DVCS at HERA & perspectives at CERN

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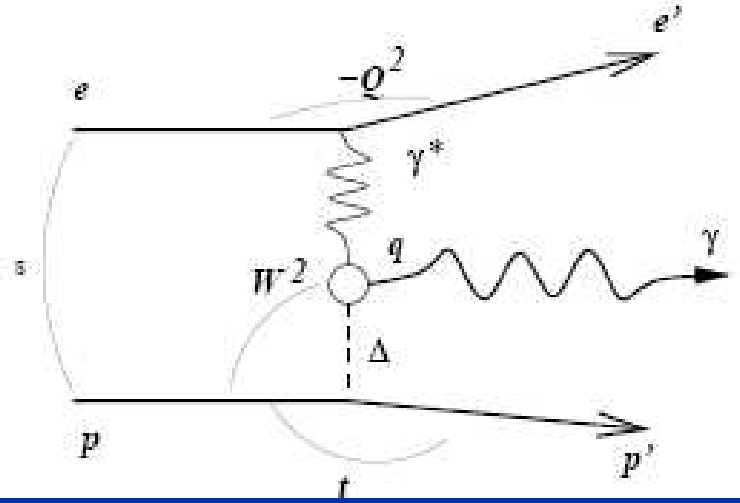
DIS 2009

Put in perspective HERA results and COMPASS prospects for DVCS with a few issues (related to GPDs/proton-spin)

DVCS kinematics

DVCS: QCD process



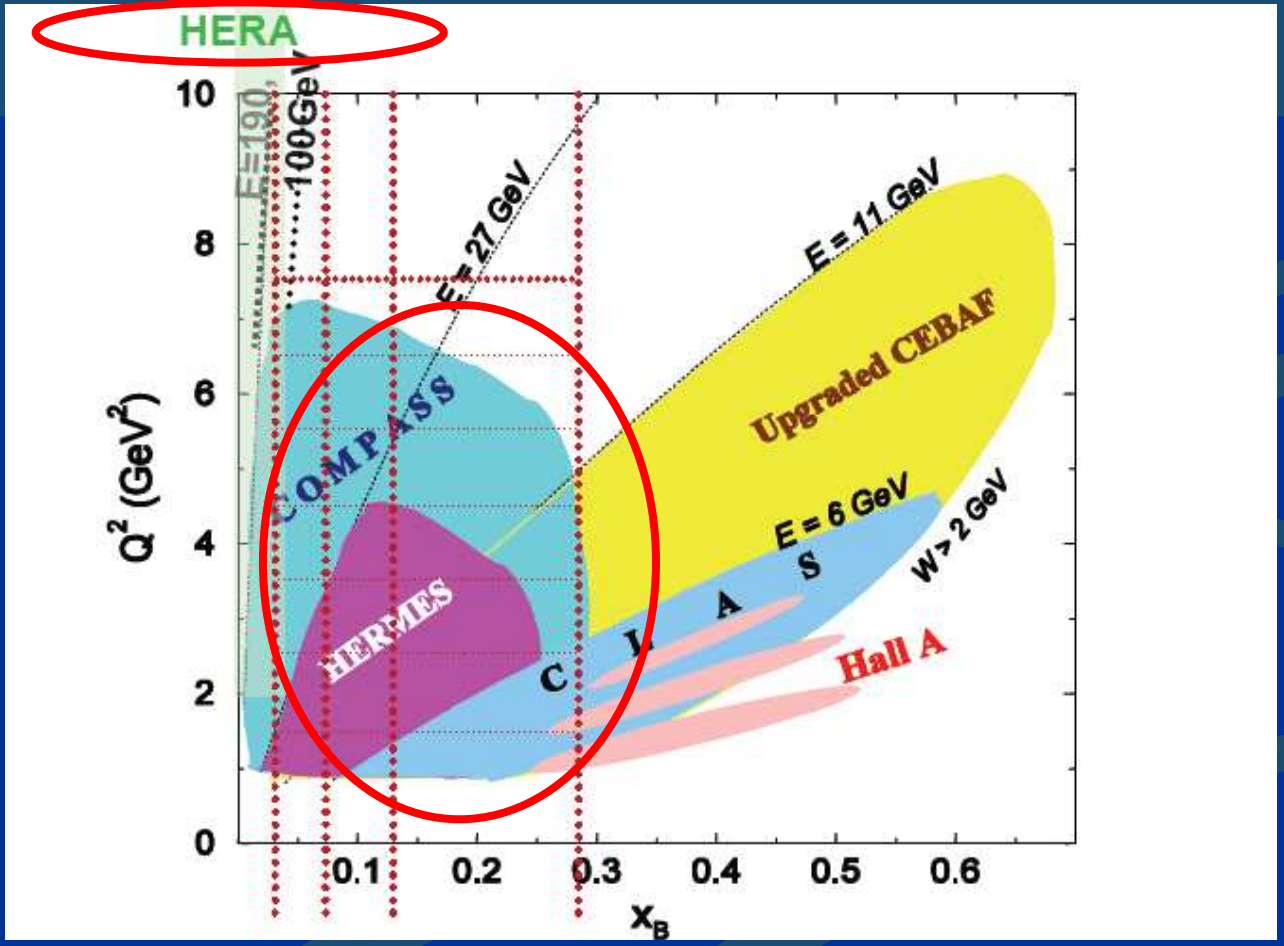
$$s = (e+p)^2$$
$$Q^2 = -q^2 = -(e-e')^2$$
$$W^2 = (q+p)^2$$
$$t = \Delta^2 = (p-p')^2 \approx -p_T'^2$$

HERA : e p → e p γ
COMPASS : μ p → μ p γ

DVCS interferes with the purely EM process BH

DVCS in the word

COMPASS/HERMES kin domain x ⊂ [0.01, 0.1]
H1/ZEUS kin domain x<0.01 (large Q^2 range 2-100 GeV^2)
Jlab experiments: kin domain x>0.1



Some basic characteristics

- H1/ZEUS: low x ($x<0.01$) : large gluon density, saturation effects?!

  DVCS cross section ~ BH cross section ($Q^2 \sim 10$ GeV^2)

  For $x<0.01$ => Direct σ_{DVCS} can be measured…

  Q^2 scale dependence can be analysed over 1 order of magnitude

- HERMES and COMPASS: similar kin domains

  Continutity with HERA (low x) domain

  At COMPASS: possibility to measure also directly σ_{DVCS}
  and DVCS/BH interference (// HERMES)

- $x>0.1/0.2$ (low Q^2): Jlab (see talks @ this workshop)

  Measure interference DVCS/BH, copious background of π^0

  HT effects on top of any observables?!

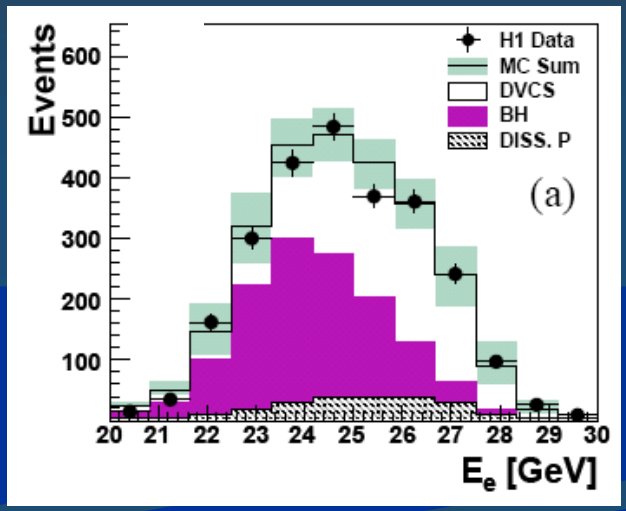
DVCS at HERA
Results on control distributions

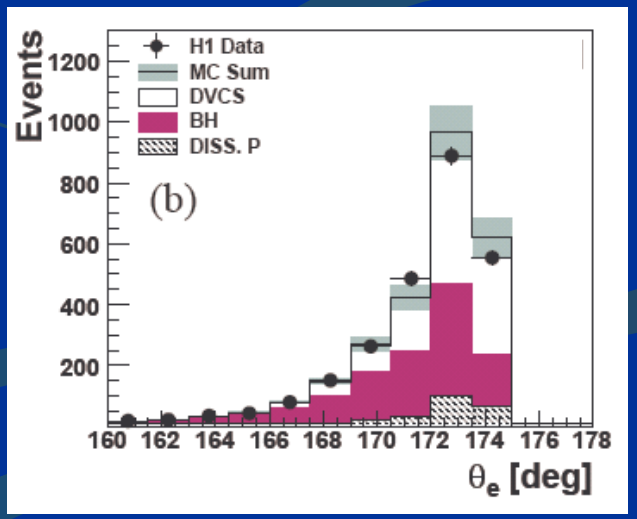
- Lepton variables

  Good description by Monte-Carlo (MC) with 2 dominant contributions:

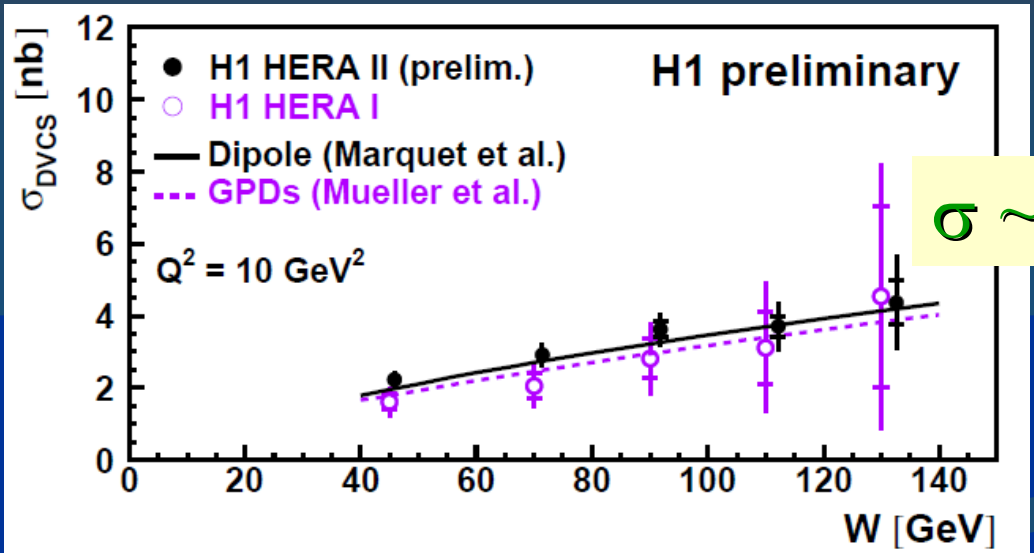
  - DVCS signal (ok)
  - BH background (irreductible)

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

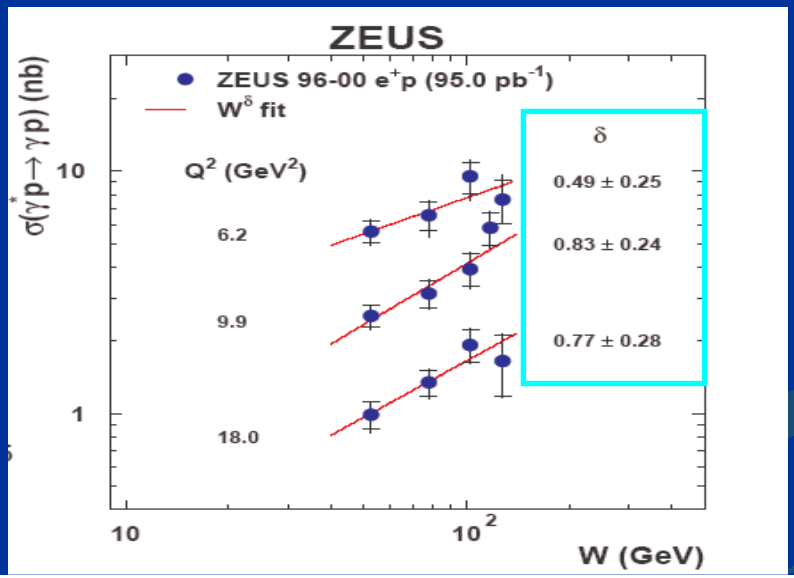




DVCS cross sections in W…
a first fundamental result (large W, low x)

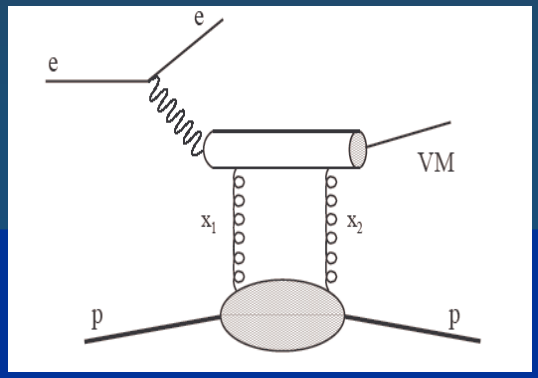


$\sigma \sim W^{0.7}$

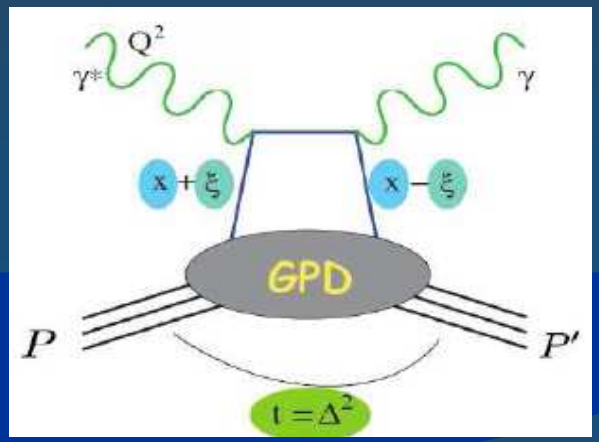


Hard W dependence
=> DVCS at HERA (low x)
is a hard process…
can be described
by pQCD…

DVCS versus Skeewing: prospects



VM => photon



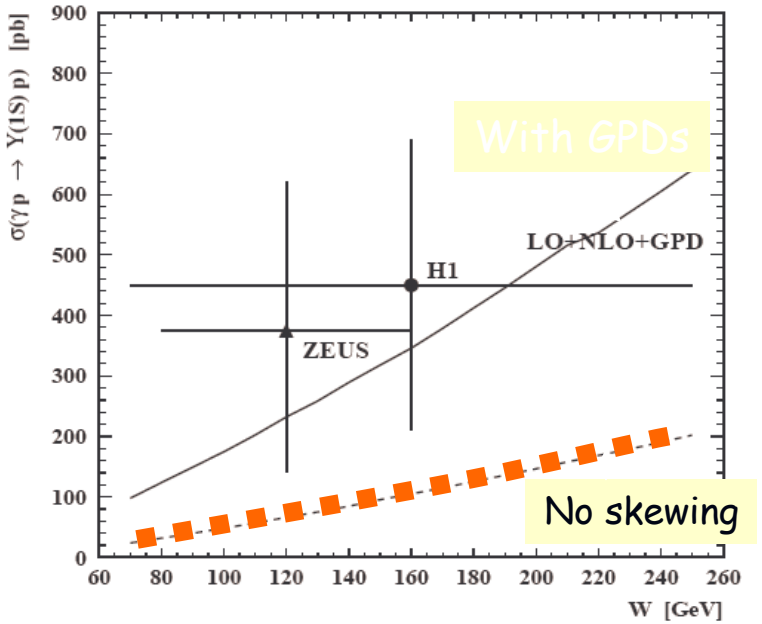
x_1-x_2 ~ [Q^2+M^2] / W^2 => $\xi \sim x_{bj}/2$

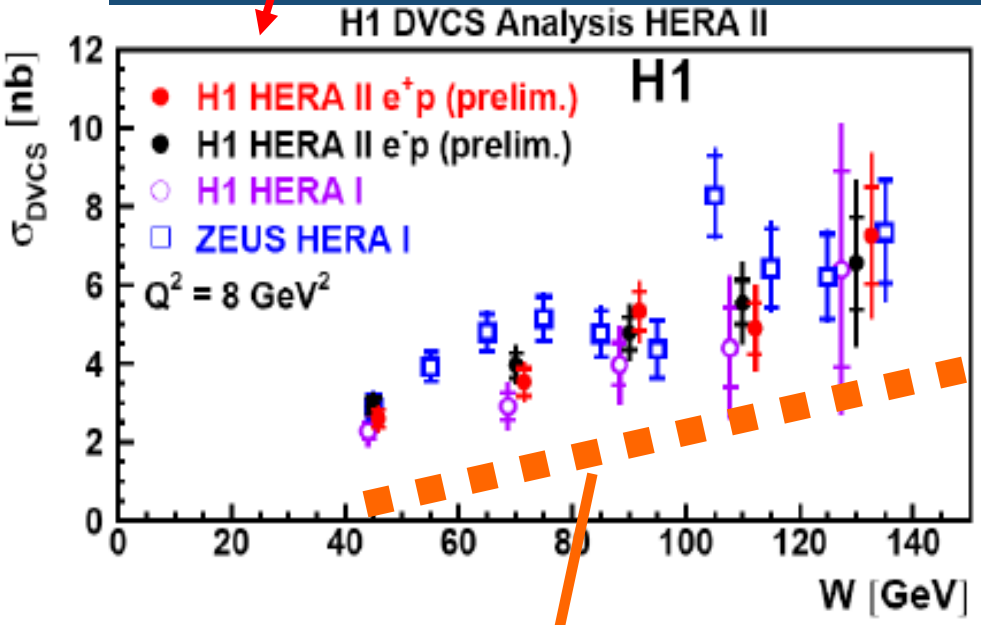
We expect skeewing effects to be important
In VM & DVCS @ HERA
=> Replacement of PDFs by GPDs ?!

Skeewing effects: 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!



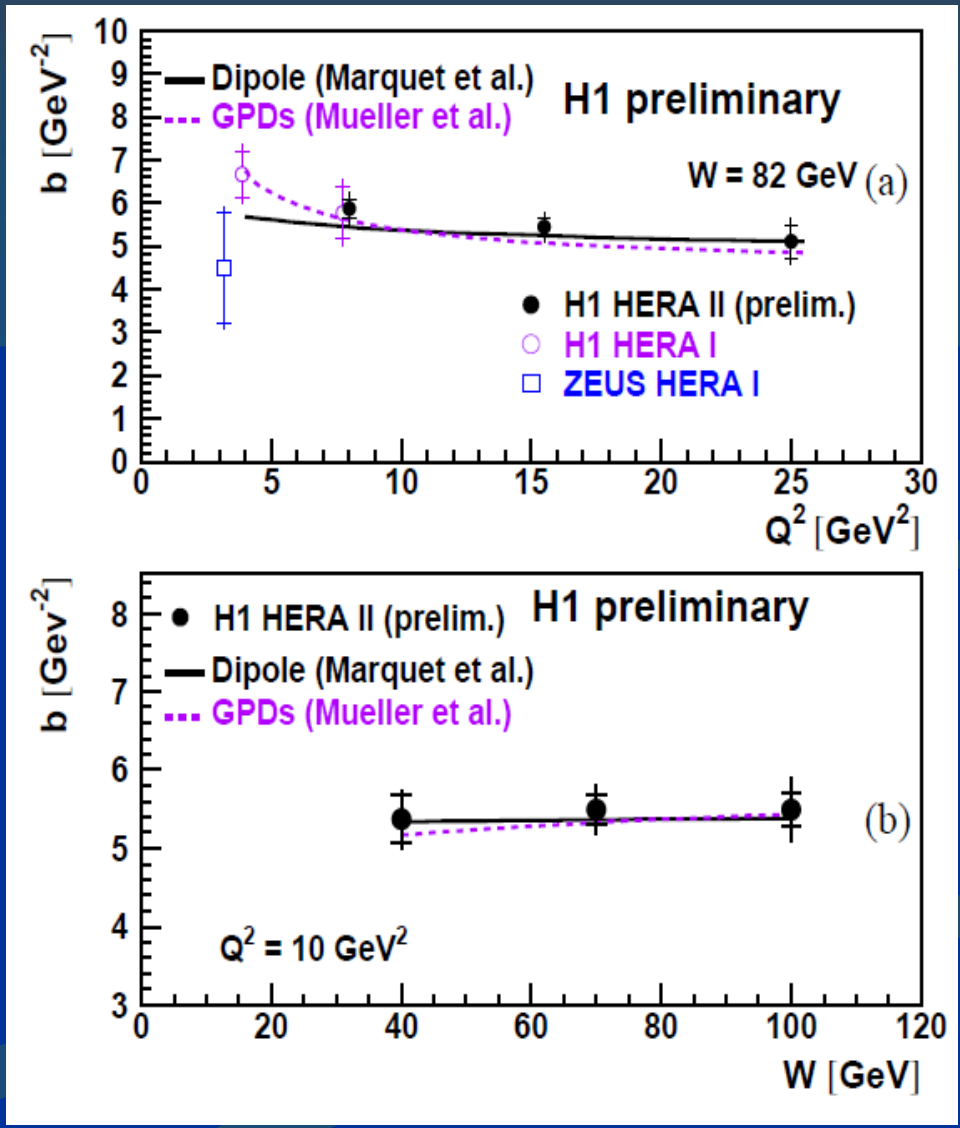


The first observation of skeewing (GPDs) impact

Prediction without skewing
a factor~4 below the data

HERA DVCS ($x \sim 10^{-3}$): $d\sigma/dt \sim e^{bt}$

- @ 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 observed (α' small)



H1/ZEUS DVCS ($x \sim 10^{-3}$): $d\sigma/dt \sim e^{bt}$

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

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

>> valence quarks value

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

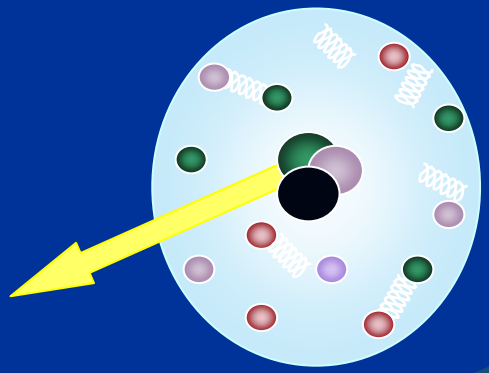
In agreement with « ideas » coming from **Lattice QCD**…

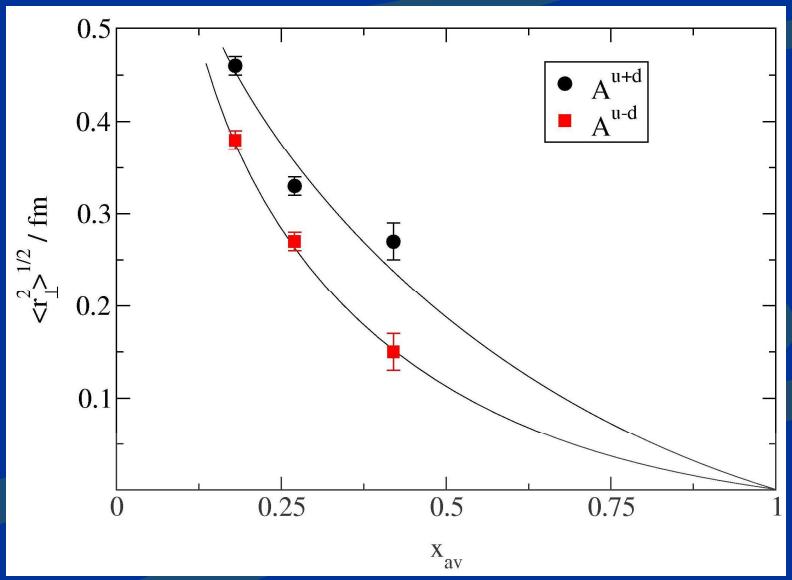
Lattice calculations (unquenched QCD):

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



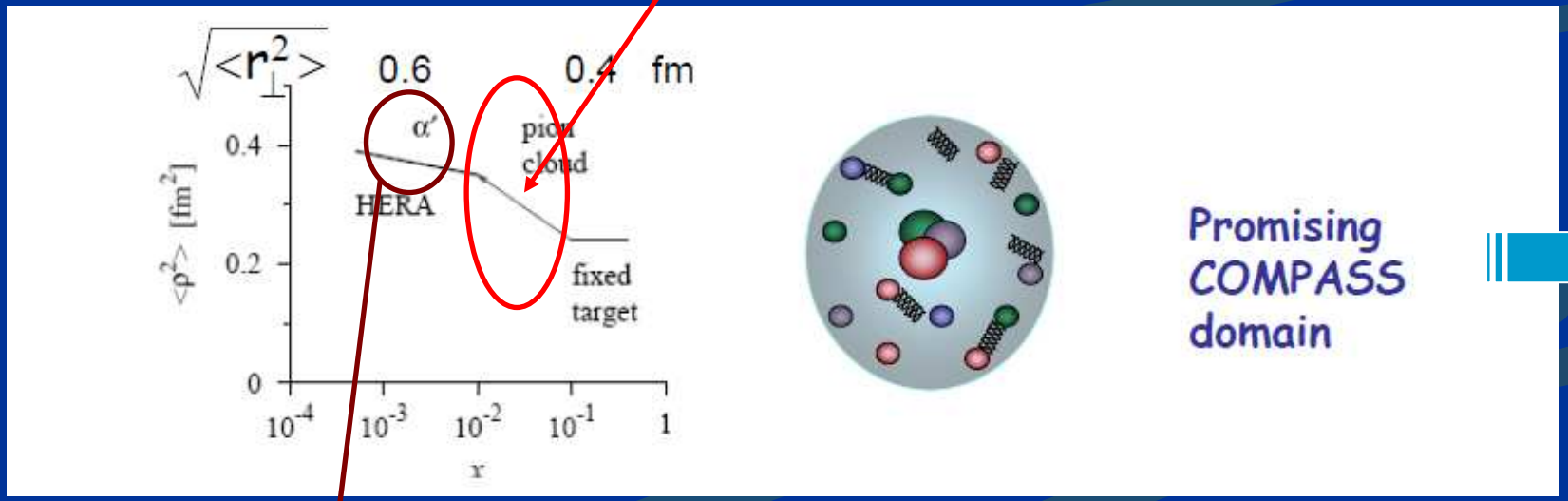


Some more picks from the t dependence…

(1) The only direct measurement of b (DVCS) is done with H1/ZEUS measurements (x<0.01)

Compatible with a « wide » pion cloud @ low x…

(2) What does it give @ COMPASS (x>0.01) ? α' small or large?

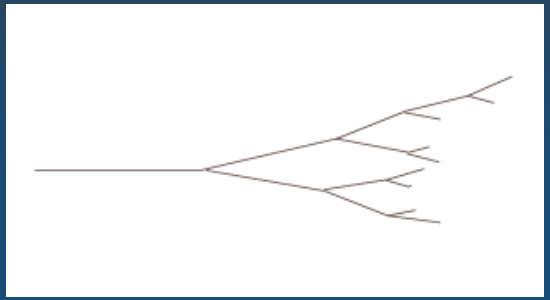


α' measured to be small for DVCS @ HERA (perturbative domain)

A brief status on α'

Gribov diffusion: parton branching as random walk in b space

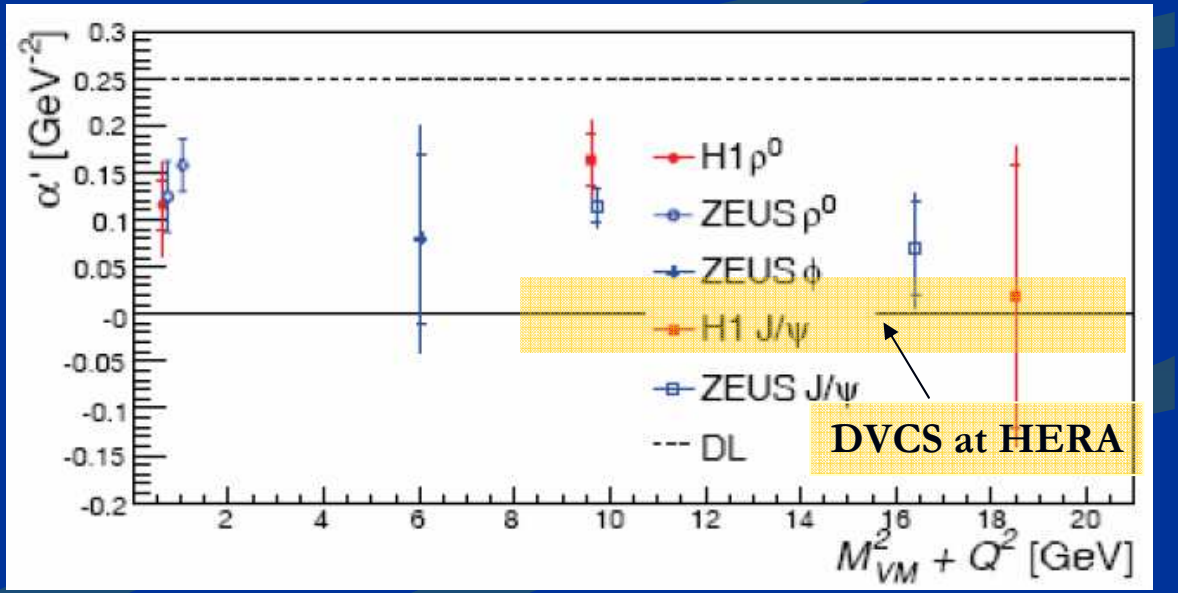
$$\rightarrow \langle b^2 \rangle \propto \alpha' \log(1/x)$$



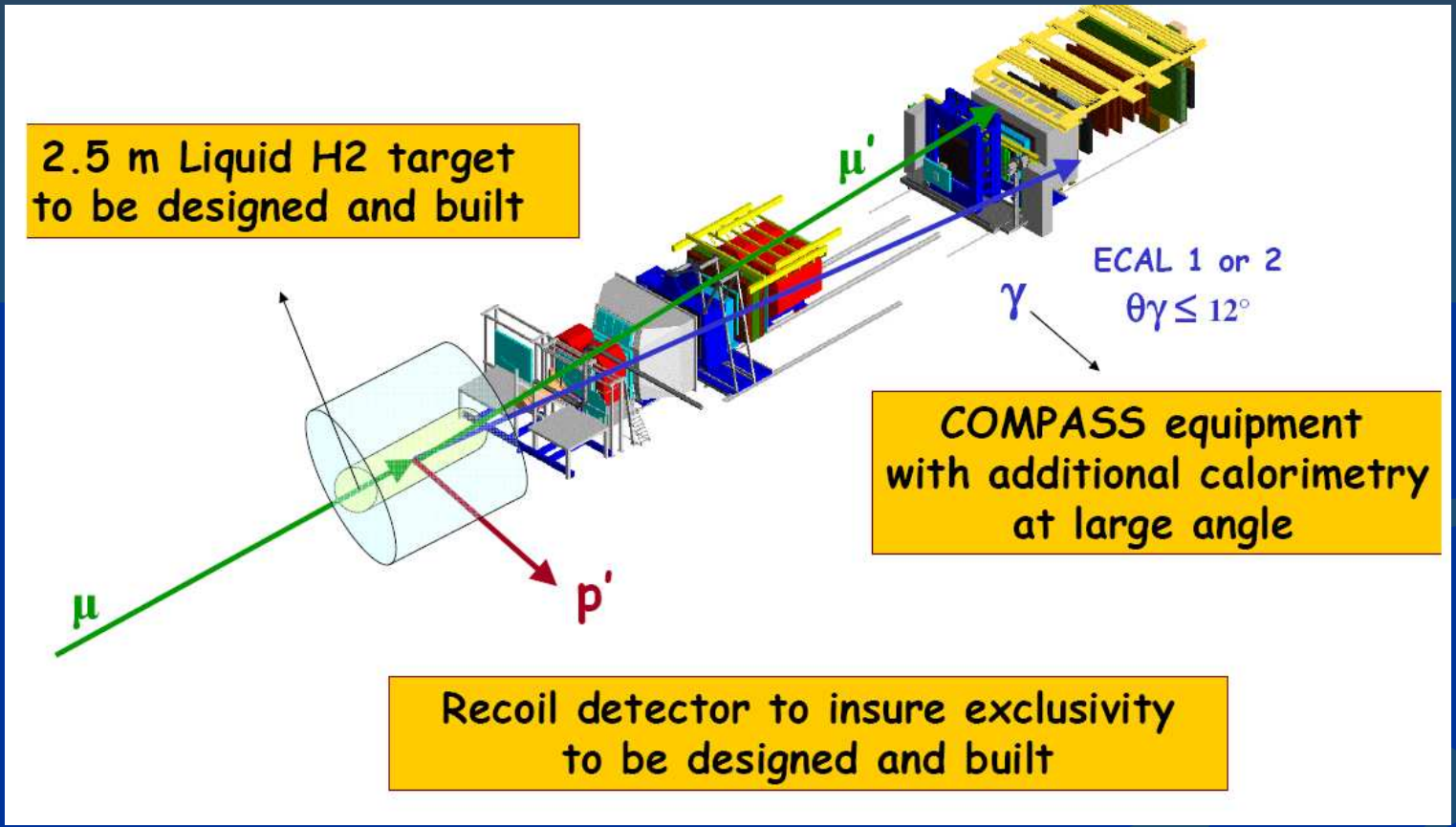
We expect a non zero value of α' due to « basic » (Gribov) diffusion:
Emission of more & more partons… **But @ large Q², low x: results are different!**

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!



How DVCS at CERN?

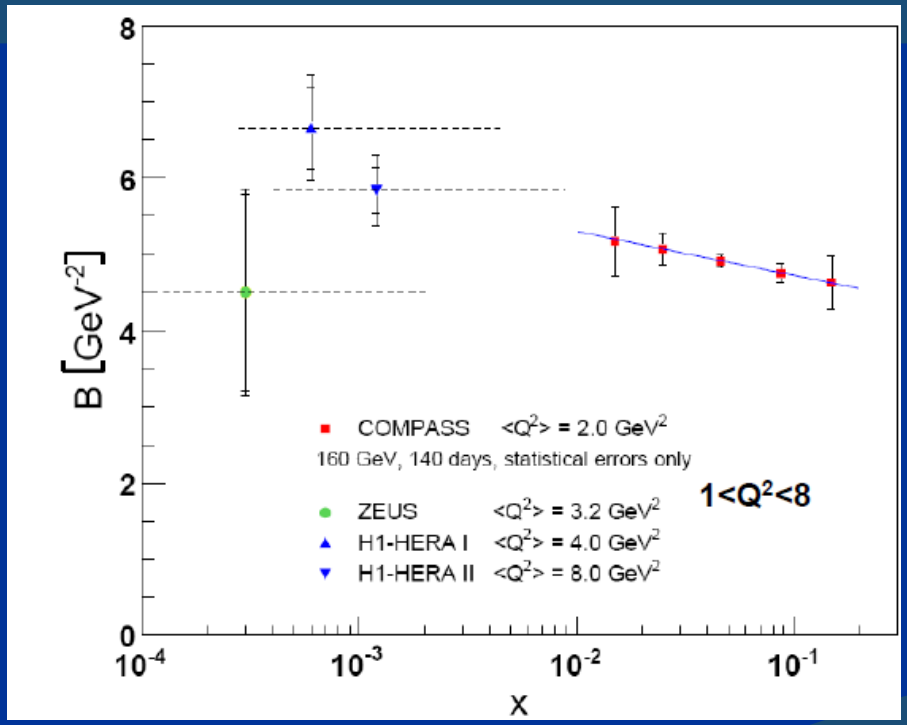


See talk of E. Burtin for a complete information

Next => 2/3 strong physics cases @ COMPASS

Direct σ_{DVCS} measurements

THEN, acces the t-slope dependence in x!
FUNDAMENTAL issue…
=> determine subsequently α' essentially unknown in this kin domain



This makes a strong experimental case, when compared to experiments that can measure only asymmetries…

THEN, COMPASS can use this first possible result on α' to interpret data on BCA

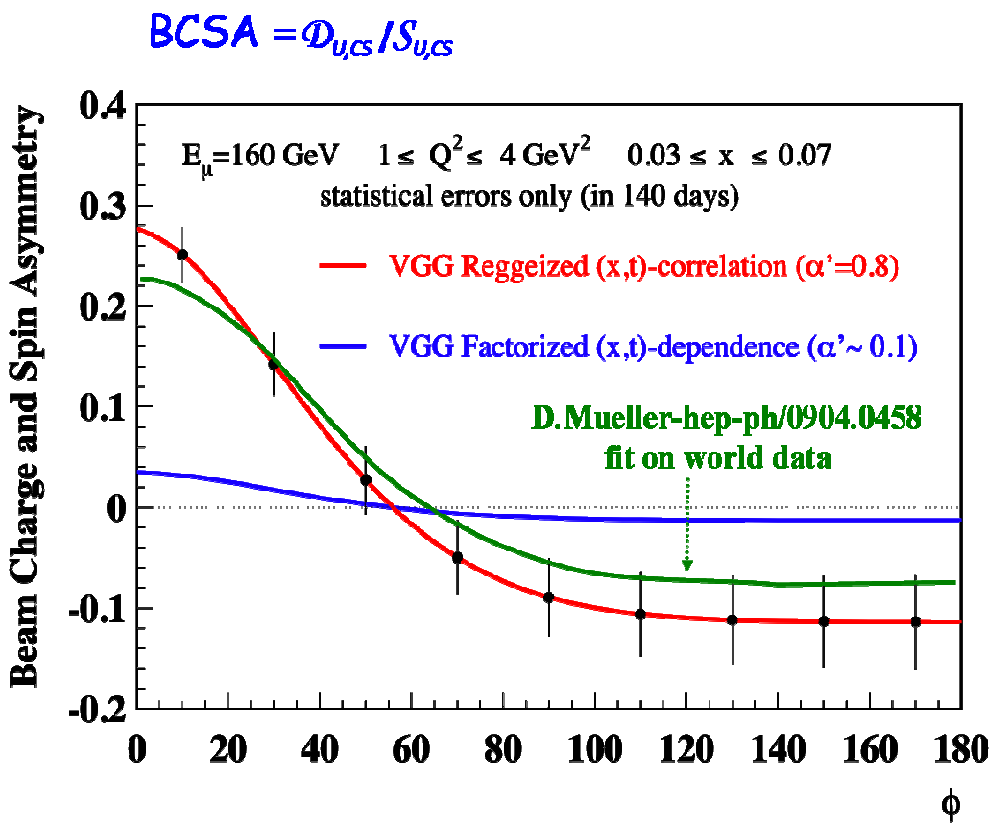
(see Talk of E. Burtin)

Beam Charge Asymmetry BCA

$$BCA \equiv \frac{d\sigma_{e^+} - d\sigma_{e^-}}{d\sigma_{e^+} + d\sigma_{e^-}} = \frac{\mathcal{A}_{\text{Interference}}}{|\mathcal{A}_{\text{DVCS}}|^2 + |\mathcal{A}_{\text{BH}}|^2}$$

Non-factorised ansatz:
Mix t/x dependences =>
$H(x,0,t)=f(x)/x^{\alpha' t}$

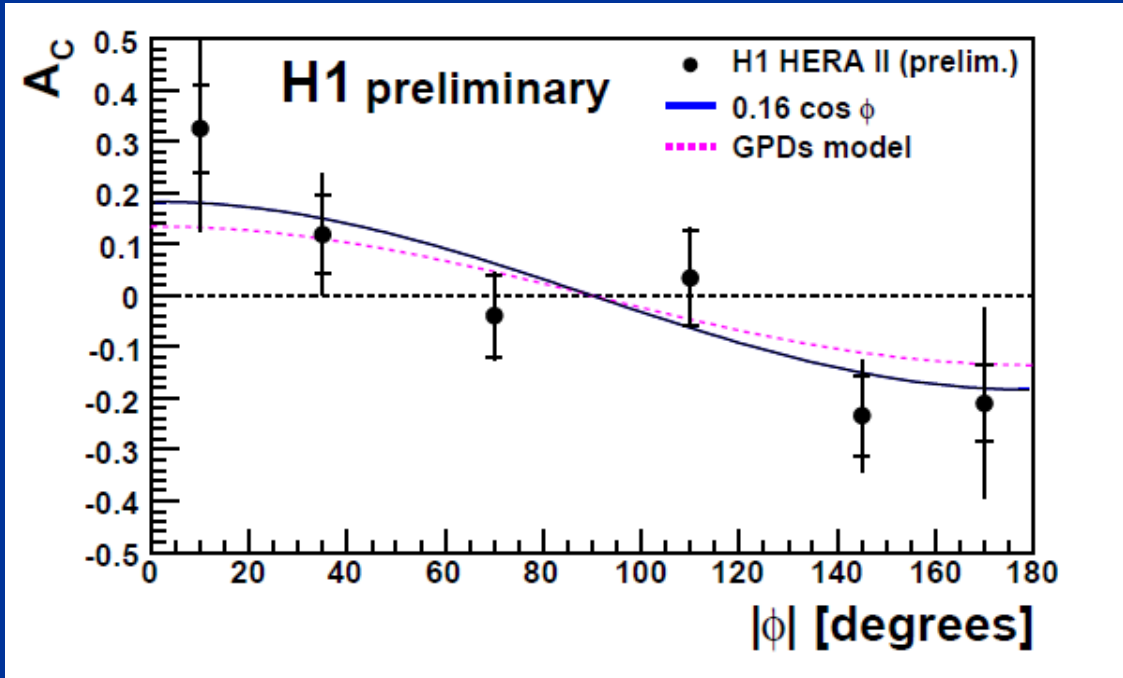
α' is then an important measurement from cross sections [t] (see previous slides)



BCA as measured by H1

See talk of P. Marage for a complete information

Main interest => provide information on Re(DVCS amplitude)…
Direct sensitivity to GPDs models
(with small α' value, as measured directly)
Extract Re/Im and check of dispersion relations



Re/Im = 0.20±0.05 ±0.08

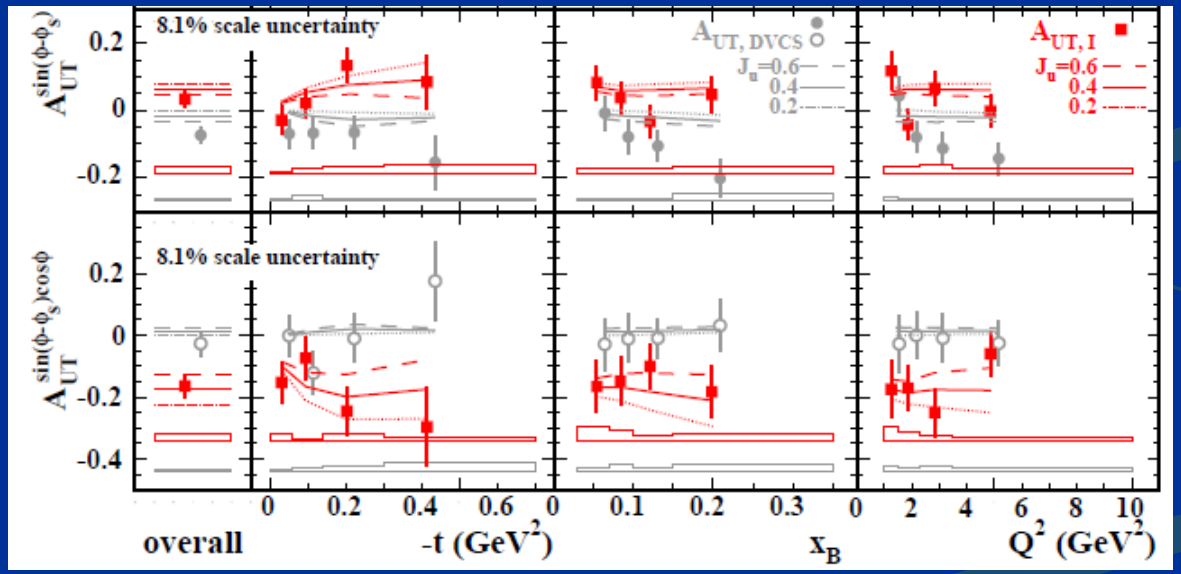
Dispersion relation
(W dependence of σ_{DVCS})
Re/Im = 0.25±0.03±0.05

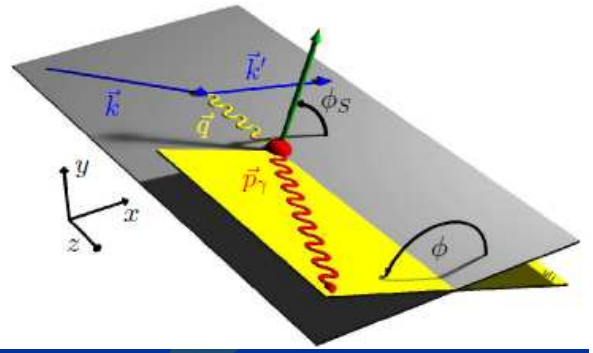
Direct sensitivity on E (and J_q)

Transverse target-spin asymmetry $\mathcal{A}_{UT}(\phi, \phi_s)$ [TTSA]:

$$d\sigma(\phi,\phi_S) - d\sigma(\phi,\phi_S+\pi) \propto \mathrm{Im}[F_2\mathcal{H} - F_1\mathcal{E}] \cdot \sin(\phi-\phi_S)\cos\phi + \mathrm{Im}[F_2\widetilde{\mathcal{H}} - F_1\xi\widetilde{\mathcal{E}}] \cdot \cos(\phi-\phi_S)\sin\phi$$

See talks from HERMES for a complete information





Also a perspective for COMPASS after 2013

Outlook

Direct continuity from **HERA to COMPASS for DVCS**

- From the kin domain (trivial)
- From observables: **direct DVCS cross sections** & BCA
- Community of interests:

  t-slopes measured @ HERA => COMPASS ?

  also what is the α' value measured @ COMPASS?

  versus HERA (low x) value which is small!

More data on DVCS cross sections => more sensitivity to GPD (Hq/Hg))=> get an information on E via BCA and more directly via TTSA

More data means also a possibility to move to the golden case of global fits of GPDs on all measured quantities