



High Q² neutral current cross sections in e⁺p DIS

Alex Tapper



Deep inelastic scattering at HERA



- Q² is the probing power
- x is the Bjorken scaling variable
- y is the inelasticity

- Neutral current: exchange of γ or Z⁰
- Probing the proton at small distance scales

$$Q^{2} = -q^{2} = -(k - k')^{2}$$
$$x = \frac{Q^{2}}{2p \cdot q} \quad y = \frac{p \cdot q}{p \cdot k}$$
$$s = (p + k)^{2} \quad Q^{2} = x \cdot y \cdot s$$

HERA I operation

- This analysis based on
 63 pb⁻¹ e⁺p data collected in
 1999 and 2000
 (DESY-03-214)
- Centre-of-mass energy ~320 GeV
- Compared later with 16 pb⁻¹ e⁻p data collected in 1998 and 1999 (DESY-02-113)



Neutral current DIS cross section

NC Reduced cross section:
$$\widetilde{\sigma}_{NC}(x,Q^2)$$

$$\frac{d^2 \sigma^{NC}(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}Y_+ \begin{bmatrix} F_2 - \frac{y^2}{Y_+}F_L \mp \frac{Y_-}{Y_+}xF_3 \end{bmatrix} \qquad Y_{\pm} = 1 \pm (1-y)^2$$
Dominant contribution
Sizeable only at high y

Contribution only important at high Q^2

$$F_{2} = F_{2}^{em} + \frac{Q^{2}}{Q^{2} + M_{Z}^{2}} F_{2}^{\gamma Z} + \left[\frac{Q^{2}}{Q^{2} + M_{Z}^{2}}\right]^{2} F_{2}^{Z} \propto \sum_{q=u...b} (q + \overline{q})$$

$$xF_{3} = \frac{Q^{2}}{Q^{2} + M_{Z}^{2}} xF_{3}^{\gamma Z} + \left[\frac{Q^{2}}{Q^{2} + M_{Z}^{2}}\right]^{2} xF_{3}^{Z} \propto \sum_{q=u...b} (q - \overline{q})$$

DIS 2004, Strbske Pleso, High Tatras, Slovakia 14-18 April 2004

Kinematic range

- Huge range of HERA
 measurements
- This analysis Q²>185 GeV² and extends to high x
- Sensitivity to valence quark distributions and electroweak effects



NC events in the ZEUS detector



Precise calibration in-situ with NC events

Event selection

- Select events with an isolated e⁺ with energy of at least 10 GeV in the calorimeter with a matched track
- Reject background with 38 GeV < E-p_z (δ) < 65 GeV P_T/ $\sqrt{E_T}$ <4 GeV^{1/2}
- Signal (Djangoh CDM) includes diffractive component (RAPGAP)
- Background from photoproduction (HERWIG)
- MC gives a good description of the data



Binning and event sample

- $200 < Q^2 < 30000 \text{ GeV}^2$
- 0.005 < x < 0.65
- x and Q² estimated using the double angle method
- Resolution of hadronic angle dominates
 - Positron: 2-5 mrad
 - Hadrons: 15-100 mrad
- Which gives resolutions of
 - Q2: ~3%
 - x: 4-15%
 - y: ~10%



Page 8

Single differential cross sections

- SM describes the data over six orders of magnitude
- γ exchange dominates at low values of Q²
- Difference between e⁺p and e⁻p at high Q²
 - γ-Z⁰ interference
 - constructive for e-p
 - destructive for e⁺p



Single differential cross sections

- Single differential cross sections in x,y and Q² for Q²>200 GeV²
- Well described by ZEUS-S fit
- Higher than MRST and CTEQ but consistent within luminosity uncertainty of 2.5%



Reduced cross section



DIS 2004, Strbske Pleso, High Tatras, Slovakia 14-18 April 2004

 F_2^{em}

- Extract F₂ electromagnetic structure function
- Combine with previous 96/97 measurement (DESY-01-064)
- In good agreement with other experiments and well described by the Standard Model



That's it for HERA I....



Completes the HERA I high Q² cross section measurements

DIS 2004, Strbske Pleso, High Tatras, Slovakia 14-18 April 2004

Summary

- Measured single and reduced cross sections
- Effect of Z-boson exchange clearly seen
- All cross sections in good agreement with the Standard Model
- F₂ electromagnetic structure function extracted and compared with measurements from other experiments
- Final ZEUS high Q² measurement from HERA I
- Looking forward to HERA II data