New measurement of charge asymmetry xF_3 from HERA

Laurent Schoeffel
CEA Saclay

March 25-27, 2009
Thomas Jefferson National Accelerator Facility
Newport News, VA

Headlines

** Very short introduction to HERA

** Definition of xF3

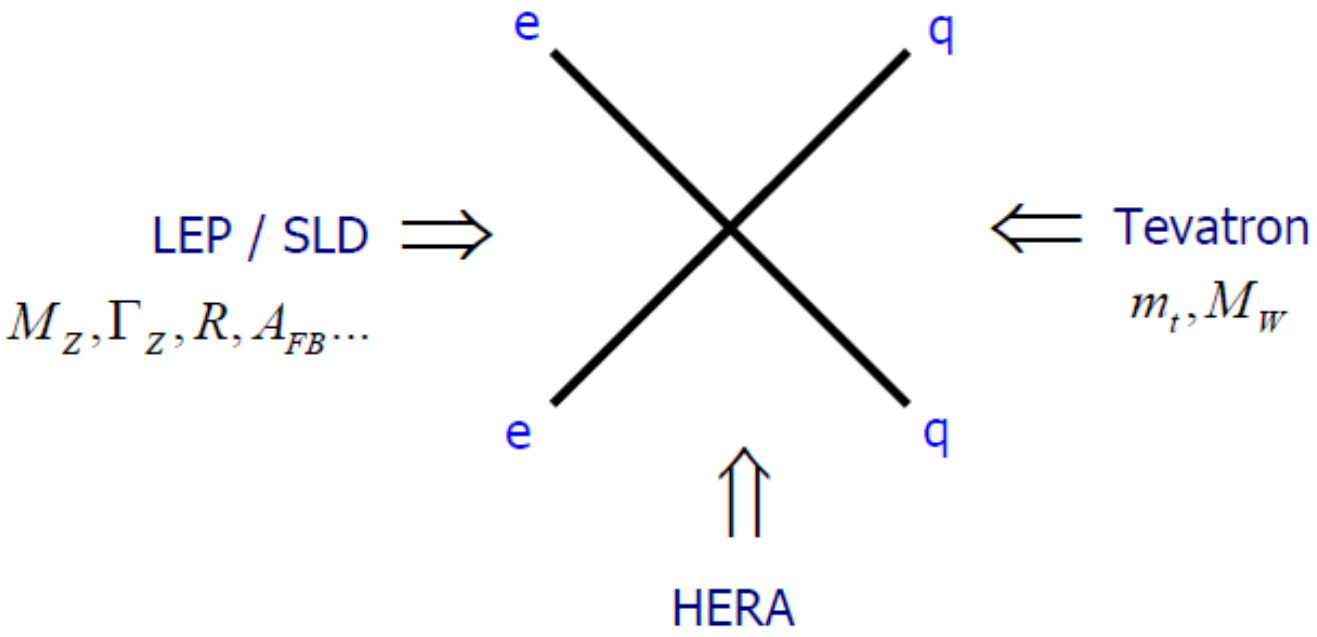
** Measurements and prospects

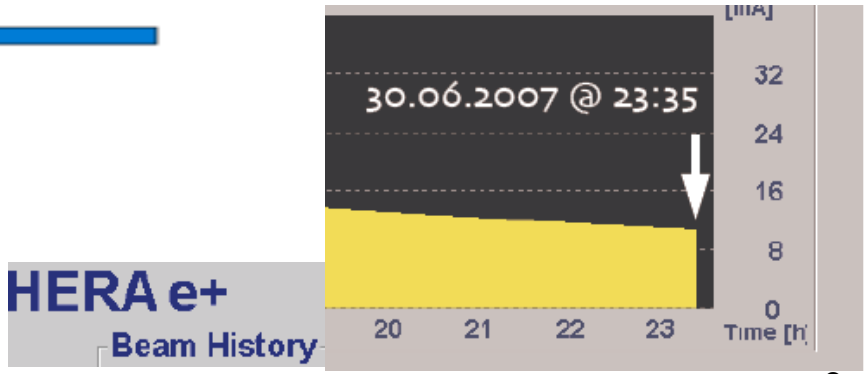
** Other cross section differences
in beam charges
-- at the Electro-Weak scale
-- at lower scale

** Outlook and future

Colliders @ EW scale

EW=Electro Weak



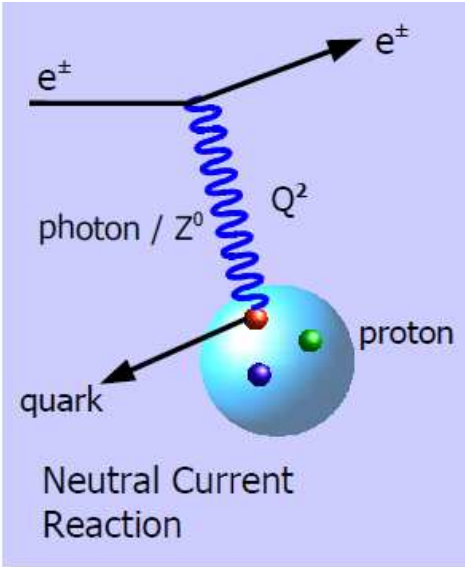


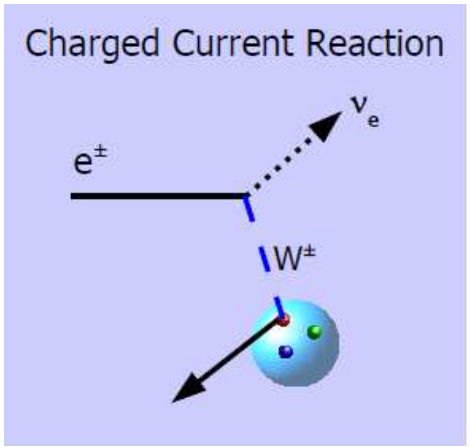
HERA @ EW scale

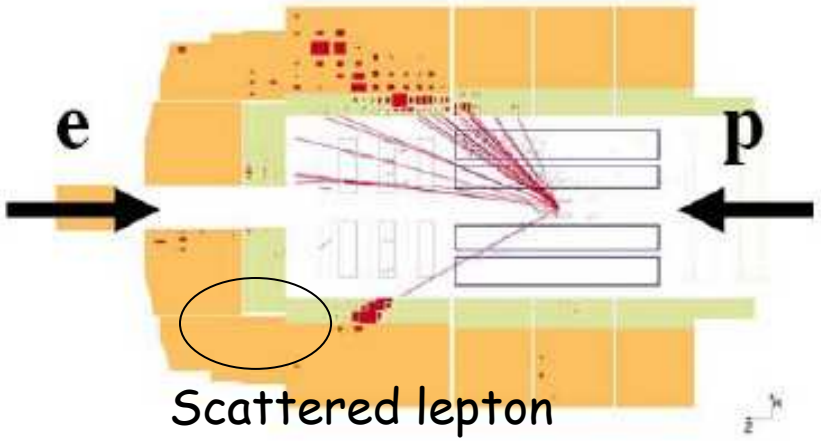
Q^2 is the Virtuality of the exchanged boson

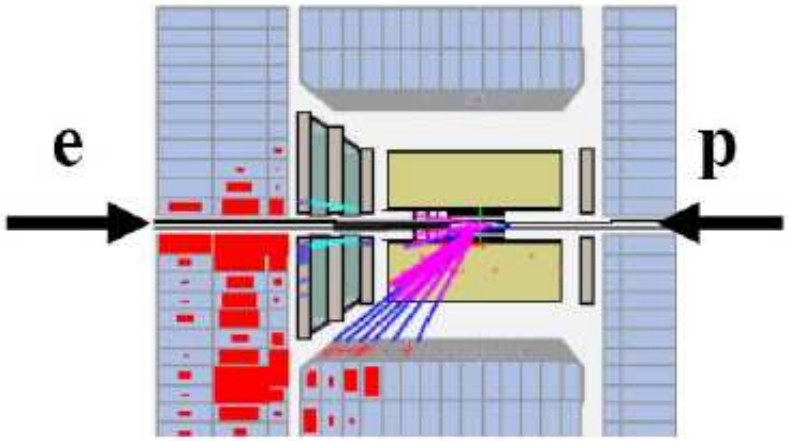
=>

Resolution in 1/Q down to ~10^{-18}m

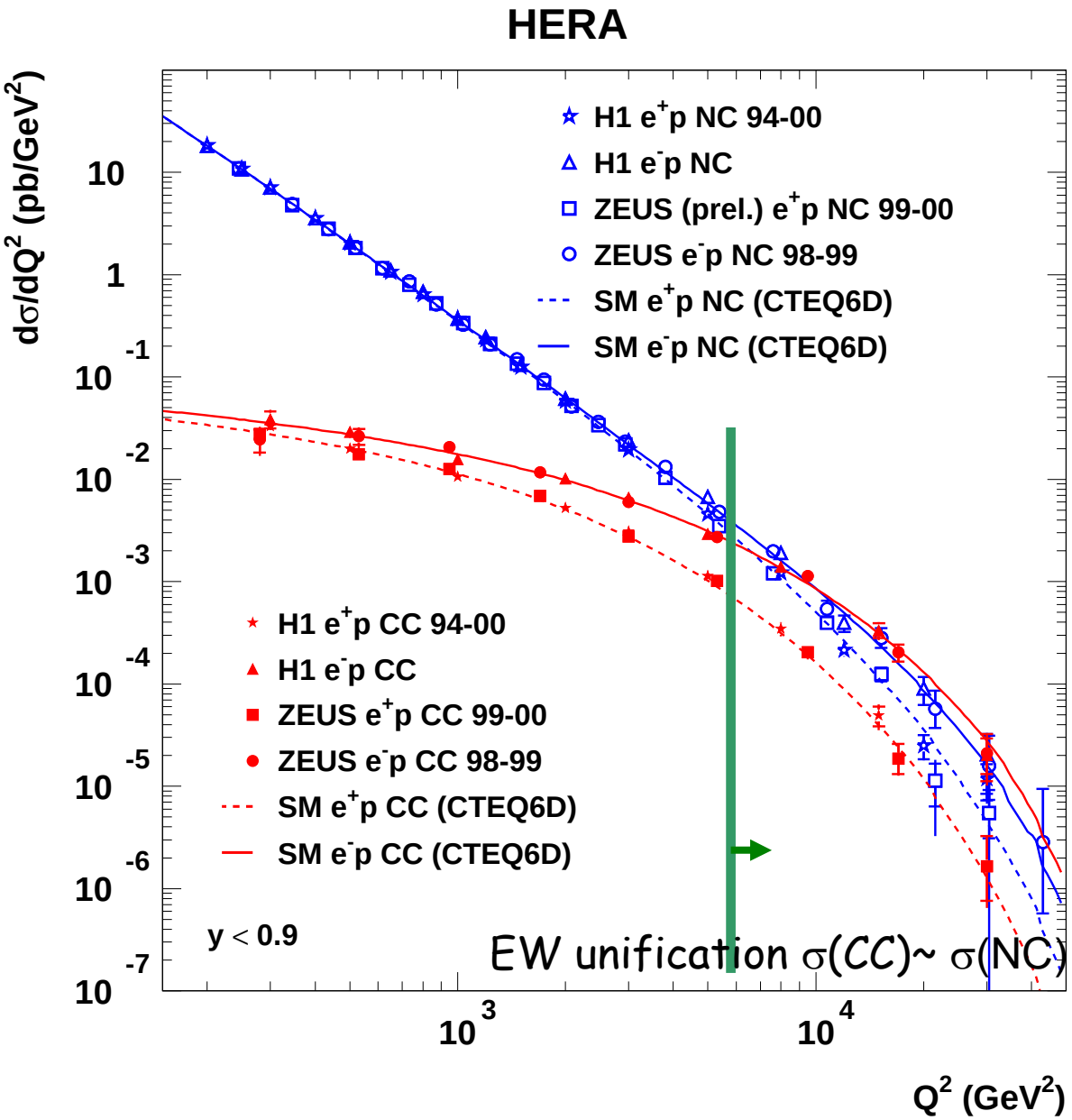








Inclusive ep cross sections



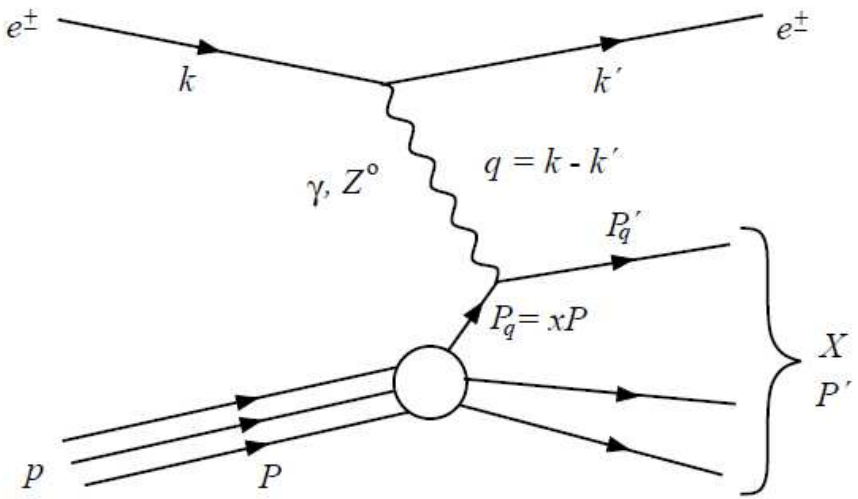
Notes:

** σ(NC)>>σ(CC) for small/medium Q^2

** σ(NC)~σ(CC) for $Q^2 > Mz^2$ and Mw^2
EW unification

** e+p and e-p gives different cross sections terms in xF3!

A bit more on kinematic variables



Diffusion angle in the e-q center of mass frame

$$y = \frac{1 - \cos\theta^*}{2}$$

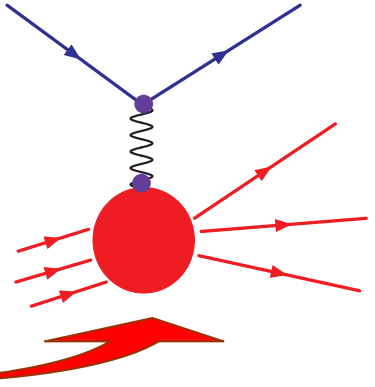
x is the (longitudinal) momentum fraction of the incident Proton carried by the struck quark

Inclusive ep cross sections

Expressions in fonction of y and $Y_{\pm}=1 \pm (1-y)^2$

$$\frac{d^2\sigma^{\pm}_{NC}}{dx\, dQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[Y_+ \tilde{F}_2 - y^2 \tilde{F}_L \mp Y_- xF_3 \right]$$

$$[\tilde{\sigma}]$$



With axial and vector couplings and Pe (lepton polarisation):

$$\tilde{F}_2^{\pm} = F_2^{\gamma} - (v_e \pm P_e a_e)\chi_Z F_2^{\gamma Z} + (v_e^2 + a_e^2 \pm P_e 2v_e a_e)\chi_z^2 F_2^Z$$

$$x\tilde{F}_3^{\pm} = -(a_e \pm P_e v_e)\chi_Z xF_3^{\gamma Z} + (2v_e a_e \pm P_e(v_e^2 + a_e^2))\chi_z^2 xF_3^Z$$

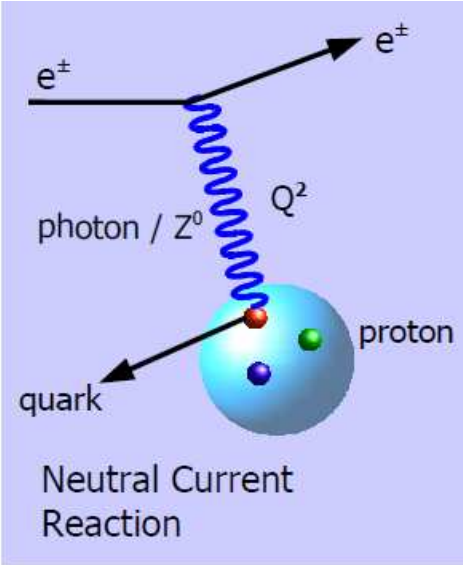
pure photon

photon/Z^0 interference

pure Z^0

χ_Z ~ Z^0 propagator

xF3 at work



xF3 comes from the γZ interference

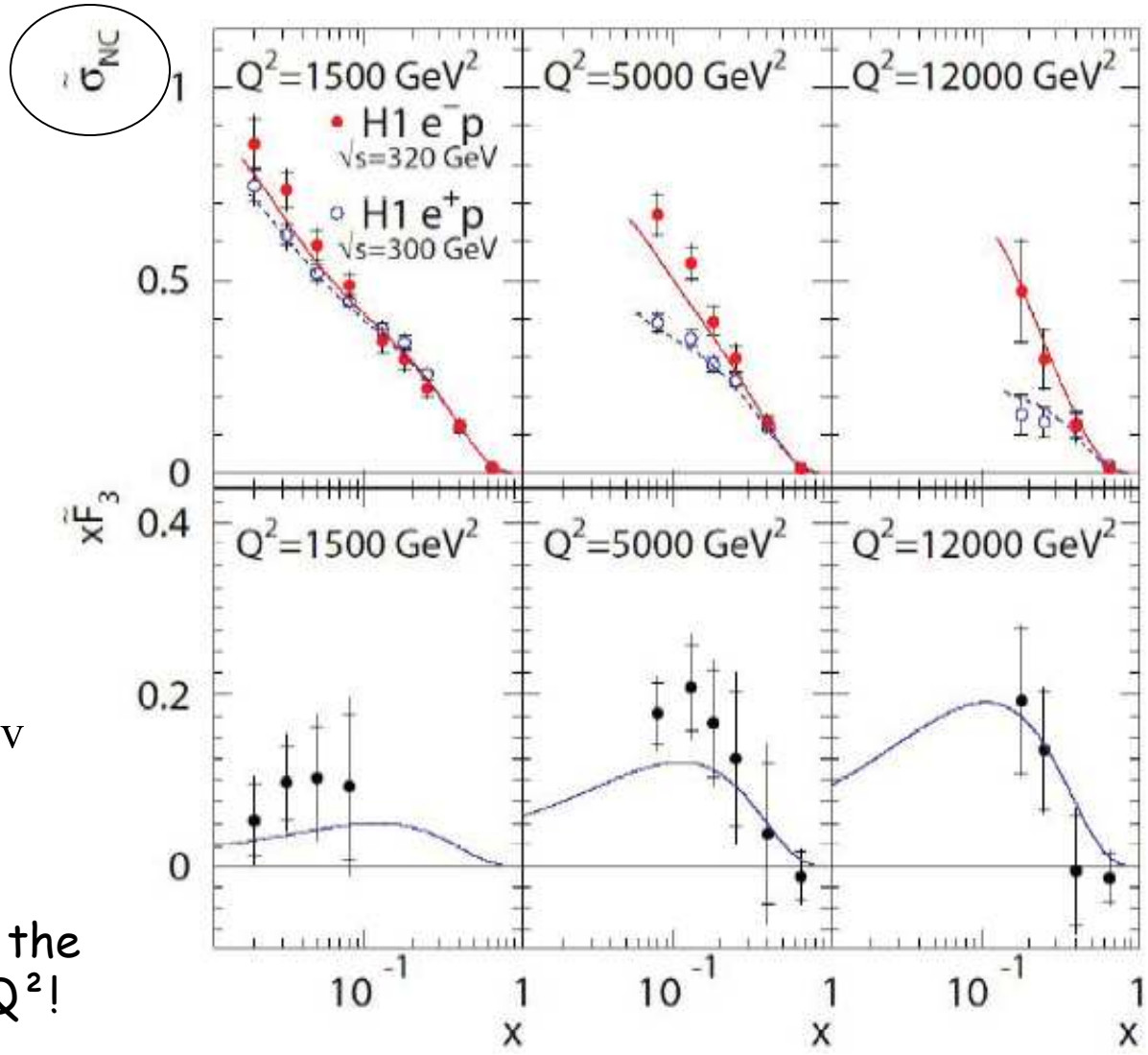
UNPOLARISED CASE

$$\tilde{\sigma}^{\pm}_{NC} \approx \tilde{F}_2 \mp \frac{Y_-}{Y_+} x\tilde{F}_3 \qquad \text{neglecting } F_L$$

$$x\tilde{F}_3 = \frac{Y_+}{2Y_-}(\tilde{\sigma}^{-}_{NC} - \tilde{\sigma}^{+}_{NC}) \approx a_e \chi_Z x F_3^{\gamma Z}$$

xF3 measurements (1)

Brut Measurements
of the cross sections
and extraction of xF3



$$x\tilde{F}_3 \propto x\tilde{F}_3^{\gamma Z} \sim 2u_v + d_v$$

Interesting constraint on the
Valence Quarks at large Q^2!

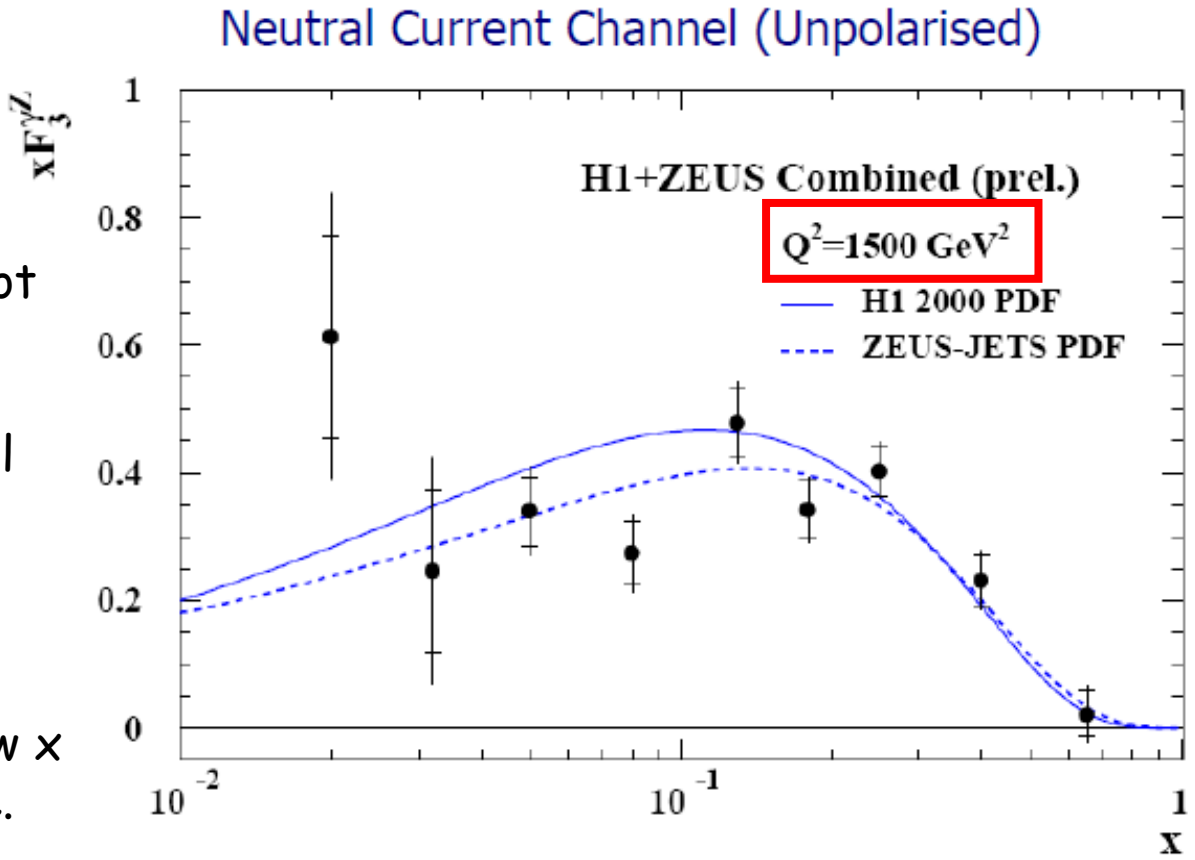
xF3 measurements (2)

COMBINATION H1+ZEUS

** not published yet
and only a part of the HERAII stat in this plot

** fluctuations?!
Some effects have still to be understood in combining experiments

** **purpose:**
Clarify the trend at low x (large Q^2)… if possible.



F2 and xF3 in quarks

$$\tilde{F}_2 \propto \sum (xq_i + x\bar{q}_i)$$

$$x\tilde{F}_3 \propto \sum (xq_i - x\bar{q}_i)$$

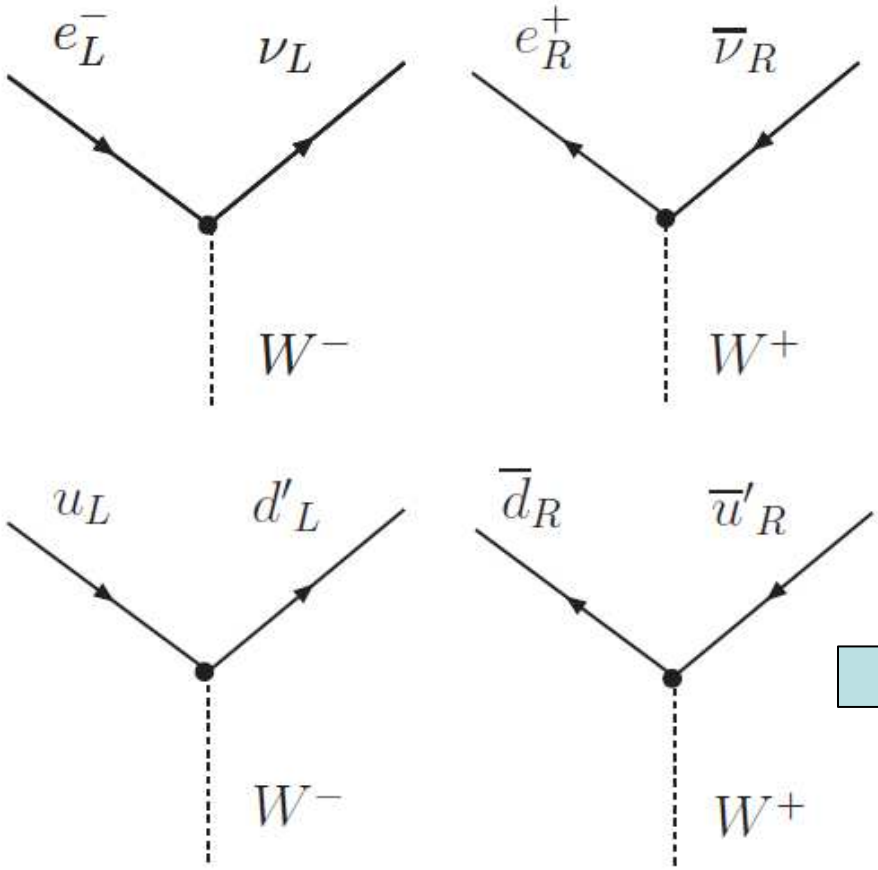
For the record

$$\begin{aligned} F_2 &= F_2^\gamma - v_e P_Z F_2^{\gamma Z} + (v_e^2 + a_e^2) P_Z^2 F_2^Z \\ &= \sum_q \left[e_q^2 - 2 e_q v_e v_q P_Z + (v_e^2 + a_e^2)(v_q^2 + a_q^2) \right] x(q + \bar{q}) \end{aligned}$$

$$\begin{aligned} xF_3 &= -a_e P_Z x F_3^{\gamma Z} + 2 a_e v_e P_Z^2 x F_3^Z \\ &= \sum_q \left[-2 a_e e_q a_q P_Z + 4 a_e v_e a_q v_q P_Z^2 \right] x(q - \bar{q}) \end{aligned}$$

The case of Charged-Current (CC)

Influence of the charge of the incident lepton is simple
(as the W is charged):



In e+p/e-p
different PDFs enter
into the
CC cross sections

CC cross sections H1/ZEUS

$$\frac{d^2\sigma_{CC}(e^{\pm}p)}{dx\,dQ^2} = \frac{G_F^2}{2\pi x}\frac{M_W^4}{(Q^2+M_W^2)^2}\frac{1}{2}[\tilde{\sigma}]$$

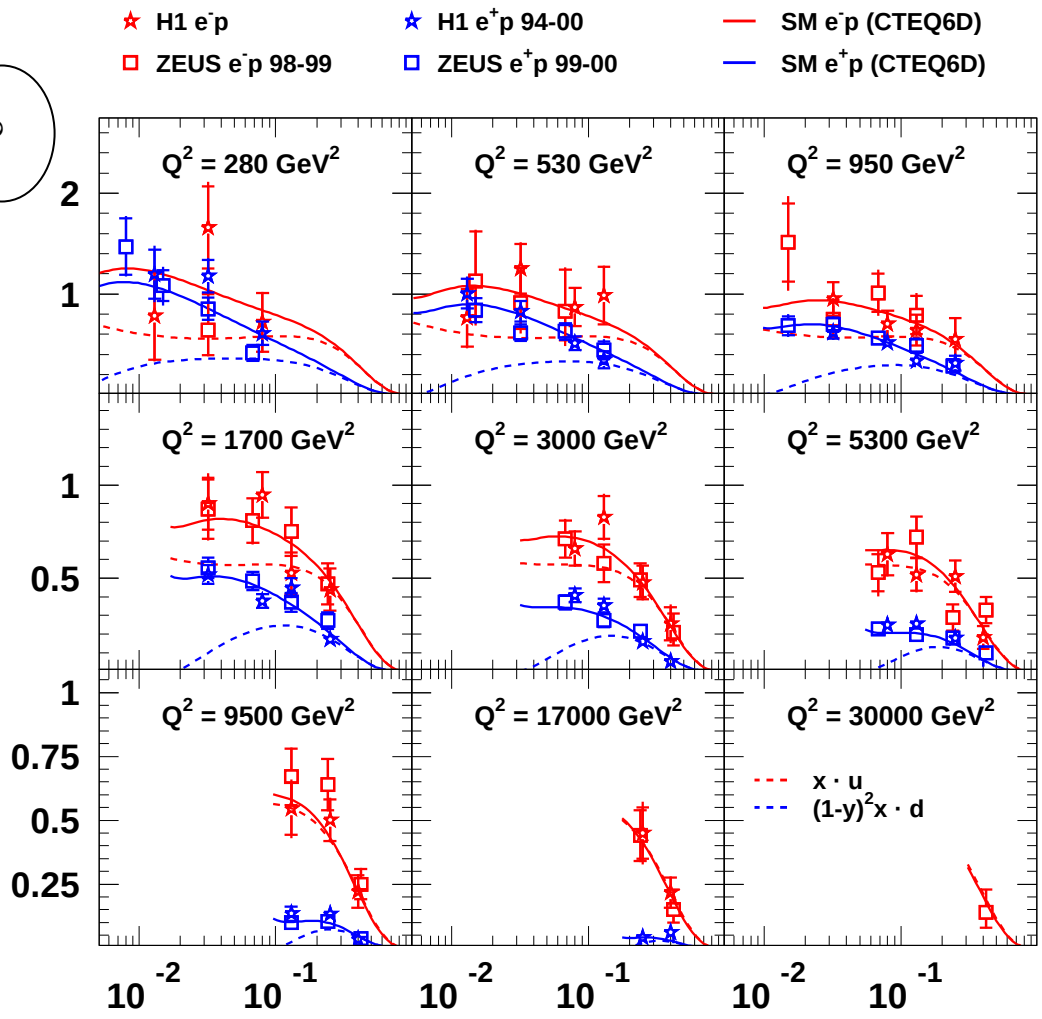
$$\tilde{\sigma}^{e^-p}_{CC}(x,Q^2) \sim (u+c)+(1-y)^2(\bar{d}+\bar{s})$$

$$\tilde{\sigma}^{e^+p}_{CC}(x,Q^2) \sim (\bar{u}+\bar{c})+(1-y)^2(d+s)$$

** low statistics as for $Q^2 \ll Mw^2$
cross section is ~2 orders
of magnitude below σ(NC)

** HERAII data(x,Q^2)
not published… even not prel.
<= **Difficult analysis** for
efficiencies like « vertex » eff,
CC selection eff…

HERA Charged Current

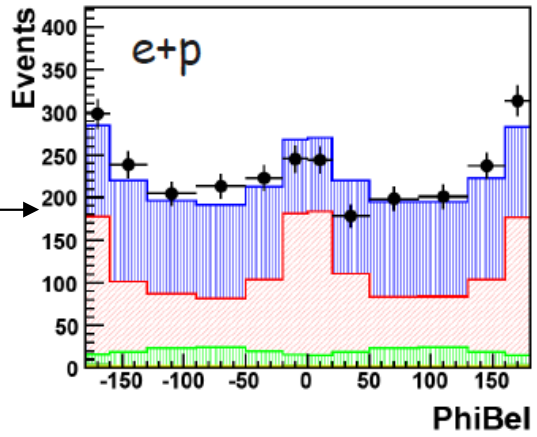


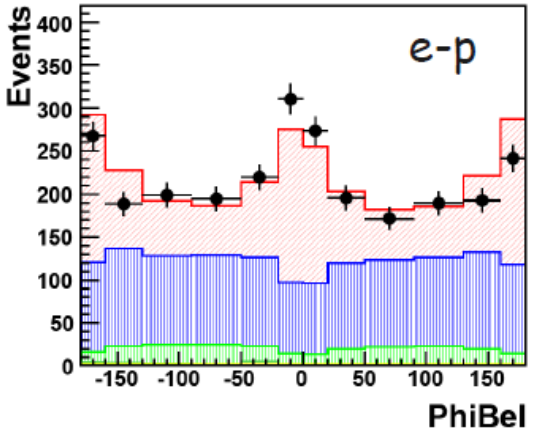
Low scale beam charge asymmetry

Exclusive γ prod:
ep->epγ

DVCS + BH

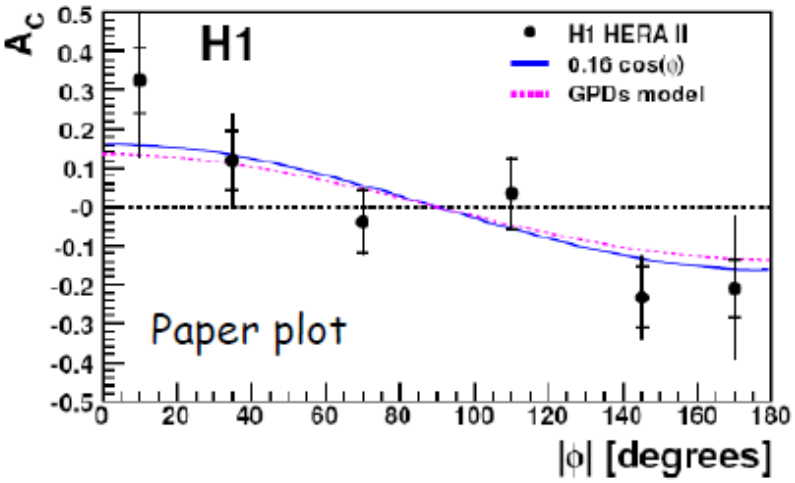
- ϕ distributions: ➔ No Φ dependence (asymmetry) in the MC





$$BCA = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-}$$

is directly proportinal the DVCS/BH interference & to the real part of the DVCS amplitude…



=> ρ = **Re/Im = 0.20 +/- 0.05 +/- 0.08**

Summary and outlook

** **Prel measurement of xF3**
still limited by statistics…
Measurement only possible
@ the EW scale

** Combination H1+ZEUS can help
Complte analysis of HERAII data
=> on going work
** essential measurement to give
some real data for 2uv+dv
@ large Q^2!

** ***CC cross sections*** give also
interesting different results
@ EW scale (for e+/e- beam)

** At lower scale: other interesting
beam charge differences
<= **DVCS/BH interference**
Paper underreview in H1 collab

The most important
result that summarises
all others…