Measurement of the Neutral Current DIS Cross Section at H1

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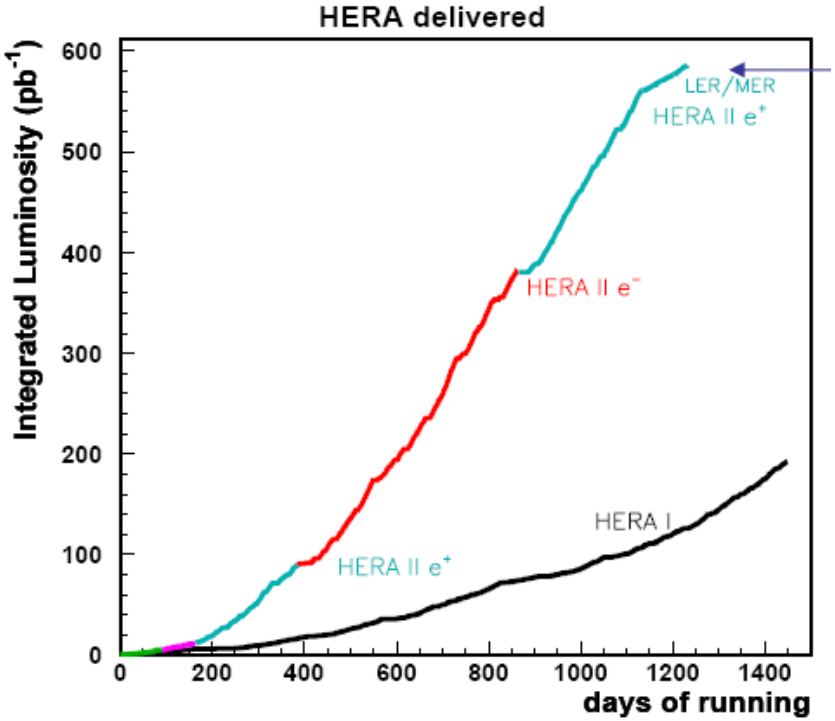
HERA and luminosity



In 2000-2002 HERA-I (E_p = 820, 920 GeV) upgraded to HERA-II (E_p = 920 GeV)

- Increased luminosity
- Polarised leptons

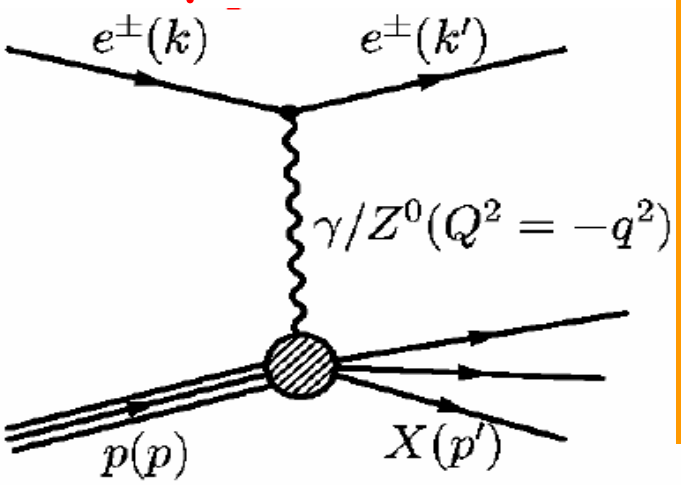
Since April 2007 until the end of June

- Low energy run (E_p = 460 GeV)
- Intermediate energy run (E_p = 575 GeV)

} Direct measurement of F_L

Neutral Current (NC) $e^{\pm}p$ Deep Inelastic Scattering (DIS)

e + p → e' + X



Virtuality of exchanged boson: $Q^2 = -q^2 = -(k-k')^2$

Fraction of proton momentum carried by struck quark: $x = Q^2/(2p\cdot q)$

Fraction of energy transferred from incoming lepton at proton rest frame $y = (p\cdot q)/(p\cdot k)$

y-p invariant mass $W = \sqrt{Q^2(1-x)/x}$

Kinematics can be reconstructed using scattered lepton (e') or hadronic final state.

$\tilde{\sigma}_{NC}(x,Q^2)$ - NC reduced cross-section

$$\frac{d^2\sigma_{NC}(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\, Y_+\left[\tilde{F}_2 - \frac{y^2}{Y_+}\tilde{F}_L \mp \frac{Y_-}{Y_+}x\tilde{F}_3\right] \qquad Y_\pm = 1 \pm (1-y)^2$$

dominant contribution

sizable contribution for high y

important only at high Q^2

Structure Functions

Leading order relations:

$$F_2 = \sum e_q^2 (x q + x \bar{q}) \qquad xF_3 = 2\sum e_q a_q (x q - x \bar{q}) \qquad F_L = 0$$

In perturbative QCD: $F_L \sim \alpha_s \cdot xg(x,Q^2)$

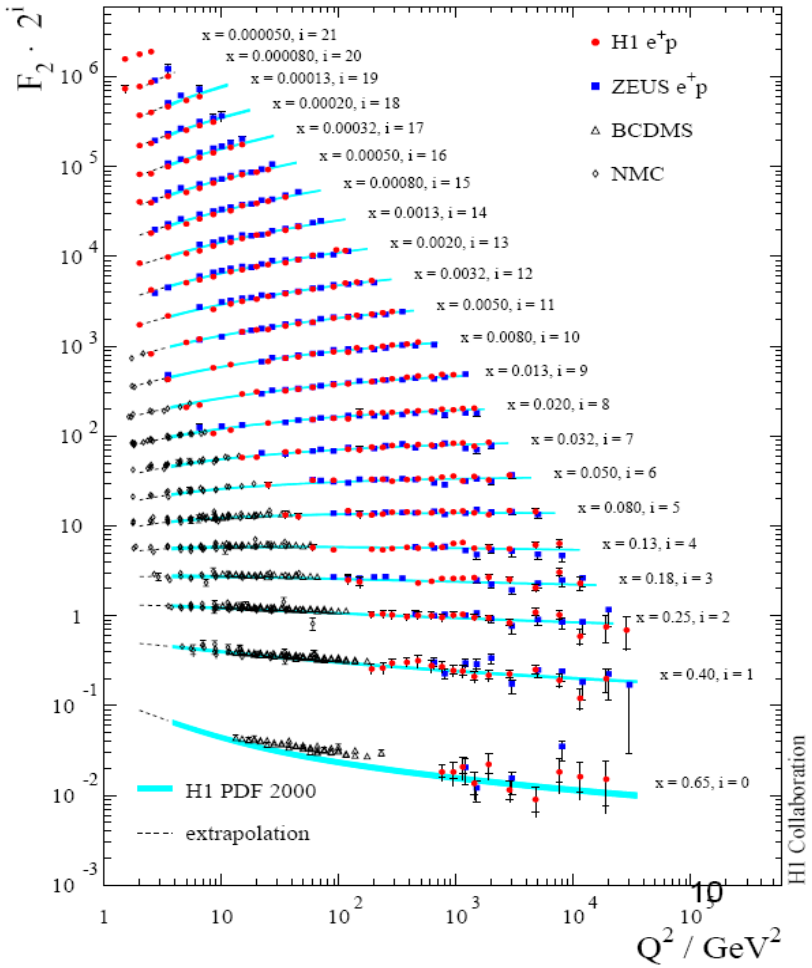
DIS one of the best tools to:

-Test the theory – validity of the DGLAP evolution

- Study proton internal structure – quark, anti-quark and gluon distribution
PDFs: $xq(x,Q^2)$, $x\bar{q}(x,Q^2)$, $xg(x,Q^2)$

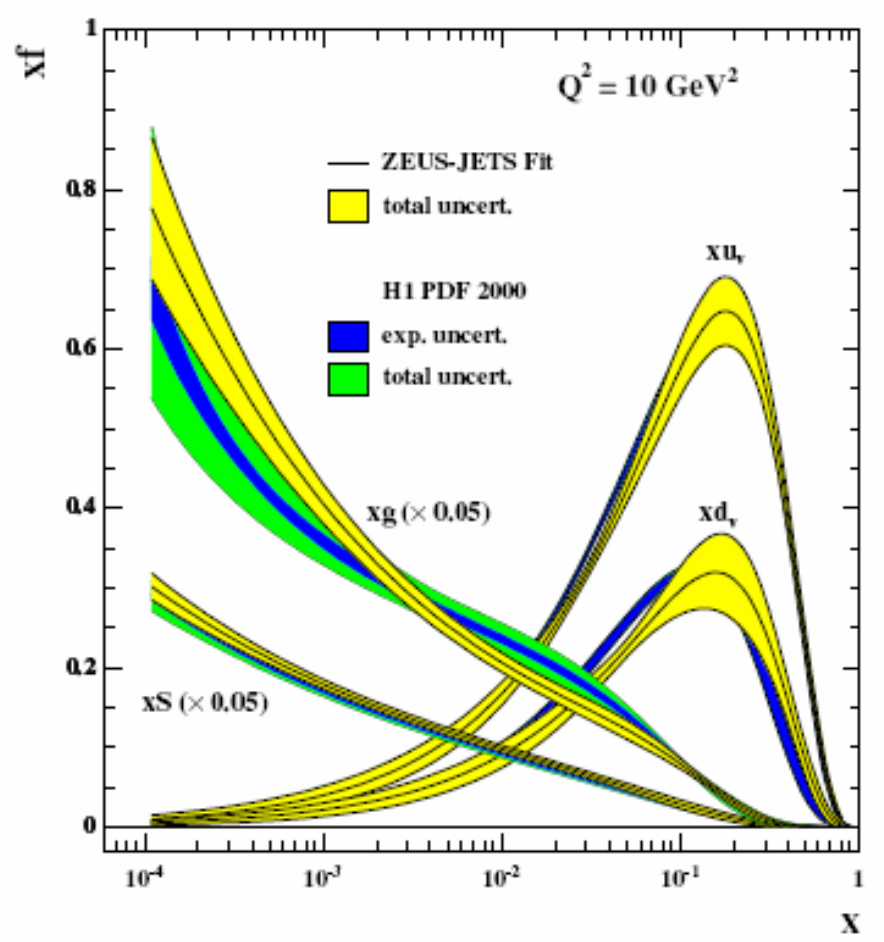
NC DIS good probe of electro-weak dynamics

Structure function - F_2



- Scaling violations are well described over 4 orders of magnitude in x and Q^2.
- Precision ~ 2-3 % in the bulk region.

Parton Density Functions - PDFs



- Cross section measurements provide input for the PDF fits.
- Sea and gluon distributions are divided by a factor of 20.
- There are still additional data and place for improvements in precision. H1 is working hard on this.

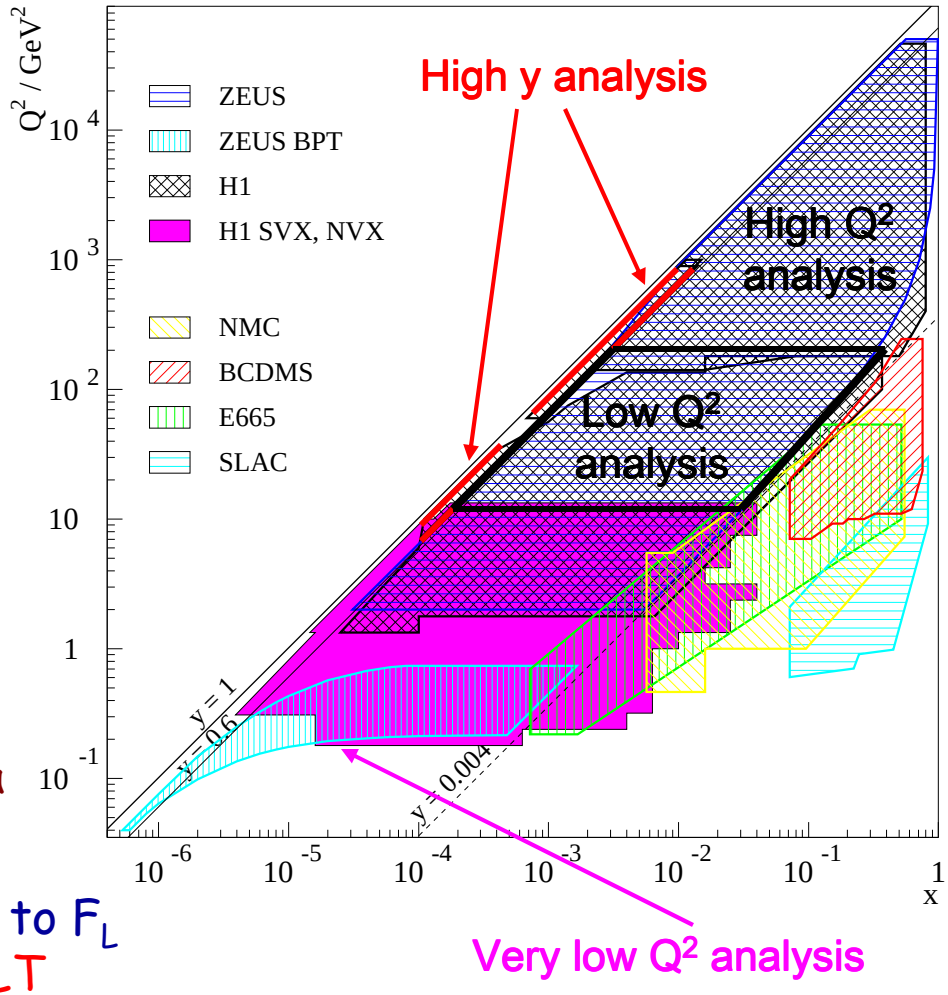
Ongoing NC analysis at H1

Measurements from HERA-I data only

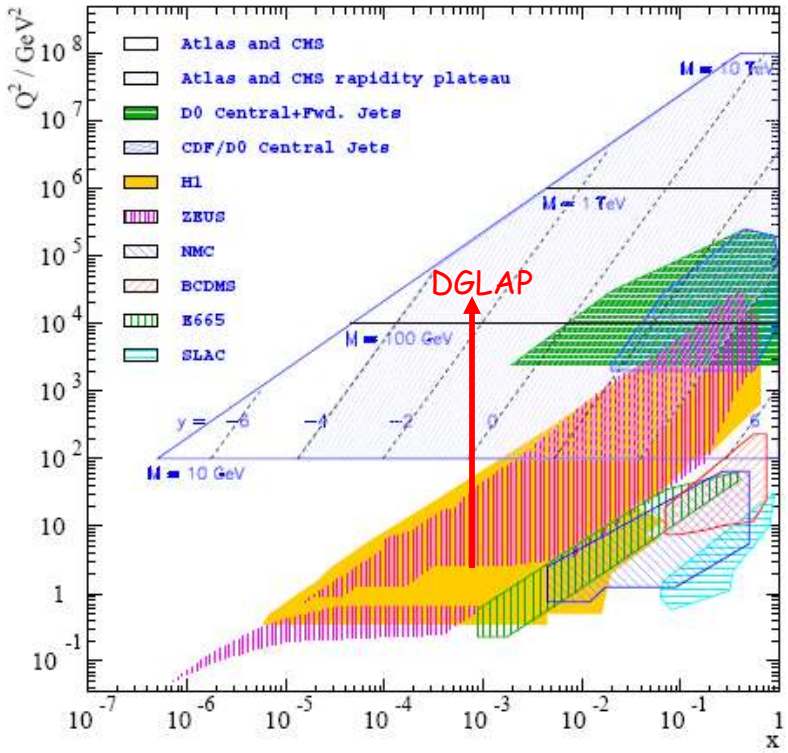
- **Domain of low Q^2 ($10 \leq Q^2/GeV^2 \leq 150$)**
  DGLAP evolution, PDFs with the highest precision – new result expected soon (down to 1% precision)
- **Lowest Q^2 domain ($Q^2 \leq 10\ GeV^2$)**
  Transition to non-perturbative region
  Phenomenological models
  NEW PRELIMINARY RESULT

Measurements from HERA-I+HERA-II

- **High Q^2 domain ($Q^2 \geq 200\ GeV^2$)**
  Polarisation effects and structure funct. - new result from the total data sample collected at H1 expected soon
- **High y domain ($y > 0.6$)** – Sensitivity to F_L
  - **low Q^2** - NEW PRELIMINARY RESULT
  - **medium Q^2** – NEW PRELIMINARY RESULT



H1 analysis well on their way to provide the highest precision measurement of the proton structure



- Proton structure described by precise PDFs needed for making accurate predictions for any process involving protons.

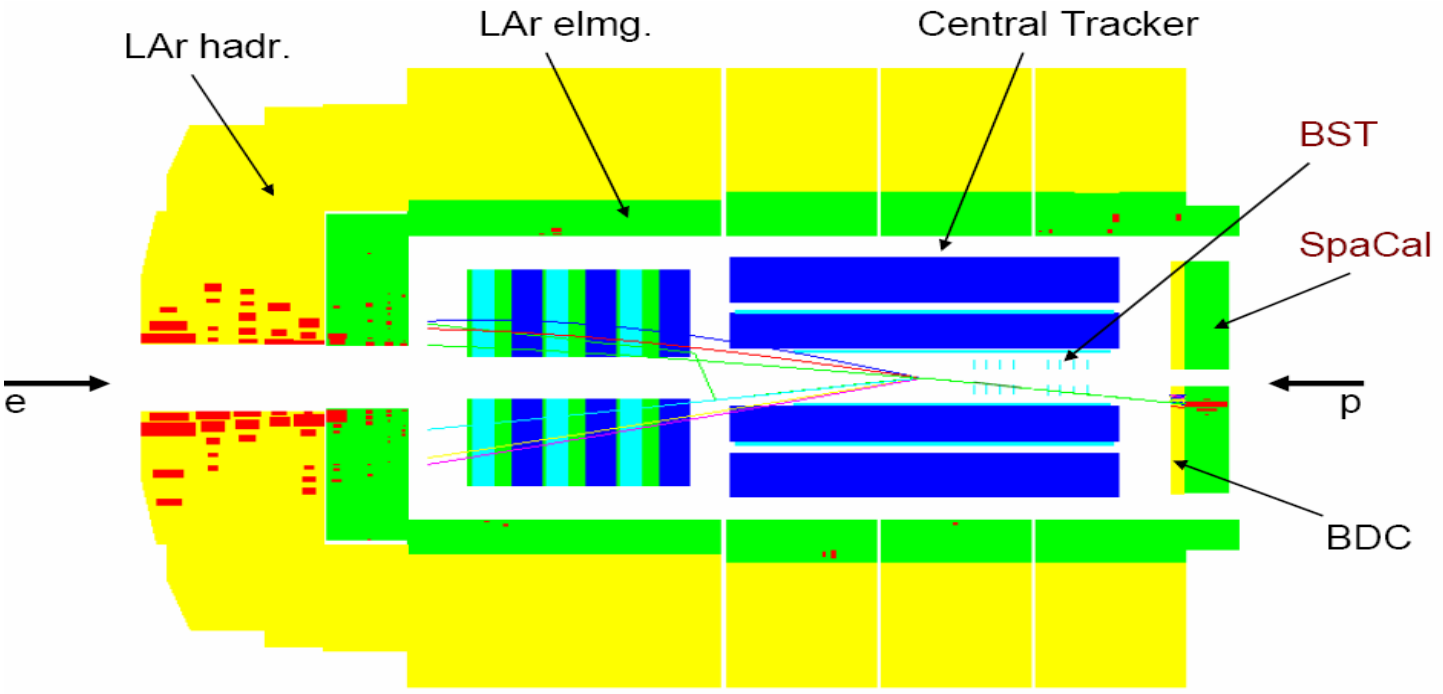
- DGLAP QCD evolution provides Q^2 dependence of the PDFs → x dependence must come from data.

HERA covers the most important region for the LHC -W, Z^0 cross section prediction.

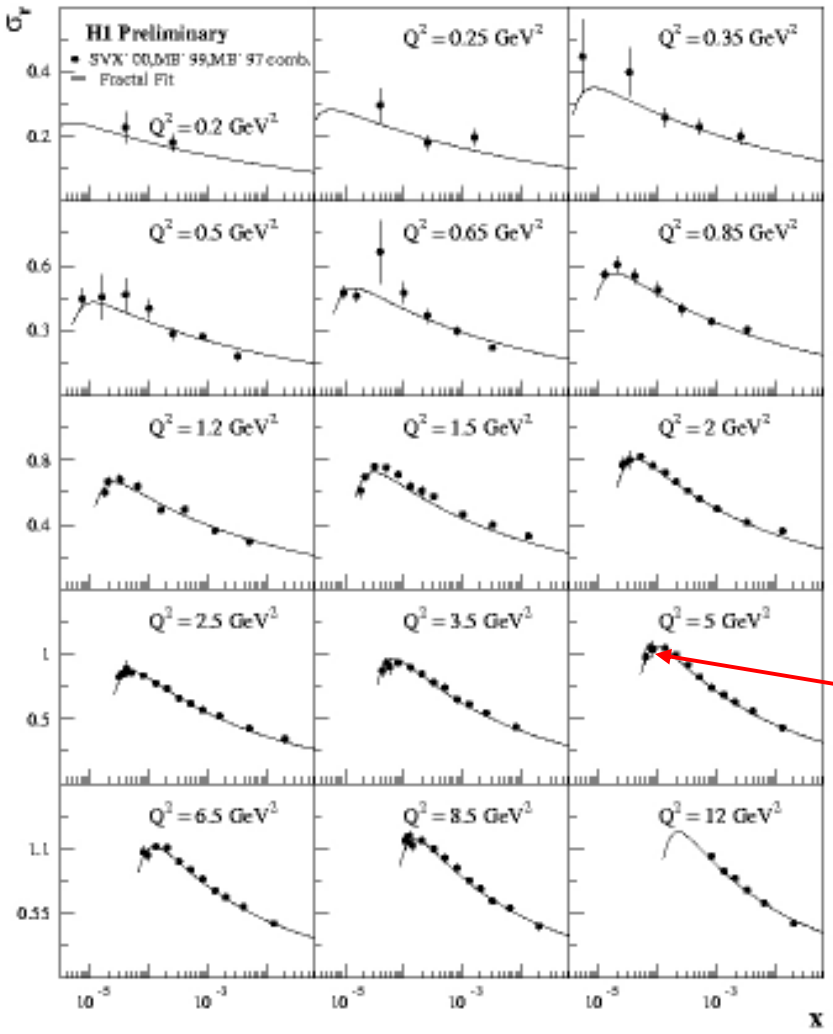
Lowest Q^2 analysis from H1

High precision in the lowest Q^2 regime obtained via special runs:

- MB – Minimum Bias runs (high trigger rate)
- SVX – shifted interaction vertex (increase acceptance at lowest Q^2)



Reduced cross section measurement at lowest Q^2



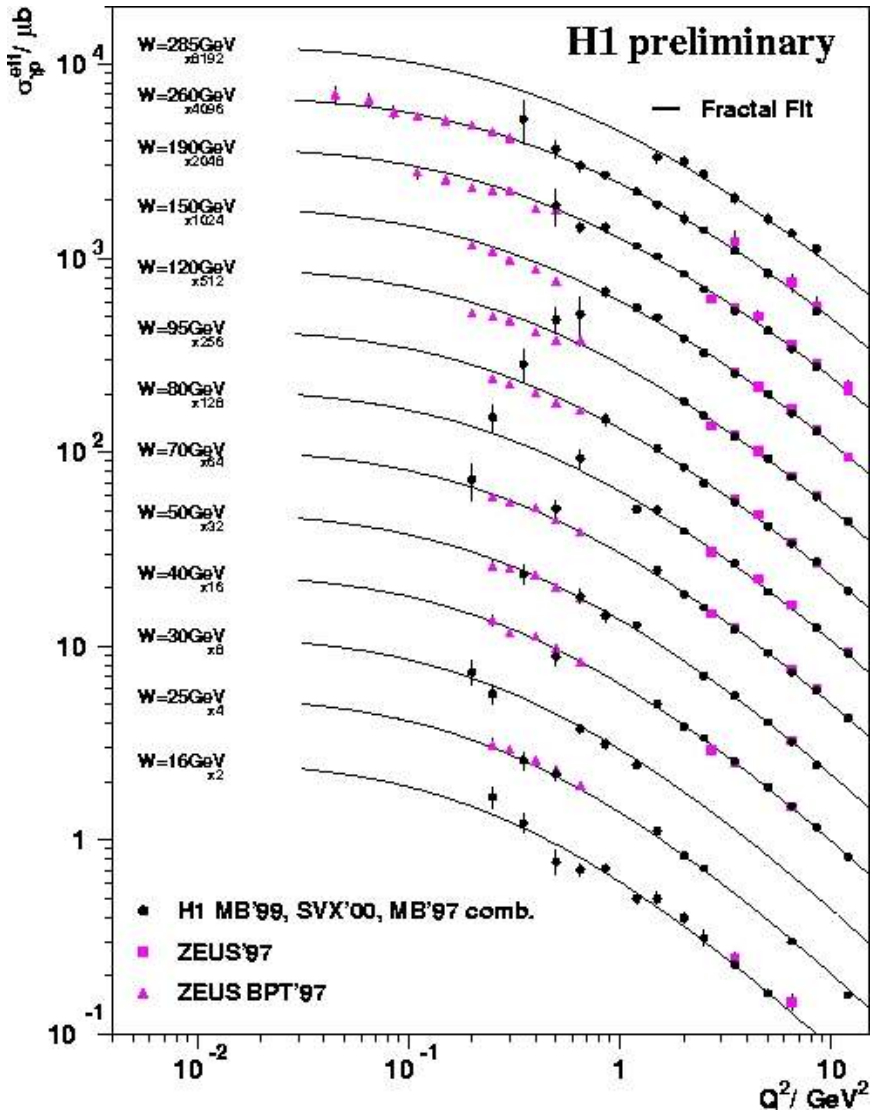
New preliminary results obtained by combining three data sets:

- MB data from 1999
  $L = 2.1\ pb^{-1}$, $0.5 \leq Q^2/GeV^2 \leq 12$
- Shifted vertex data from 2000
  $L = 504\ nb^{-1}$, $0.2 \leq Q^2/GeV^2 \leq 3.5$
- MB data from 1997
  $L = 1.8$ pb-1, $1.5 \leq Q^2/GeV^2 \leq 12$

Combined datasets → 2-3% precision

$$\sigma_r(x,Q^2) = F_2(x,Q^2) - \frac{y^2}{1+(1-y)^2} F_L(x,Q^2)$$

Effective γ*p cross section at lowest Q^2



$$F_2 = \frac{Q^2}{4\pi^2\alpha}(1-x)(\sigma_L+\sigma_T)$$

$$F_L = \frac{Q^2}{4\pi^2\alpha}(1-x)\sigma_L$$

} at low Q^2

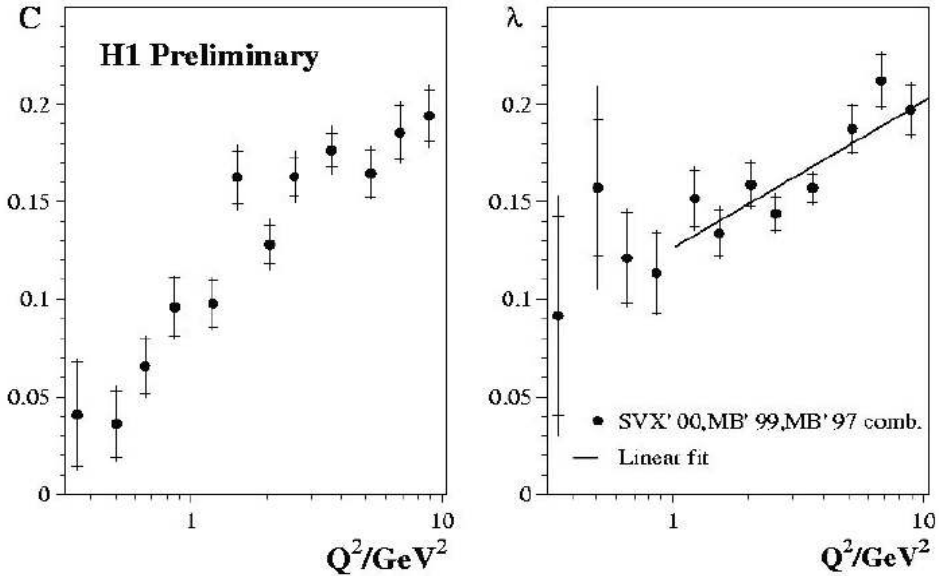
$$\sigma_{\gamma p}^{eff} = \sigma_T + [1-y^2/(1+(1-y)^2)]\sigma_L$$

- Data fill the transition region at $Q^2 \sim 1$ GeV^2
- New preliminary H1 measurements in agreement with ZEUS

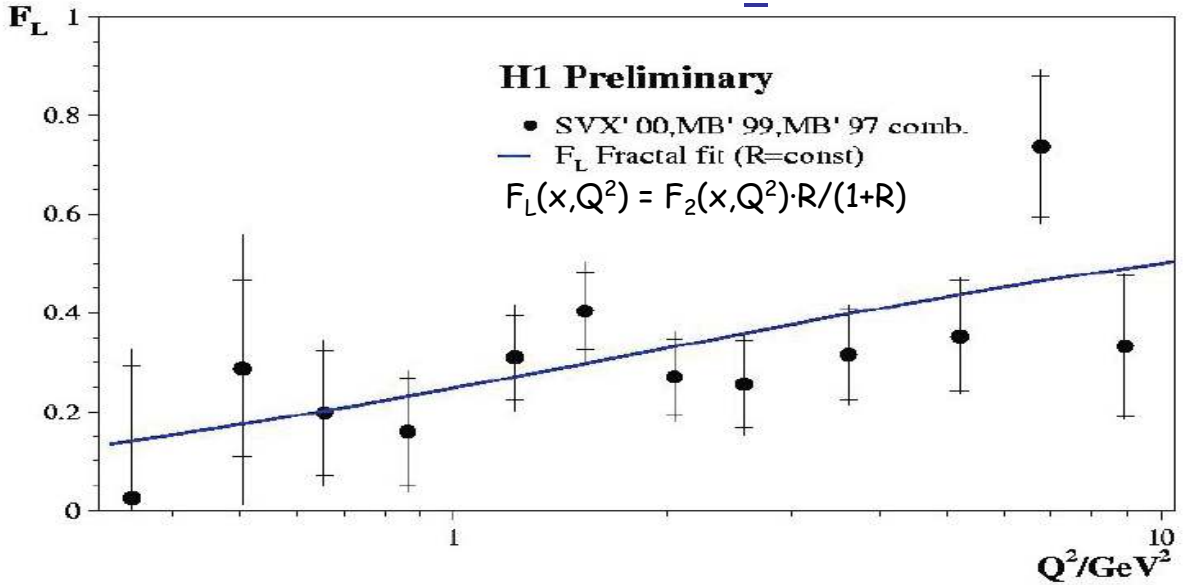
Precision for $Q^2 > 5$ GeV^2 reaches 1.5%

Raise of F_2

$$\sigma_r(x,Q^2) = \underbrace{c(Q^2)x^{-\lambda(Q^2)}}_{F_2(x,Q^2)\text{ at low x (<0.01)}} - \frac{y^2}{y_+}F_L(Q^2)$$



Extraction of F_L at high y



High y analysis with HERA-II data

- For kinematic reconstruction electron method is used

$$y = 1 - \frac{E_e'}{E_e} \sin^2(\theta_e/2)$$

To reach high y with low and medium Q^2
→ as low as possible E'_e required

Good sample to study experimental conditions for the F_L measurement

Two analysis at H1 in parallel:

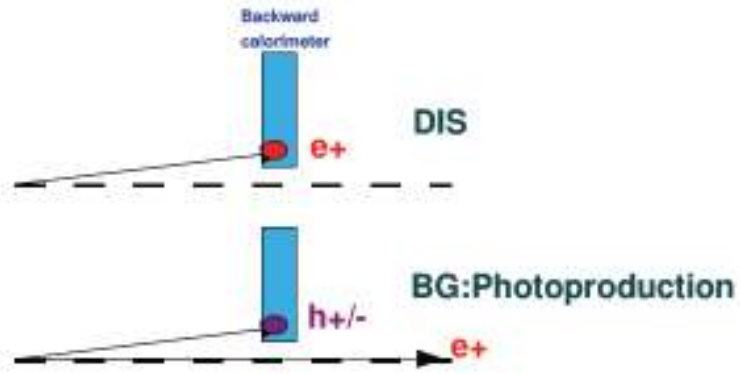
- High y analysis at low values of Q^2: $L \approx 96\ pb^{-1}$
- High y analysis at medium values of Q^2: $L \approx 315\ pb^{-1}$

Luminosities of e^+p and e^-p samples nearly symmetric

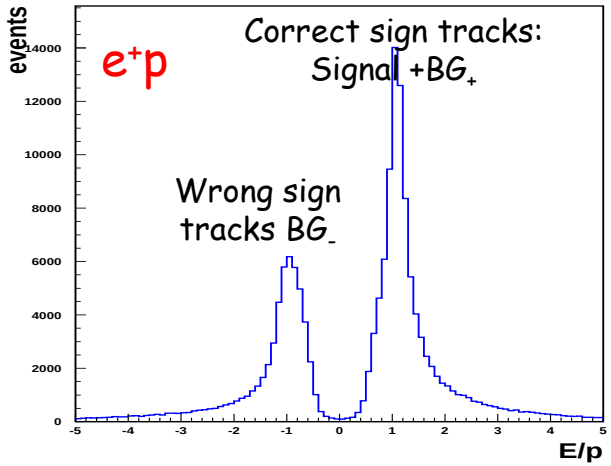
High y, low Q^2 analysis with HERA-II data

Analysis strategy

- At high y there is a large photoproduction background in which hadronic final state can mimic the signature of the scattered lepton with low energy.

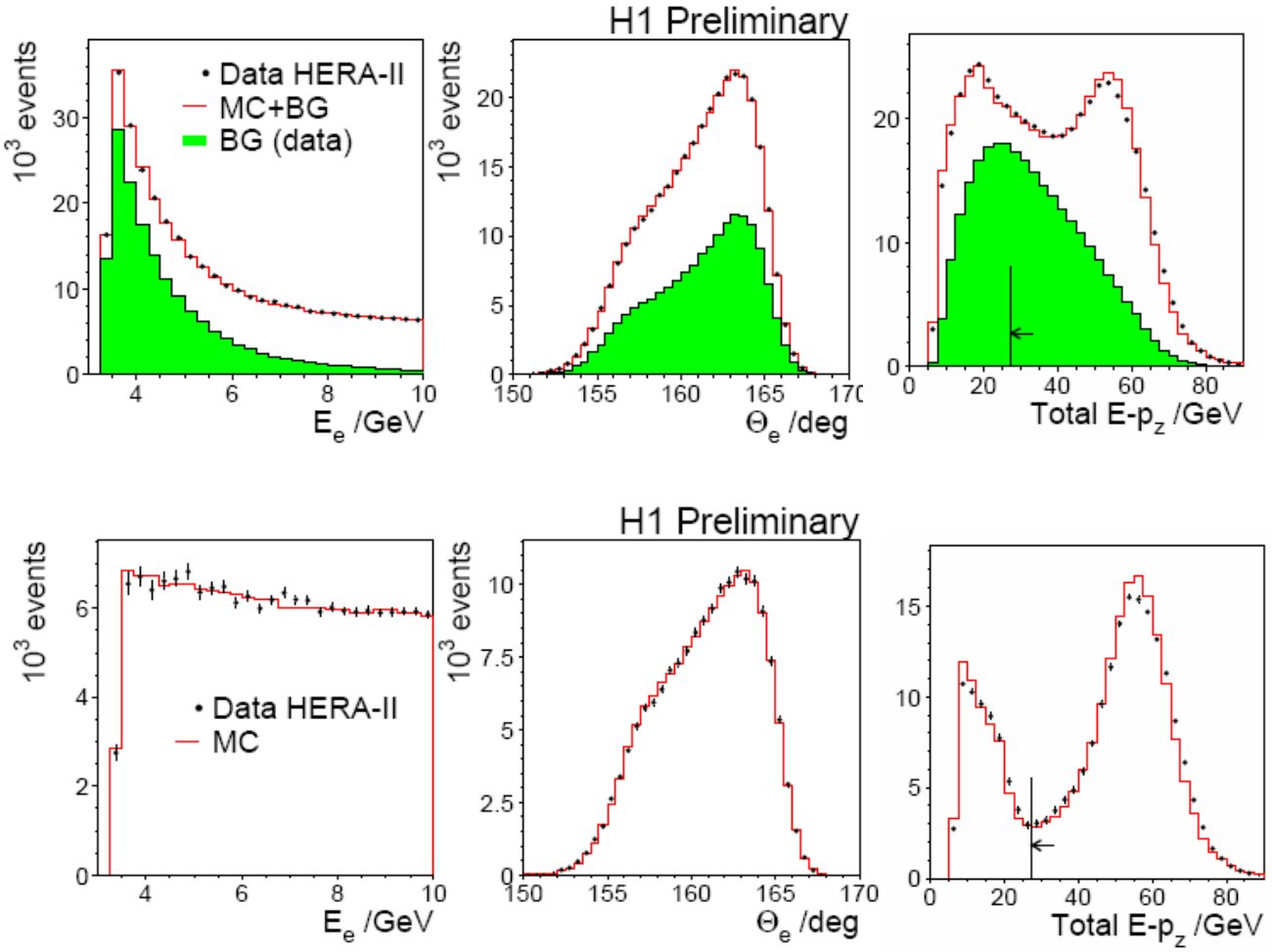


- Scattered lepton is identified by a cluster from SpaCal linked to a track in the Central Tracker (CT) which is used to measure its momentum and identify its charge from the sign of ratio of energy and momentum.



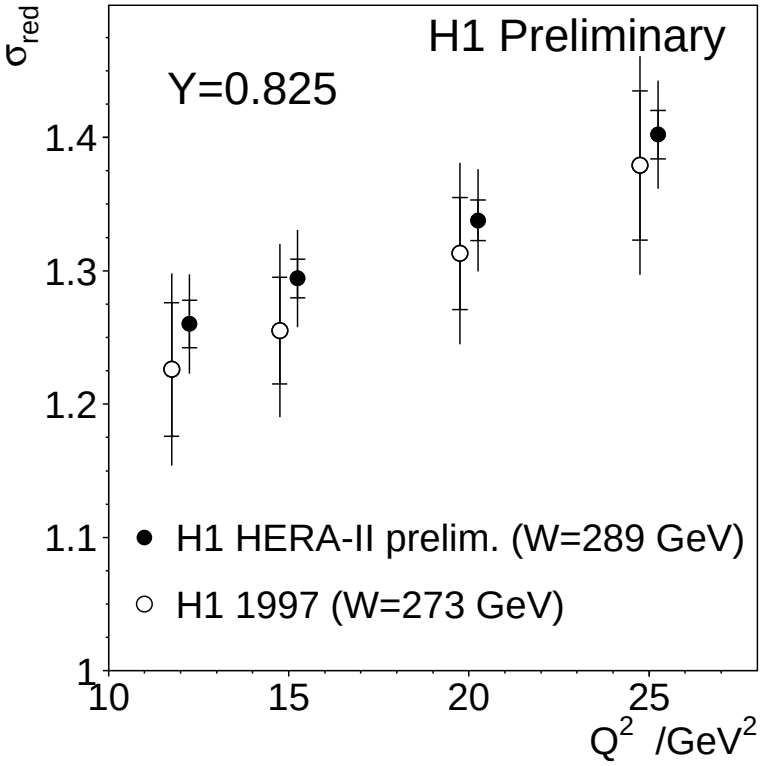
Background estimated using lepton candidates associated with wrong sign tracks. Charge symmetric lepton beam sample eliminates calorimeter response induced by background charge asymmetry.

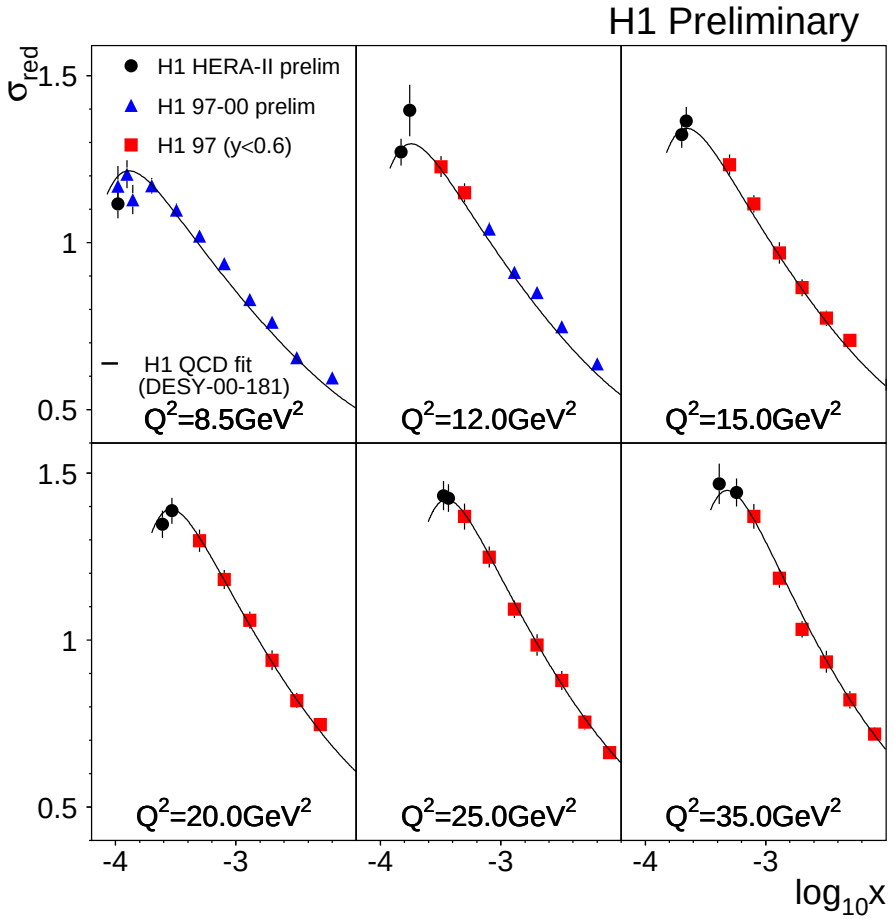
Control plots



$E\text{-}p_z = (E - p_z)_{HFS} + (E - p_z)_{e'} = 2 \cdot (\text{measured beam energy})$

High y cross section at low Q^2





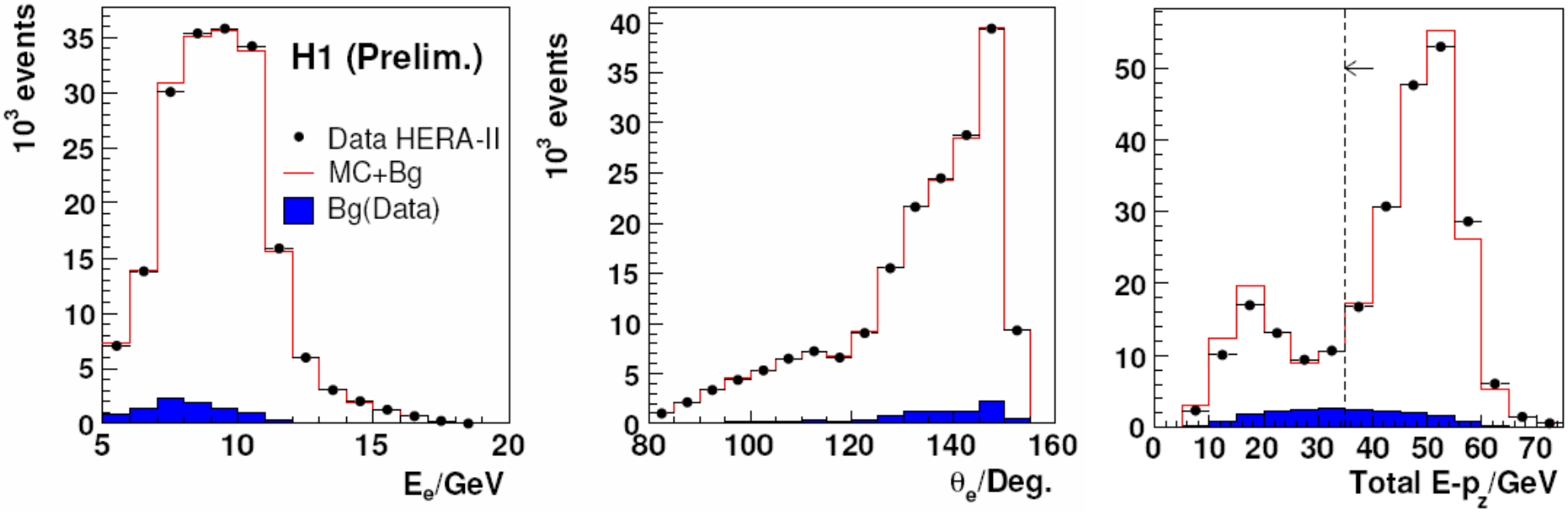
At y = 0.825

- About factor of 2 improvement in total uncertainty and about factor of 3 improvement in statistical uncertainty versus published results from HERA-I.

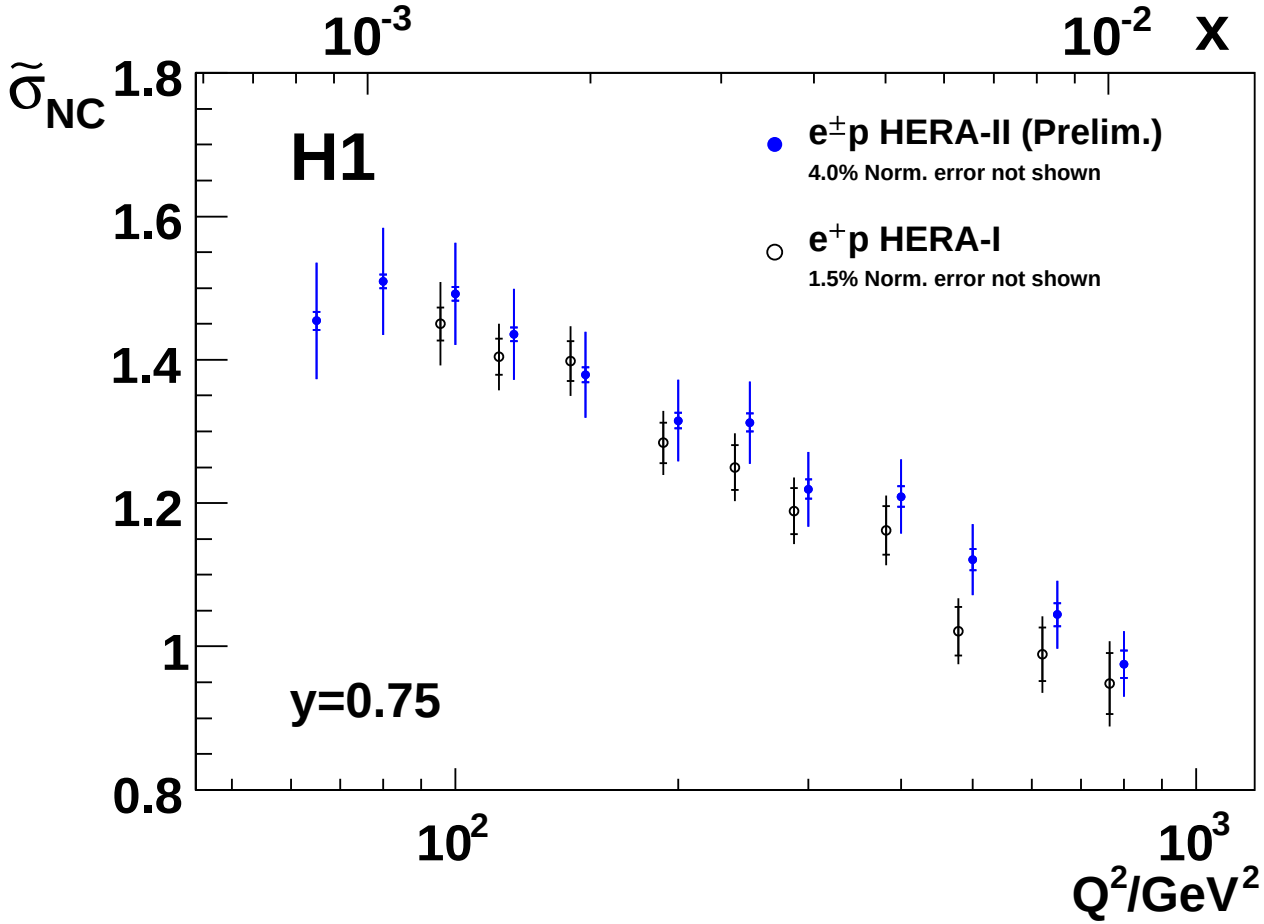
High y, medium Q^2 analysis with HERA-II data

- Cluster required in LAr calorimeter
- Background subtraction procedure as for the low Q^2 region

Control plots

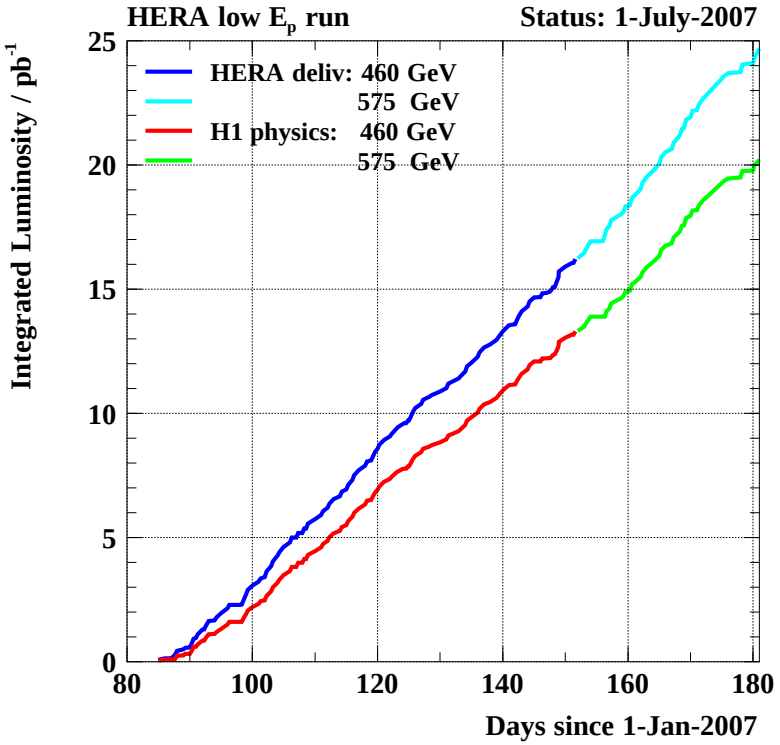


High y cross section at medium Q^2



- Statistical errors significantly improved and phase space extended with respect to the published measurements.

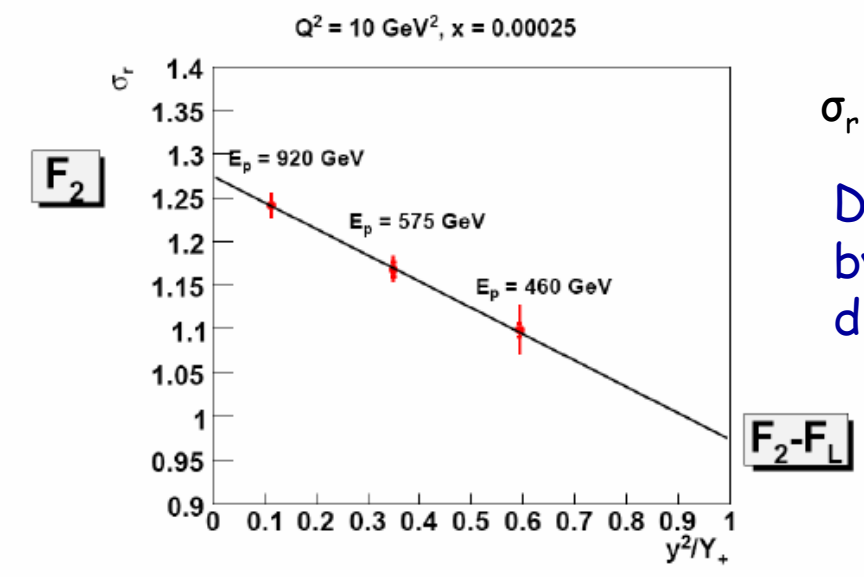
H1 data from e^+p from reduced proton beam energy



Since March 2007 – proton beam energies reduced

- $L \approx 13\ pb^{-1}$ at lowest $E_p = 460$ GeV
- $L \approx 7\ pb^{-1}$ at intermediate $E_p = 575$ GeV

Direct measurement of F_L at HERA

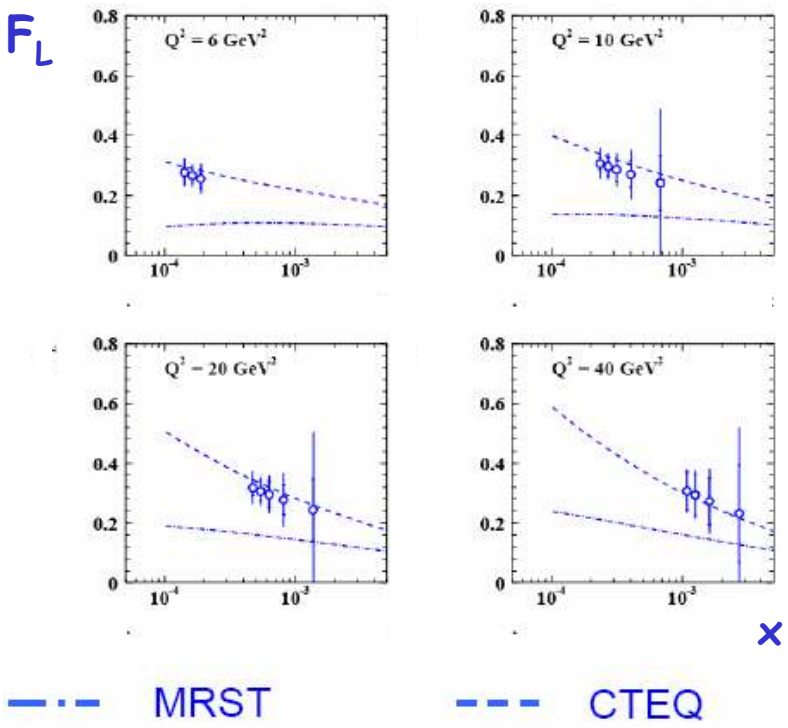


$$\sigma_r(x,Q^2) = F_2(x,Q^2) - \frac{y^2}{Y_+} F_L(x,Q^2)$$

Direct measurement of F_L can be obtained by measuring σ_r at the same x, Q^2 for different beam energies.

- Precise measurement of F_L will provide constraints on the gluon contribution which are complementary to that obtained from the scaling violations of F_2 assuming DGLAP evolution.
- Direct F_L measurement will allow to distinguish between different PDF fits.

Simulation results



Summary and Outlook

- New preliminary results on Neutral Current DIS cross section from H1 at
  - lowest Q^2 domain,
  - high y, low Q^2 domain,
  - high y, medium Q^2 domain.
- 2-3% precision of HERA measurements is reached in the region important for W, Z, H cross section prediction at the LHC. Next step is 1-1.5% precision from H1.
- Direct measurements of the F_L structure function using data with different proton beam energies will be important check of the theory and will put new constraints on the gluon density.