BH cross section! Interesting feature which allows direct measurement of DVCS xs

DVCS at HERA
What do we measure?

2 Electro-Magnetic clusters:
1 photon & 1 electron (or positron)

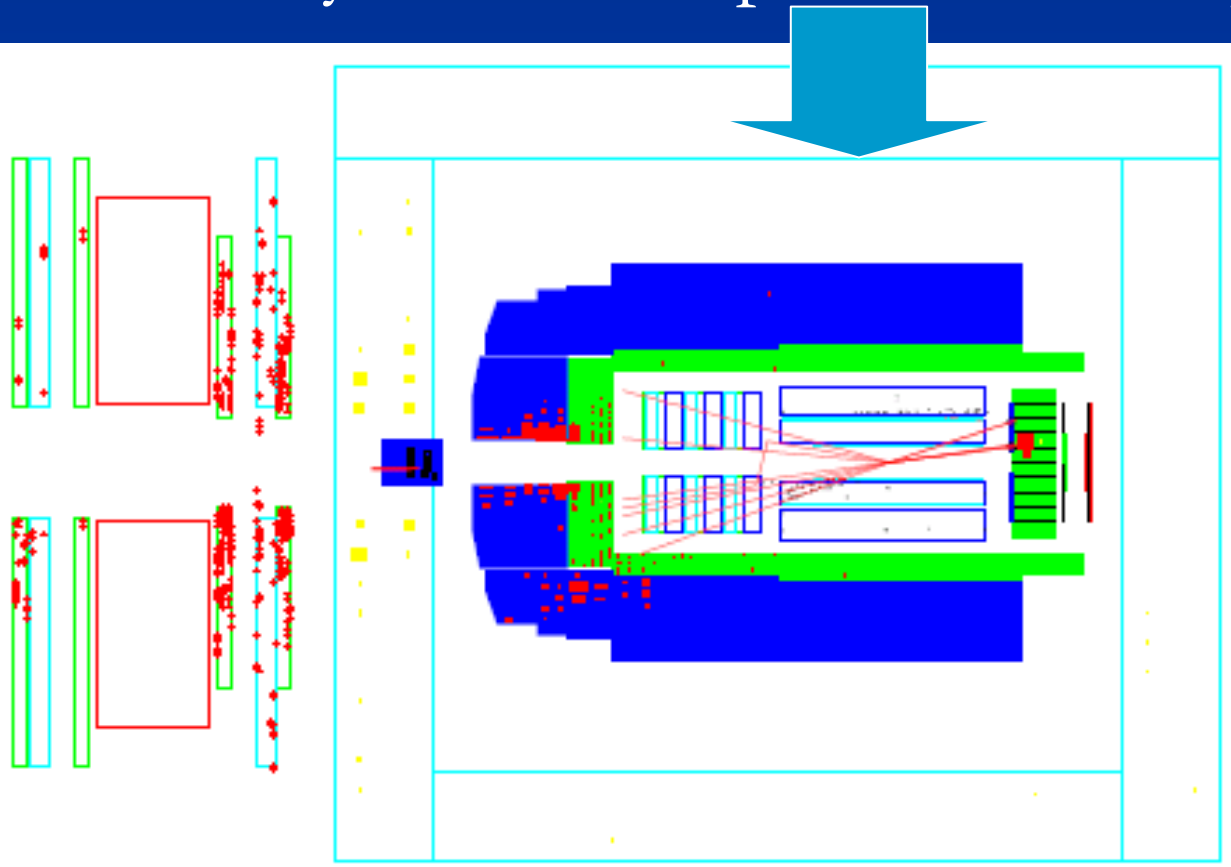
and no other activity in detectors



$e + p \rightarrow e + \gamma + Y \qquad Y \sim p'$

DVCS at HERA
On the visibility of the signal?

Most DIS events @ low x presents some activity due to the proton break up

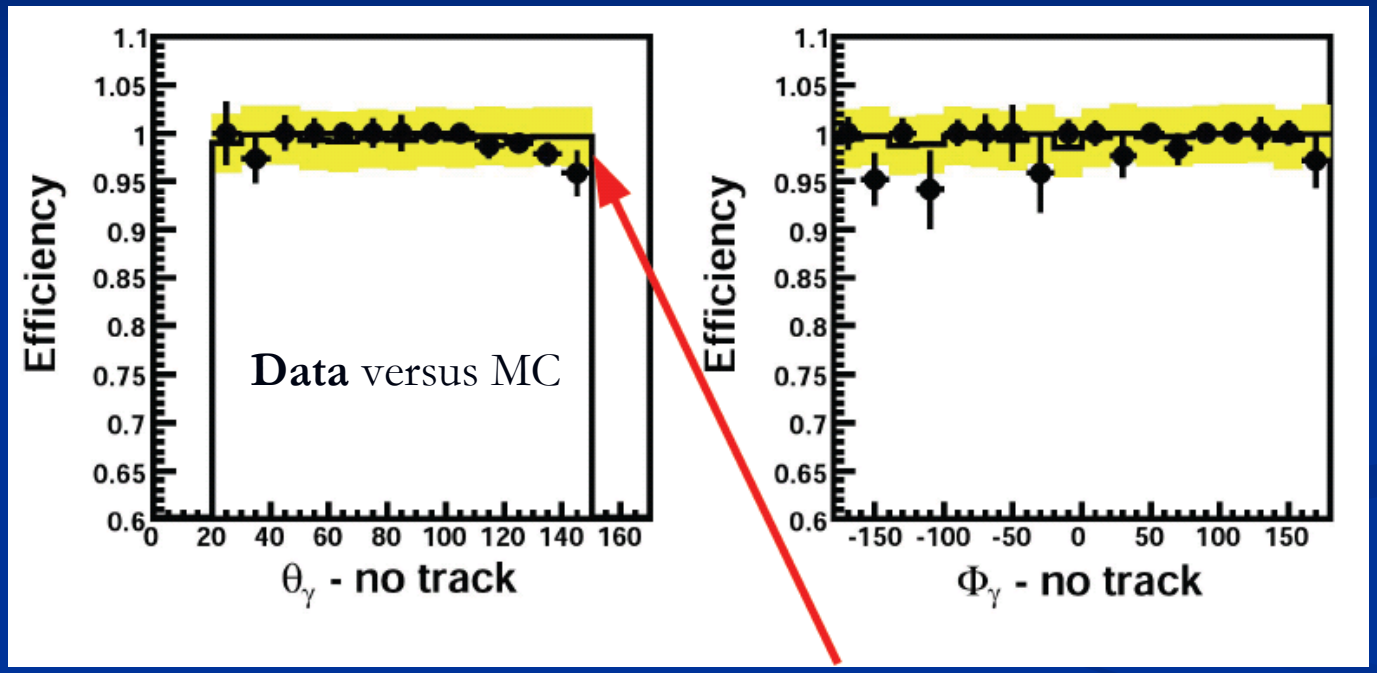


DVCS represents **~1/1000** of the DIS recorded events

DVCS at HERA
experimental considerations

- Simple signal with 2 EM clusters: but simple is not easy!
- **Not easy to trigger with a high efficiency 1 event out of 1000 standard DIS events recorded on tape**
- Not easy to cope with low multiplicity DIS backgrounds: need to manage photon conversion, track reconstruction efficiency etc.

1 example: efficiency of γ identification in the central part of the detector

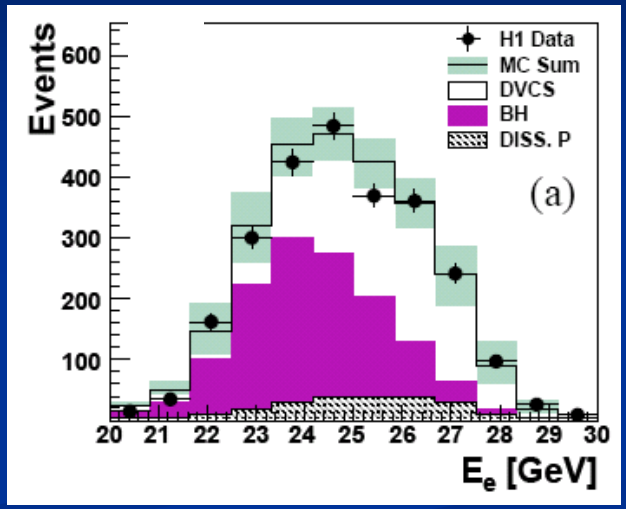


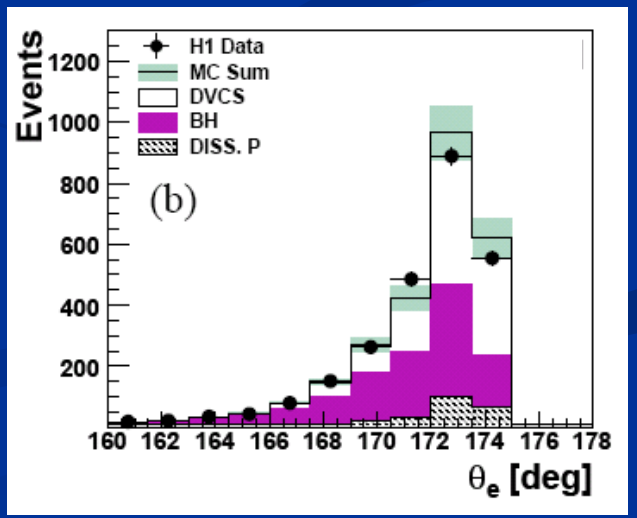
- Small correction applied to MC if θ_γ>120°, to match efficiency observed in the data
  - 3% of systematic error applied

DVCS at HERA
Results on control distributions

- Lepton variables
  Good description by Monte-Carlo (MC) with 2 dominant contributions:
  - DVCS signal (ok)
  - BH background (irreductible)

- Note: interference contribution <1% as we integrate over ϕ (lepton-proton azimuthal angle)

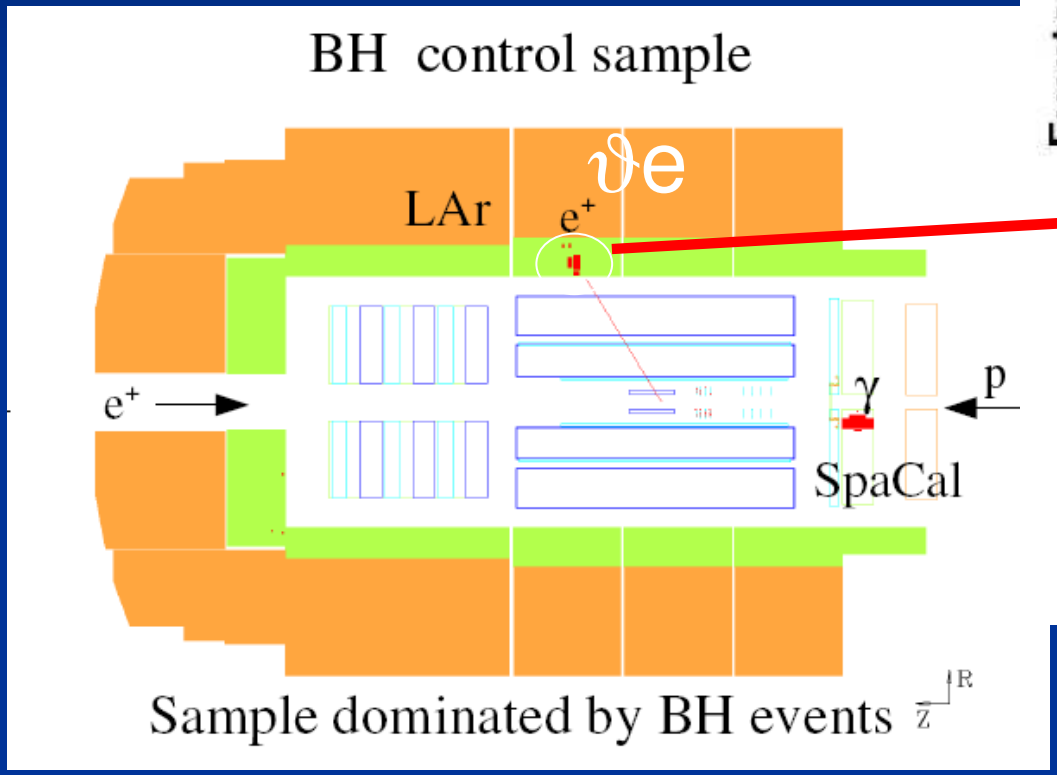


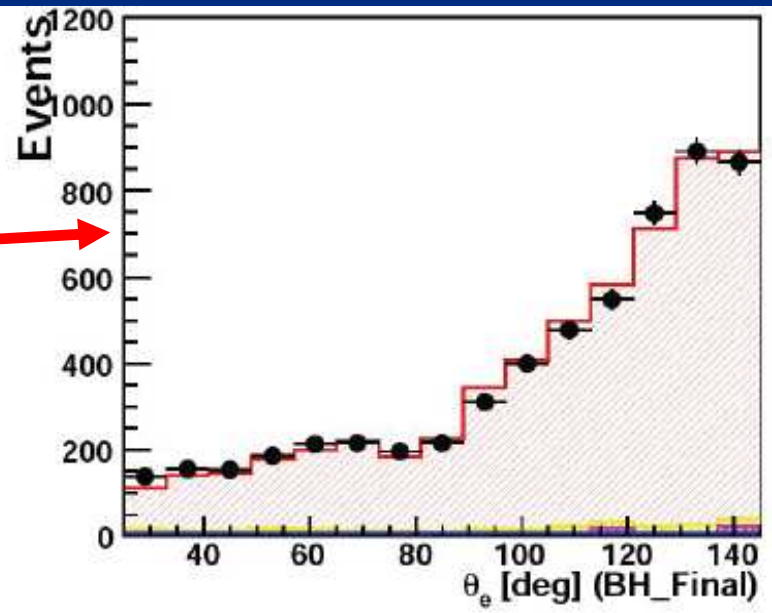


From data events to cross sections

- We measure $\mathbf{N_{data}}$ in a kinematic bin
- **We need to CORRECT this number:**
  - Ndata **corrected in** $N_{data} * N_{gen}/N_{rec}$
  - Then, we get the cross section!
  - **The correction factor $\mathbf{N_{gen}/N_{rec}}$ is calculated with the MC: it can be large ~1.5 or 2.**
- Therefore, it is an obligation to start with Data/MC comparisons at the best level! No other way to do… **This is not for aesthetical purposes…**

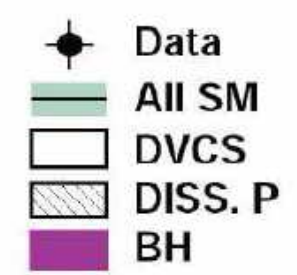
How do we control the BH component ?





Data	MC	DVCS ela.	DVCS pdis.	BH	e-e Grape	ρ	Satellites
5717	5714 ± 404	5.9 ± 0.7	1.0 ± 0.3	5430 ± 391	204 ± 12	67 ± 13	6.6 ± 2.2

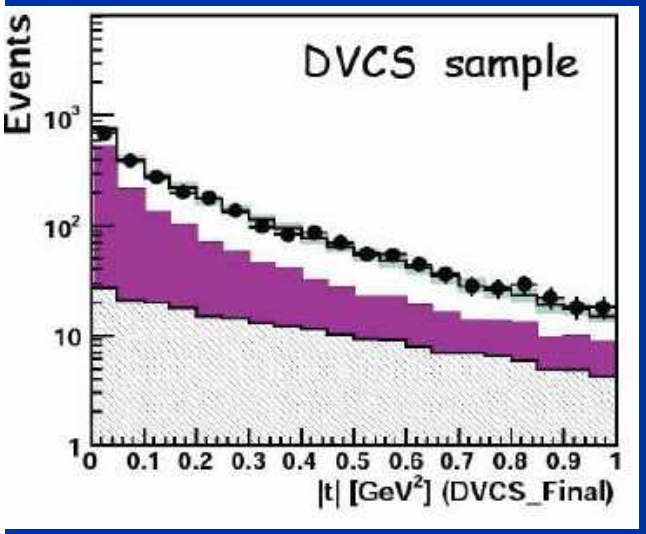
Backgrounds & MCs within the t-spectrum

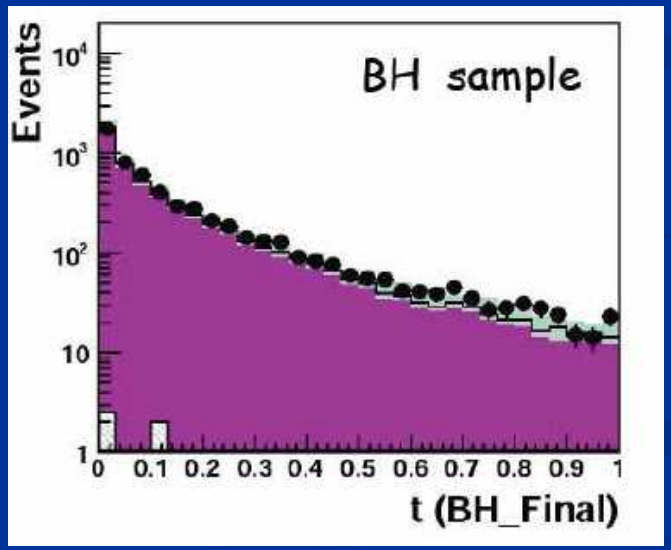


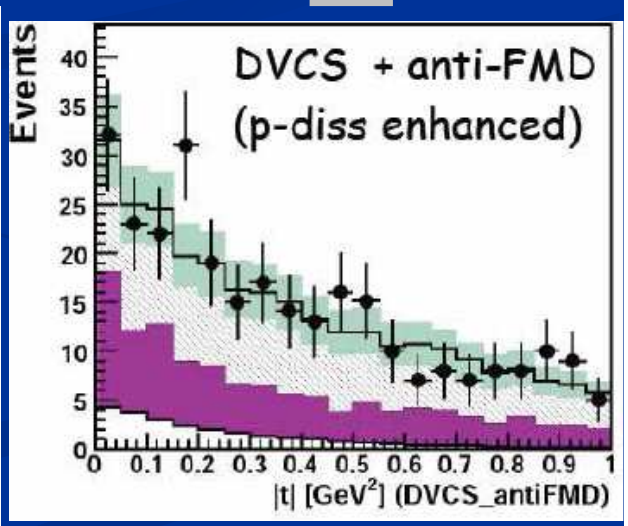
DVCS signal sample

BH control sample

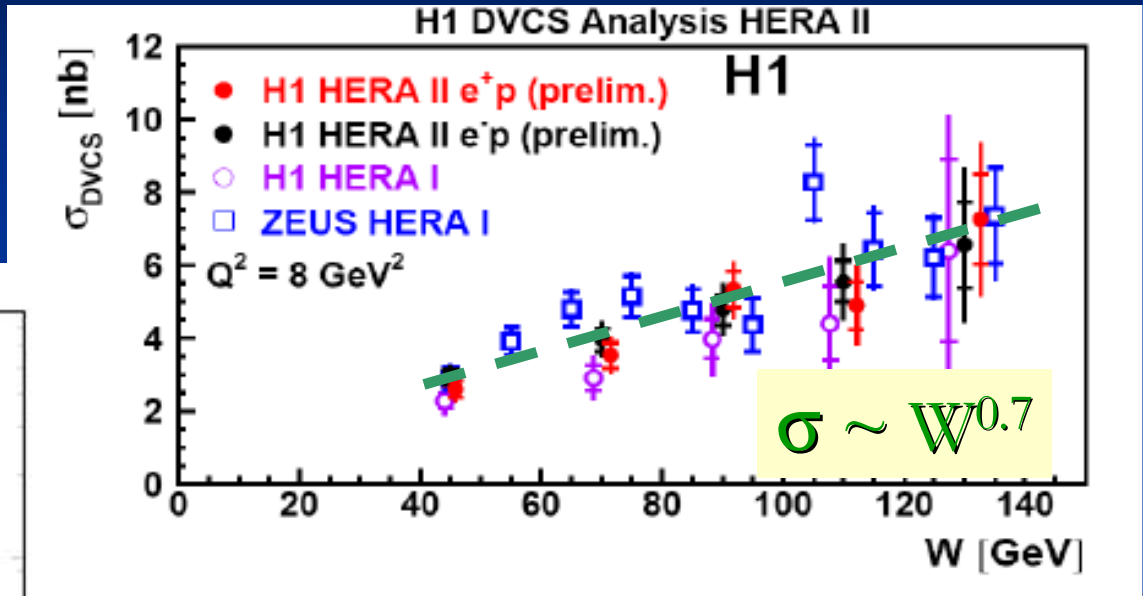
DVCS sample focused On the large M_Y values
From it, we understand this inelastic background

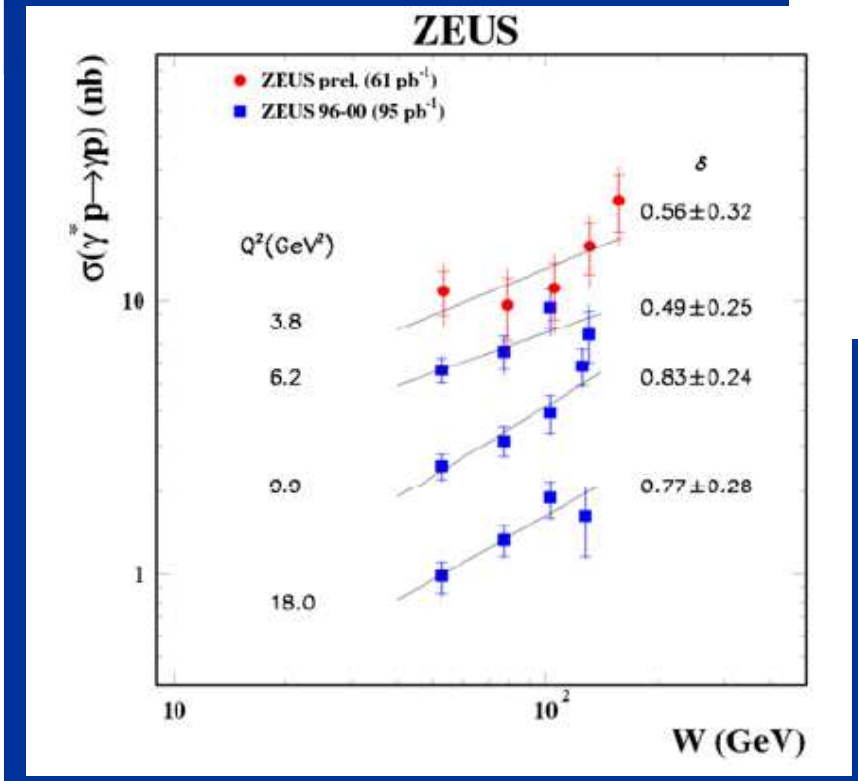






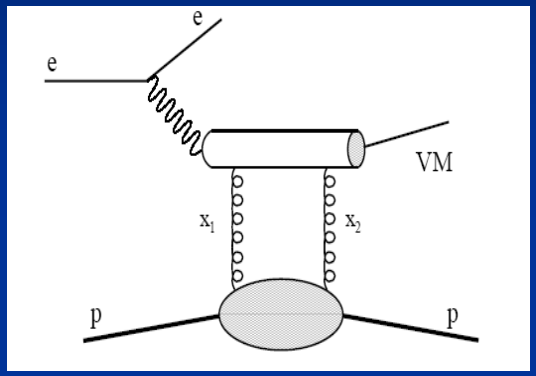
DVCS cross sections in W…
a first fundamental result



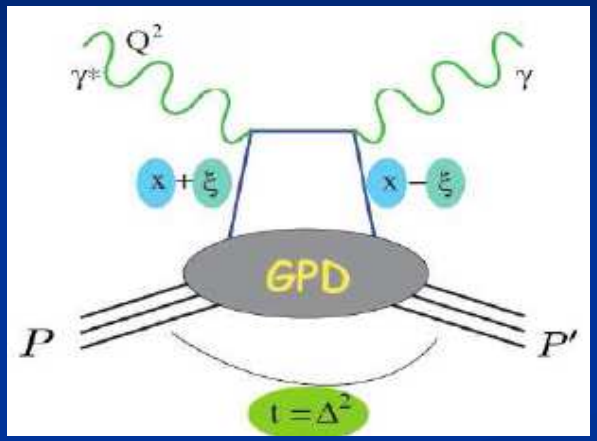


Hard W dependence
=> DVCS at HERA (low x)
is a hard process…
can be described (a priori)
by pQCD…

DVCS versus Skewing: the prospects



VM => photon



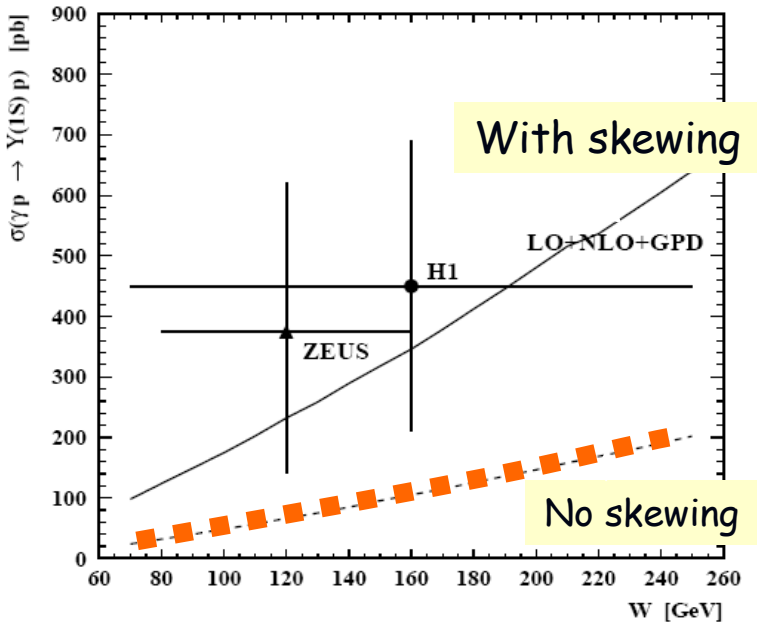
x_1-x_2 ~ [Q^2+M^2] / W^2 => $\xi \sim x_{bj}/2$

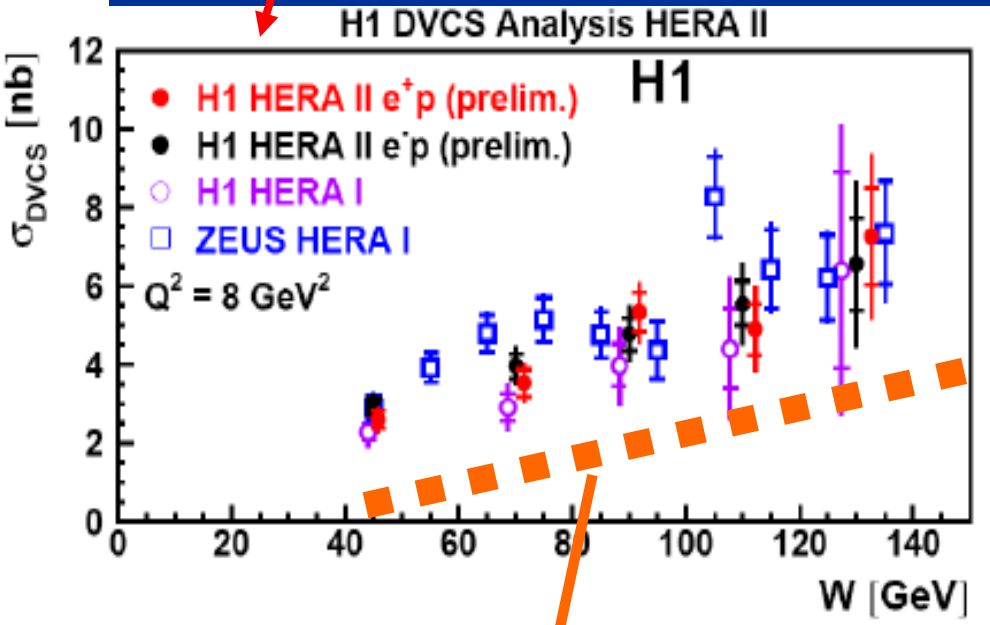
We expect skewing effects to be important
in VM & DVCS processes @ HERA
=> Replacement of PDFs by GPDs ?!

Skewing effects: the PROOF

The DVCS xs calculations include terms in $|GPD(x1,x2)|^2$ (skewing)

If we forget these effects, we replace GPD by PDF in calulations but it fails!



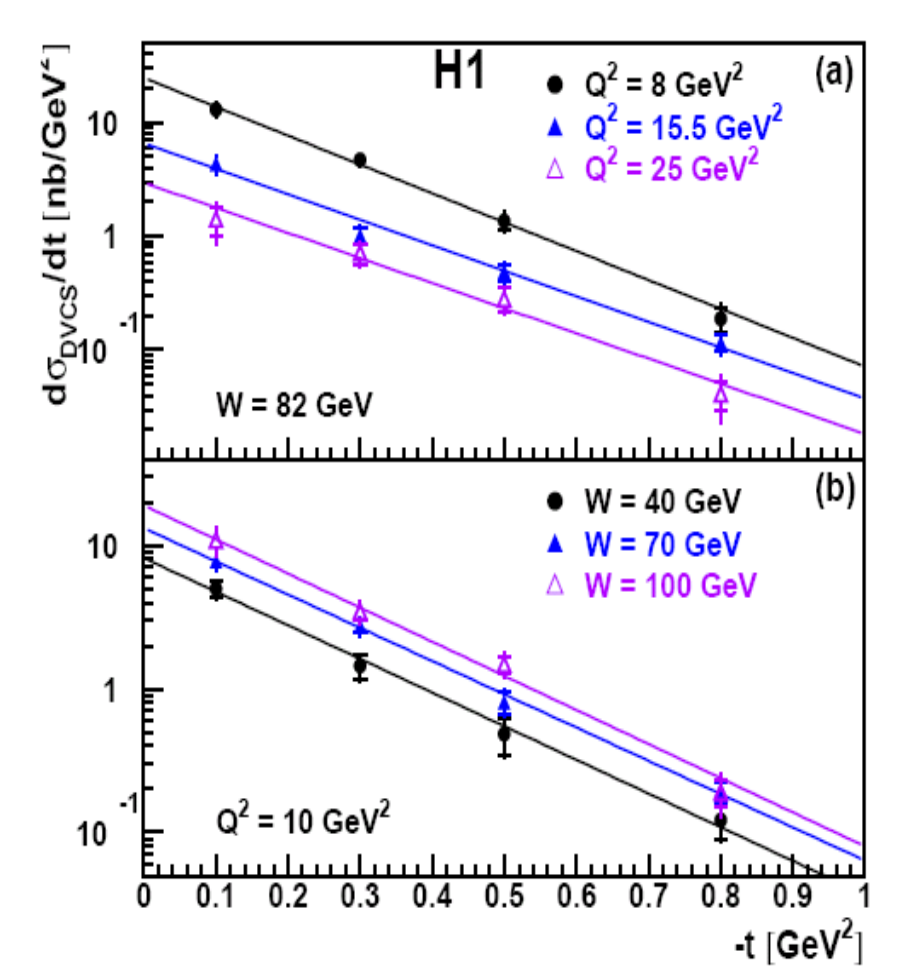


The first observation of skewing (GPDs) impact

Prediction without skewing
a factor~4 below the data

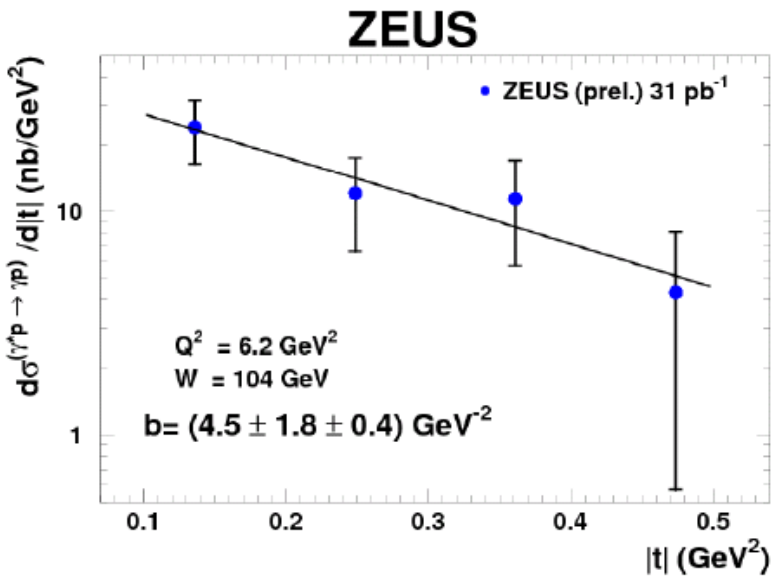
Measurement of the t dependence

- As we observe, $d\sigma/dt \sim \exp(bt)$ where b is the effective t-slope in a given kinematic domain
- Then, $\sigma \sim 1/b$ (something) where « something » is proportional to GPD²…
- Therefore, **b measurement is essential to allow any data/theory comparison!**



Measurement of the t dependence Last result from ZEUS

Central value a bit lower than the H1 result but compatible within the errors…



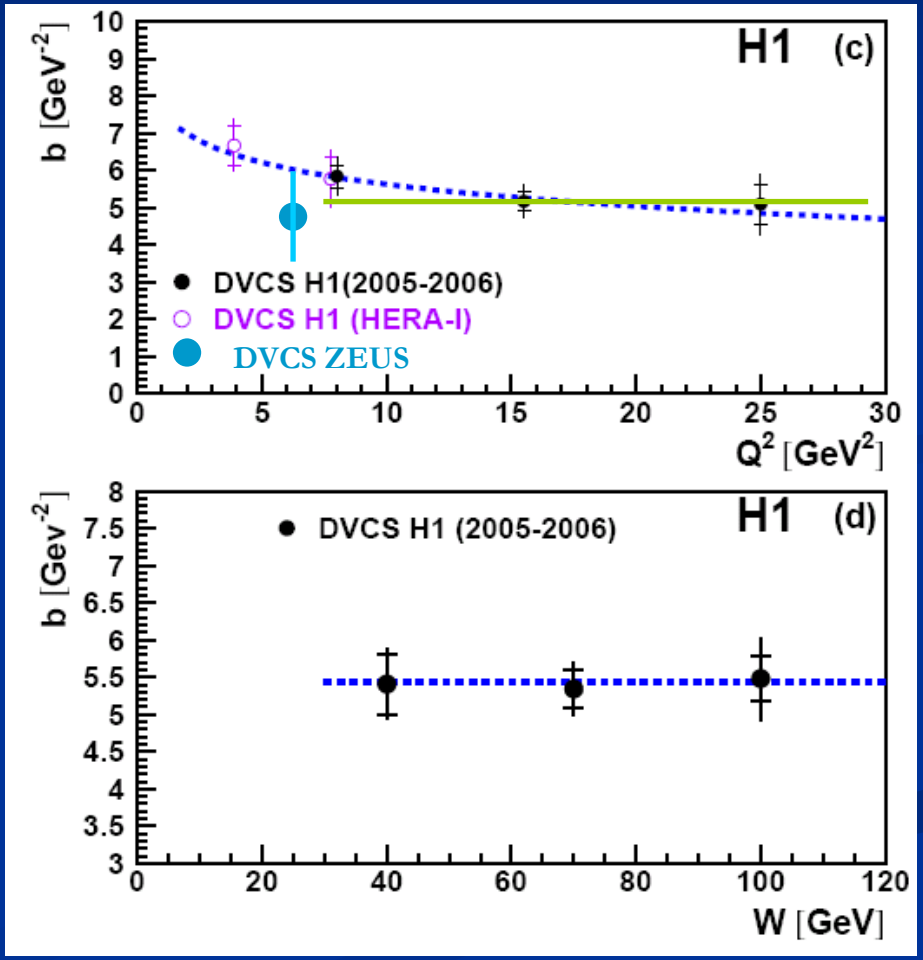
First direct measurement of differential cross section as a function of t using LPS

Measurement of the t dependence What do we learn?

- @ low Q^2: higher twists effects in $1/Q^2$: finite size of the qqbar pair probe?!
- @ large Q^2: scaling in Q^2… we are really probing the proton structure with a « pointlike » qqbar pair configuration
- No dependence in W

  for the singlet part & the low x kin. domain…

  More on this in 3 slides!



H1/ZEUS data & Lattice estimations

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

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

>> valence quarks value

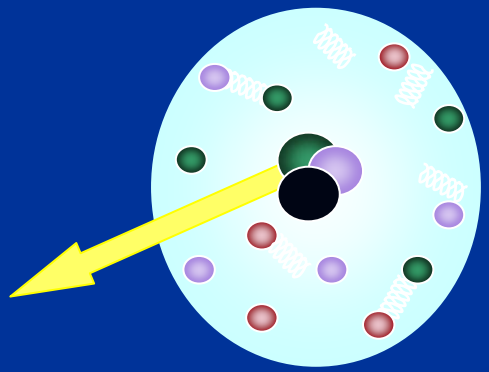
Smaller central value found by ZEUS but compatible within the uncertainty…

Lattice calculation (unquenched QCD):

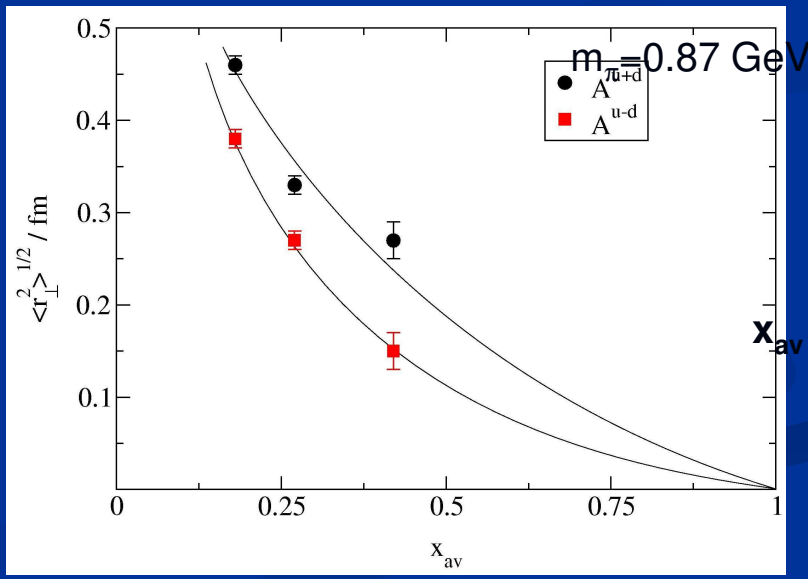
Negele *et al.*, NP B128 (2004) 170

Göckeler *et al.*, NP B140 (2005) 399

- fast parton close to the N center
  - ≡ small valence quark core
- slow parton far from the N center
  - ≡ widely spread sea q and gluons



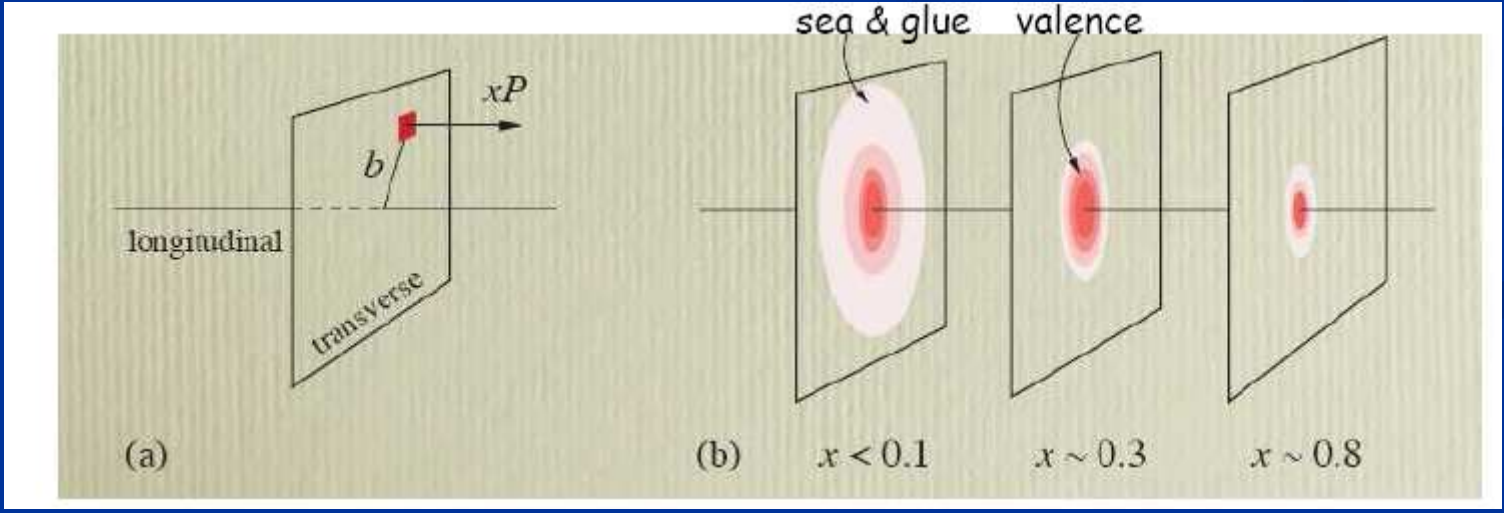
In agreement with « ideas » coming from Lattice QCD…



Some more picks from the t dependence…

- Most probable scenario: t & x dependence are correlated and $d\sigma/dt \sim \exp\{(b_0+\alpha' \ln(1/x))t\}$

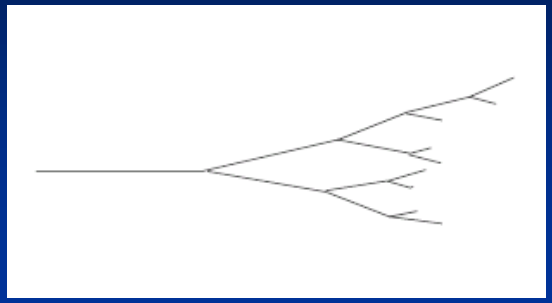
- **With H1 DVCS results we access directly to b_0 & α'** in a specific kin. domain ($x_{Bj}<0.01$) => it has a direct consequence on the quark imaging in the proton (see plot below)…



A brief status on α'

Gribov diffusion: parton branching as random walk in b space

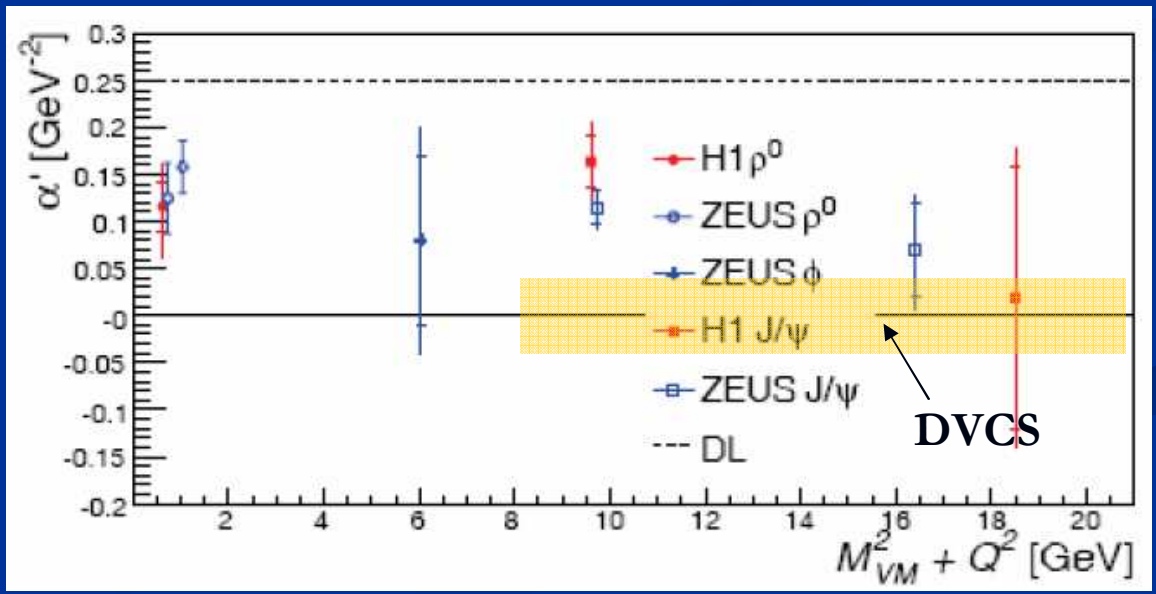
$$\rightarrow \langle b^2 \rangle \propto \alpha' \log(1/x)$$



We expect a non zero value of α' due to « basic » (Gribov) diffusion:
Emission of more & more partons… **But @ large Q², low x: results are different!**

The 2D-size of a p-p system
grows 2 times faster
than the size of γ-p system
with ln(W)
& the size of a γ*(Q² large)-p
system does not grow…

Not trivial Fact!



A way to measure x/t correlations with a single observable…

With 2 beam charges (e+ & e- @ HERA) we can measure the difference of DVCS cross section for these 2 beams (or the asymetry)

=> Beam Charge Asymetry == $(\sigma(+)- \sigma(-))/ (\sigma(+) + \sigma(-))$

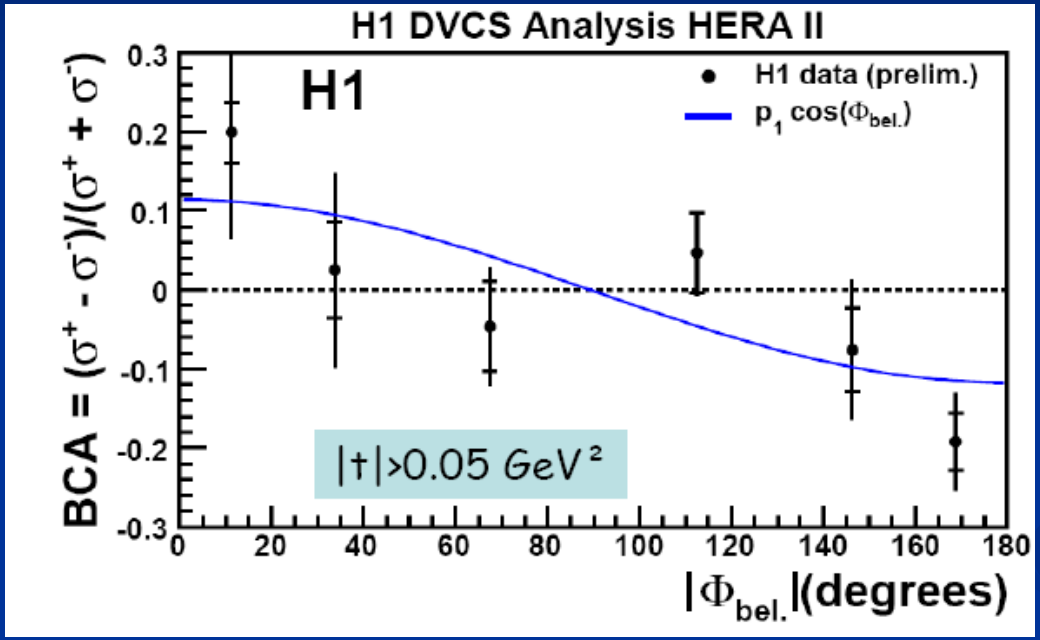
THEN

$BCA \sim Re(M) \sim -\Sigma e_q^2$ P.P. $\int dx \left[1/ (x-x_{Bj}+i\varepsilon) - 1/ (x+x_{Bj}+i\varepsilon)\right] GPD(x,\ldots,t)$

Let admit this relation for this talk… (see theory talks for proofs)

=> it gives directly a correlation between x & t
as for each t values, the integral covers the "all" x range (P.P.)

BCA in H1



Low x_{Bj}~0.005

We extract a fit in
0.17 (+/-0.06) cos(ϕ)

@ Q^2=10 GeV^2

A non zero asymetry has been extracted
=> It favors non-factorised x/t approaches! (under study)

Another look at this measurement

- From BCA & DVCS cross section, we can determine a key observable: $\eta = \mathrm{Re}(a_{DVCS})/\mathrm{Im}(a_{DVCS})$

  => η = 0.23 +/- 0.10 (1)

- We have another way to extract this ratio from dispersion relations:
  $\eta = \mathrm{Re}(a_{DVCS})/\mathrm{Im}(a_{DVCS}) == \tan(\pi/2\ \delta/4)$
  @ low x with $\sigma_{DVCS} \sim W^{\delta}$ with $\delta \sim 0.75$ (similar value for H1 & ZEUS)

  => η = 0.28 +/-0.07 (2)

- Both values (1) & (2) are in good agreement => Good confidence in the difficult BCA measurement…

Conclusions & Outlook

DVCS cross sections have been studied since almost 8 years @ HERA

It was a great experimental contest… where H1 & ZEUS contributed with success… Data H1/ZEUS are based on very solid analysis grounds

Still the complete set of data to be published in final papers…

The essential role of Skewedness (& thus GPDs) have been shown

A challenging measurement of BCA is under process
=>First evidence in the data that a non factorised approach is favored ?!

Thanks for your attention