

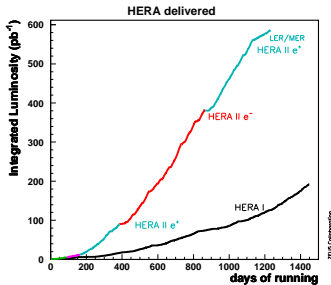
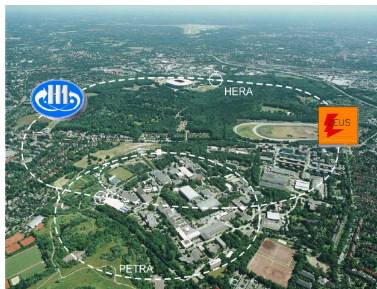
# High $Q^2$ structure functions at HERA

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on behalf of the H1 & ZEUS collaborations



Moriond QCD, La Thuile, Thursday 13.Mar.2008

## HERA - H1 &amp; ZEUS

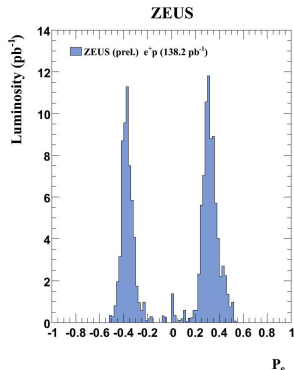
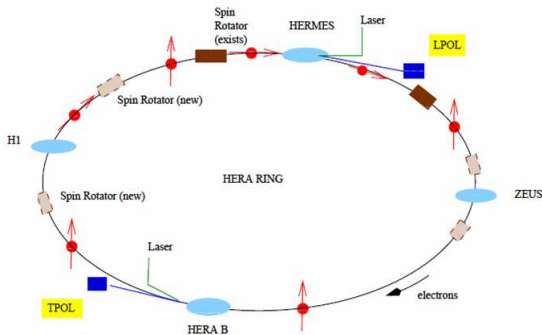


$$E_e = 27.6 \text{ GeV}$$

HERA	$E_p$ [GeV]	$\sqrt{s}$ [GeV]
I	820	300
I,II	920	318

Upgrade between HERA I & II: longitudinally polarised  $e^\pm$  beams

# Polarised electron beam



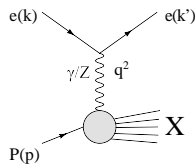
Sokolov-Ternov effect  $\rightarrow$   $e^\pm$ -beam transversely polarised  
Spin rotators turn it into longitudinal polarisation.

$$P_e = \frac{N_R - N_L}{N_R + N_L}$$

## Kinematic variables & structure functions

Kinematic variables:

$$Q^2 = -q^2, \quad x = \frac{Q^2}{2pq}, \quad y = \frac{pq}{pk}$$



Dependence of unpolarised reduced xsec on **structure functions**:

$$\sigma_r(e^\pm p) = \frac{d^2\sigma}{dx dQ^2} \frac{Q^4 x}{2\pi\alpha^2 Y_+} = F_2 \mp \frac{Y_-}{Y_+} xF_3 - \frac{y^2}{Y_+} F_L$$

where  $Y_\pm = 1 \pm (1 - y^2)$ .

$F_2$	: dominates cross section	$F_2 \propto \Sigma(q + \bar{q})$
$xF_3$	: contributes at high $Q^2$	$xF_3 \propto \Sigma(q - \bar{q})$
$F_L$	: contributes at high $y$	$F_L \propto \alpha_s xg(x, Q^2)$

## Recent results

- ▶ Neutral Current (NC) & Charged Current (CC) in  $e^{\pm}p$  at high  $Q^2$  and **with longitudinally polarised electron**
- ▶ Electroweak & QCD fits
- ▶ Combination of H1 & ZEUS published HERA I cross sections

# H1 NC & limit on quark radius

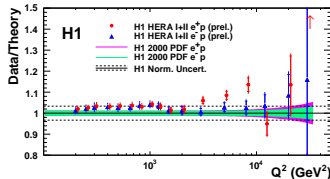
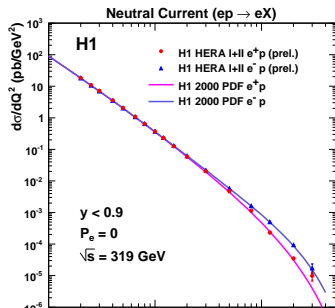
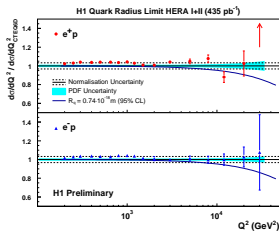
## Data:

NC  $e^\pm p$  from HERA I+II  
with  $Q^2 \geq 200 \text{ GeV}^2$ ,  $y < 0.9$

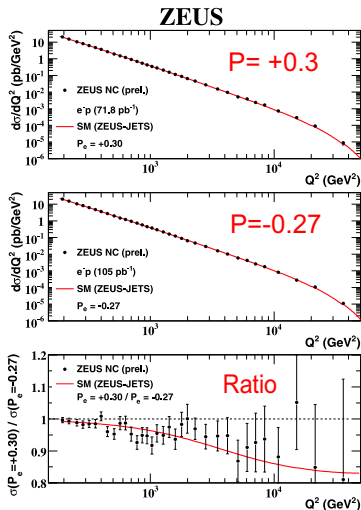
## Lumi:

$270 \text{ pb}^{-1} (e^+p)$ ,  $165 \text{ pb}^{-1} (e^-p)$

$R_q < 0.74 * 10^{-18} \text{ m} @ 95\% \text{ CL}$



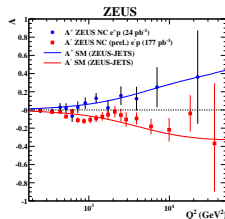
# ZEUS NC with longitudinally polarised electrons ( $P_e \neq 0$ )



Asymmetry:

$$A \equiv \frac{\sigma(P_e = +1) - \sigma(P_e = -1)}{\sigma(P_e = +1) + \sigma(P_e = -1)}$$

HERA II  $e^-p, e^+p$ :



→ Parity violation in NC at high  $Q^2$

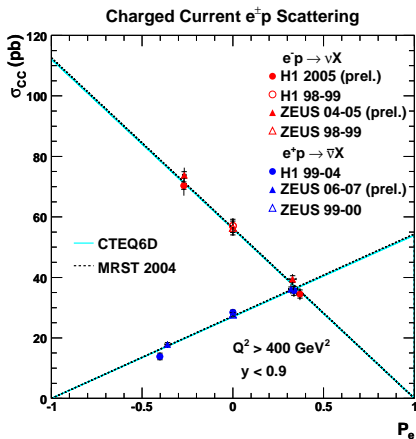
ZEUS CC with  $P_e \neq 0$ 

$$\sigma_{CC}^{e^\pm p}(P_e) = (1 \pm P_e)\sigma_{CC}^{e^\pm p}(P_e = 0)$$

Linear dependence as expected.

Extrapolate to full polarisation.

→ No RH charged currents.

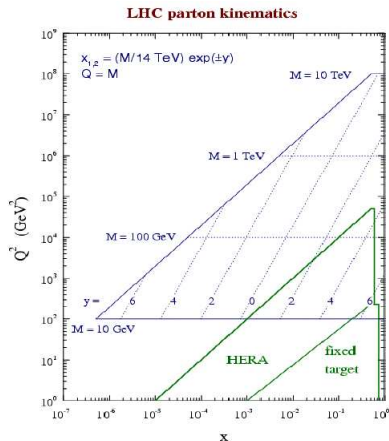




# Electroweak & QCD fits

## Method:

- ▶ Measure  $\frac{d^2\sigma^\pm}{dx dQ^2} (P_e \neq 0)$
- ▶ Obtain  $F_2, xF_3$
- ▶ Extract PDFs  $q(x, Q^2), \bar{q}(x, Q^2)$
- ▶ Fit  $v_i, a_i$  quark couplings

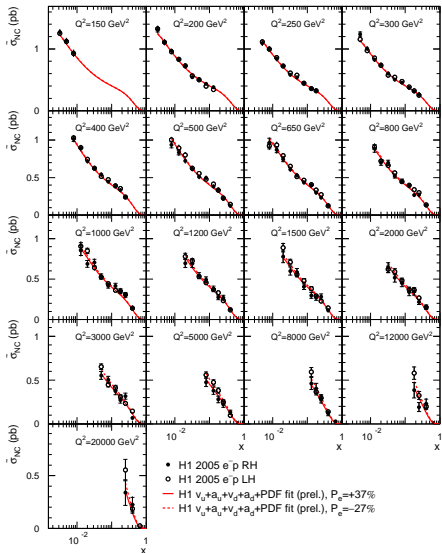


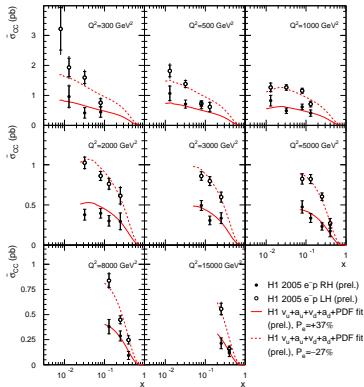
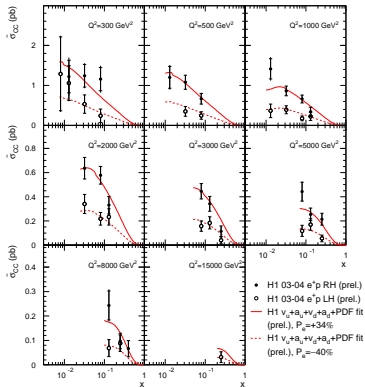
NB: H1 and ZEUS fits use their respective data sets.

# H1: $\tilde{\sigma}_{NC}$ for $e^\pm p$

Measure NC over large range of  $Q^2$ .

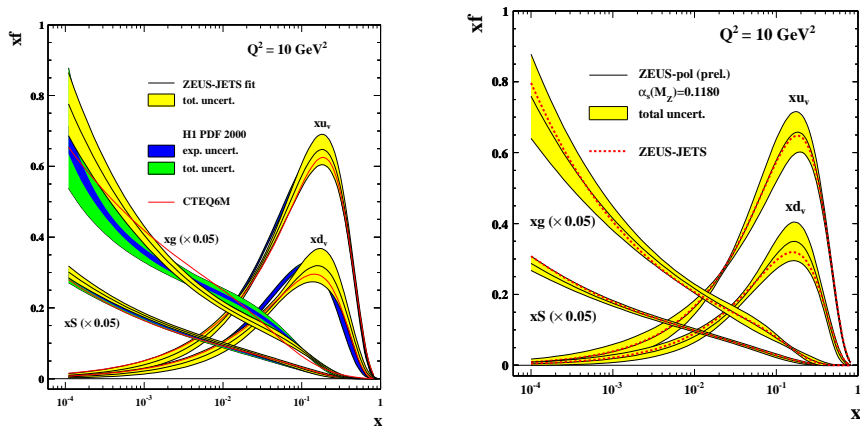
Use data as input to fit.



H1:  $\tilde{\sigma}_{CC}$  for  $e^\pm p$ 

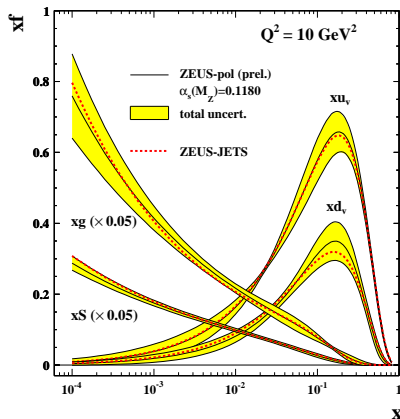
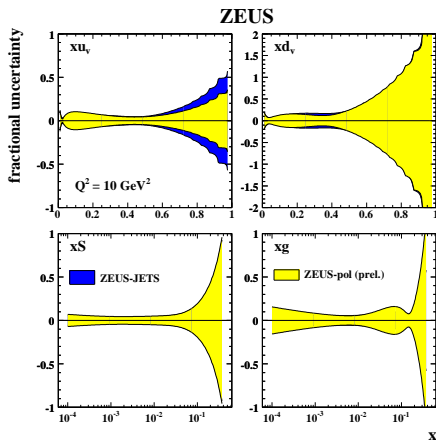
NB: RH data dominates  $\tilde{\sigma}$  in  $e^+p$ , LH dominates in  $e^-p$ .

# Extracted PDFs - H1 & ZEUS



ZEUS-pol = new fit including polarised data, ZEUS-JETS = old fit.

# Fractional uncertainties



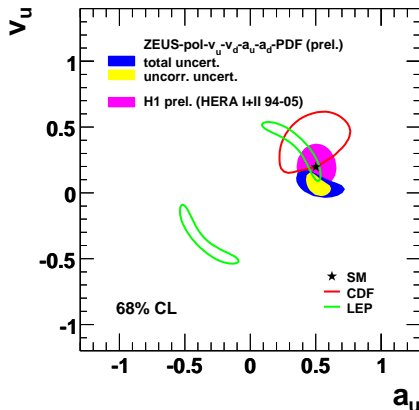
Uncertainty on  $u_v$  improved.

# Extraction of electroweak parameters

$$F_{2,3} = F_{2,3}(v_e, a_e, v_i, a_i)$$

Extract couplings of  $u$ ,  $d$  quarks:  
vector ( $v$ ) & axial vector ( $a$ )

4-param. fits from ZEUS & H1  
compared to other experiments.

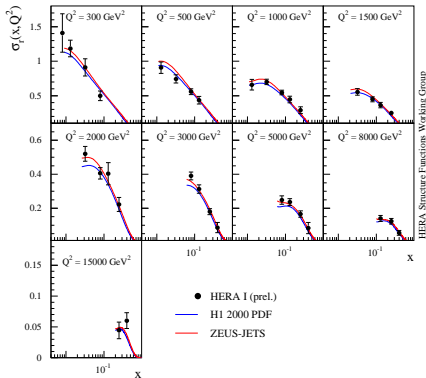
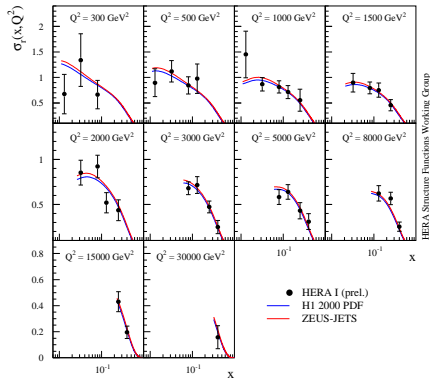


## H1-ZEUS combination results

- ▶ Combine published DIS  $\sigma$  from H1 & ZEUS
- ▶ Data from HERA I (96-00) with  $Q^2 > 1.5 \text{ GeV}^2$
- ▶ Systematic correlations are taken into account  
→ significant reduction of overall uncertainty
- ▶ Will form final word from HERA on fits.

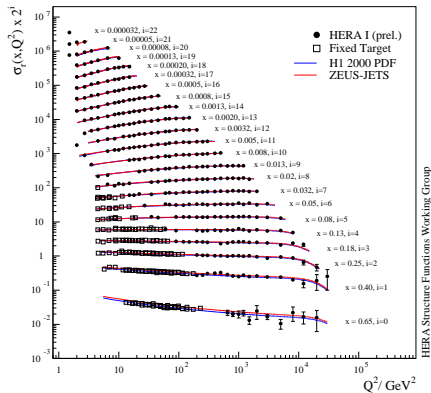
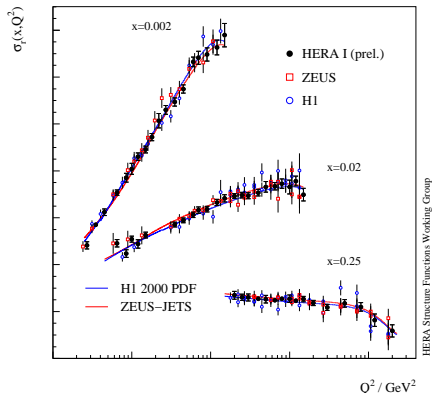
Method see: *S.Glazov XIII International Workshop on Deep Inelastic Scattering*

# CC $\sigma_r(e^\pm p)$

HERA I  $e^+p$  Charged Current Scattering - H1 and ZEUSHERA I  $e^-p$  Charged Current Scattering - H1 and ZEUS

Good agreement with both H1 2000 PDF and ZEUS-JETS.



HERA I  $e^+p$  Neutral Current Scattering - H1 and ZEUSHERA I  $e^+p$  Neutral Current Scattering - H1 and ZEUS

Strength of method:

@ low  $Q^2$ : dominant systematic uncert. reduced

@ high  $Q^2$ : dominant statistical uncert. reduced

# Summary

## Presented here:

- ▶  $\tilde{\sigma}(NC)$ ,  $\tilde{\sigma}(CC)$  with  $P_e \neq 0$   
→ H1, ZEUS individually & combined
- ▶ Asymmetry, Parity violation, no right-handed CC
- ▶ Parton density functions
- ▶ Electroweak fit of couplings

## Outlook:

- ▶ Combine HERA II data.
- ▶ Final word from HERA with  $1 \text{ fb}^{-1}$