Study of Charged-Current ep Interactions at $Q^2 > 200\ GeV^2$ with the Zeus Detector at Hera (*)

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Zeus Collaboration

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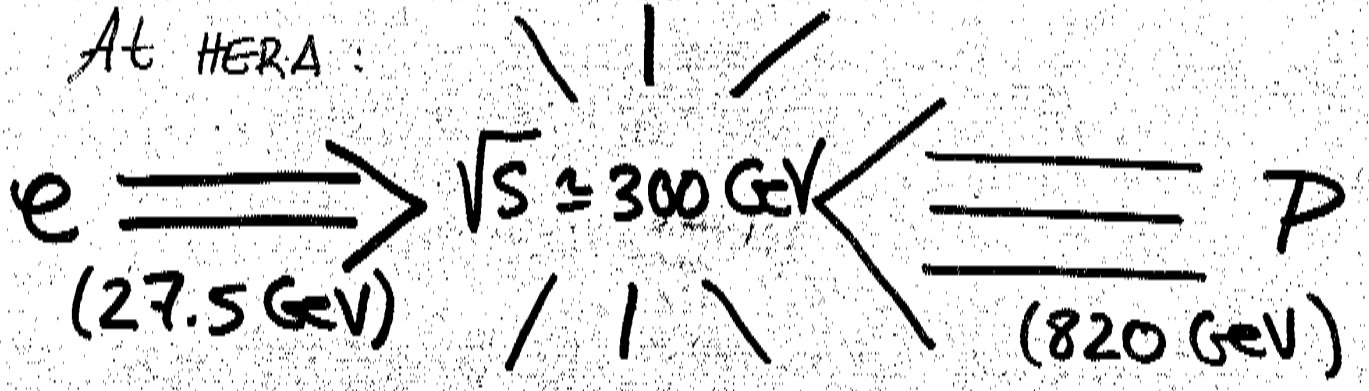
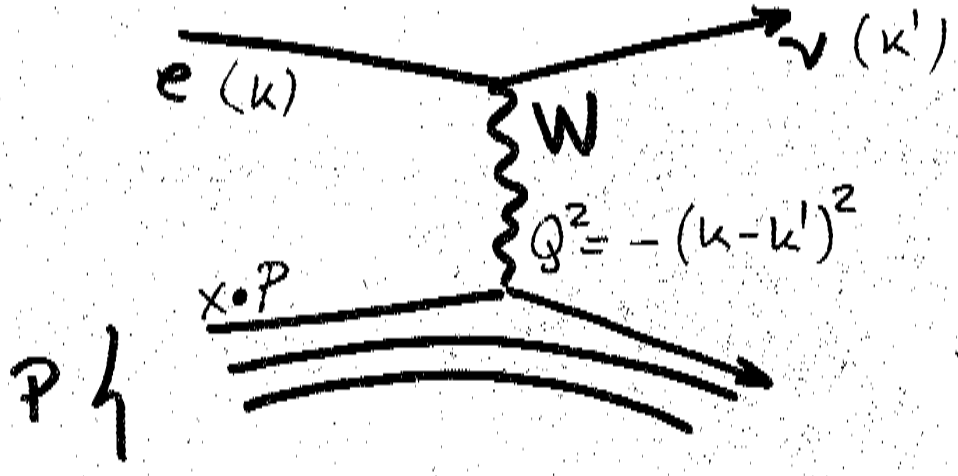


(*) DESY-Preprint-96-104 (1996)

Charged Current Physics



$$y = \frac{Q^2}{x \cdot s}$$

In leading order approximation:

$$\frac{d\sigma}{dQ^2 dx}(e^+ p) = \frac{G_F^2}{2\pi}\left[\frac{M_W^2}{M_W^2+Q^2}\right]^2 \sum_{i=1}^{2}\left[\bar{u}_i + (1-y)^2 d_i\right]$$

$$\frac{d\sigma}{dQ^2 dx}(e^- p) = \frac{G_F^2}{2\pi}\left[\frac{M_W^2}{M_W^2+Q^2}\right] \sum_{i=1}^{2}\left[u_i + (1-y)^2 \bar{d}_i\right]$$

- From the propagator term $\Rightarrow M_W$
- From the $\frac{\sigma_{e^+}}{\sigma_{e^-}}$ ratios $\Rightarrow$ different contributions of valence and sea quarks within the proton.

RECONSTRUCTION OF Q^2, x, y

IN CHARGED CURRENT REACTIONS THE FINAL ν REMAINS UNDETECTED

⇓

- WE MUST COMPUTE Q^2, x, y FROM THE HADRONIC SYSTEM (JACQUET-BLONDEL METHOD)

USING THE INFORMATION FROM THE CALORIMETER CELLS

- $\not{P}_T = \sqrt{\left(\sum_i P_x^i\right)^2 + \left(\sum_i P_y^i\right)^2}$
- $\delta = \sum_i (E^i - P_z^i)$

⇓

$$y_{JB} = \frac{\delta}{2E_e^*} \quad ; \quad Q^2_{JB} = \frac{\not{P}_T^2}{(1-y_{JB})}$$

$$x_{JB} = \frac{\not{P}_T^2}{s\, y_{JB}(1-y_{JB})}$$

* E_e = ELECTRON BEAM ENERGY

SELECTION CRITERIA

ν UNDETECTED $\Rightarrow$ LARGE $\not{P}_T$ MISSING IN THE CALORIMETER

- **FOR $\not{P}_T > 30$ GeV**

  CUTS WERE APPLIED TO REMOVE BACKGROUND FROM $\bar{p}$-GAS INTERACTIONS AND MUONS

  - VERTEX
  - TRACKS
  - MATCHING CALORIMETER – TRACKS

  . . . .

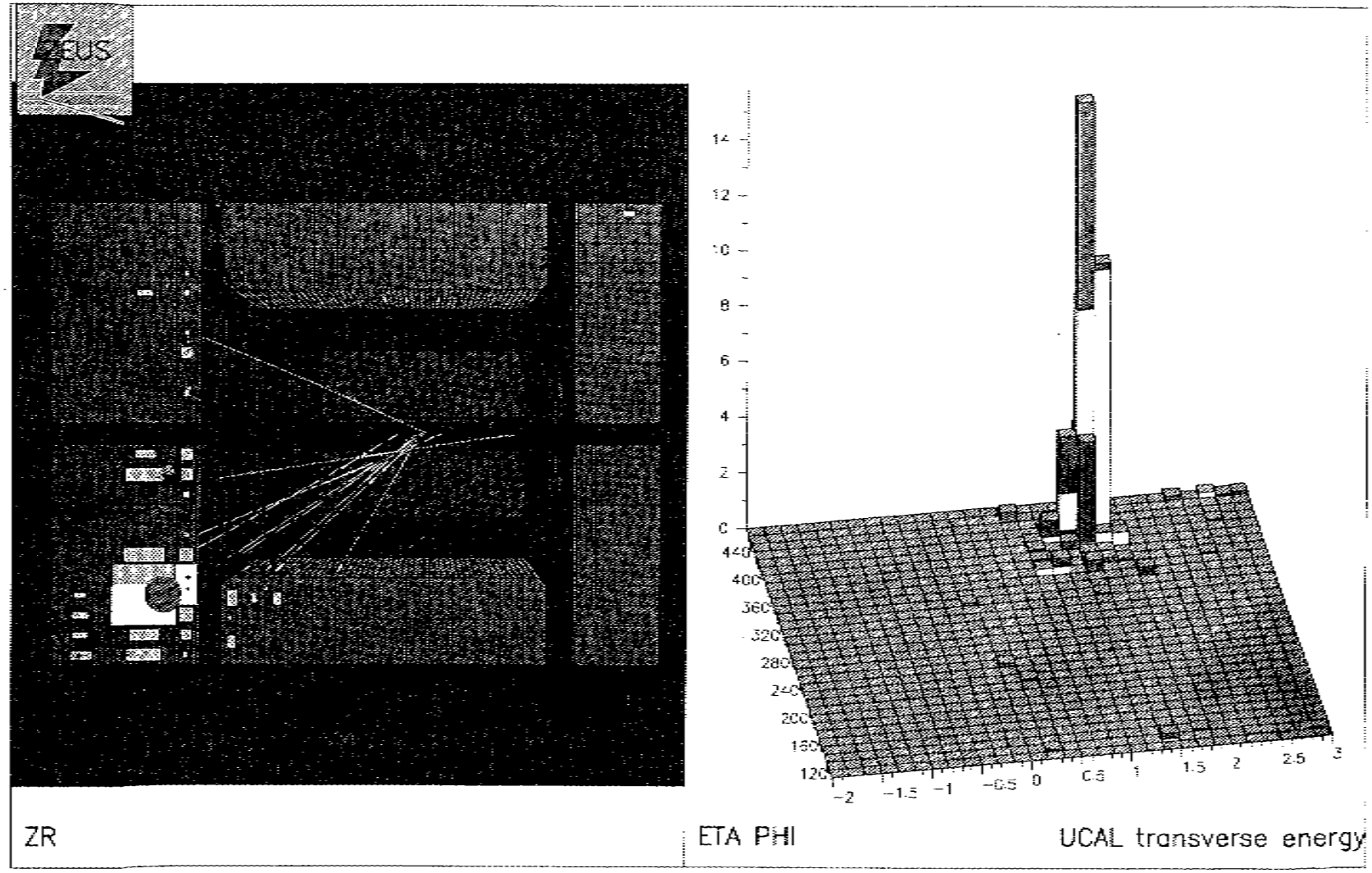
- **FOR $\not{P}_T < 30$ GeV**

  - **$\not{P}_T > 11$ GeV**

    - THE SAME CUTS AS BEFORE
    - ADDITIONAL CUTS TO REDUCE BACKGROUND FROM NEUTRAL CURRENT INTERACTIONS
      - Y_{JB} CUT
      - MOMENTUM OF THE TRACKS
      - $\not{P}_T/E_T$ CUT $\quad (E_T = \Sigma\sqrt{P_x^2 + P_y^2})$

56 events $(e^+p \to \bar{\nu}X)$ $\mathcal{L} \simeq 2.9\ pb^{-1}$ $(\varepsilon_f = 63\%)$

30 events $(e^-p \to \nu X)$ $\mathcal{L} \simeq 0.8\ pb^{-1}$ $(\varepsilon_f \simeq 66\%)$


ZEUS
14
12
10
8
6
4
2
0
440
400
360
320
280
240
200
160
120
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3
ZR
ETA PHI
UCAL transverse energy

(5)

CORRECTION PROCEDURE & SYSTEMATICS

- WE CORRECTED THE DATA IN TWO STEPS
  - A FIRST GLOBAL CORRECTION OF P_T AND y
    $\Rightarrow$ CORRECTED Q^2 AND x

R.M.S WIDTHS OF $\delta A = \frac{A_{cor} - A_{TRUE}}{A_{TRUE}}$ $(A = Q^2, x, y)$ }
- $Q^2 \simeq 25\%$
- $x \simeq 20\%$
- $y \simeq 10\%$

  - THE DATA WERE UNFOLDED USING A BIN-TO-BIN CORRECTION METHOD

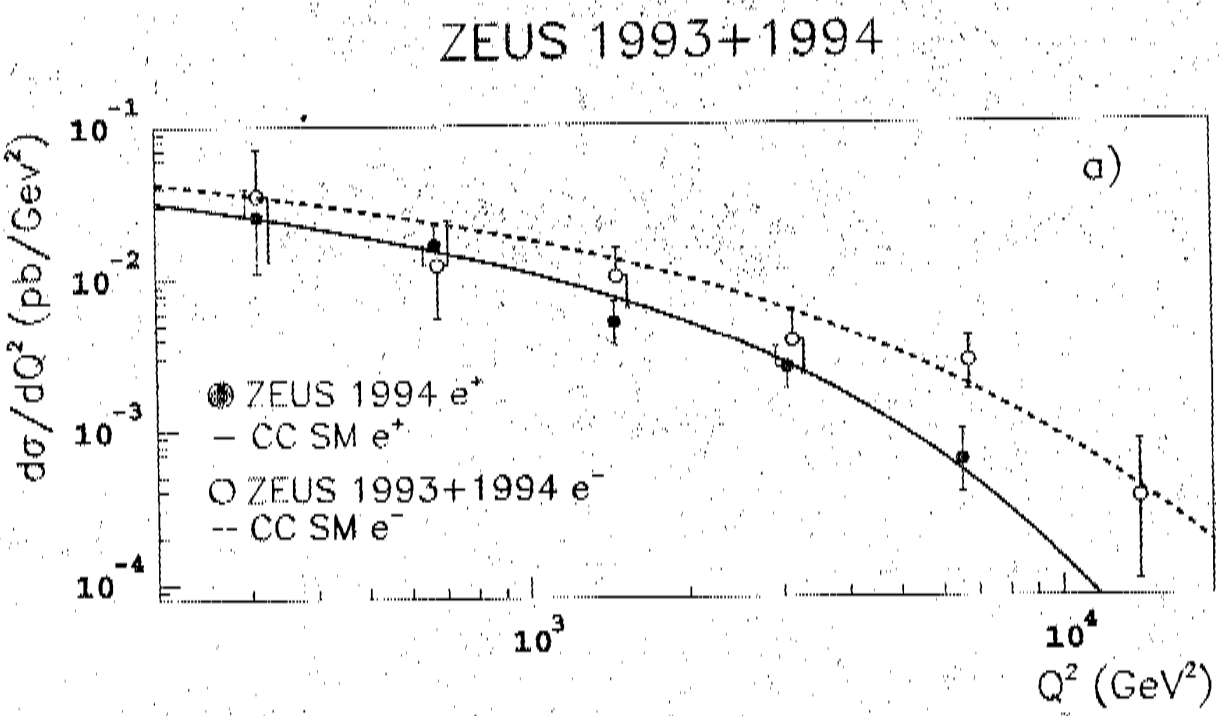
- SYSTEMATICS

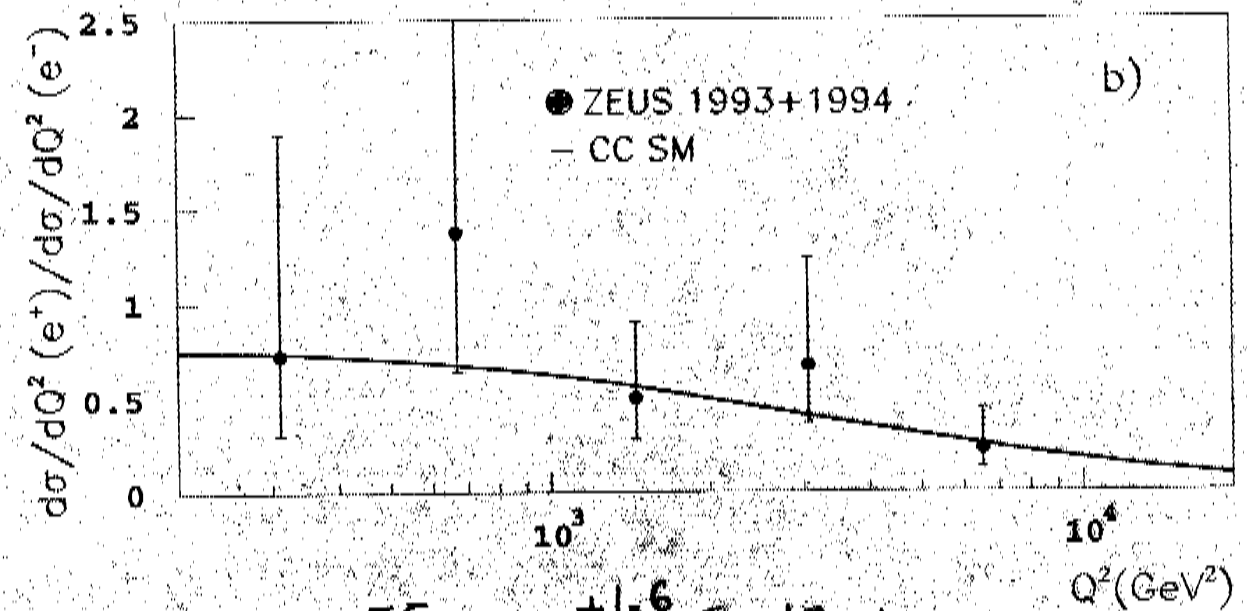
$\Rightarrow$
- $\pm 3\%$ ENERGY SCALE OF THE CALORIMETER
- LUMINOSITY
- UNFOLDING
- TRACKING ACCEPTANCE
- VARIABLES RECONSTRUCTION
- TRIGGER SIMULATION
- BACKGROUND SUBTRACTION

- NEUTRAL CURRENT CONTROL SAMPLE
  - WE USED A NC DATA SAMPLE (AFTER REMOVING THE FINAL $e^{\pm}$ AND REWEIGHTING BY THE NC/CC CROSS SECTION DIFFERENCES) TO CHECK EFFICIENCIES AND SYSTEMATICS

RESULTS

- $\frac{d\sigma}{dQ^2}$ $(Q^2 > 200\ GeV^2)$



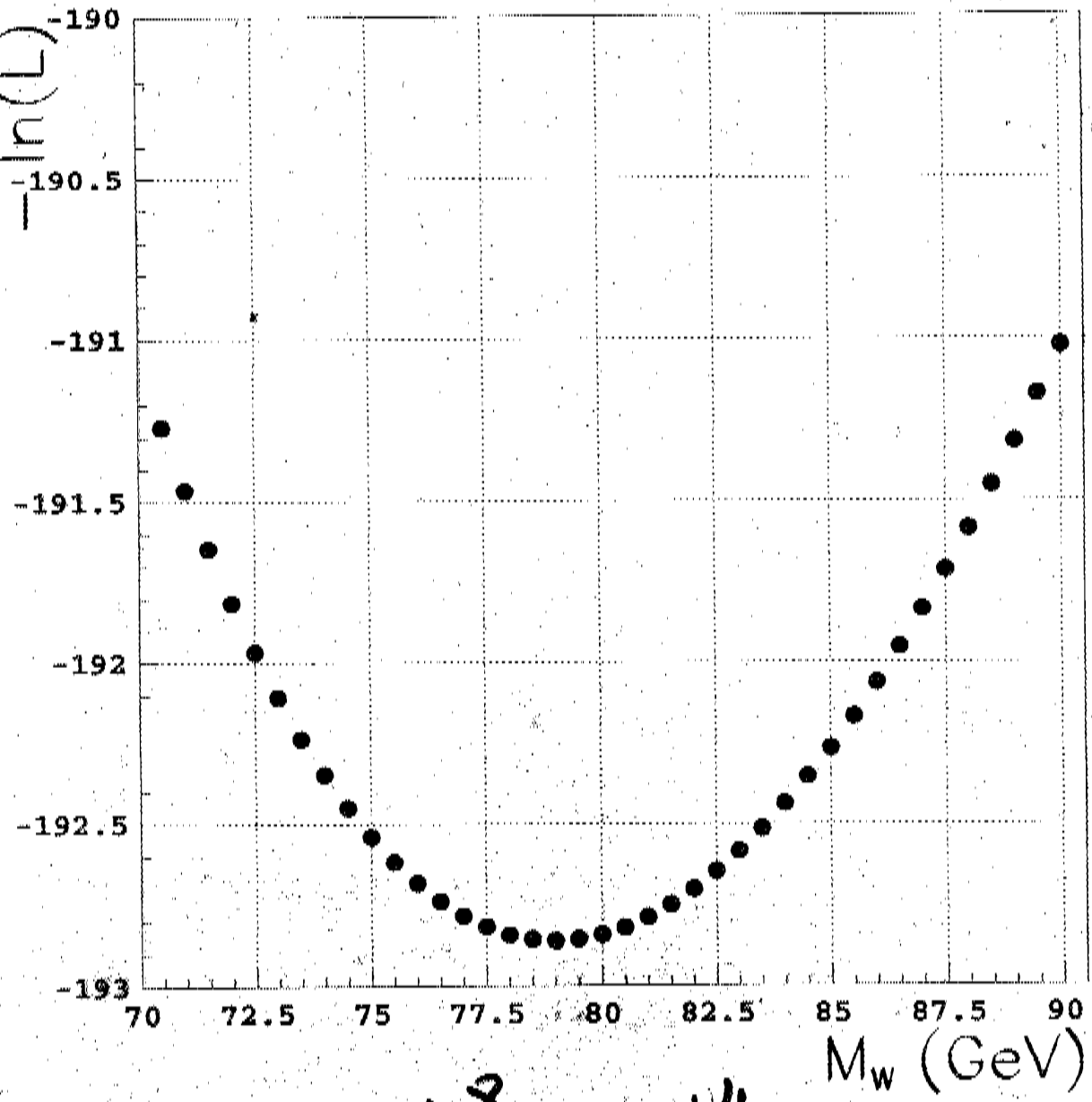


$\sigma_{e^+p} = 30.3^{+5.5}_{-4.2}[stat]^{+1.6}_{-2.6}[syst]$ pb SM = 32.3 pb

$\sigma_{e^-p} = 54.7^{+15.9}_{-9.8}[stat]^{+2.8}_{-3.4}[syst]$ pb SM = 65.8 pb

$$\frac{d\sigma}{dQ^2} = \left[\frac{M_W^2}{M_W^2 + Q^2}\right]^2 f(Q^2) \qquad (8)$$

A BINNED log-LIKELIHOOD FIT, APPLIED SIMULTANEOUSLY TO e^+p AND e^-p

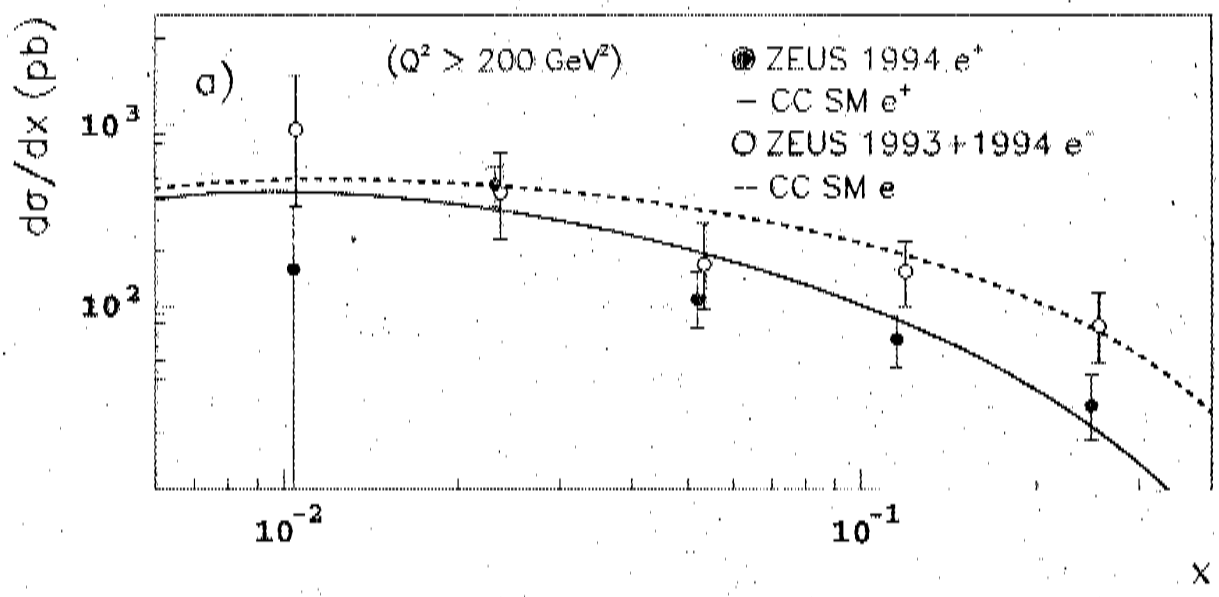


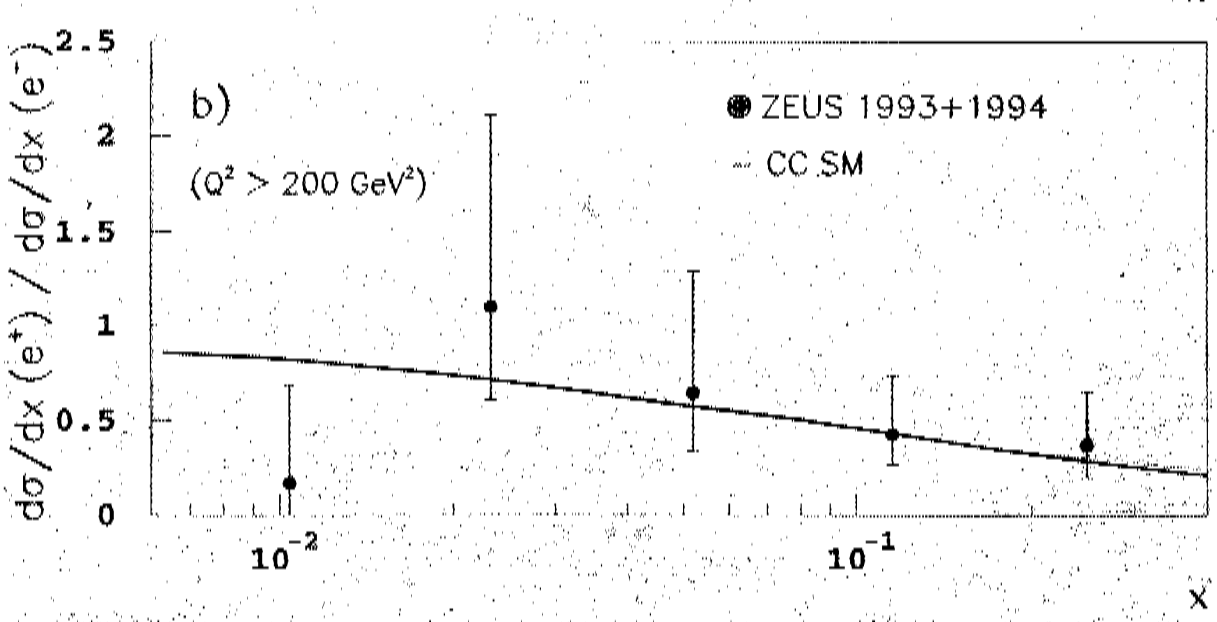
$$M_W = 79^{+8}_{-7}(\text{stat})^{+4}_{-4}(\text{syst})\ \text{GeV}$$

$(M_W = \ldots \pm \ldots\ (\text{GeV})$

- $\frac{d\sigma}{dx}$ $(Q^2 > 200\ GeV^2)$

ZEUS 1993+1994

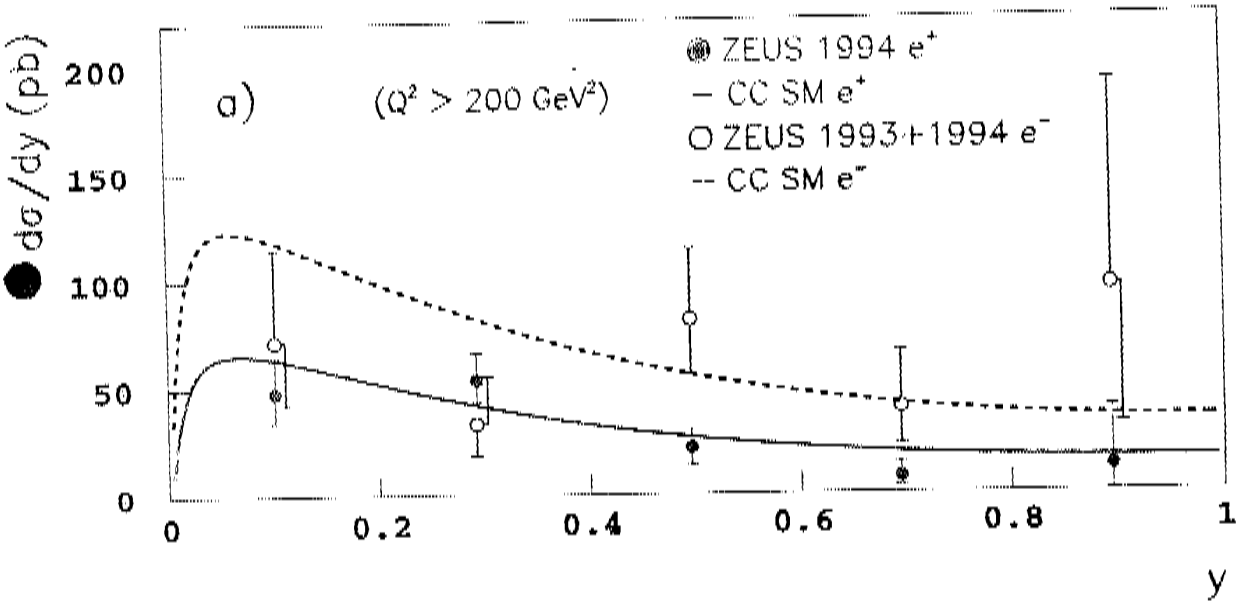


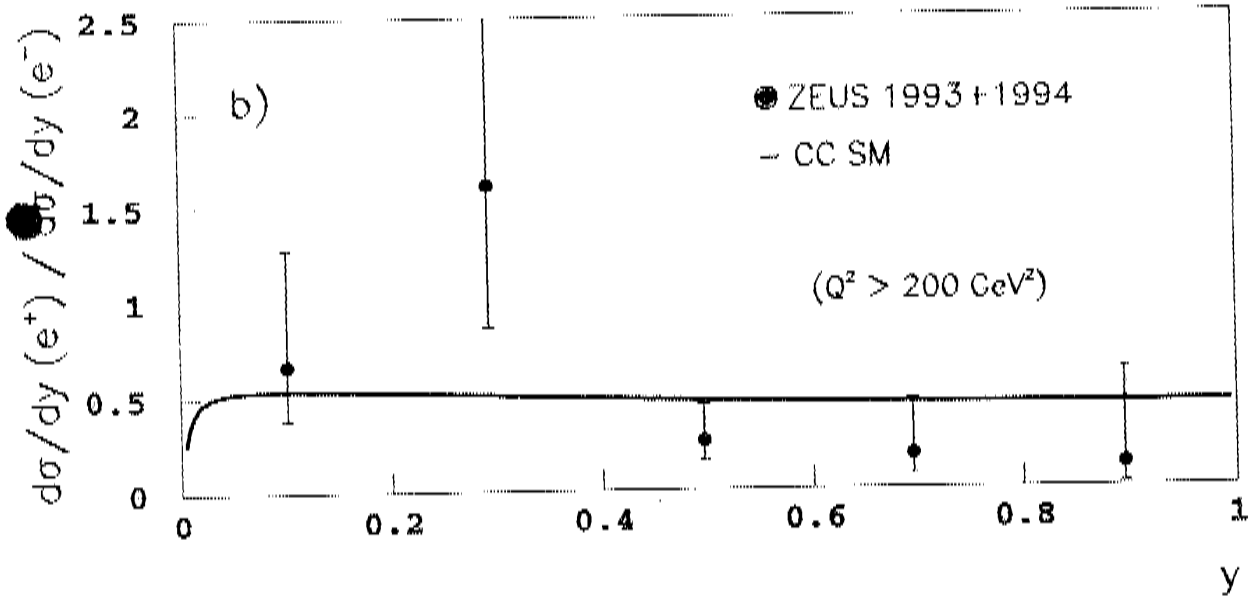


$$\frac{\sigma_{e^+}}{\sigma_{e^-}} \sim \frac{\bar{u} + (1-y)^2 d}{u + (1-y)^2 \bar{d}}$$

- $\frac{d\sigma}{dy}$ $(Q^2 > 200\ GeV^2)$

ZEUS 1993+1994



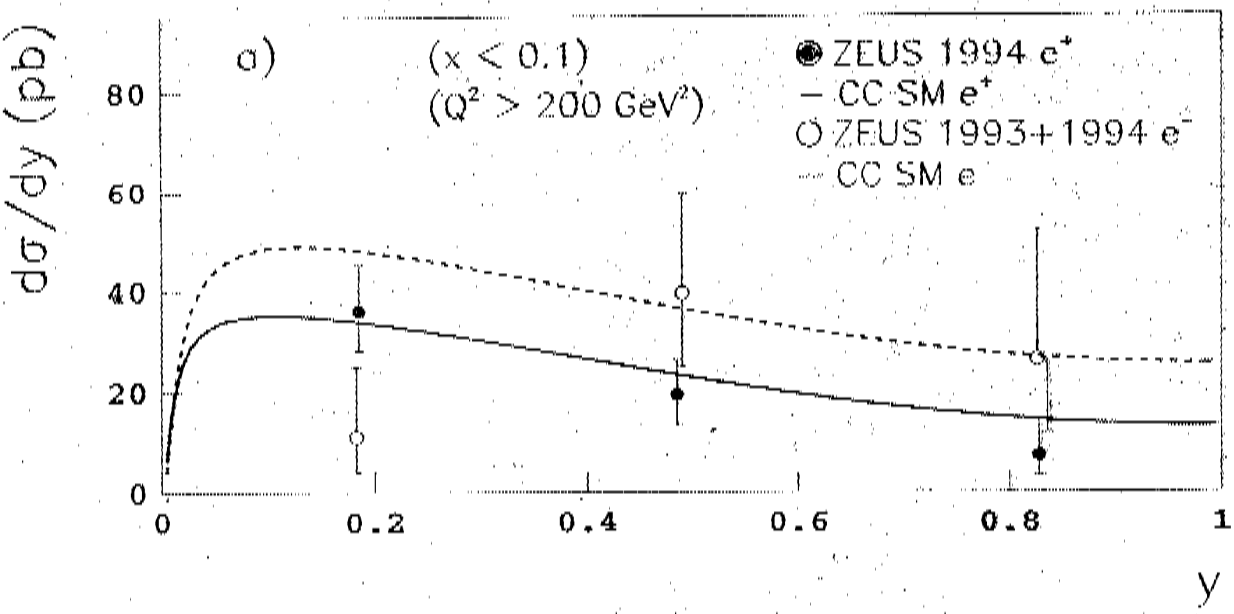


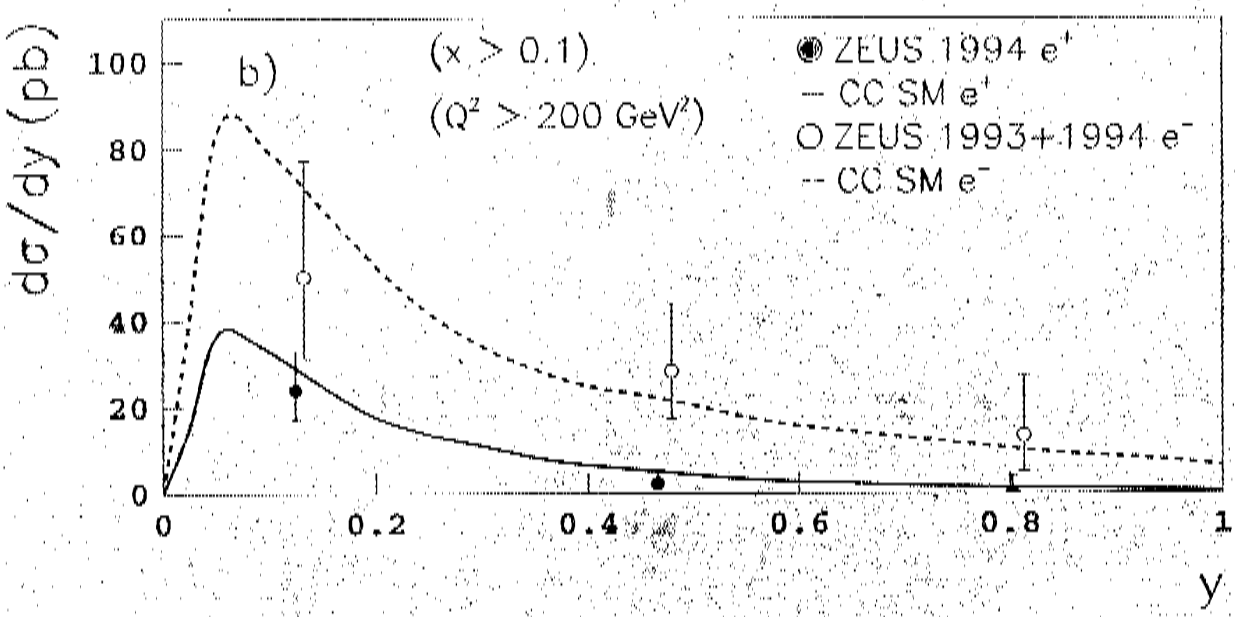
$$\frac{\sigma_{e^+}}{} \sim \frac{\bar{u} + (1-y)^2 d}{u + (1-y)^2 \bar{d}}$$

• $\frac{d\sigma}{dy}$ for $\begin{cases} x<0.1 \\ x>0.1 \end{cases}$ $\Big\}$ $Q^2 > 200\ GeV^2$

GIVEN AN X VALUE: HIGHER Y ⇒ HIGHER Q^2 ⇒

⇒ SEA CONTRIBUTION ↑ VALENCE CONTRIBUTION ↓





$$\sigma_{e^+p} \sim \mathcal{P}(Q^2)\left[\bar{u} + (1-y)^2 d\right]$$

$$\sigma_{e^-p} \sim \mathcal{P}(Q^2)\left[u + (1-y)^2 \bar{d}\right]$$

CONCLUSIONS

- WE MEASURED TOTAL AND DIFFERENTIAL CROSS SECTIONS IN Q^2, x, y FOR CC INTERACTIONS AT $Q^2 > 200\,GeV^2$
  - $\sigma_{e^+p}\,(Q^2 > 200\,GeV^2) = 30.3^{+5.5\,+1.6}_{-4.2\,-2.6}\ pb$ [32.3 pb]
  - $\sigma_{e^-p}\,(Q^2 > 200\,GeV^2) = 54.7^{+15.9\,+2.8}_{-9.8\,-3.4}\ pb$ [65.8 pb]
- THE DIFFERENCES BETWEEN e^+p AND e^-p EXPECTED FROM THE V-A STRUCTURE OF THE WEAK COUPLING AND FROM THE QUARK CONTENT OF THE PROTON ARE CLEARY OBSERVED.
- NO SIGNIFICANT DESVIATION FROM THE SM PREDICTIONS IS FOUND.
- THE MEASURED $\frac{d\sigma}{dQ^2}$ FOR e^+p AND e^-p CC REACTIONS IS USED TO DETERMINE THE W MASS:

  $M_W = 79^{+8\,+4}_{-7\,-4}\ GeV$ IN GOOD AGREEMENT WITH DIRECT MEASUREMENTS PERFORMED AT $p\bar{p}$ COLLIDERS.