Neutral and Charged Current Cross Sections and Extraction of Structure Functions and Parton Distributions

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Lake Louise 2008

Outline:

- HERA Collider and the H1 and ZEUS Detectors
- Inclusive Physics at HERA
- Recent Results:
  - H1 and ZEUS Combined Reduced Cross Sections
  - High y Cross Section Measurements
  - Parity Violation
- Summary and Outlook

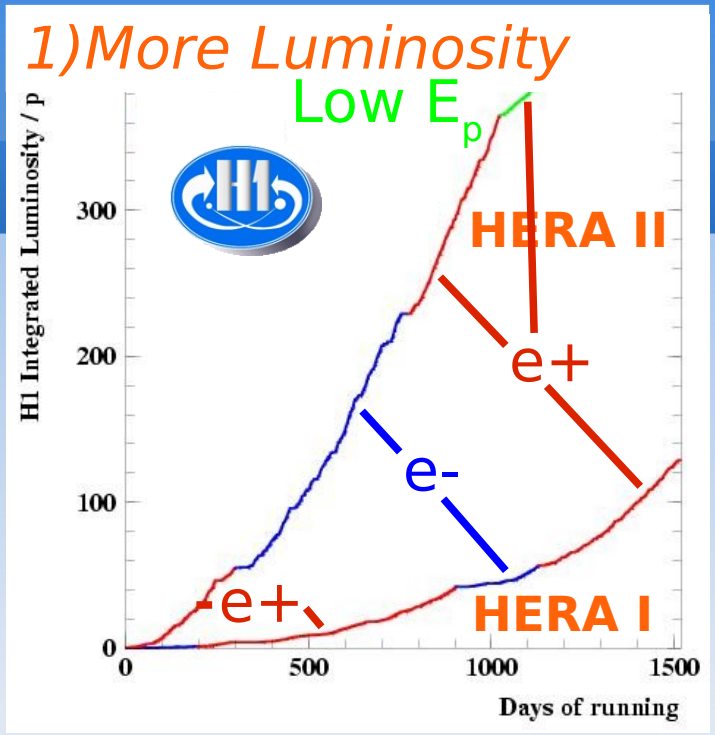
HERA Collider and the H1 and ZEUS Detectors

E_e=27.6 GeV

E_p	√s
820	301GeV
920	319GeV
460	225GeV
575	252GeV

Different √s allows *direct measurement* of the different structure functions contributions at a given point in phase space.

2000 Lumi Upgrade



Average Specific Lumi increased by x4 from HERAI->HERAII

Luminosity Summary (per Detector)

Total : 0.5 fb^{-1}

e+/e- : 1.6

HERA Collider and the H1 and ZEUS Detectors

$e^{\pm}$ p

E_e=27.6 GeV

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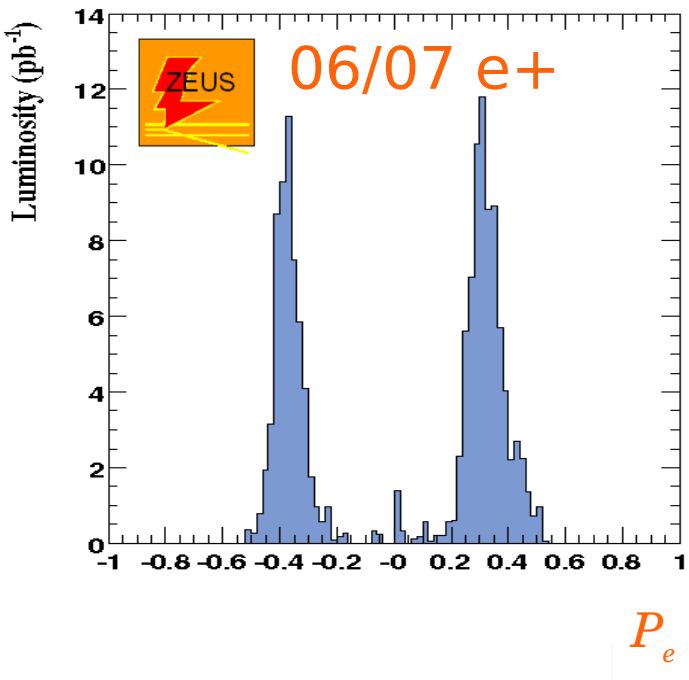
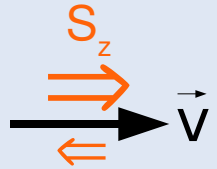
2000 Lumi Upgrade

2)Longitudinal Pol. $e^{\pm}$

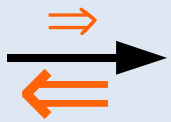


$$Pe = \frac{N_R - N_L}{N_R + N_L}$$

P_e>0:



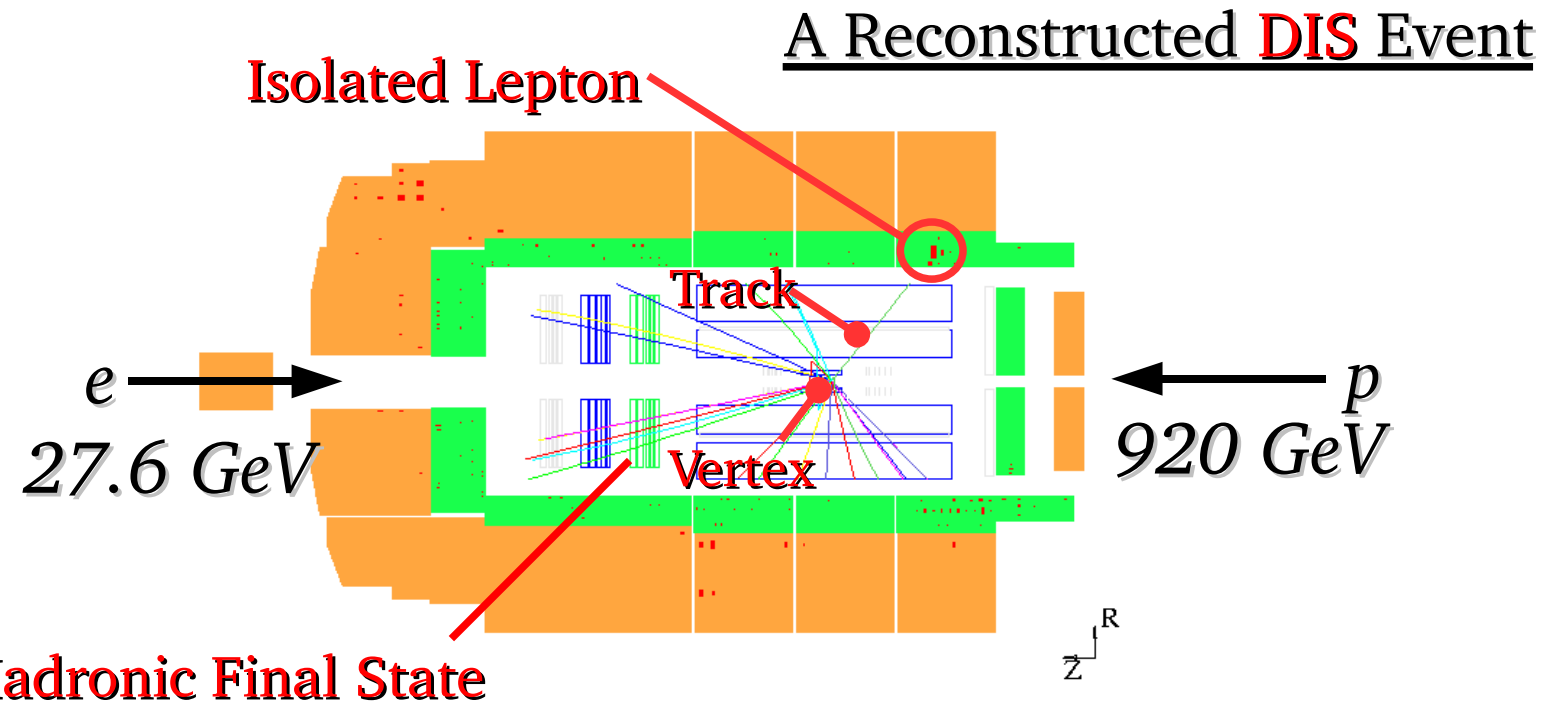
P_e<0:



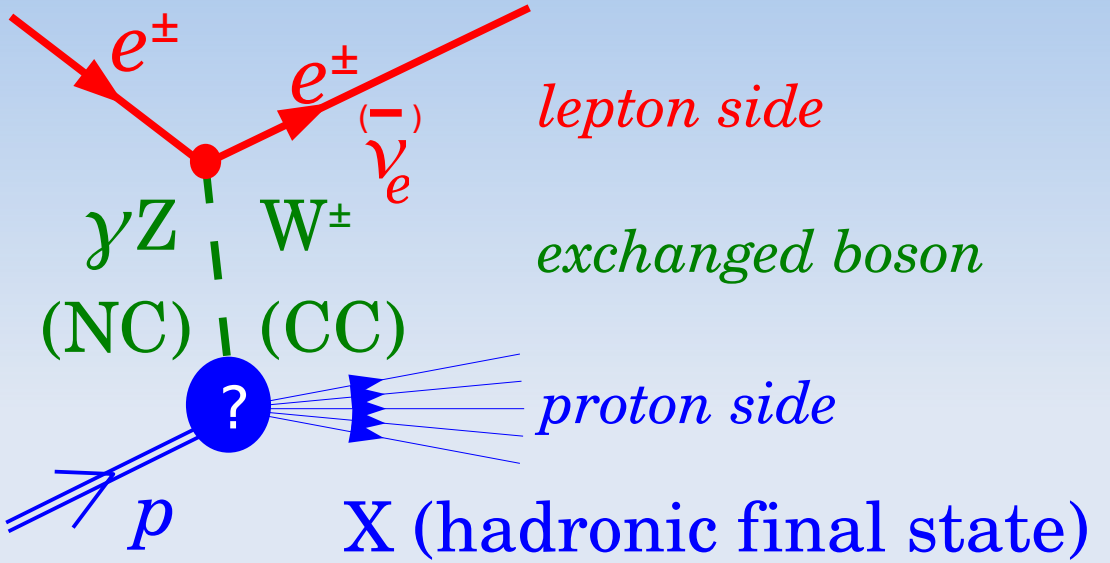
Different √s allows *direct measurement* of the different structure functions contributions at a given point in phase space.

Some Figures:

		H1	ATLAS
Volume	[m³](x x y x z)	12 x 15 x 10	25 x 25 x 46
Mass	[tonnes]	2800	7000



Inclusive Physics at HERA

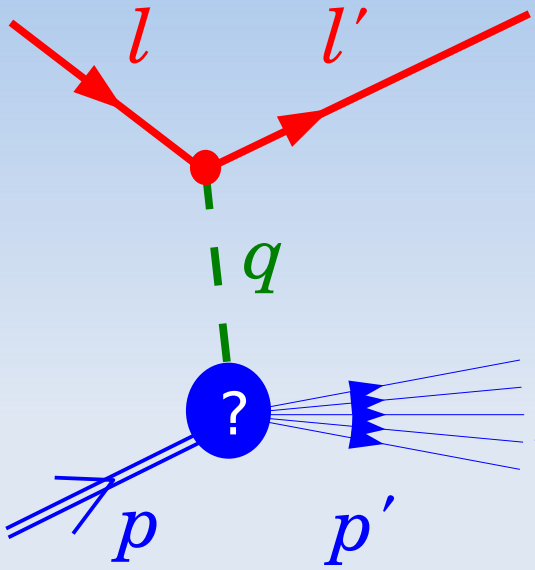


lepton side

exchanged boson

proton side

Inclusive Physics at HERA



lepton side

exchanged boson

proton side

Kinematics uniquely specified by 2 of 3 variables:

- $Q^2 = -q^2$
- $x = Q^2 / 2q \cdot p$
- $y = q \cdot p / l \cdot p$

$Q^2 = sxy$

Unpolarized Reduced Cross Section:

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

Dominant Contribution

Contributes at high y

$$Y_{\pm} \equiv 1 \pm (1 - y)^2$$

From Weak Interaction ⇒ contributes at high Q^2

Recent Results:

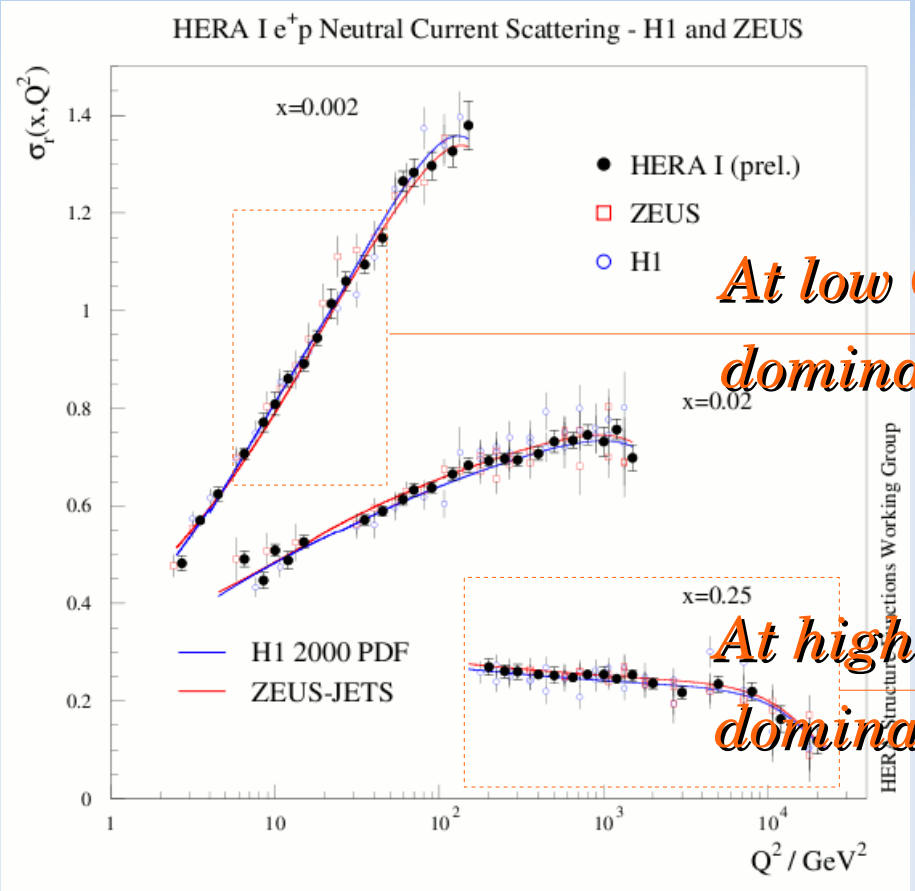
H1 and ZEUS Combined Reduced Cross Sections

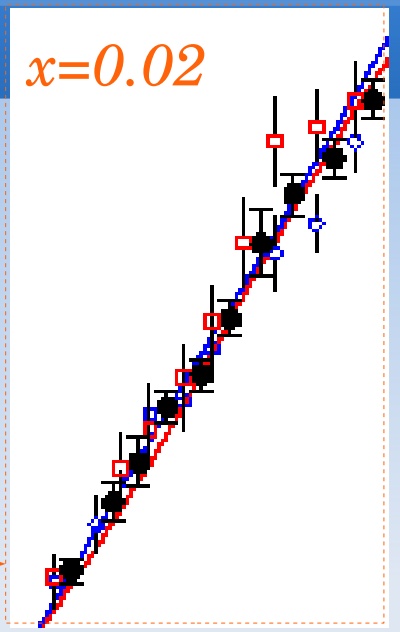
- The NC and CC Reduced Cross Sections are the main input used to determine Parton Distributions (PDFs) by performing QCD Fits.
- H1 and ZEUS have combined their published HERA I Cross Sections with the aim of reducing both the statistic and systematic uncertainty.
- The Method used [*See: S.Glazov XIII International Workshop on Deep Inelastic Scattering*] uses a novel approach in taking correlations between the measurements of the 2 experiments into account.

Recent Results

- H1 and ZEUS Combined Reduced Cross Sections

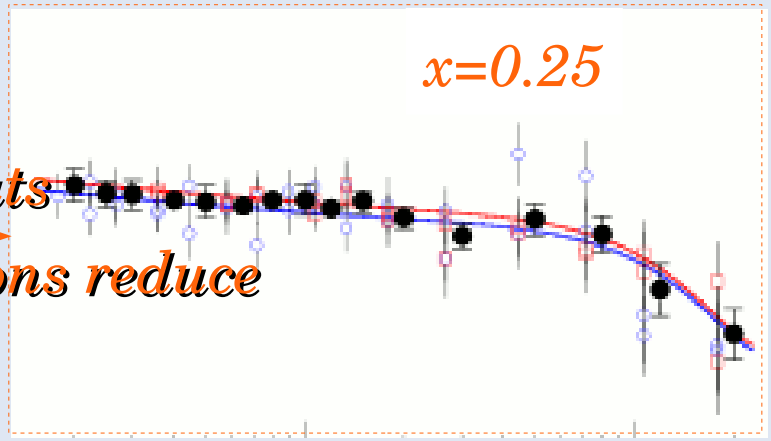
HERA e^+p NC Reduced Cross Sections





At low Q^2 where systematics dominate, error improves

At high Q^2 where stats dominate, fluctuations reduce

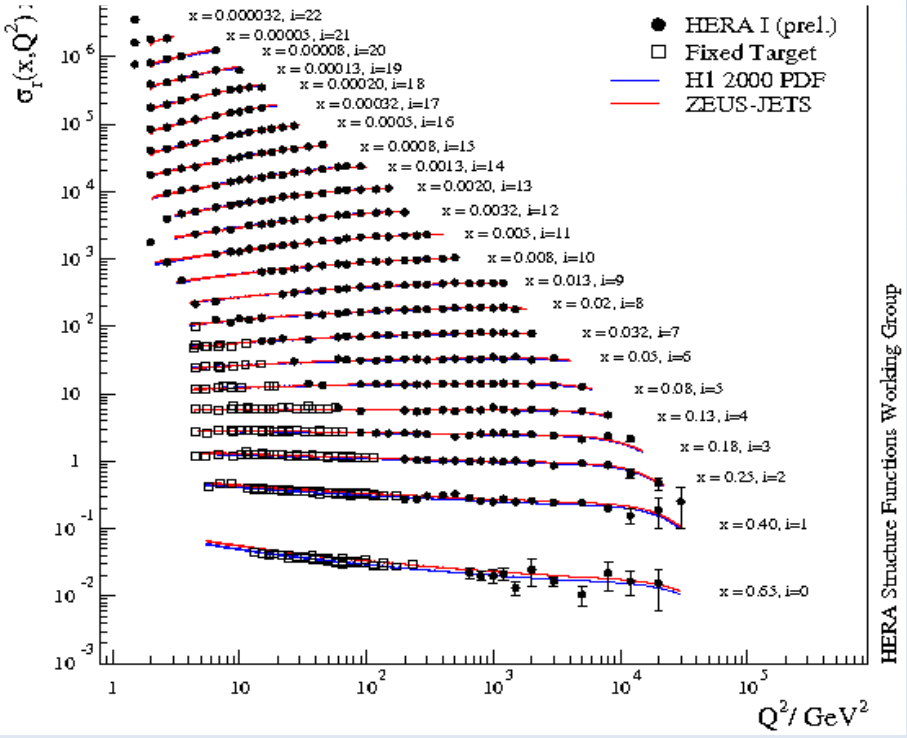


Combined points agree well with both the H1 2000 PDF and ZEUS-JETS QCD Fits

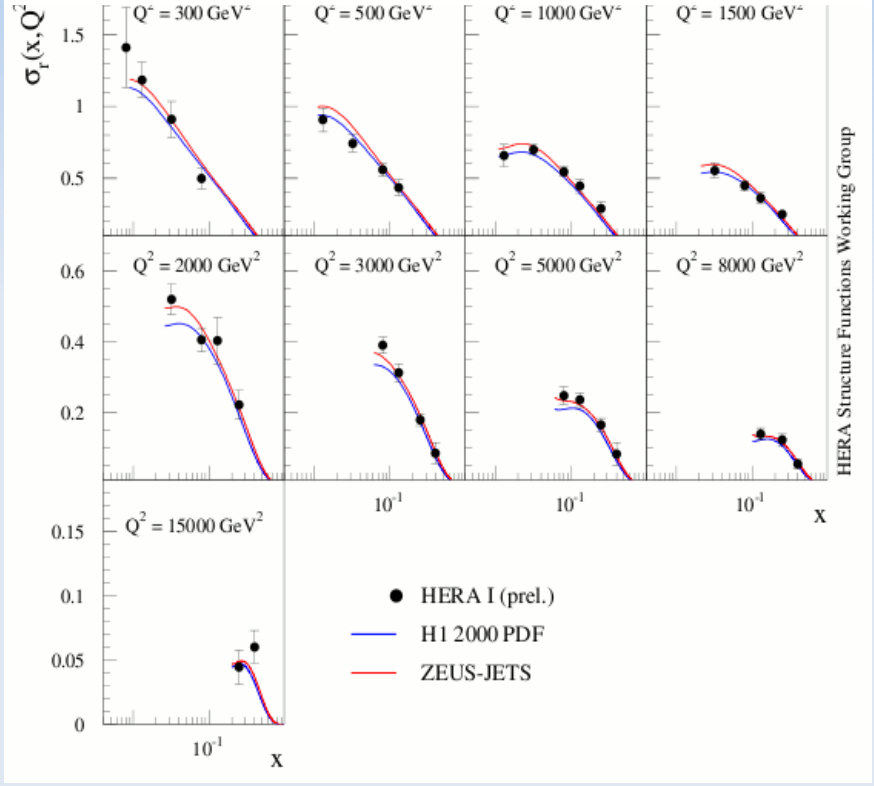
Recent Results

- H1 and ZEUS Combined Reduced Cross Sections

HERAI e^+p NC Reduced Cross Sections relative to fixed target experiments



HERA I e^+p CC Scattering



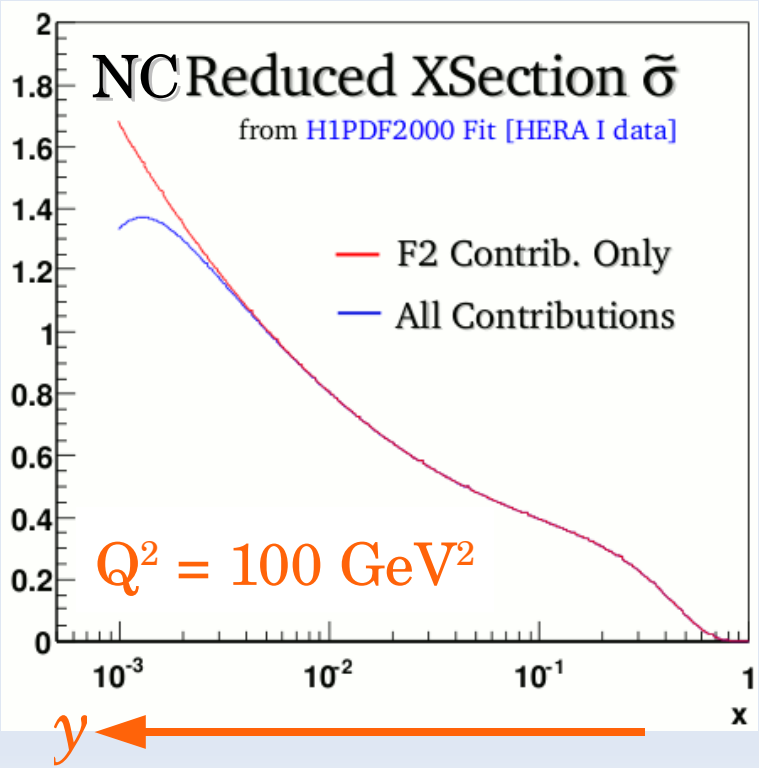
Next: Combine All HERAI / HERAII Cross Sections of the 2 Experiments

H1 and ZEUS Combined Reduced Cross Sections should play a significant role in establishing final PDFs at HERA

Recent Results

High y Cross Section Measurements

- F_L Structure Function is one of the basic measurements of Proton Structure
- F_L is also sensitive to the gluon density which is important for many LHC processes e.g. SM Higgs, W and Z Production
- F_L contributes to the Cross Section only at high y ($\sigma_r^{\pm} = \ldots - y^2 F_L / Y_+$)



- High $y \Rightarrow$ low energies of the scattered electron.

e.g. $Q2 = 100\,\mathrm{GeV}^2$: $E'(y) \simeq 1 + 27.6\,(1 - y)$

$E'(0.1) \simeq 26\ GeV$

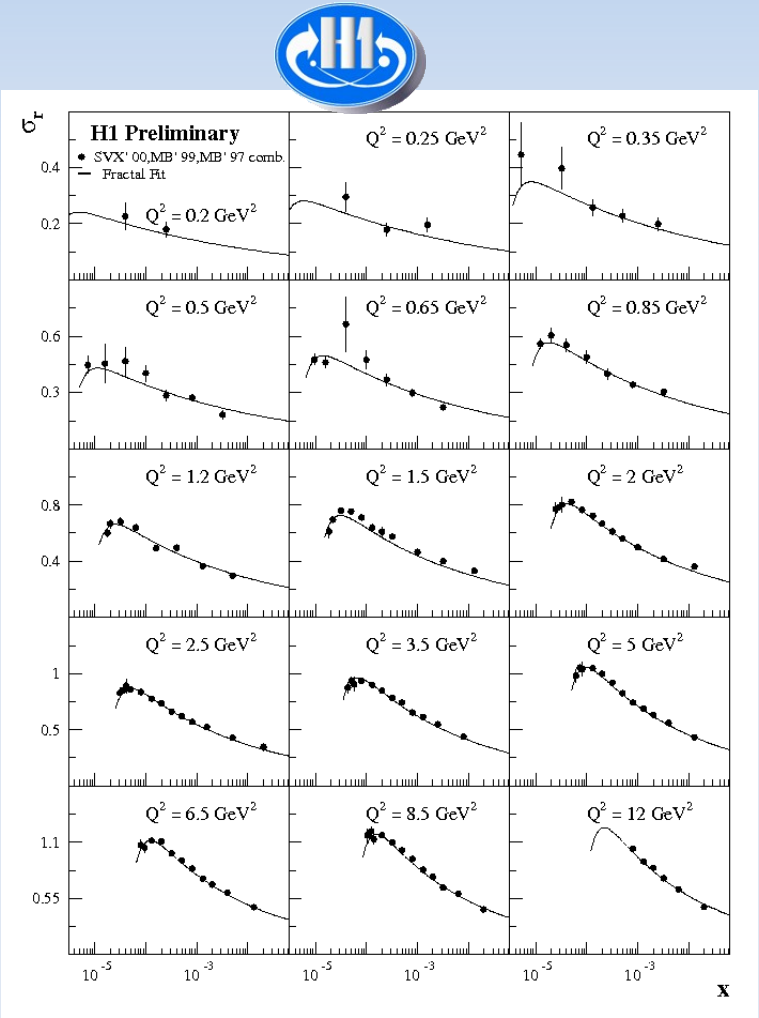
$E'(0.75) \simeq 8\ GeV$

- At Low energies detector imperfections (cracks) and inefficiencies begin to take hold. Signal also becomes easier to fake.

$\Rightarrow$ Require Dedicated *High y Analysis*!

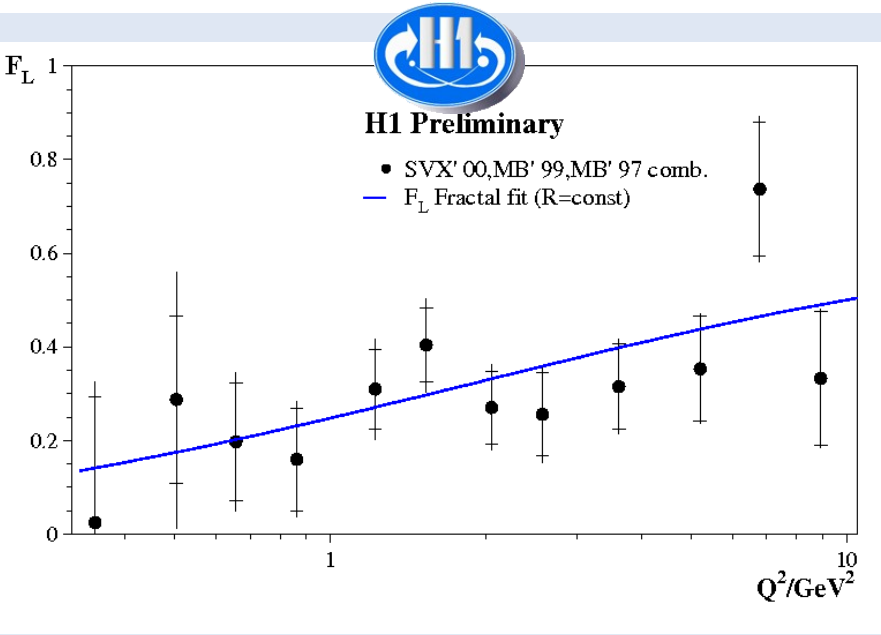
Recent Results

- High y Cross Section Measurements : **Photoproduction-DIS Transition**
- Low Q^2 [0.2 to 12 GeV^2] Cross Sections measured using e^+p HERA I Data [SVX`00, MB`99, MB`97] and then combined



- Outside pQCD validity
  ⇒ Phenomenological Models
- Cross Sections fitted to a Model where F_L is a fit parameter.

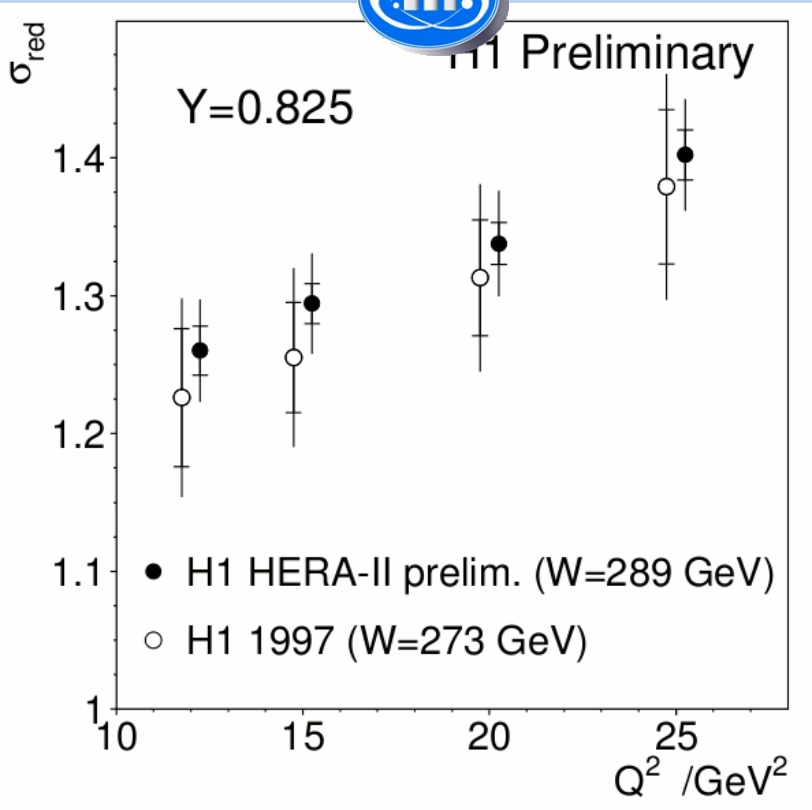
$$\sigma_r(x,Q^2) = c(Q^2)x^{-\lambda(Q^2)} - \frac{y^2}{Y_+}F_L(Q^2)$$



Recent Results

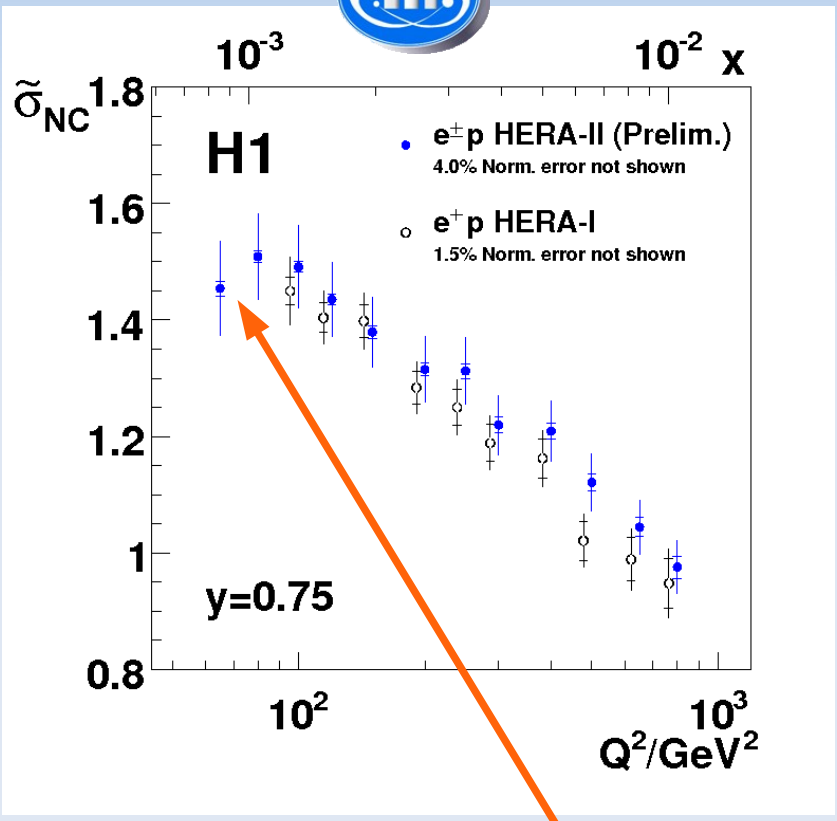
- High y Cross Section Measurements : **Q2 > 10 GeV²**

96pb^{-1} of $e^{\pm}p$



- Factor 2 better error

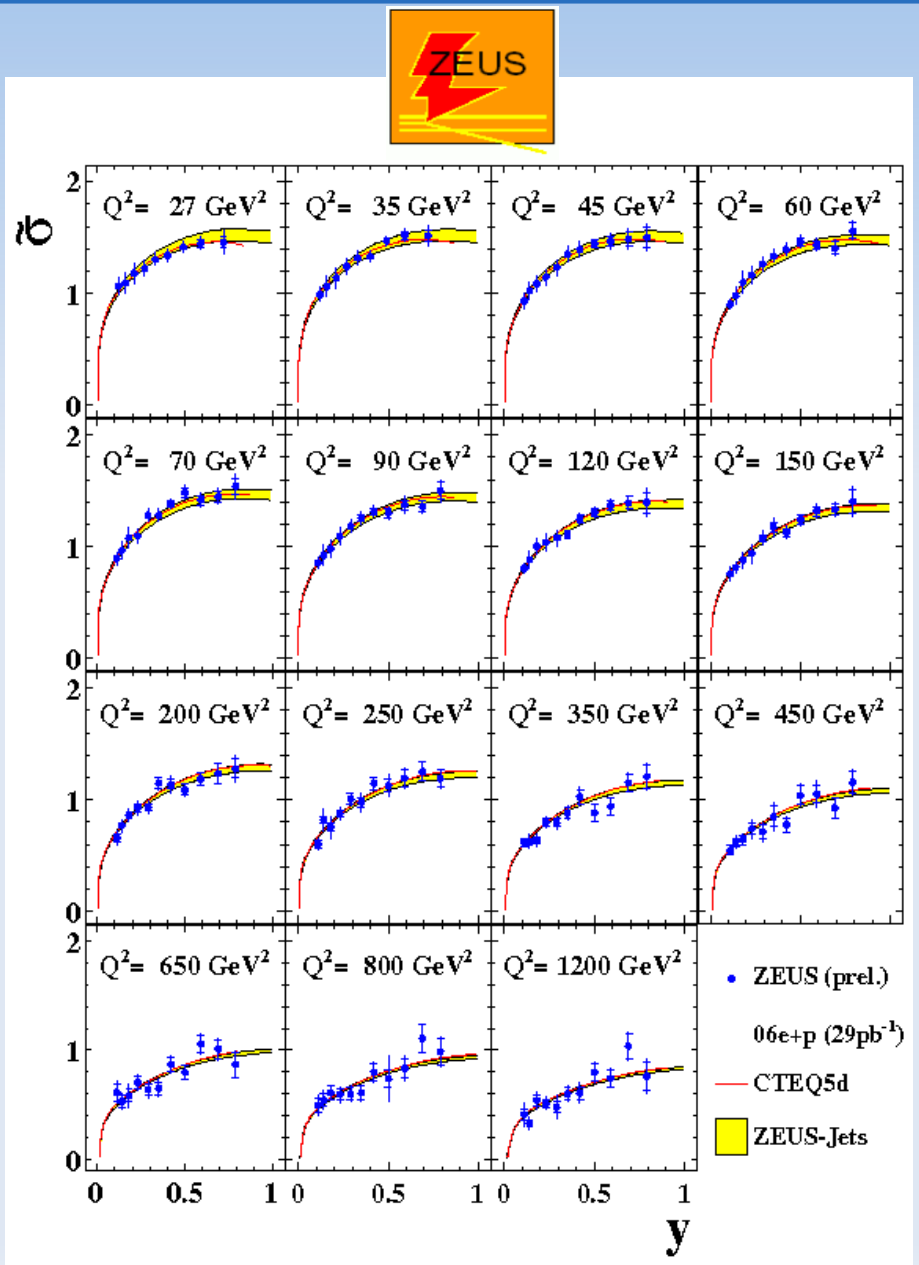
All HERA II 315 pb^{-1} of $e^{\pm}p$



- New measurements at lower Q^2
- Errors systematically dominated but should improve.

Recent Results

- High y Cross Section Measurements : **Q2 > 25 GeV²**



- Extension of phase space to high y at low Q^2.
- Data well described by QCD Prediction

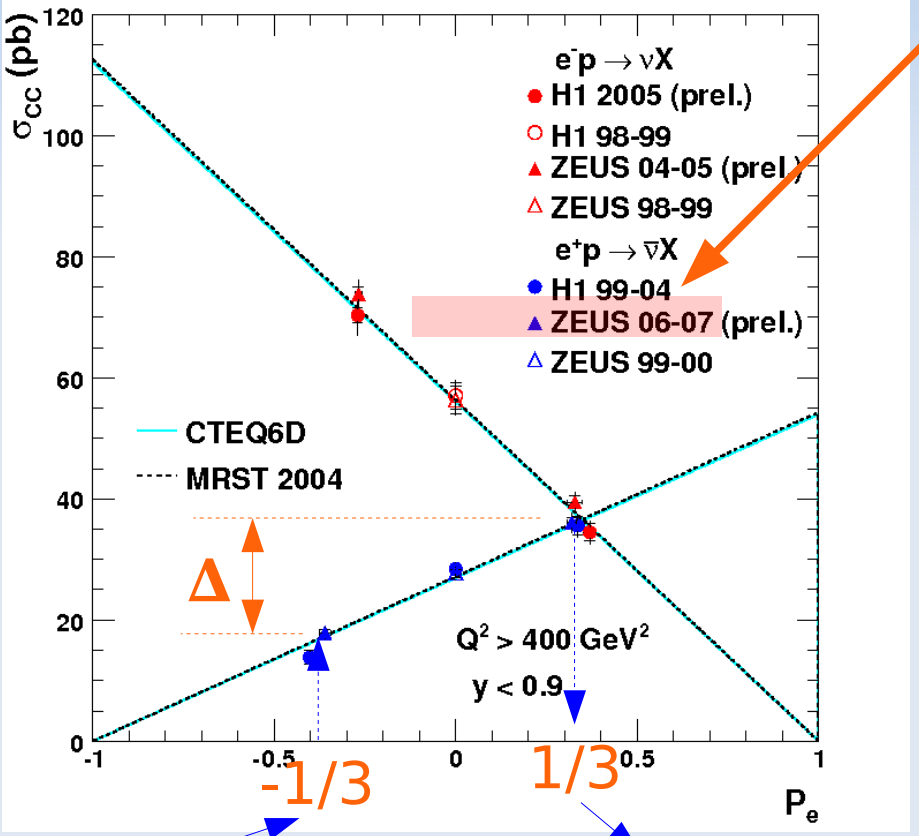
Next: Extract FL from the High y Cross Sections using F2 prediction from QCD Fits.

*Low energy data (Ep=460,575GeV) of approx 20 pb^{-1} are being analysed to **measure** F_L directly.*

Recent Results

Parity Violation

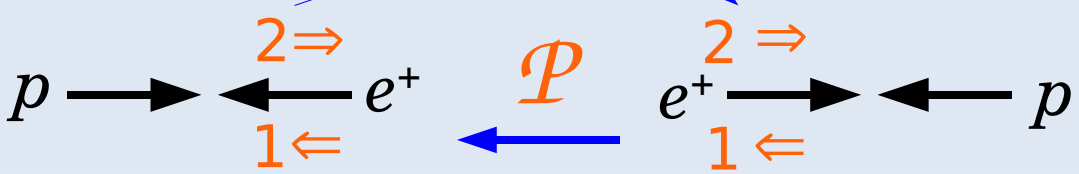
$$\sigma^{\pm}_{CC}(P_e)$$



ZEUS`s 0607 Prel. (138pb^{-1} e^-p)

$\Delta \neq 0 \Rightarrow$ PARITY VIOLATION

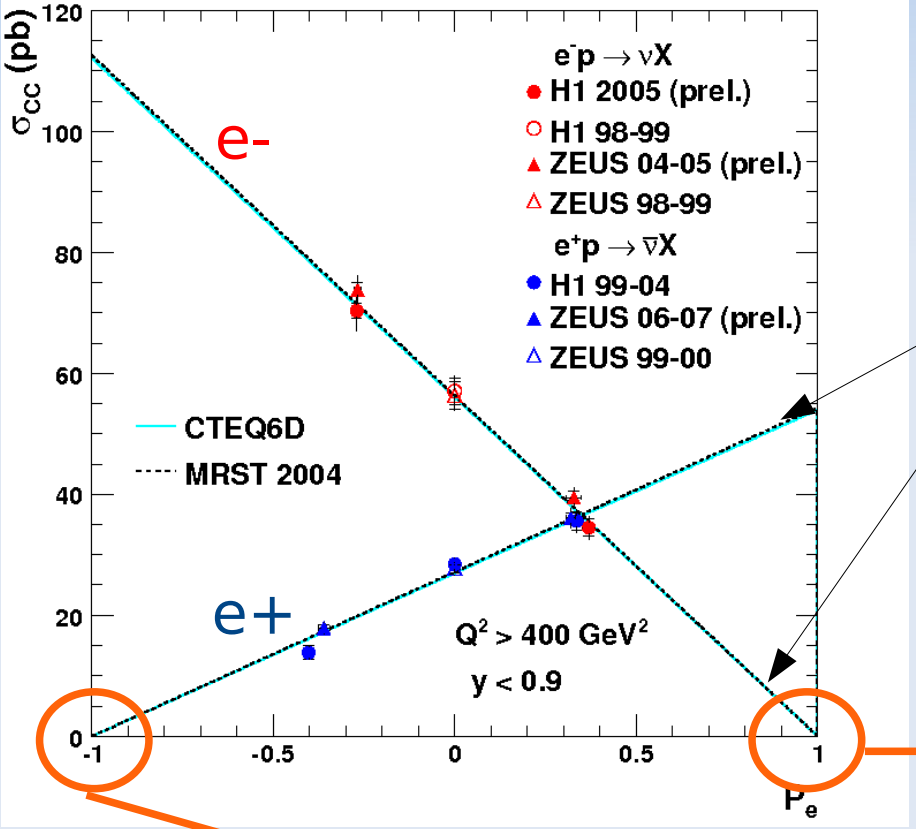
which is the case!



Recent Results

Parity Violation

$$\sigma^{\pm}_{CC}(P_e)$$



Matter of Fact , From SM:

$$\sigma^{\pm}_{CC}(P_e) = (1 \pm P_e)\,\sigma^{\pm}_{CC}(0)$$

HERAI

SM Expectation based on CTEQ6D and MRST2004 Parameterisations.

Data agrees with SM prediction supporting that W`s do not couple to

right-handed e^- (particle)

and

left-handed e^+ (anti-particle)

Summary & Outlook

- H1 and ZEUS are well on the way to combining their Inclusive Cross Sections for all of HERA Data (1 fb^{-1}) to provide the most accurate knowledge we have of Proton Structure.

- High y Cross Sections have been measured using HERA II data by both experiments in new regions of phase space. This will help to provide precise knowledge of F_L and Gluon densities and thus predict various Cross Sections at the LHC.

Thanks

(in memory of Prof. Beate Naroska)