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Sixth International Conference on Perspectives in Hadronic Physics

12 - 16 May 2008

Deeply virtual Compton scattering at HERA and perspectives at CERN

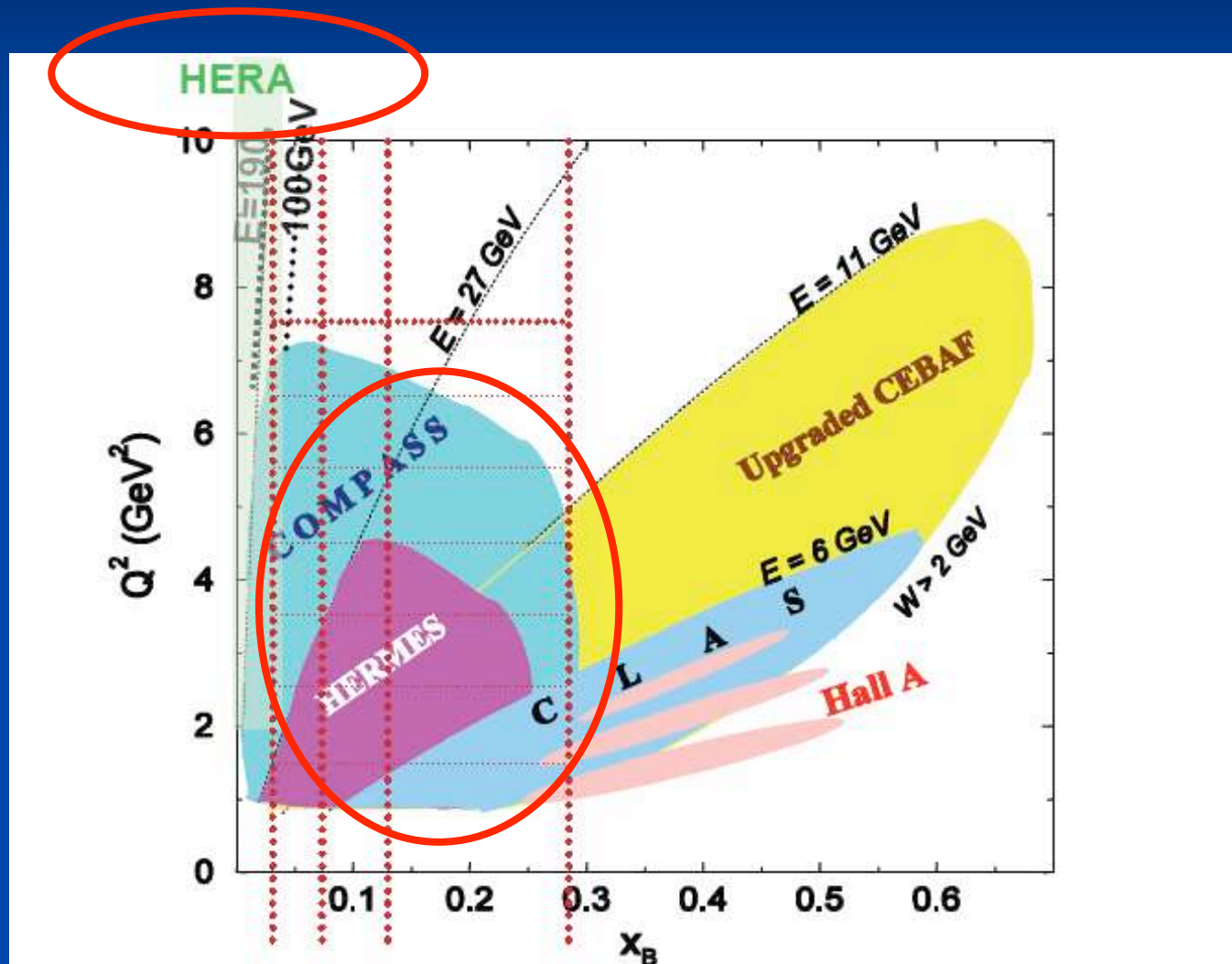L. Schoeffel

CEA Saclay
France

DVCS at HERA & perspectives at CERN
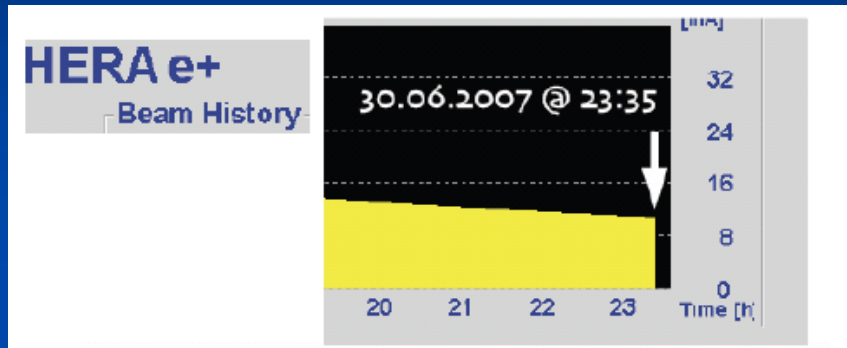
Laurent Schoeffel
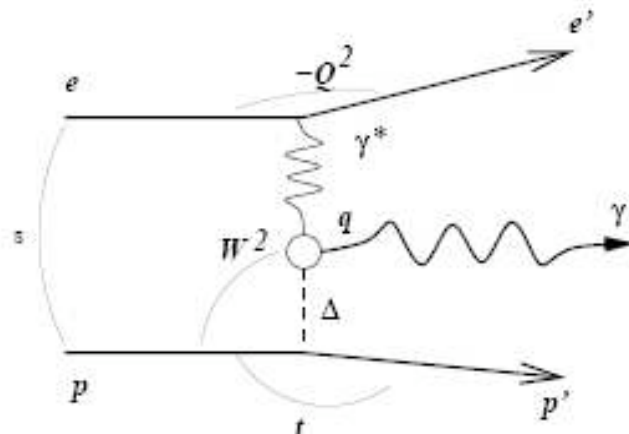
CEA Saclay

Trieste – 17/05/2008

1. HERA
2. CERN

DVCS around the word present & future

DVCS kinematics @ HERA

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 GeV² till 100 GeV² : 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)
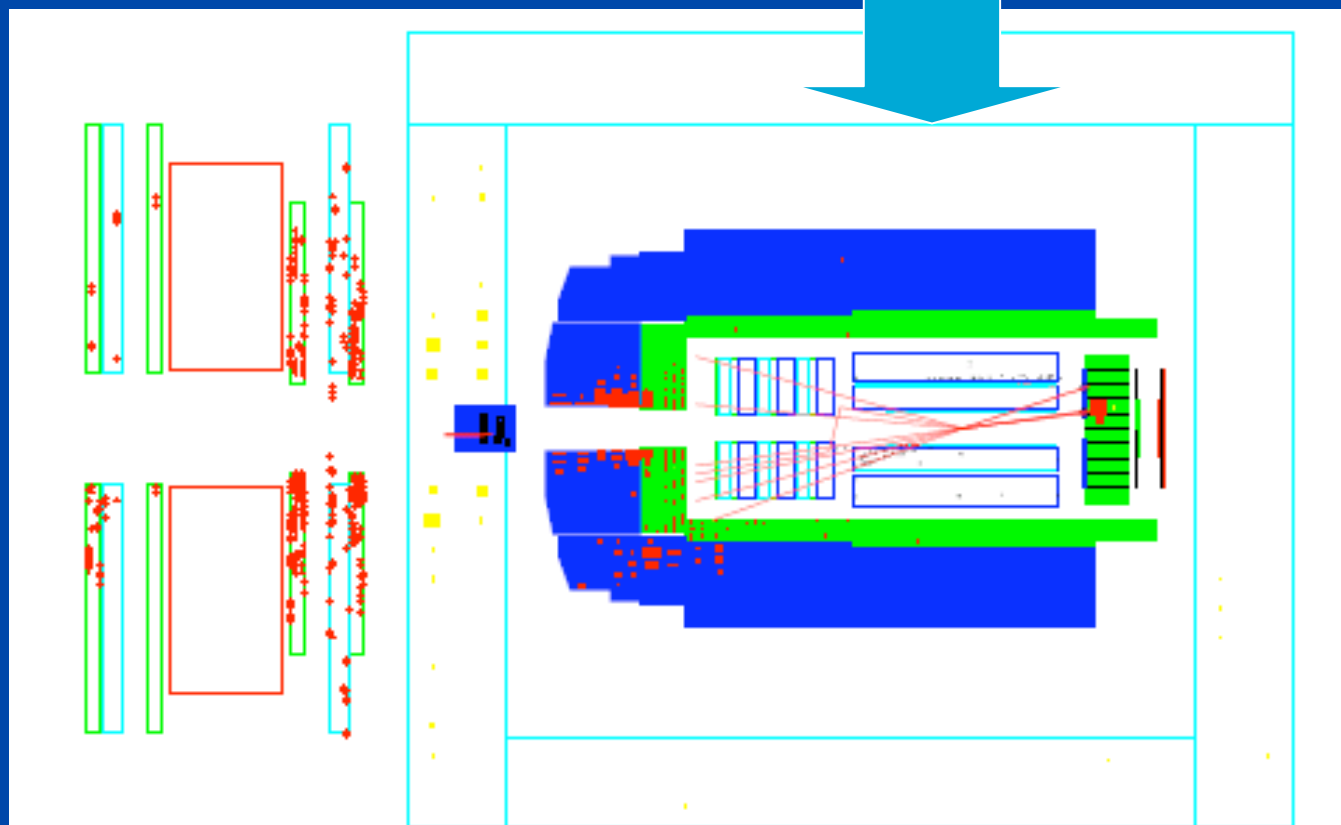
and no other
activity in
H1 detectors
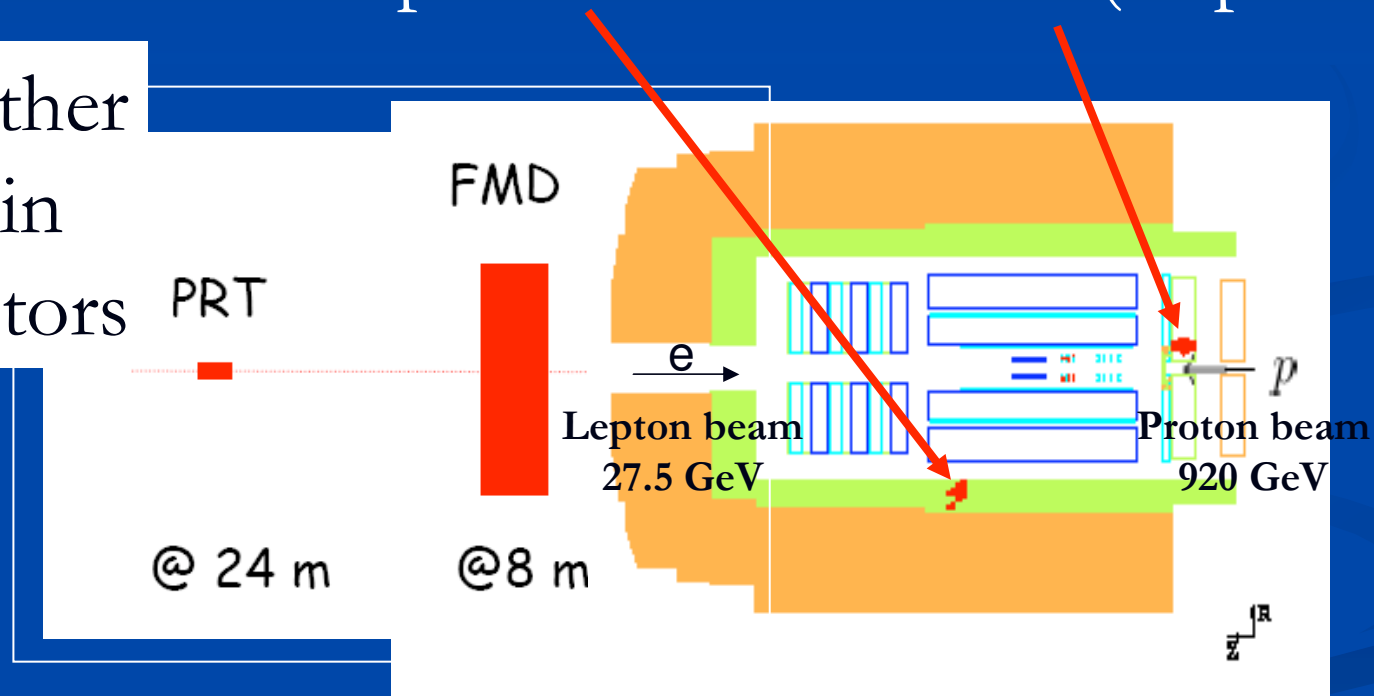
$$e + p \rightarrow e + \gamma + Y \qquad Y \sim p'$$

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)
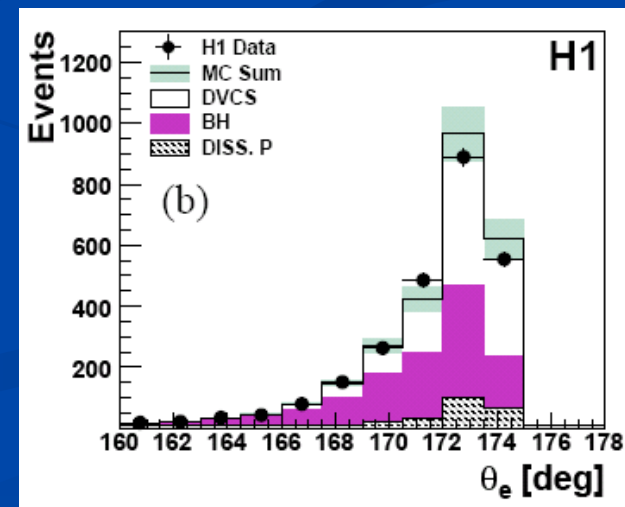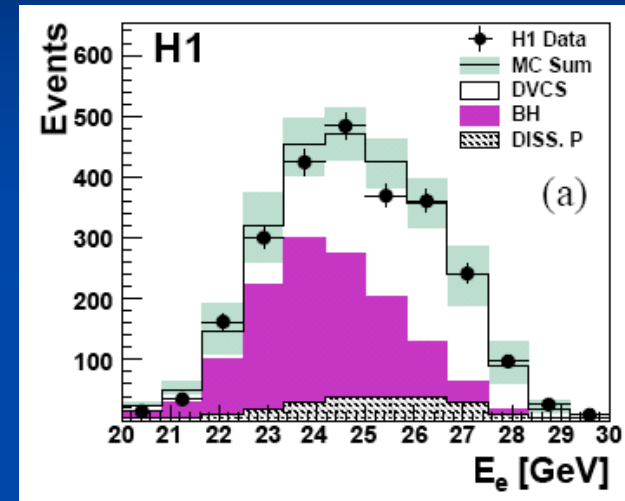
From data events to cross sections

- We measure 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 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…**
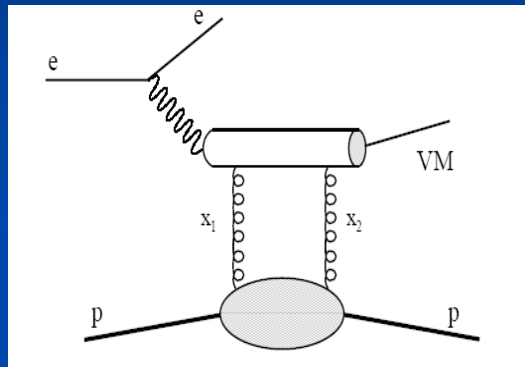
DVCS cross sections in W…
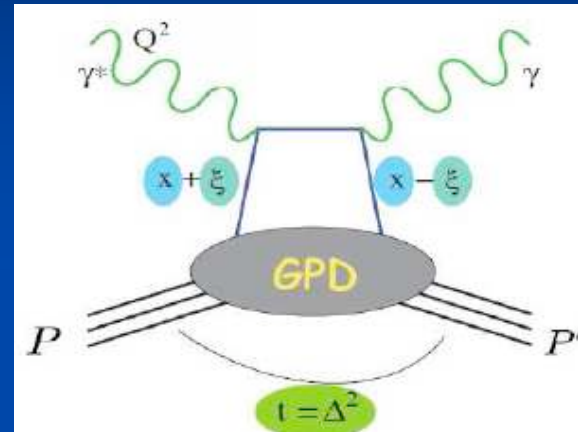## a first fundamental result

$$\sigma \sim W^{0.7}$$
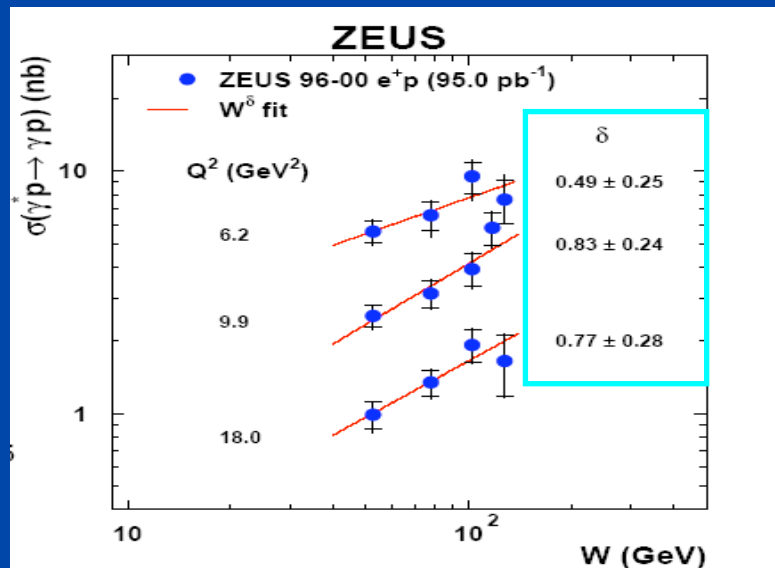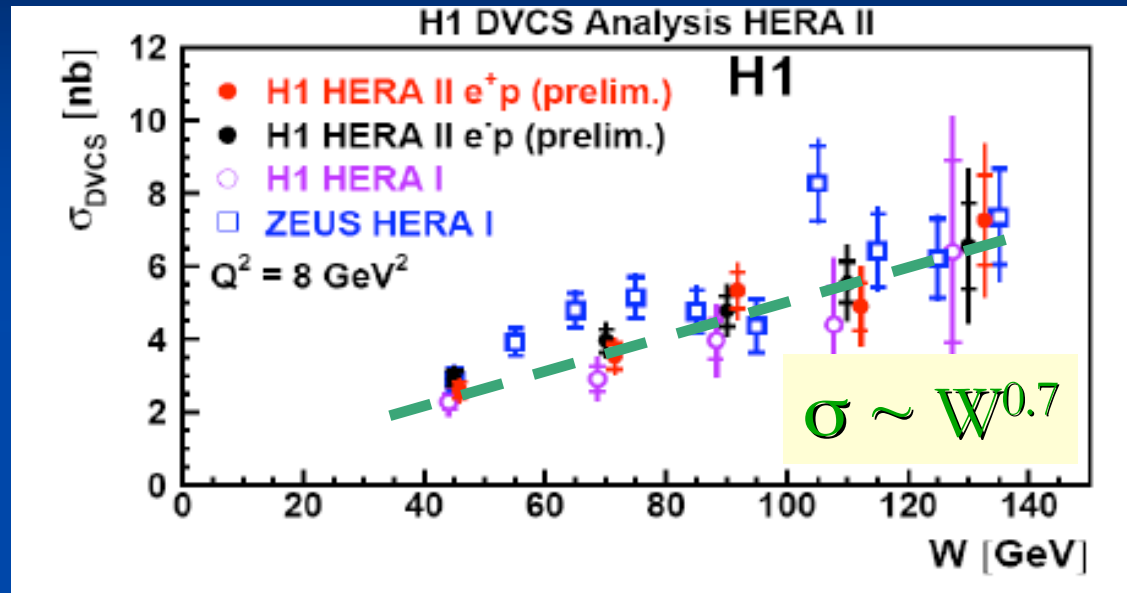
Hard W dependence
=> DVCS at HERA (low x)
is a hard process…
can be described (a priori)
by pQCD…

DVCS versus Skeewing: the prospects

VM => photon

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

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!
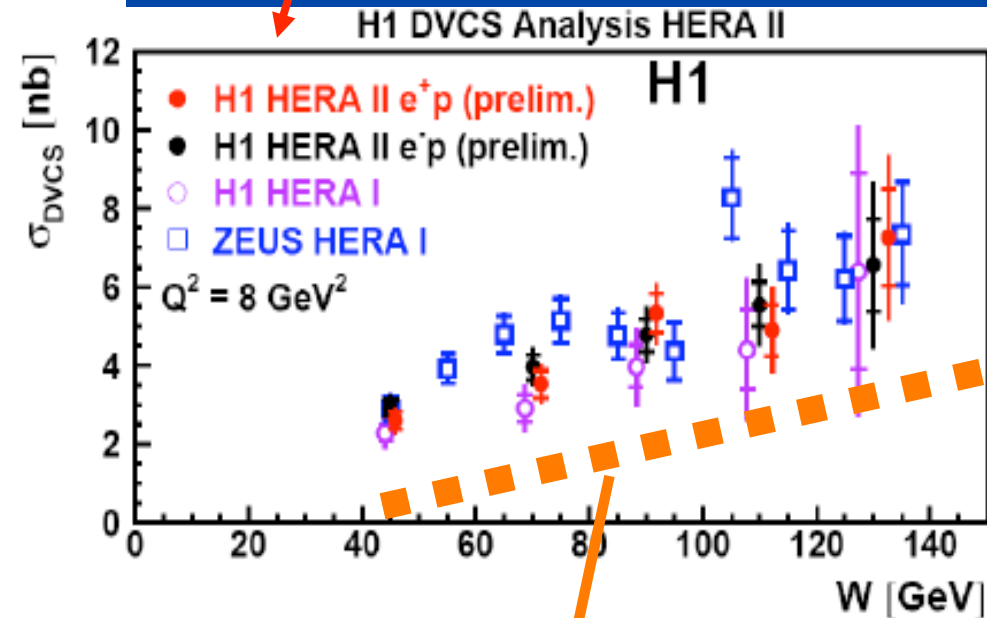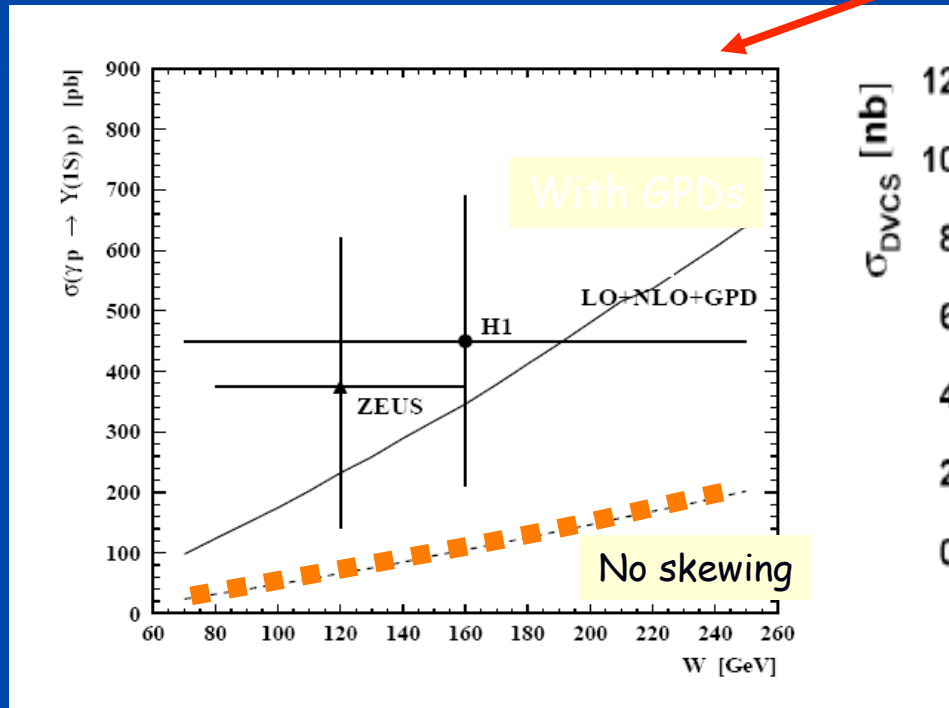
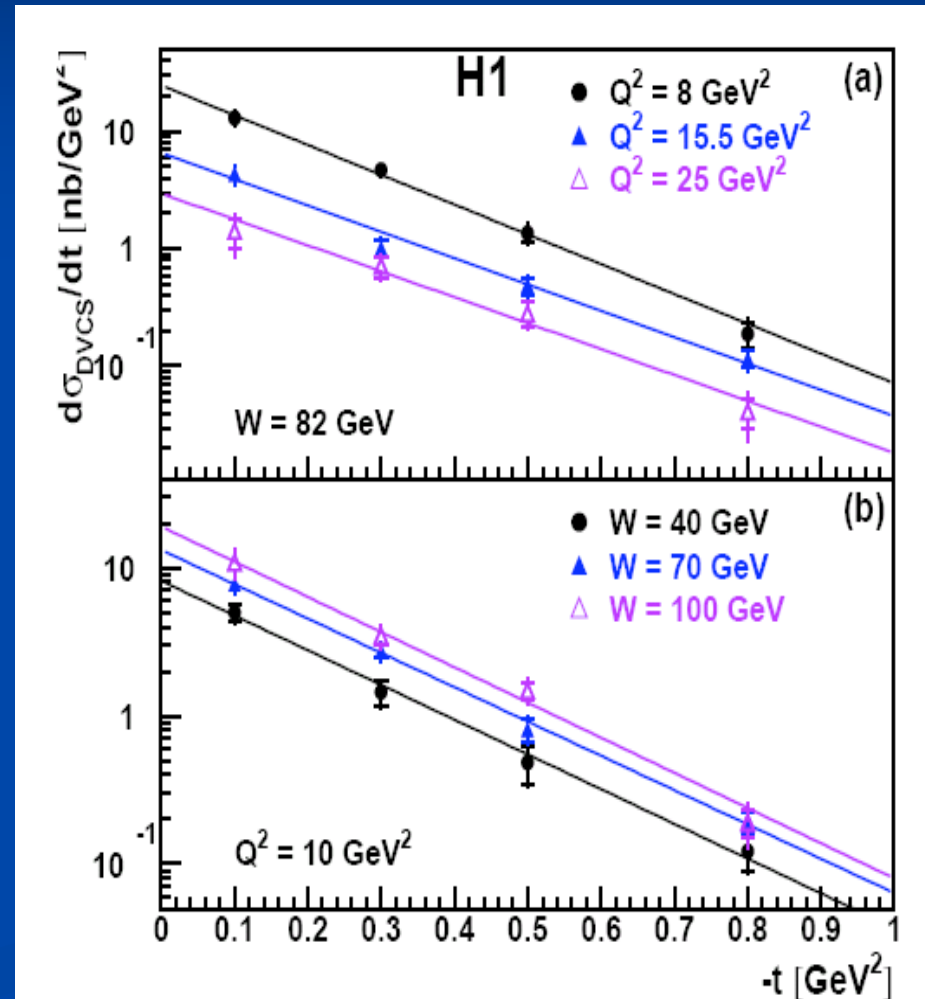**The first observation of skeewing (GPDs) impact**

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 Q²: higher twists effects in 1/Q²: finite size of the qqbar pair probe?!

- @ large Q²: scaling in Q²... we are really probing the proton sturcture with a « pointlike » qqbar pair configuration

- No dependence in W

  => α' ~ 0 GeV⁻²

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

14
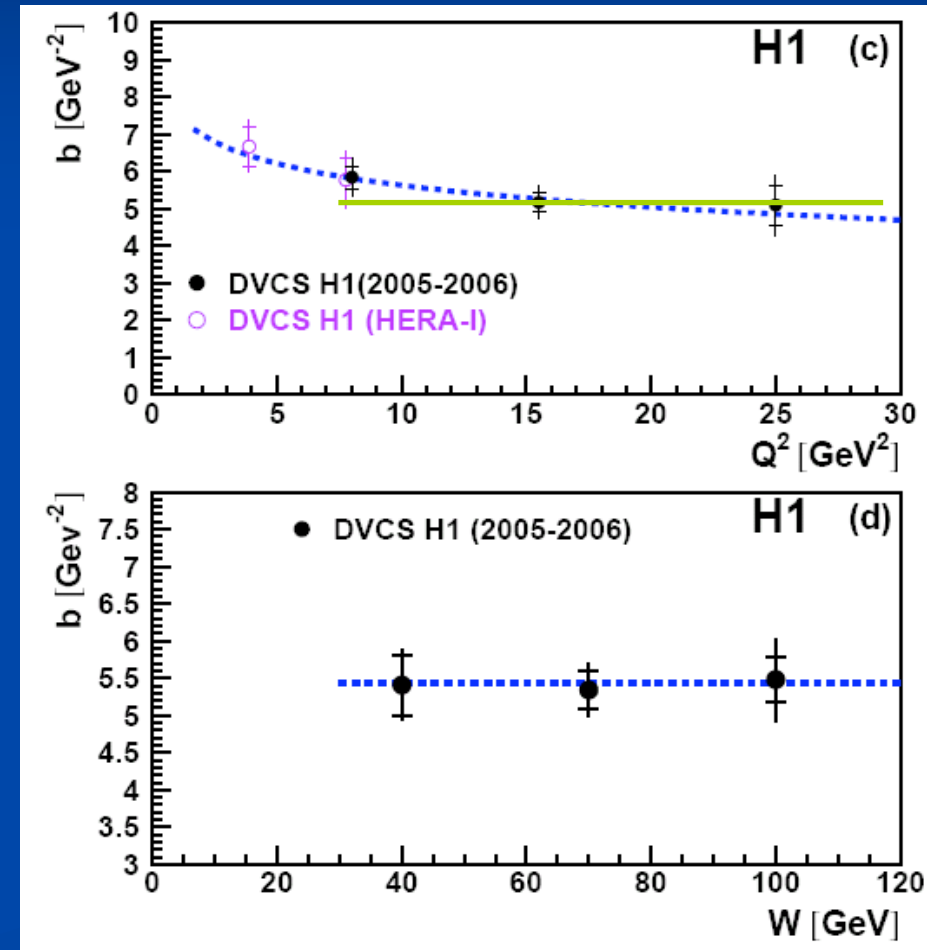
H1 data & Lattice estimations

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

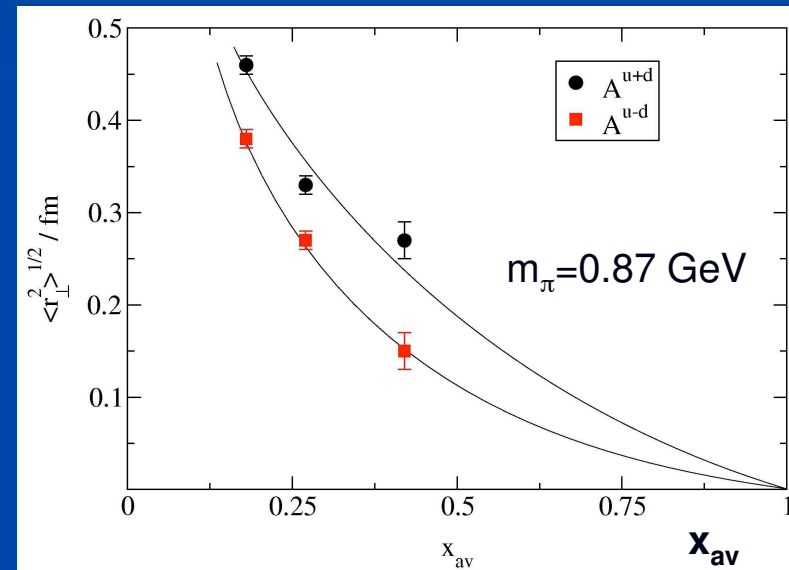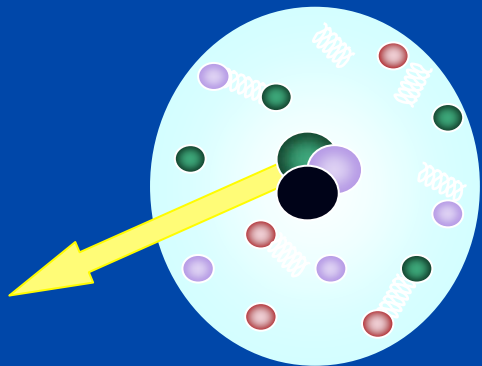=> $\sqrt{\langle r_T^2 \rangle}$ = 0.65 fm

>> 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!**
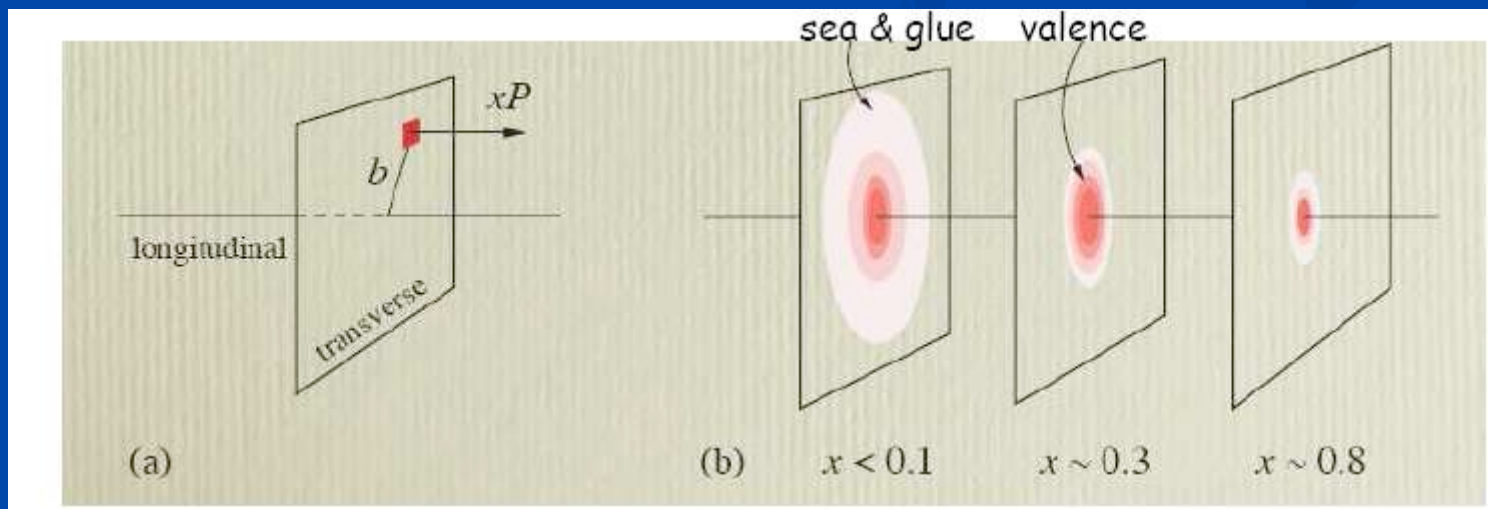
DVCS at CERN

- 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?

2.5 m Liquid H2 target
to be designed and built

μ′

γ

ECAL 1 or 2
$\theta\gamma \leq 12°$

COMPASS equipment
with additional calorimetry
at large angle

μ

p′
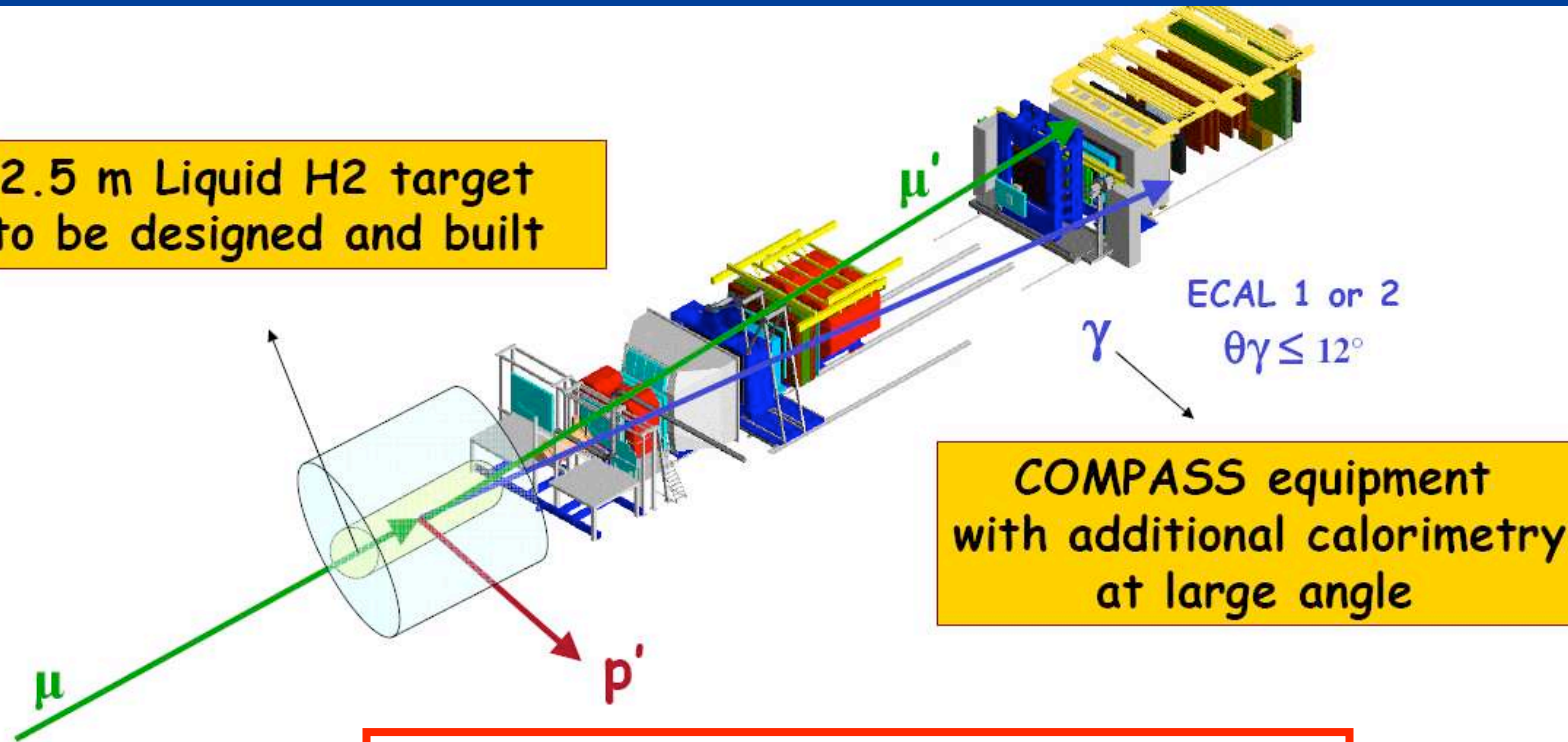
Recoil detector to insure exclusivity
to be designed and built

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:

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

    ~ **Beam Charge Asymmetry (BCA)**

- **COMPASS with μ+ and μ- beams can do it!**

- => New frontier after first results with HERMES & H1

VGG : double-distribution in x,ξ

model 1: H(x,ξ,t) ~ q(x) F(t)

model 2 and 2*: correl x and t

$\langle b^2_\perp \rangle = \alpha'\, \ell n\, 1/x$
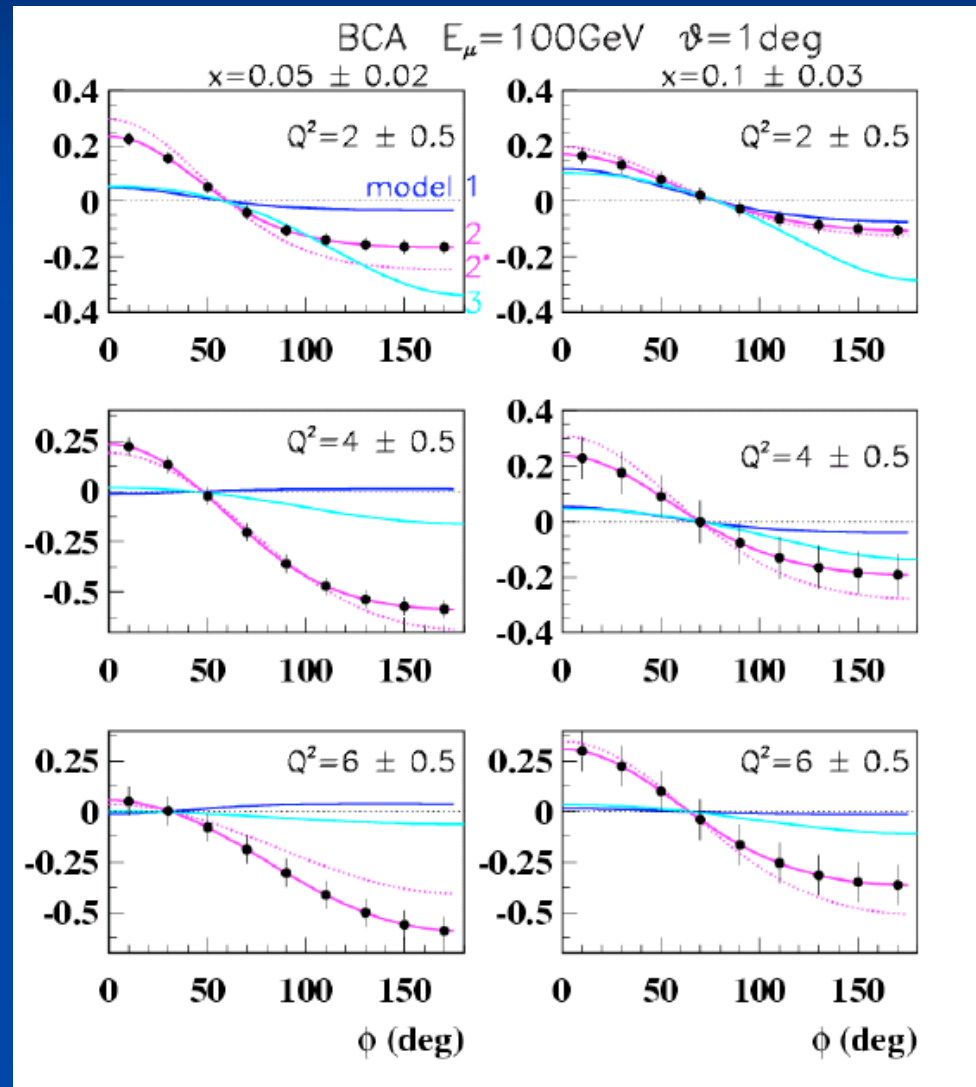
$H(x,0,t) = q(x)\, e^{\,t\, \langle b_\perp^2 \rangle}$
$= q(x)\, /\, x^{\alpha' t}$

α' slope of Regge traject.
———— α'=0.8
········ α'=1.1

Guzey: Dual parametrization
model 3: also Regge-motivated
t-dependence with α'=1.1

BCA E_μ=100GeV ϑ=1deg

x=0.05 ± 0.02   x=0.1 ± 0.03

Q^2=2 ± 0.5   model 1   2   2*   3 Q^2=2 ± 0.5

Q^2=4 ± 0.5 Q^2=4 ± 0.5

Q^2=6 ± 0.5 Q^2=6 ± 0.5

φ (deg)   φ (deg)

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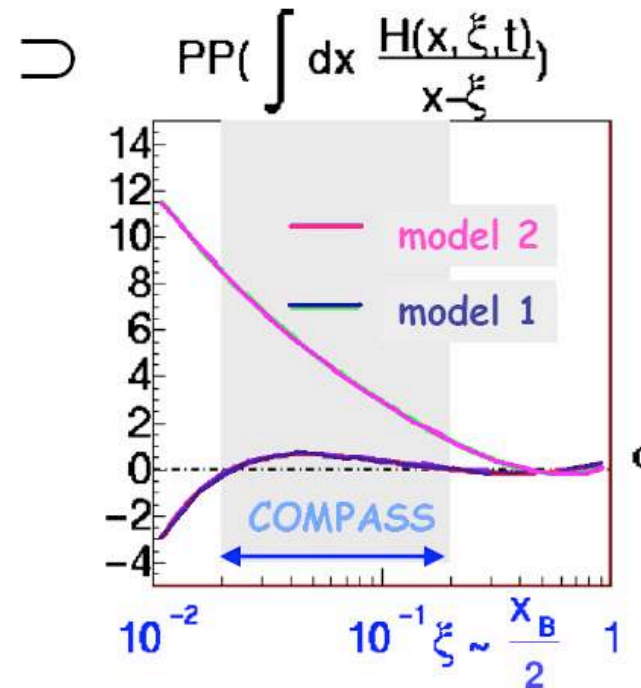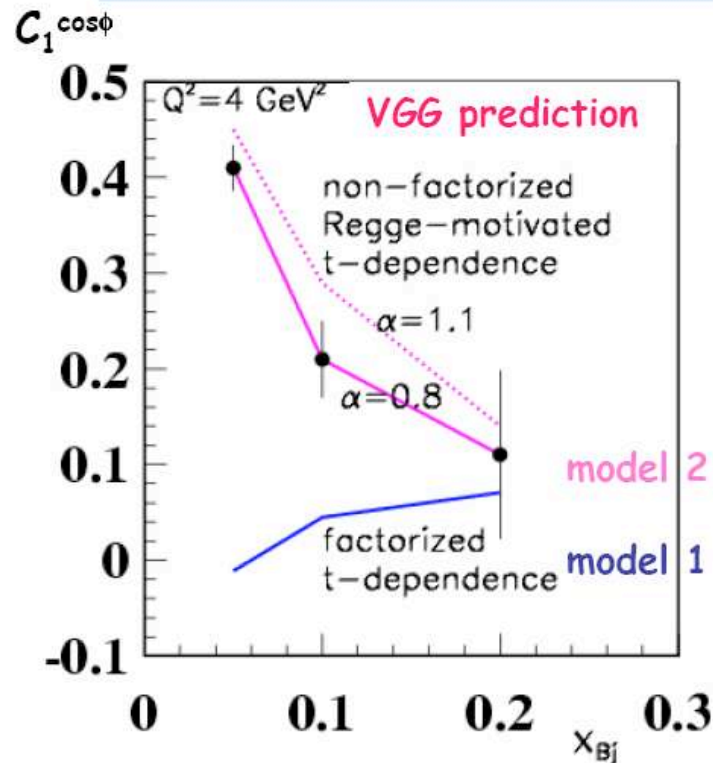
Conclusions & Outlook

- 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