DVCS at HERA & perspectives at CERN

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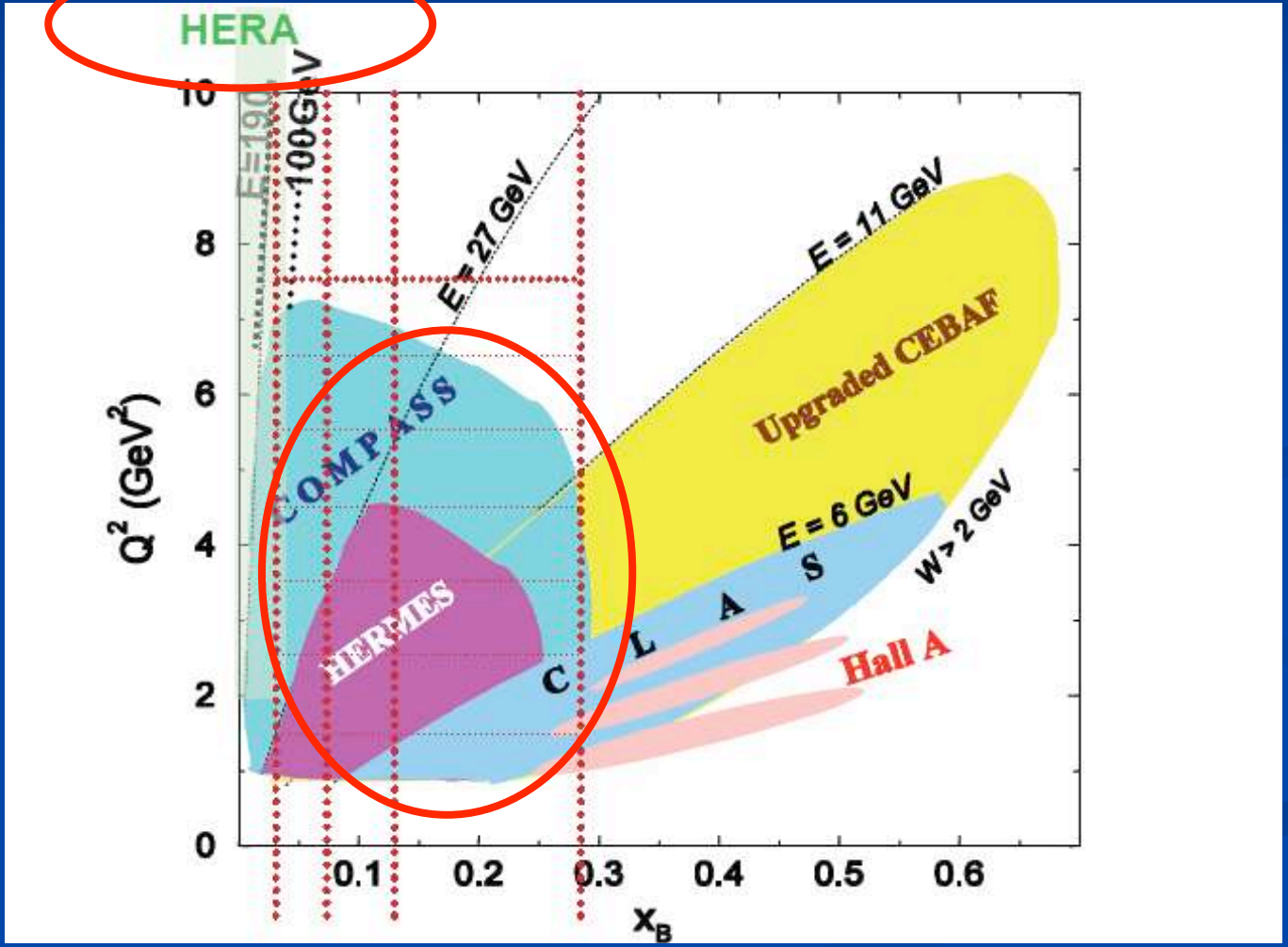
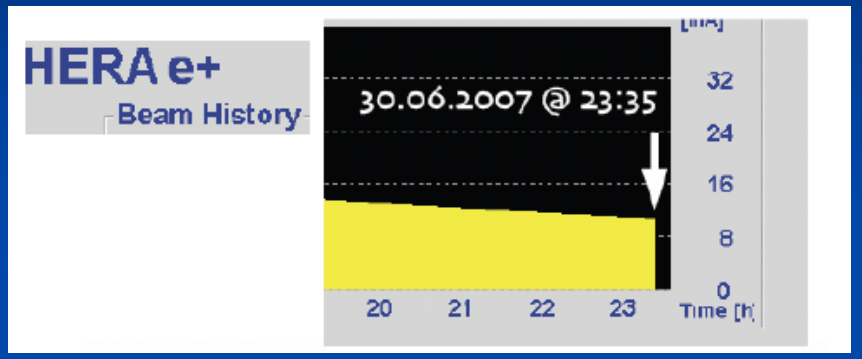
1. HERA
2. CERN

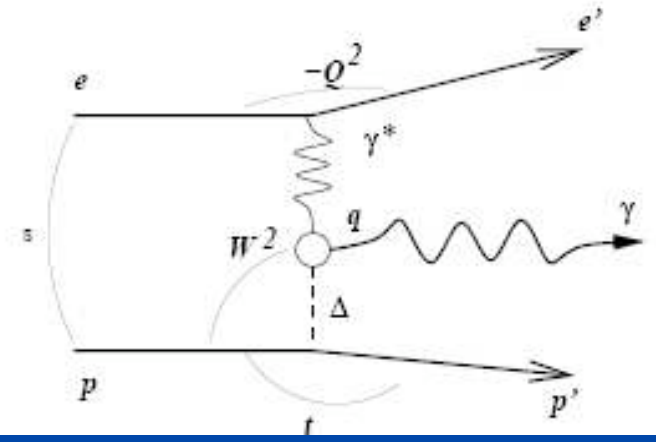
DVCS around the word present & future



DVCS kinematics @ HERA



DVCS: QCD process



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

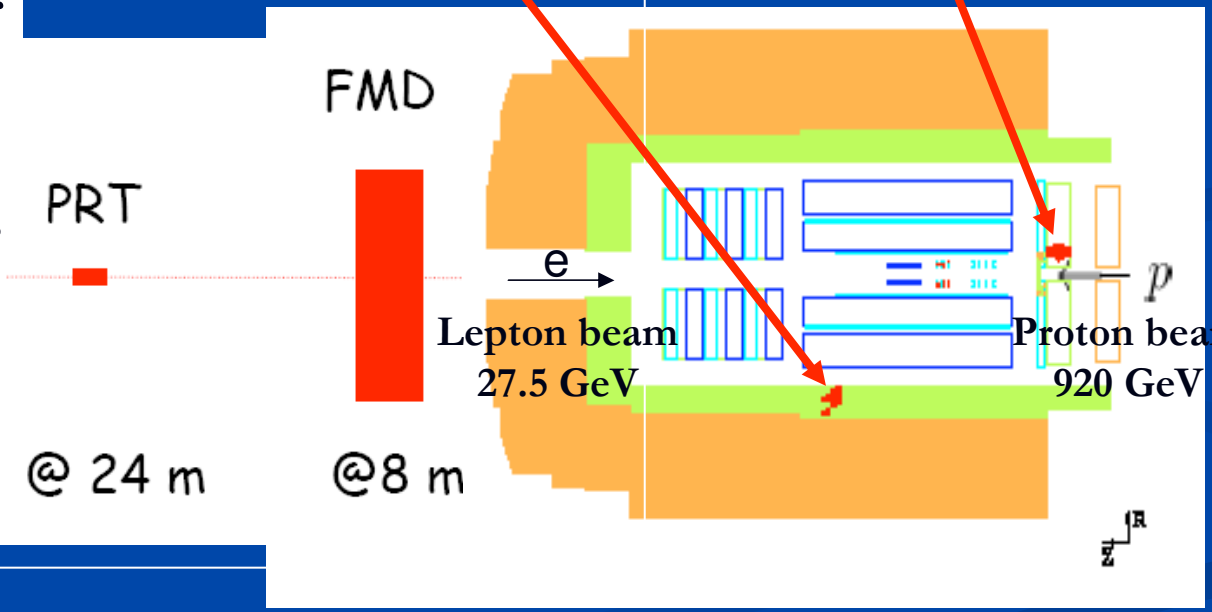
DVCS at HERA (H1/ZEUS)
some basic characteristics

- 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)

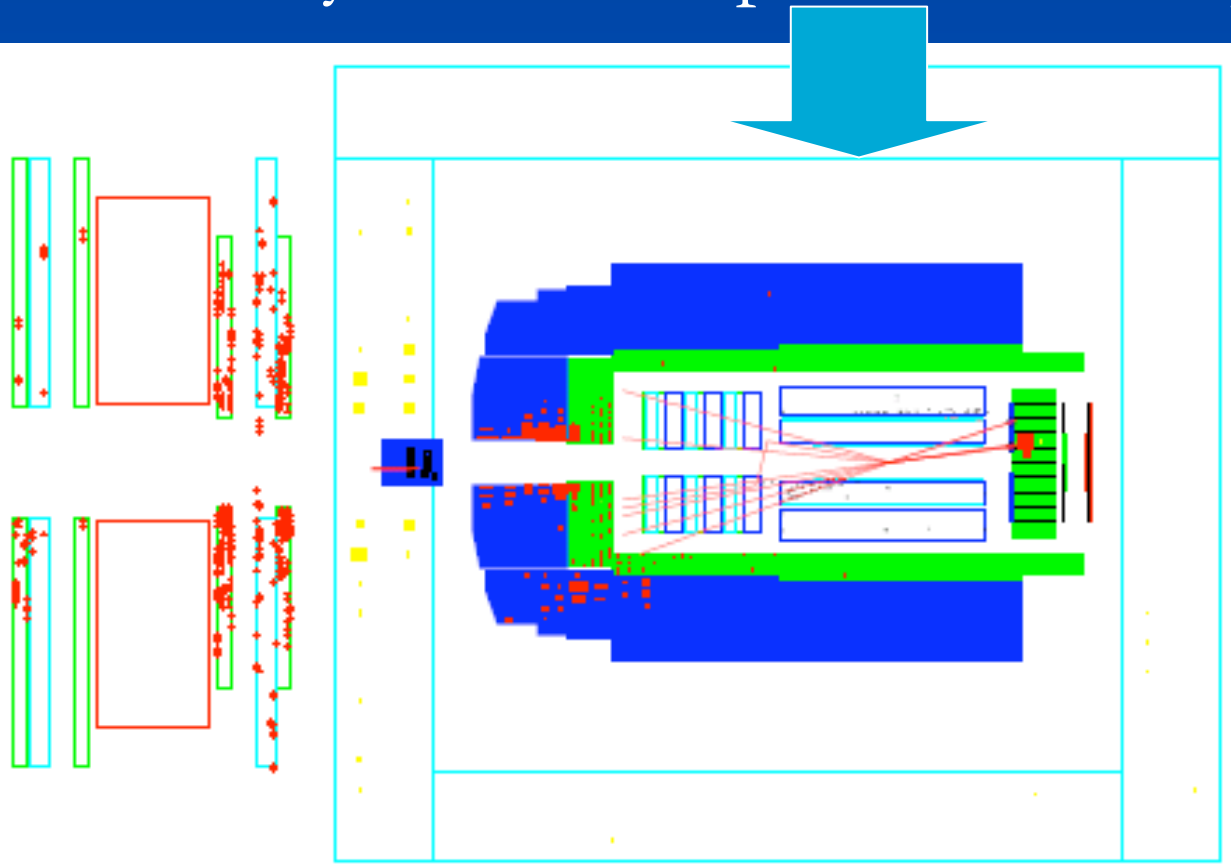
and no other activity in H1 detectors



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

DVCS at HERA
On the visibility of the signal?

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



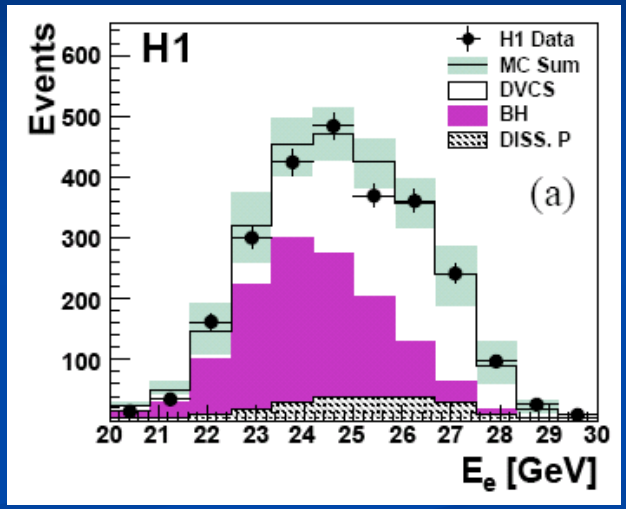
DVCS represents **~1/1000** of the DIS recorded events

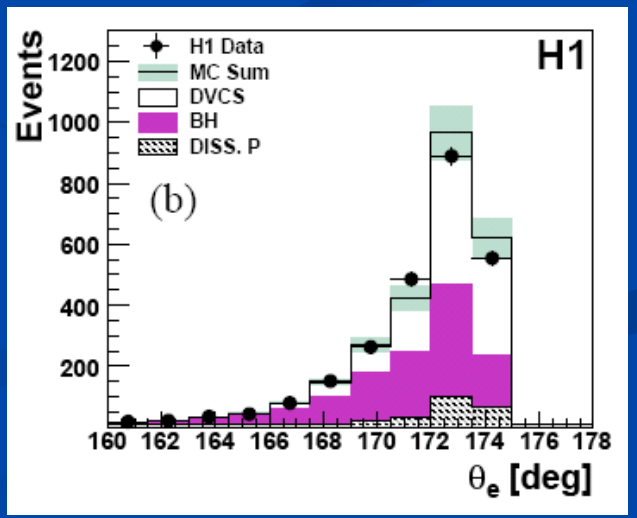
DVCS at HERA
experimental considerations

- Simple signal with 2 EM clusters: but simple is not easy!
- **Not easy to trigger with a high efficency 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.

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)

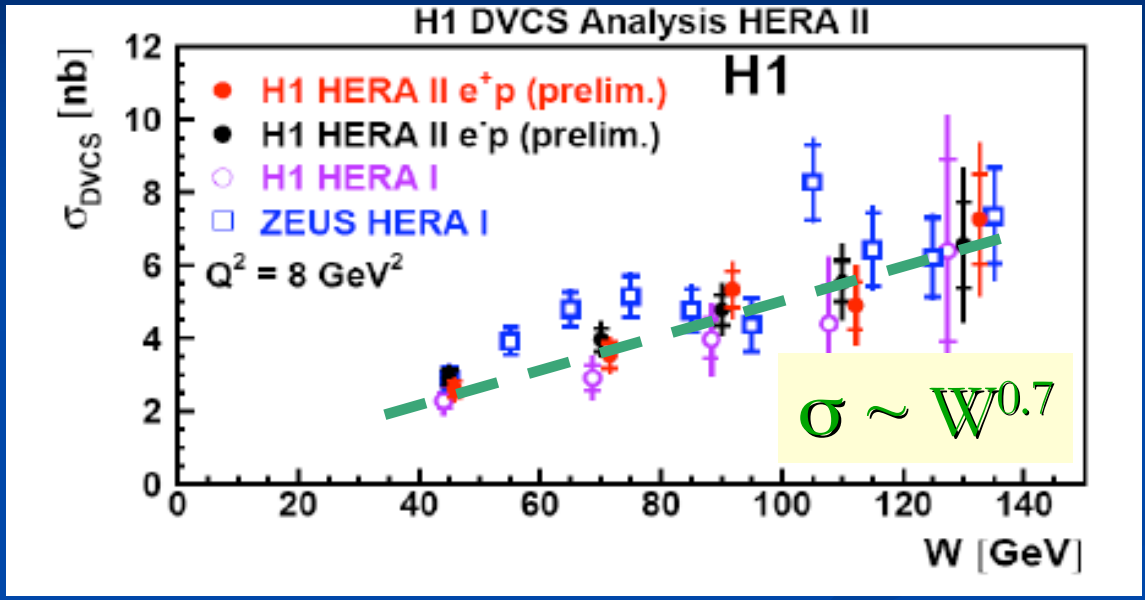


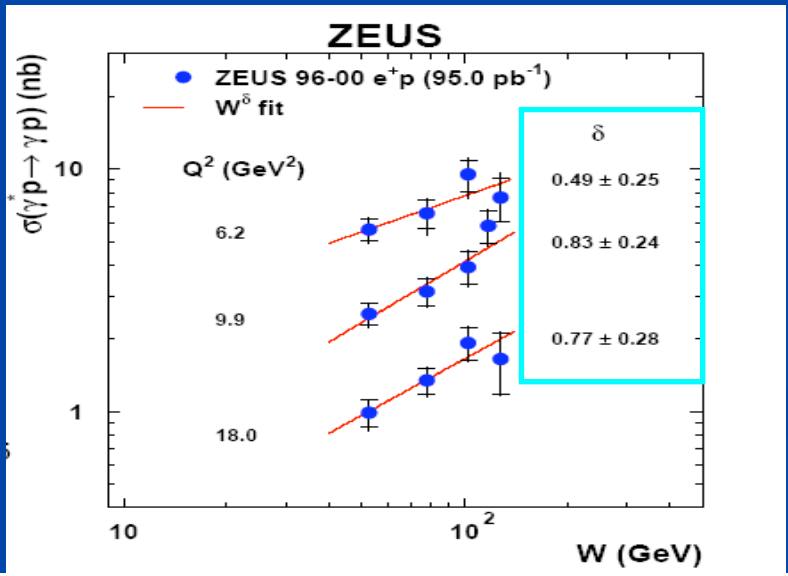


From data events to cross sections

- 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…**

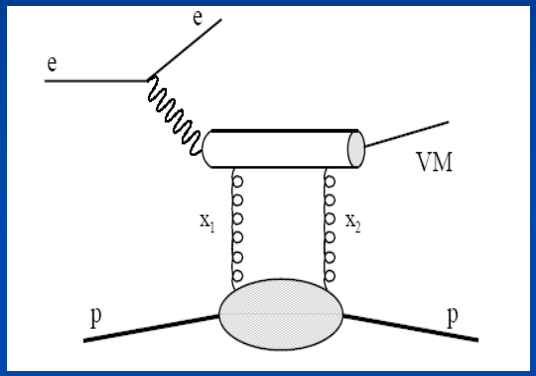
DVCS cross sections in W…
a first fundamental result



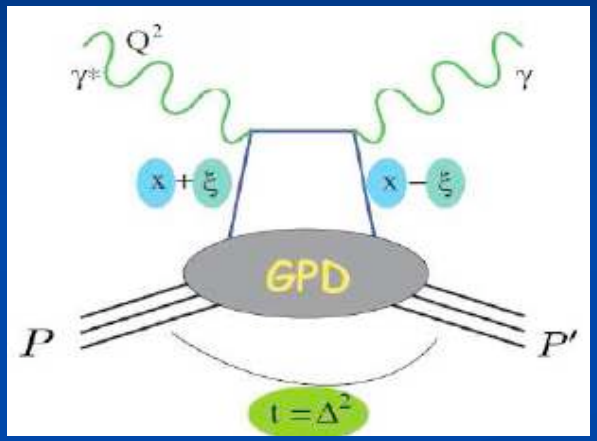


Hard W dependence
=> DVCS at HERA (low x)
is a hard process…
can be described (a priori)
by pQCD…

DVCS versus Skeewing: the prospects



VM => photon



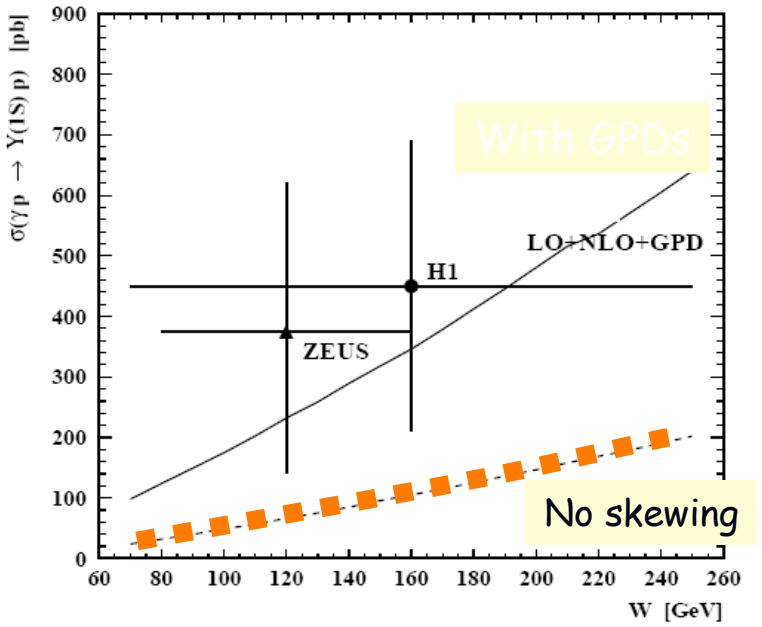
x_1-x_2 ~ [Q^2+M^2] / W^2 => $\xi \sim x_{bj}/2$

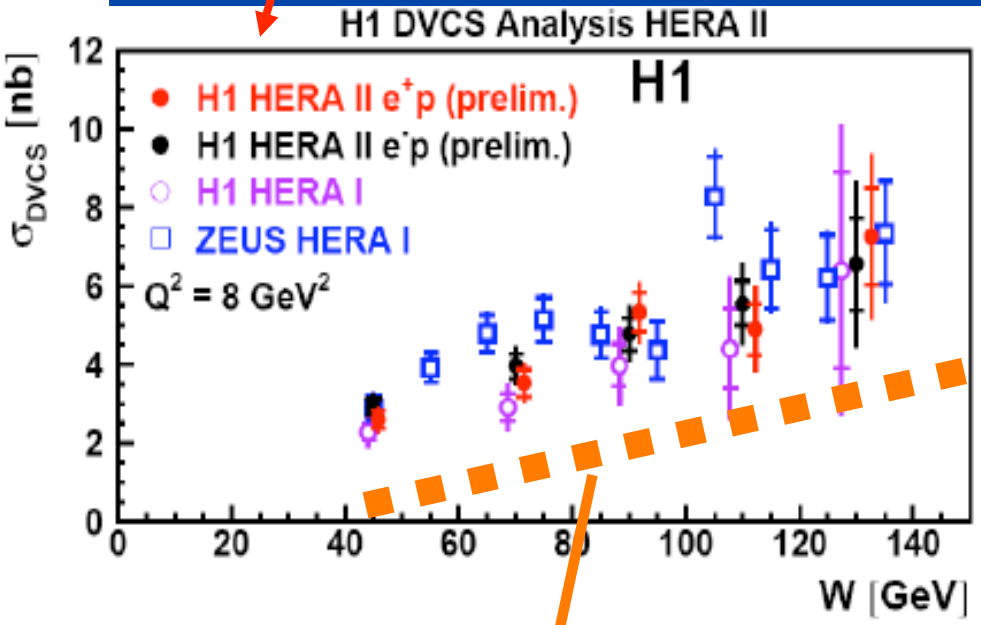
We expect skeewing effects to be important
In VM & DVCS @ HERA
=> Replacement of PDFs by GPDs ?!

Skeewing effects: the PROOF

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

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



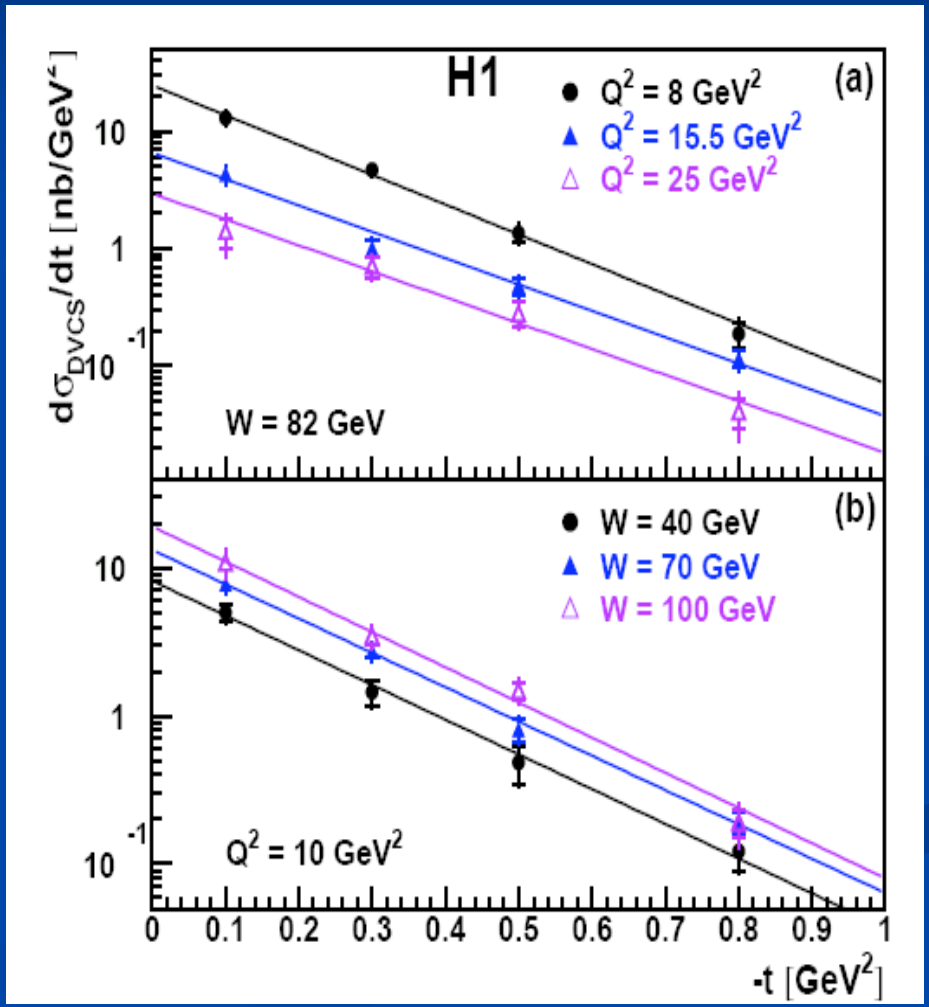


The first observation of skeewing (GPDs) impact

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!**

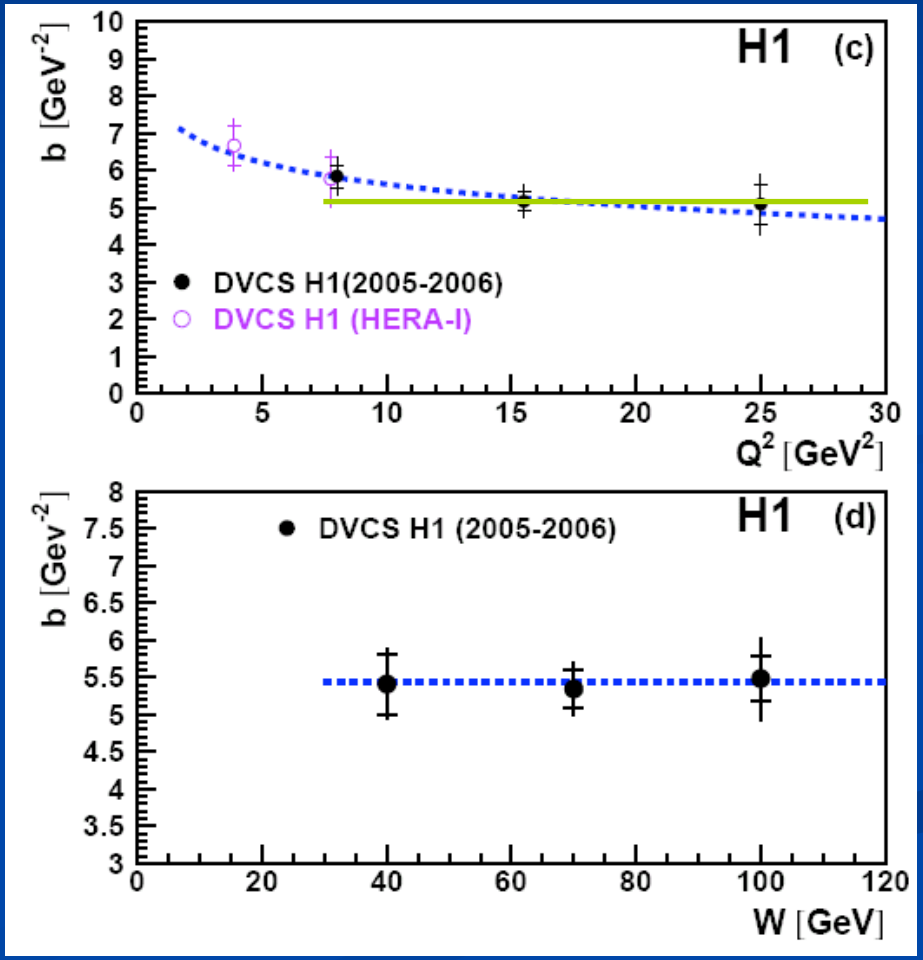


Measurement of the t dependence What do we learn?

- @ 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 sturcture with a « pointlike » qqbar pair configuration
- No dependence in W

  => **$\alpha' \sim 0$ GeV^{-2}**

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



H1 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

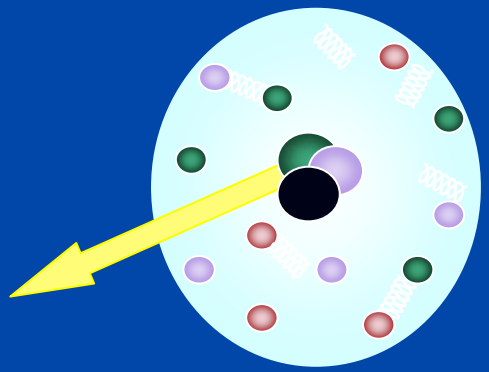
In agreement with « ideas » coming from Lattice QCD…

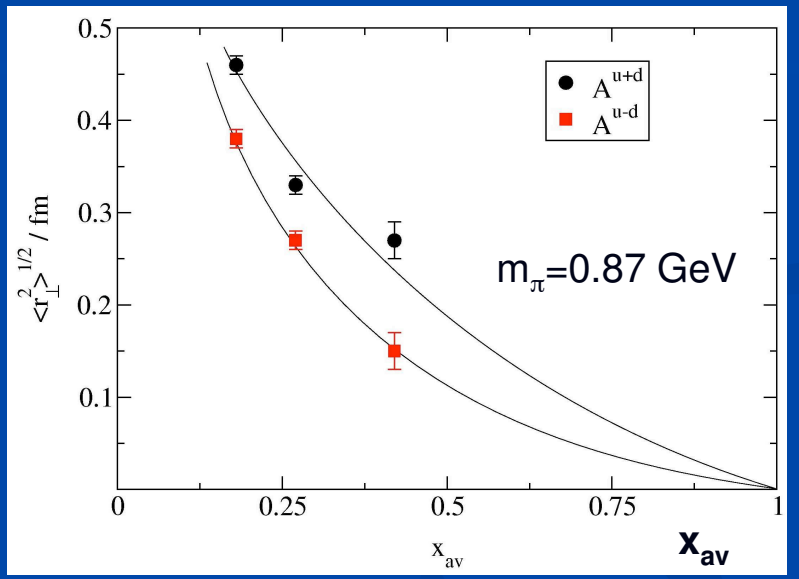
Lattice calculation (unquenched QCD):

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

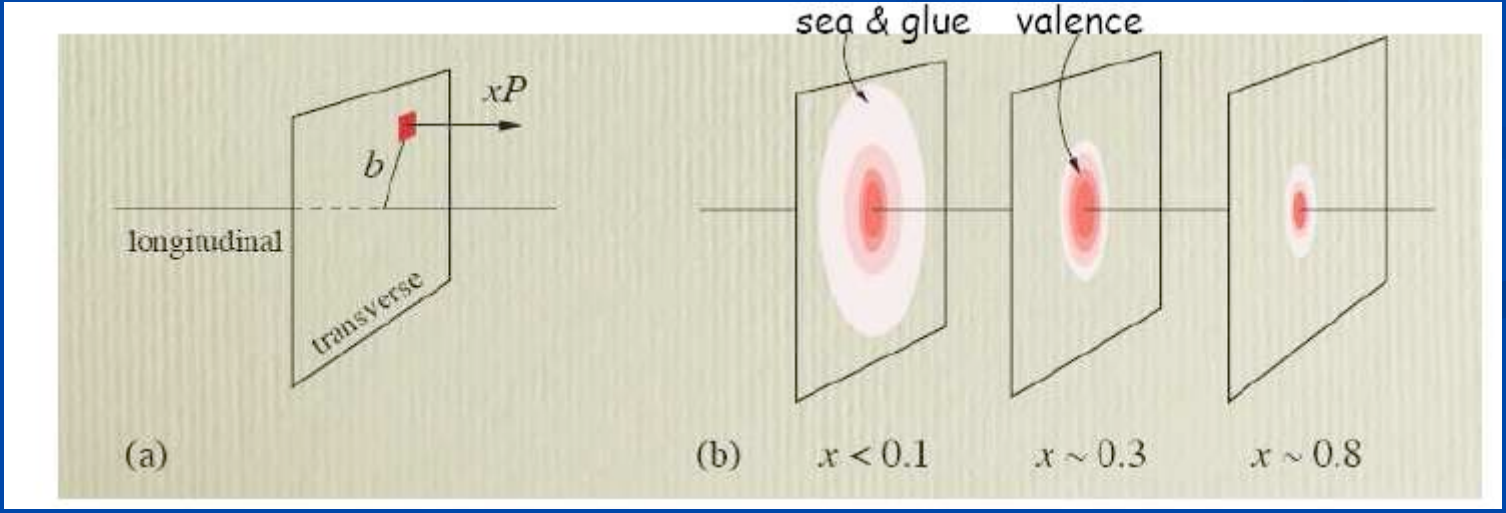




Some more picks from the t dependence… the way to CERN

- 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)…
- **It will be the same for the COMPASS GPD project!**



DVCS at CERN

- A very first point: COMPASS @ CERN is an active collaboration…

- COMPASS needs to define new opportunities for years after 2010:
  - In the shadow of LHC! This is a fact & also a chance as we can expect some physicists to be interested in smaller projects if the dynamic & physics contents are strong enough…
  - There are several projects (in competition) at COMPASS for the future.
  - Here, I cover only one: the DVCS project (DVCS @ CERN).

Why DVCS at CERN?

- COMPASS fixed target kinematic (with 100 GeV muon beam) offers an interesting kinematic domain $0.05<x_{Bj}<0.15$ and a reasonnable range in Q^2 in [2,6] GeV^2

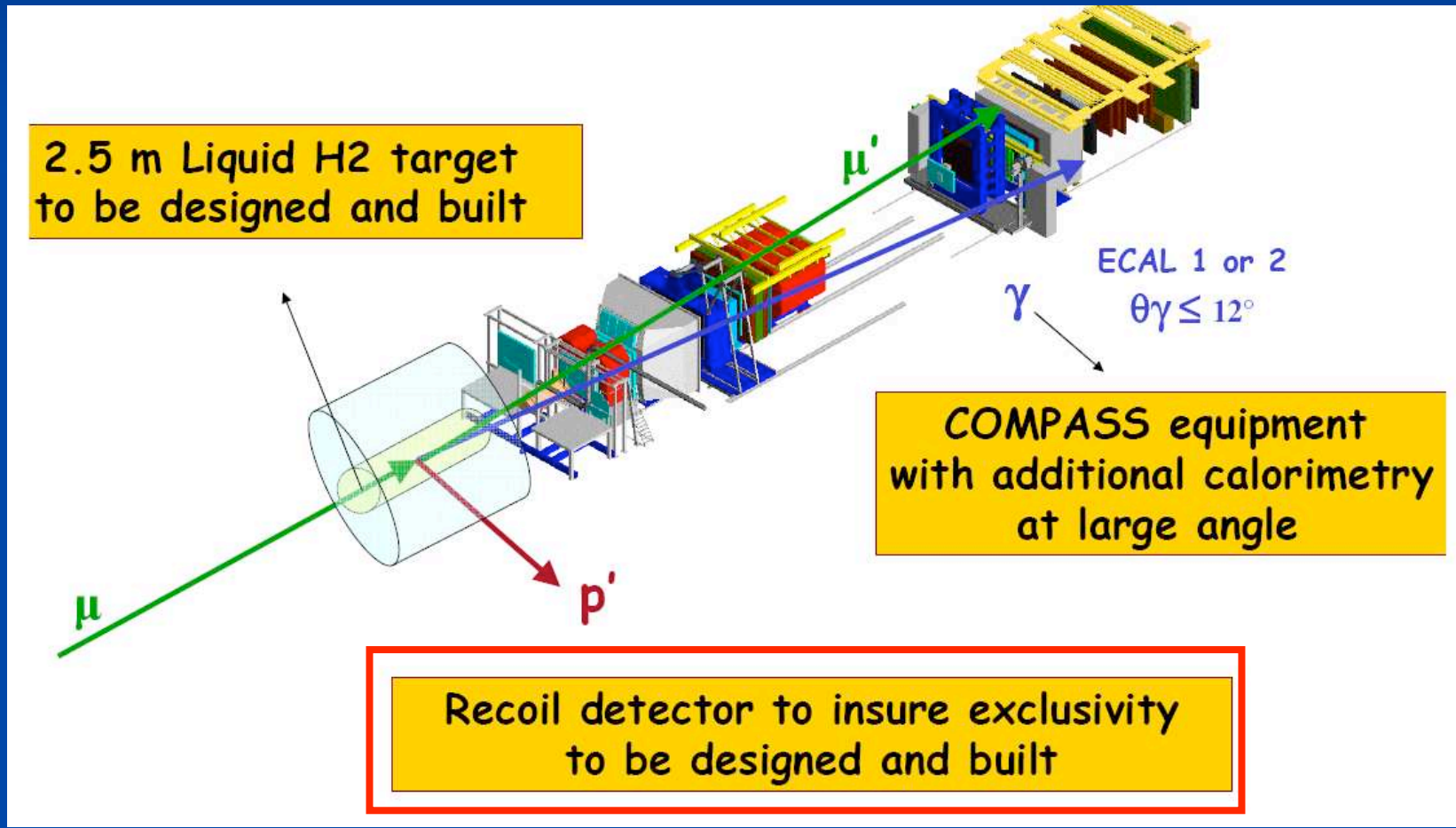
- Possibility to measure DVCS cross sections (like H1 or ZEUS)! => efficiency to constraint GPDs models… in particular in a kin. domain where they are poorly known

- Possibility to use $\mu+$ and $\mu-$ beams at COMPASS

  => Beam Charge Asymetry

- **Then, in the context of GPDs physics, DVCS @ CERN would be essential!**

How DVCS at CERN?



Team & key status

- Team organised @ CERN in a specific working group…
- A prototype of the Recoil Proton Detector (RPD) is running well @ COMPASS present data taking
- Complete feasbality studies are well advanced…
- A first draft of the project is circulating
- A test run of 5 days with muon beams and the full DVCS experiment setup have been accepted by the collaboration & is scheduled in a few months…
- **The key moment**, the date of the defense at SPSC is not fixed yet: **end of 2008** would be fine to keep the dynamic…

The core of the DVCS project at CERN

- DVCS cross section presents a **prejudice**: they are related to $|GPDs(x,\xi,t;Q^2)|^2$ at $x=\xi$!

- If you want to study the x_{Bj}/t correlations, you need to measure $d\sigma/dt$ at many values of x_{Bj}… impossible due to acceptance bias…

- **One way to overcome this prejudice** => Measure directly the real part of the DVCS amplitude:

  $$Re(M) \sim P.P. \int dx \, [1/ (x-x_{Bj}+i\varepsilon)] \, GPD(x,\ldots,t) + c.t.$$

  ~ **Beam Charge Asymmetry (BCA)**

- **COMPASS with μ+ and μ- beams can do it!**
- => New frontier after first results with HERMES & H1

Simulation done for: 100 GeV muon(+/-) beams

L = 1.3 1032 cm-2 s-1 <=> **6 month data taking** with 25 % global efficiency

VGG: double-distribution in x,ξ

model 1: $H(x,\xi,t) \sim q(x)\, F(t)$

model 2 and 2*: correl x and t

$\langle b^2_\perp \rangle = \alpha' \ln 1/x$

$H(x,0,t) = q(x)\, e^{t \langle b^2_\perp \rangle}$

$= q(x) / x^{\alpha' t}$

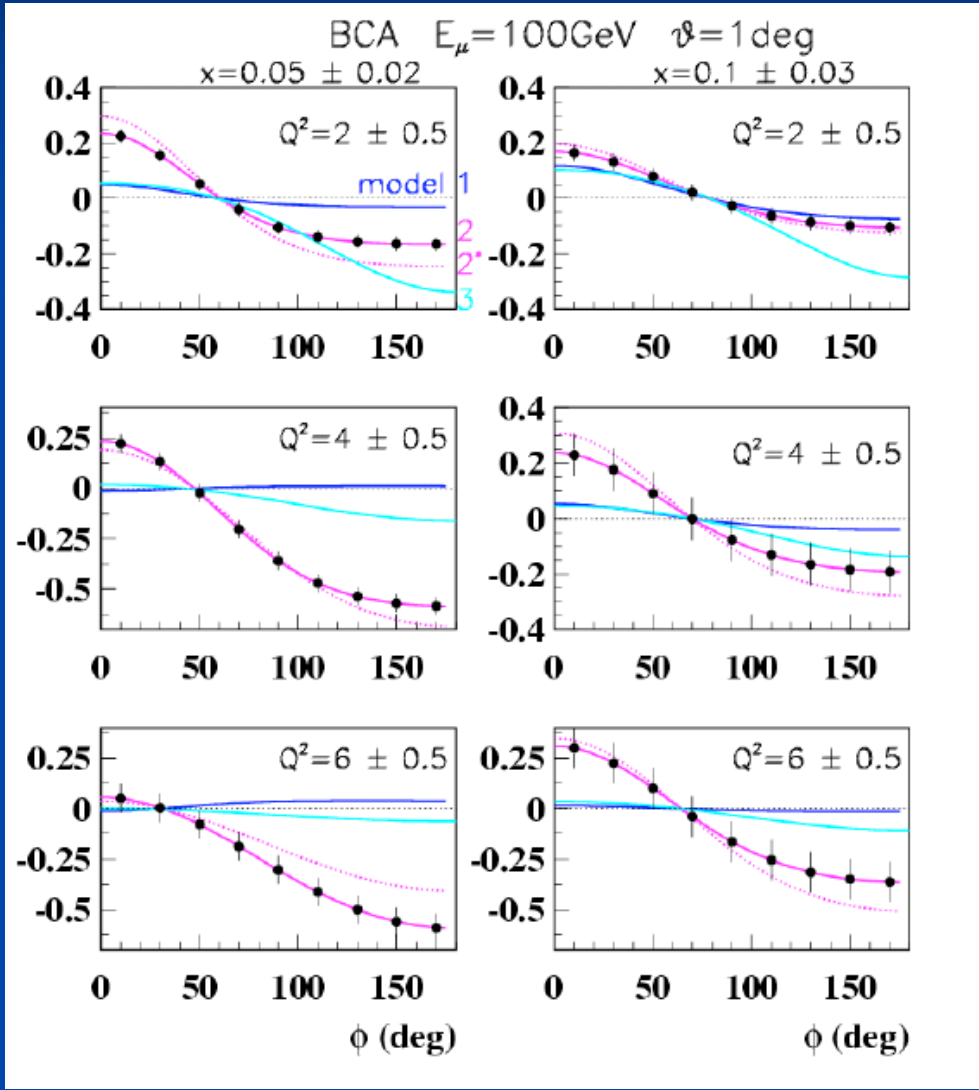
α' slope of Regge traject.

—— $\alpha'=0.8$

..... $\alpha'=1.1$

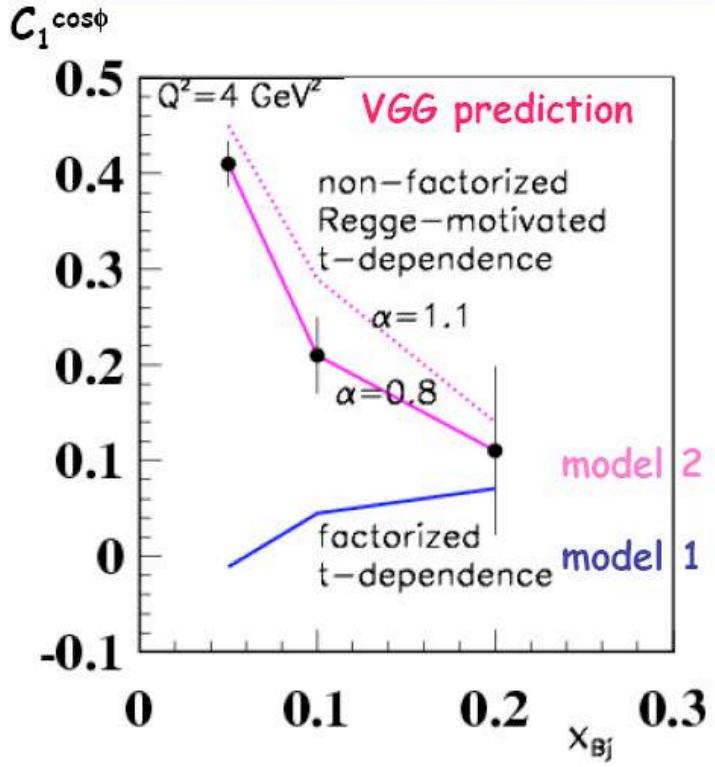
Guzey: Dual parametrization

model 3: also Regge-motivated t-dependence with $\alpha'=1.1$

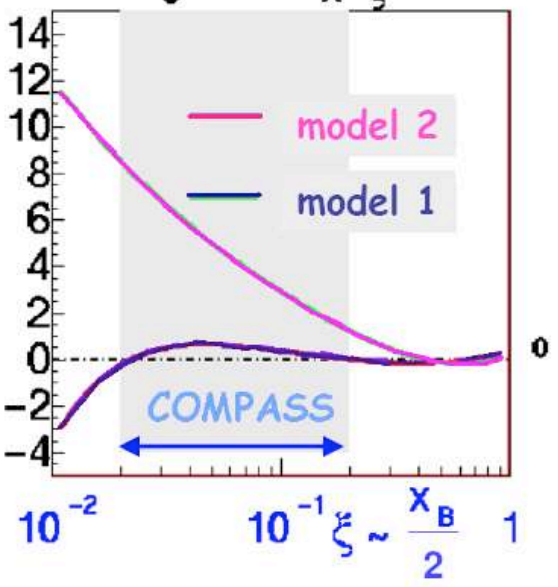


Excellent discrimination power of COMPASS => fondamental interest for clarifying the « GPD forest »

$$BCA = \frac{c_0^{int} + c_1^{int}\cos\Phi + c_2^{int}\cos 2\Phi + c_3^{int}\cos 3\Phi}{\text{denominator(BH+DVCS)}}$$



$\supset$ $PP\left(\int dx \frac{H(x,\xi,t)}{x-\xi}\right)$



α' determined within an accuracy of ~10% at xBj =0.05 and 0.1

Conclusions & Outlook

- DVCS cross sections have been studied since almost 6 years @ HERA (H1/ZEUS)
- It was a Great experimental contest!
- **Still the complete set of data to be published in a final paper…**
- **The essential role of Skewedness have been shown!**

- The new frontier for DVCS cross sections & BCA

  => **dedicated experiment @ COMPASS**
- Towards a selection in the « GPDs model forest »…

Thanks for your attention