EPS99, July 1999
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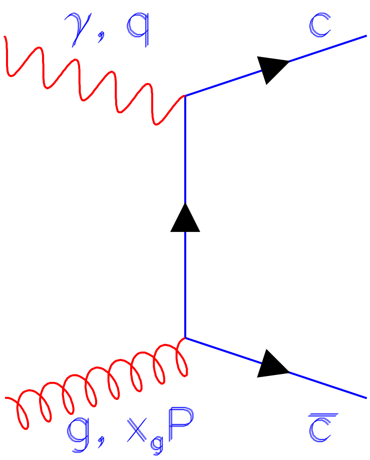
D^* Cross Sections in DIS and Extraction of F_2^c

OUTLINE

- Motivation.
- D^* cross sections.
- NLO QCD calculations.
- Comparison to NLO QCD. Fragmentation effects.
- F_2^c: extraction and discussion.
- Conclusions.

Motivation.

- Charm production in DIS dominated by Photon Gluon Fusion (PGF) mechanism *. This process is sensitive to the gluon in the proton.



- The presence of high scales (Q^2 and m_c) allows to perform perturbative QCD calculations.

- A comparison to those calculations is a test of QCD and of the universality of the proton pdf's .

- The aim of this analysis is to study charm production dynamics and the charm contribution to F_2 via D^* tagging.

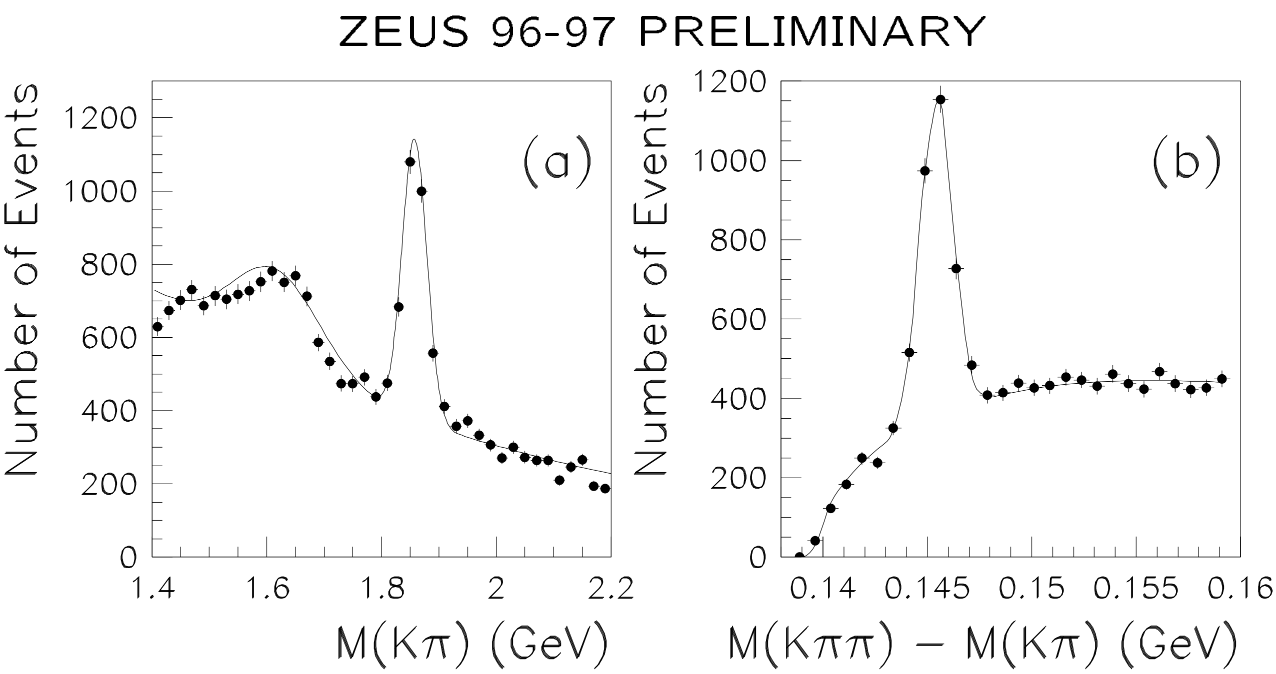
*H1 Collab. C. Adloff et al., Z. Phys. C72, 593 (1996). ZEUS Collab., J. Breitweg et al., Phys. Lett. B407, 402 (1997)

Cross Sections.

ZEUS 96+97 ($\sim$ $37 pb^{-1}$)

- Gain of $\sim$ factor 5 in the statistical error with respect to previous published ZEUS results.
- The measured region has been extended to lower and higher Q^2.

- $D^* \to \pi_s D^0$, $D^0 \to K\pi$



In the kinematical region:

$0.02 < y < 0.7$; $1\ GeV^2 < Q^2 < 600\ GeV^2$

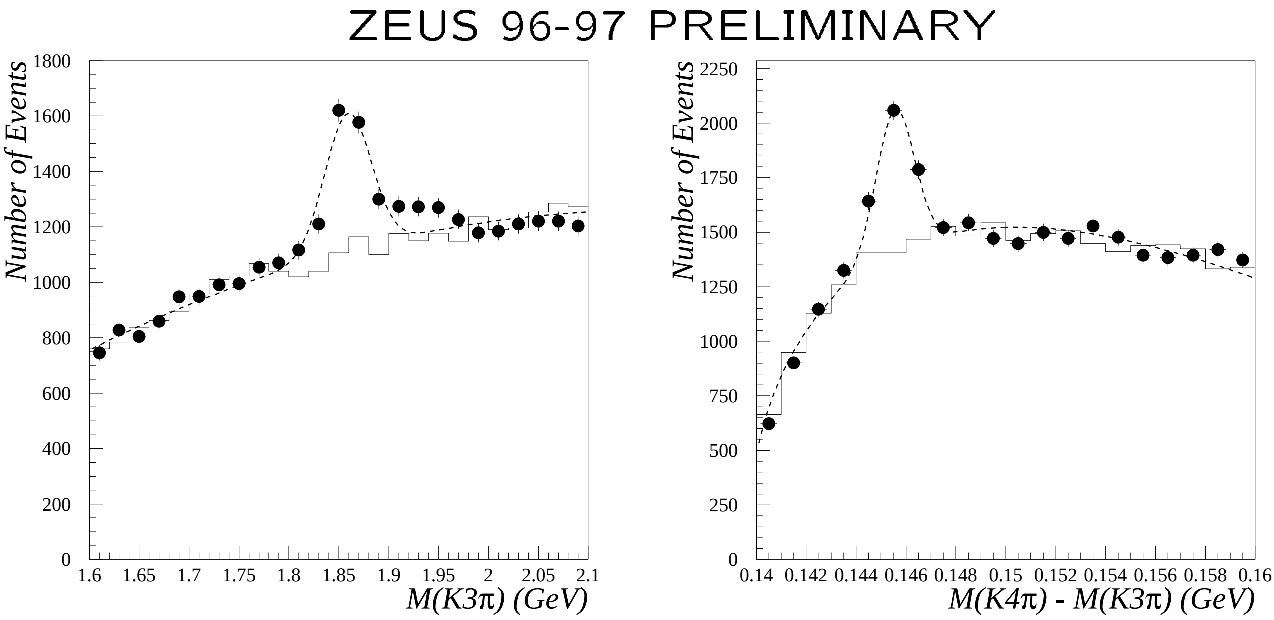
$1.5\ GeV < p_T(D^*) < 15\ GeV$; $|\eta(D^*)| < 1.5$

$\sigma(e^+p \to e^+D^{*\pm}X) = 8.31 \pm 0.31(stat)^{+0.30}_{-0.50}(sys)\ nb$

• $D^* \to \pi_s D^0$

$\quad\quad\quad\quad \lfloor\!\!\to K3\pi$

BR(K3π) ∼ 2 BR(Kπ)



$$0.02 < y < 0.7 \;;\; 1\ GeV^2 < Q^2 < 600\ GeV^2$$

$$2.5\ GeV < p_T(D^*) < 15\ GeV \;;\; |\eta(D^*)| < 1.5$$

$$\sigma(e^+p \to e^+D^{*\pm}X) = 3.65 \pm 0.36(stat)^{+0.20}_{-0.41}(sys)\ nb$$

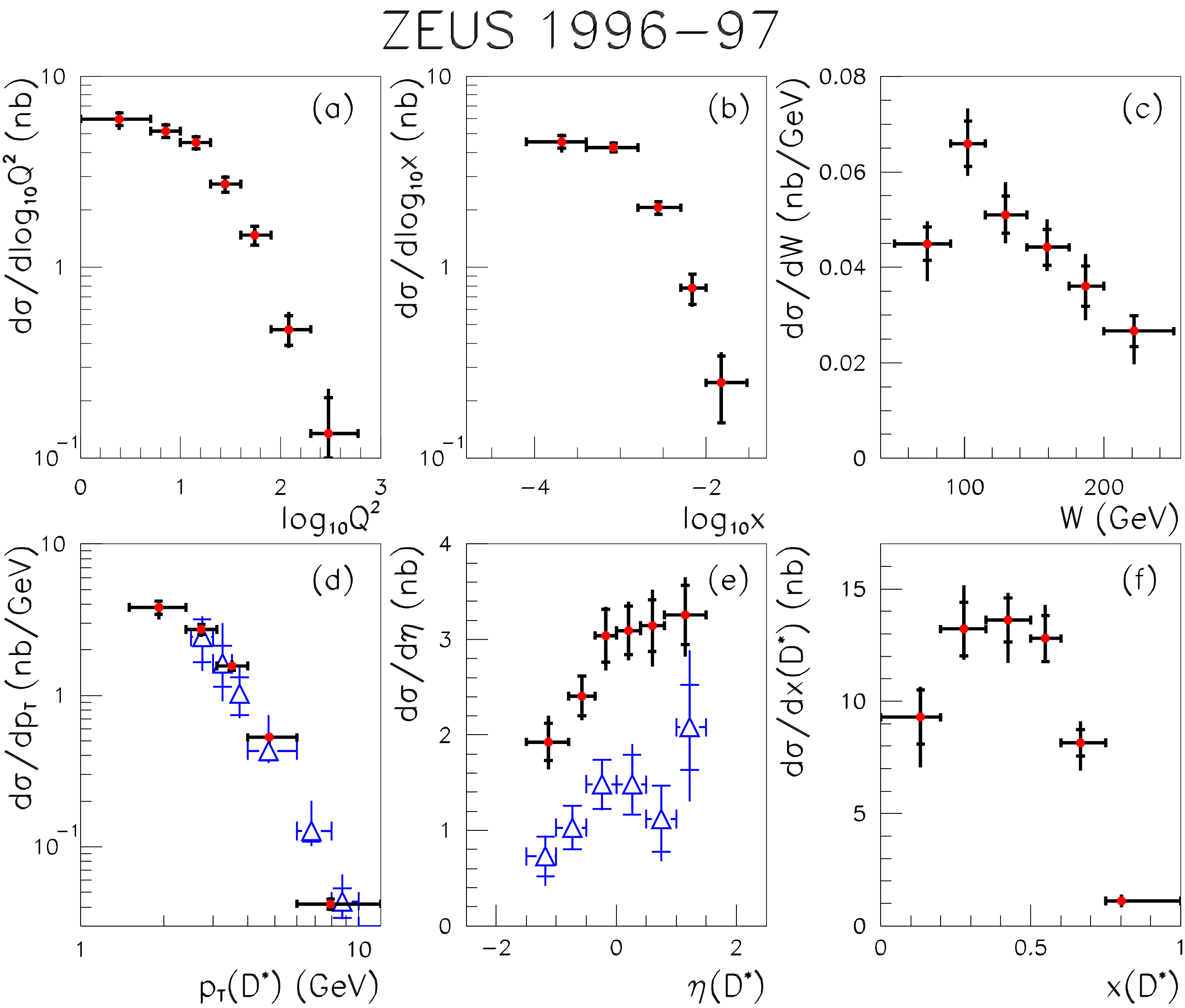
• **Extrapolate to** $1.5\ GeV < p_T(D^*)$ **region** →

$$\sigma(e^+p \to e^+D^{*\pm}X) = 7.50 \pm 0.74(stat)^{+0.40}_{-0.80}(sys) nb$$

$$\sigma(e^+p \to e^+D^{*\pm}X)_{k\pi} = 8.31 \pm 0.31(stat)^{+0.30}_{-0.50}(sys)\ nb$$

Differential Cross Sections

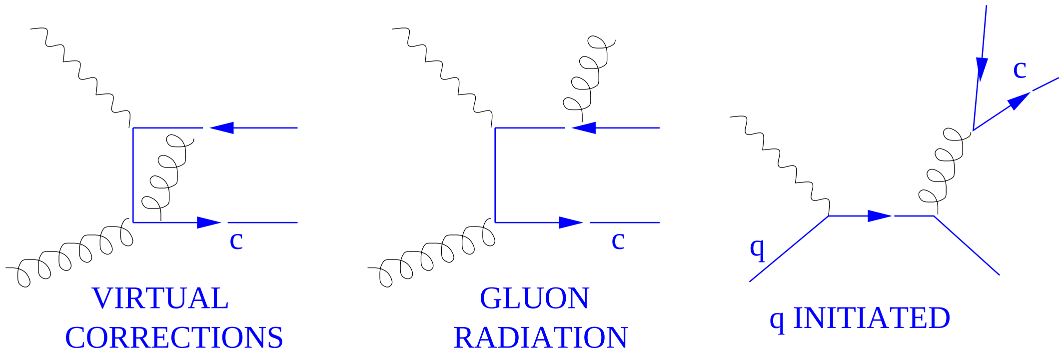
$$log_{10}(Q^2), log_{10}(x), W$$
$$p_T,\ \eta = -log(tan(\Theta/2)),\ x(D^*) = 2 \mid p^* \mid /W$$



$$0.02 < y < 0.7\ ;\ 1\ GeV^2 < Q^2 < 600\ GeV^2$$
$$1.5(2.5)\ GeV < p_T(D^*) < 15\ GeV; \mid \eta(D^*) \mid < 1.5$$

- Results from the two decays in agreement.
- Cross section decreases strongly with Q2, x and p_T, increases with η and peaks at low W and low-medium $x(D^*)$.

NLO QCD calculations.



- HVQDIS[†]: hypothesis

- Three Flavour Number Scheme (TFNS)→ charm is produced from u,d,s,g; no c is present in the proton.

- Peterson fragmentation function → Phenomenological approach, simple (only one parameter), and successful at e^+e^-.

It does not take into account the interaction with the rest of the colour charges in the event during the fragmentation (remnant).

- pdf used: ZEUS-NLO (fitted to Zeus94 F_2 data)

[†]B.W. Harris and J. Smith, Phys. Rev. D57, 2806 (1998)

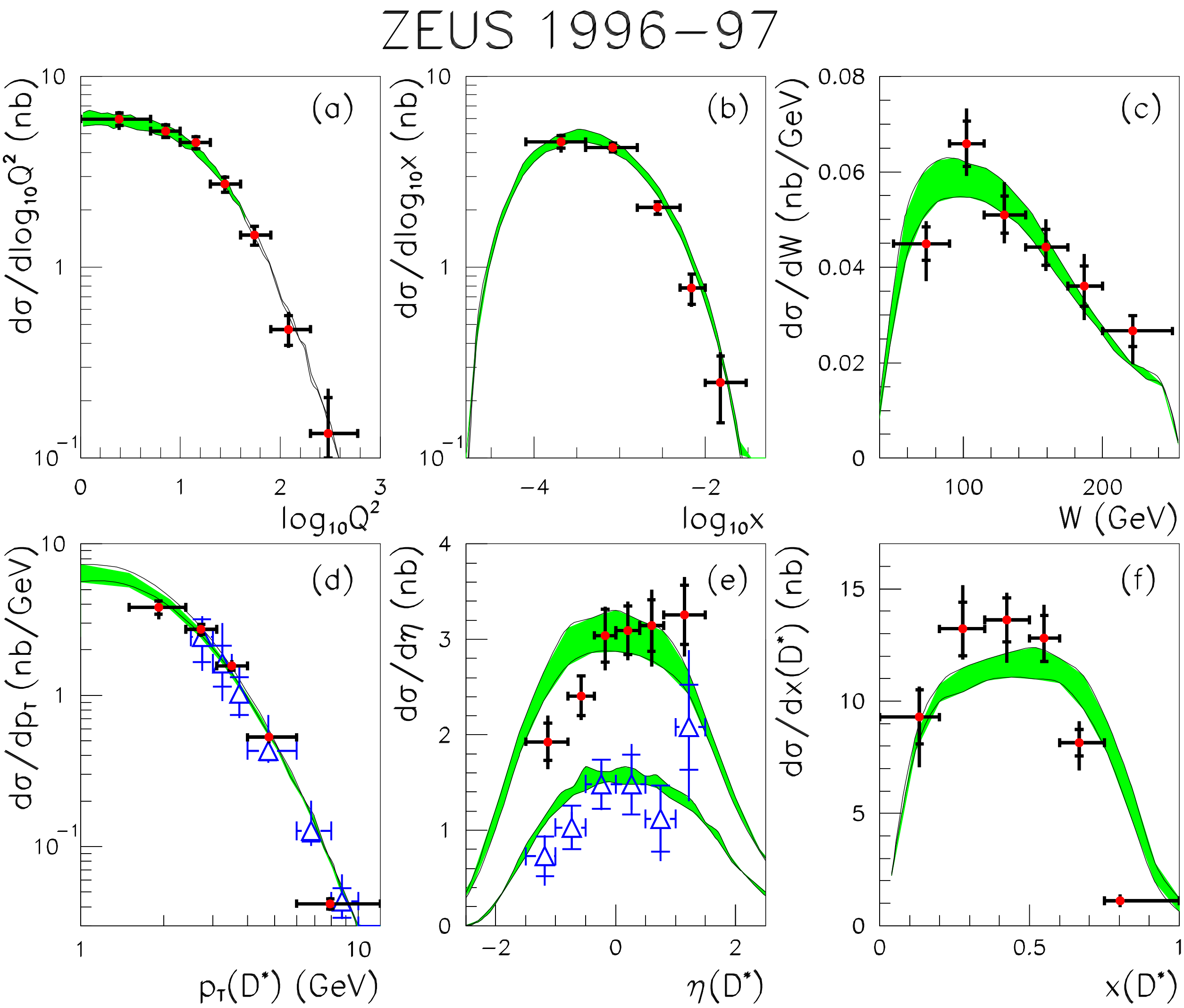
Comparison to NLO QCD.

$$\sigma(e^+p \to e^+D^{*\pm}X)_{k\pi} = 8.31\pm0.31(stat)^{+0.30}_{-0.50}(sys)\ nb$$

HVQDIS $\to 8.44 \pm 0.55(m_c \pm 0.1)\ nb$

$$\sigma(e^+p \to e^+D^{*\pm}X)_{k3\pi} = 3.65\pm0.36(stat)^{+0.20}_{-0.41}(sys)\ nb$$

HVQDIS $\to 4.12 \pm 0.20(m_c \pm 0.1)\ nb$



NLO (TFNS) Band:

$\epsilon = 0.035, pdf = ZEUS94, mc = 1.3 - 1.5\ GeV$

$\to$ Agreement in Q^2, x, W, $p_T(D^*)$ and σ_{KIN}

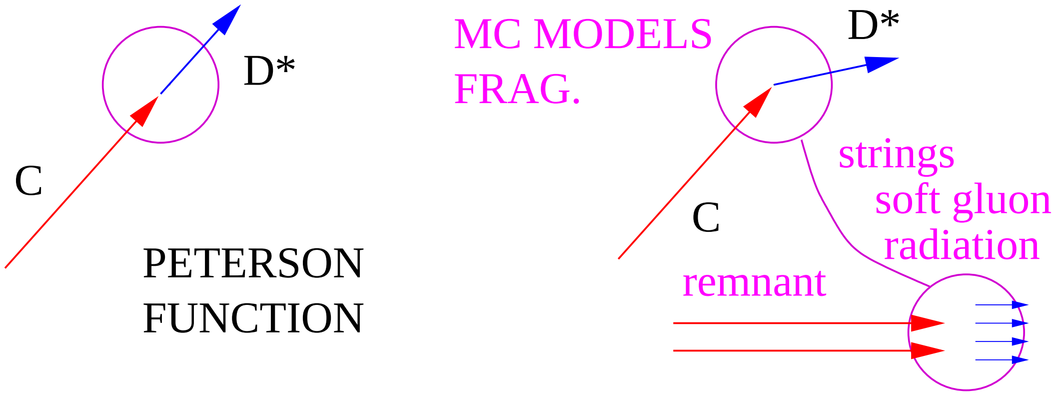
$\to$ $p_T(D^*)$ too low in first bin.

$\to$ η shifted towards the proton remnant.

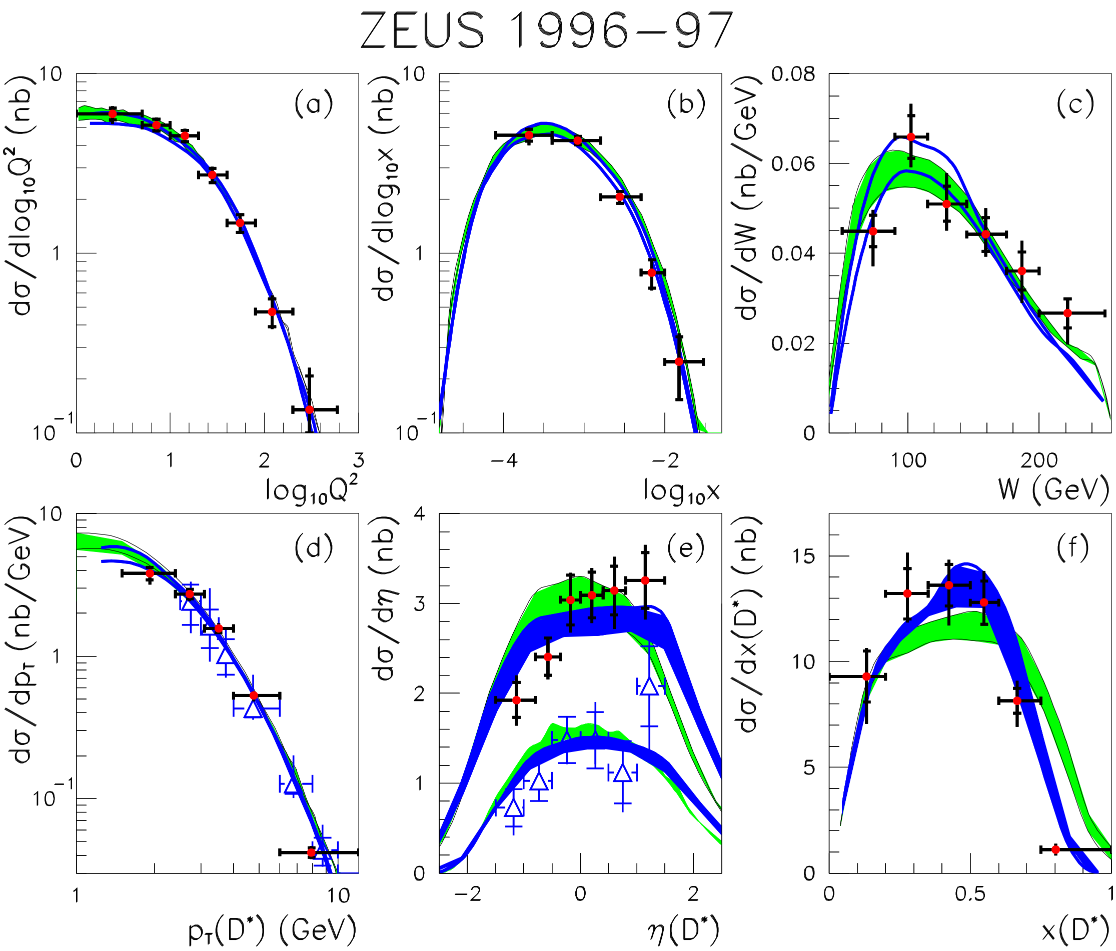
$\to$ $x(D^*)$ shifted towards lower values.

Fragmentation Effects.

- In MC models (HERWIG, JETSET), a shift towards the forward direction is produced during the fragmentation (Beam drag).



$\Rightarrow$ Reweight RAPGAP (JETSET) MC to follow NLO $p_t(c), \eta(c)$ distribution.



- Better description of the data.

Extraction of F_2^c

$$\frac{d^2\sigma^{c\bar{c}}(x,Q^2)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\{[1+(1-y)^2]F_2^c(x,Q^2) - y^2F_L^c\}$$

- Extrapolate outside the kinematical region (KIN) in p_{T}, η :

$$F_2^{cM}(Q^2,y) = \sigma^M_{KIN}(Q^2,y) \times \frac{F_2^{cNLO}(Q^2,y)}{\sigma^{NLO+MC}_{KIN}(Q^2,y)}$$

- Assumptions:

$\rightarrow$ TFNS,
$\rightarrow$ $\frac{\sigma_{KIN}}{\sigma}$ is well described,
$\rightarrow$ neglect $F_L^c (< 1\%)$,
$\rightarrow$ neglect bound charm (2.5-4.5 %),
$\rightarrow$ $BR(c \rightarrow D^*)$ from e^+e^- is valid at HERA.

- How is the extrapolation affected by the fragmentation?

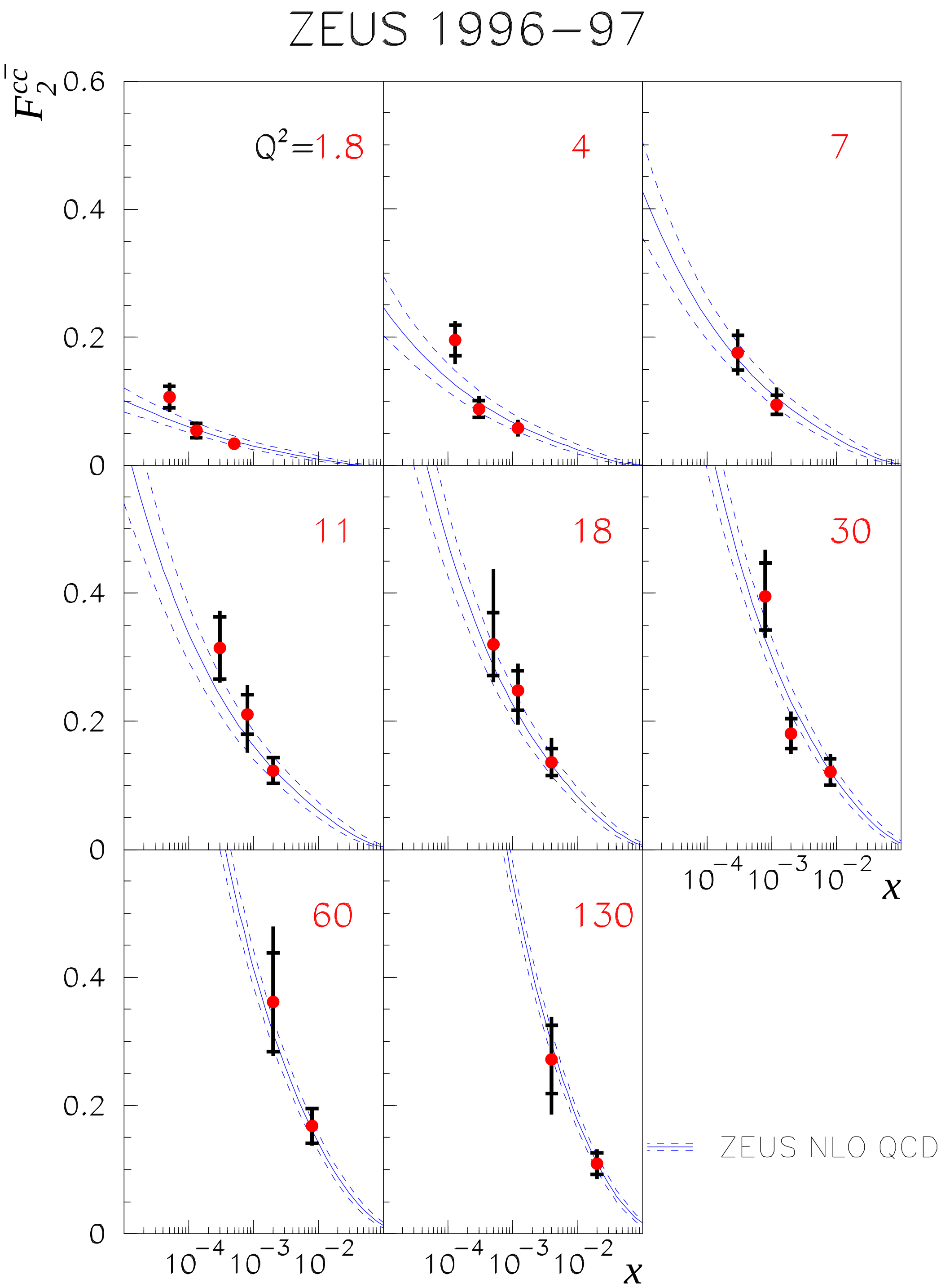
$$\sigma^{NLO+MC}_{KIN} \leftrightarrow \sigma^{NLO+Pet}_{KIN}$$

Small effect $\Rightarrow \sim 1/2$ stat error, typically

- Combine F_2^c from both decays.

F_2^c vs. x in Q^2 bins.

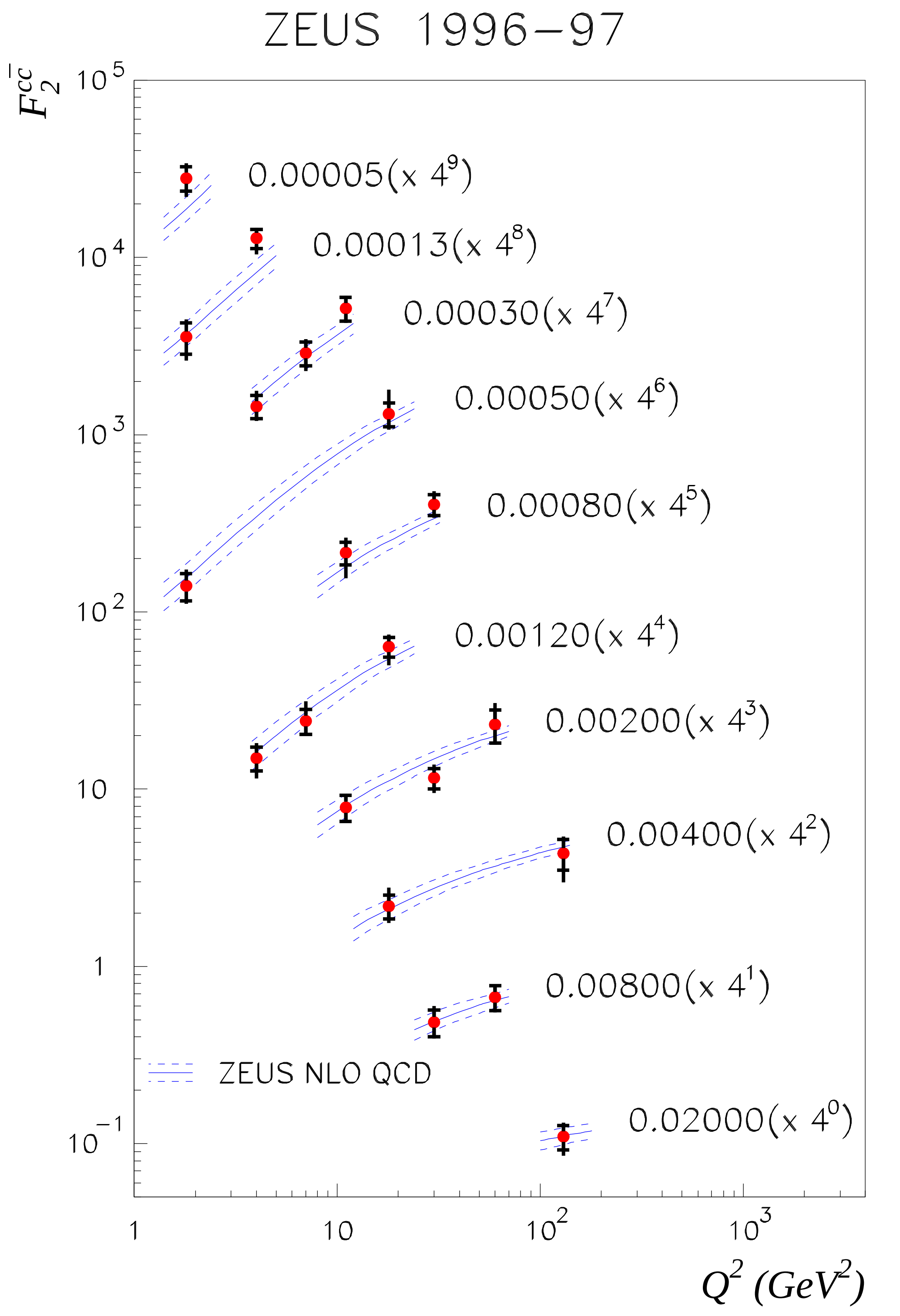
$$F_2^{c\mathrm{M}}(Q^2, \mathrm{y}) = \sigma_{\mathrm{KIN}}^{\mathrm{M}}(Q^2, \mathrm{y}) \times \frac{F_2^{c\mathrm{NLO}}(Q^2, \mathrm{y})}{\sigma_{\mathrm{KIN}}^{\mathrm{NLO+MC}}(Q^2, \mathrm{y})}$$



≡≡ NLO QCD (ZEUS94 NLO pdf)

- F_2^c exhibits a steep rise as we go to lower x. → gluon distribution.

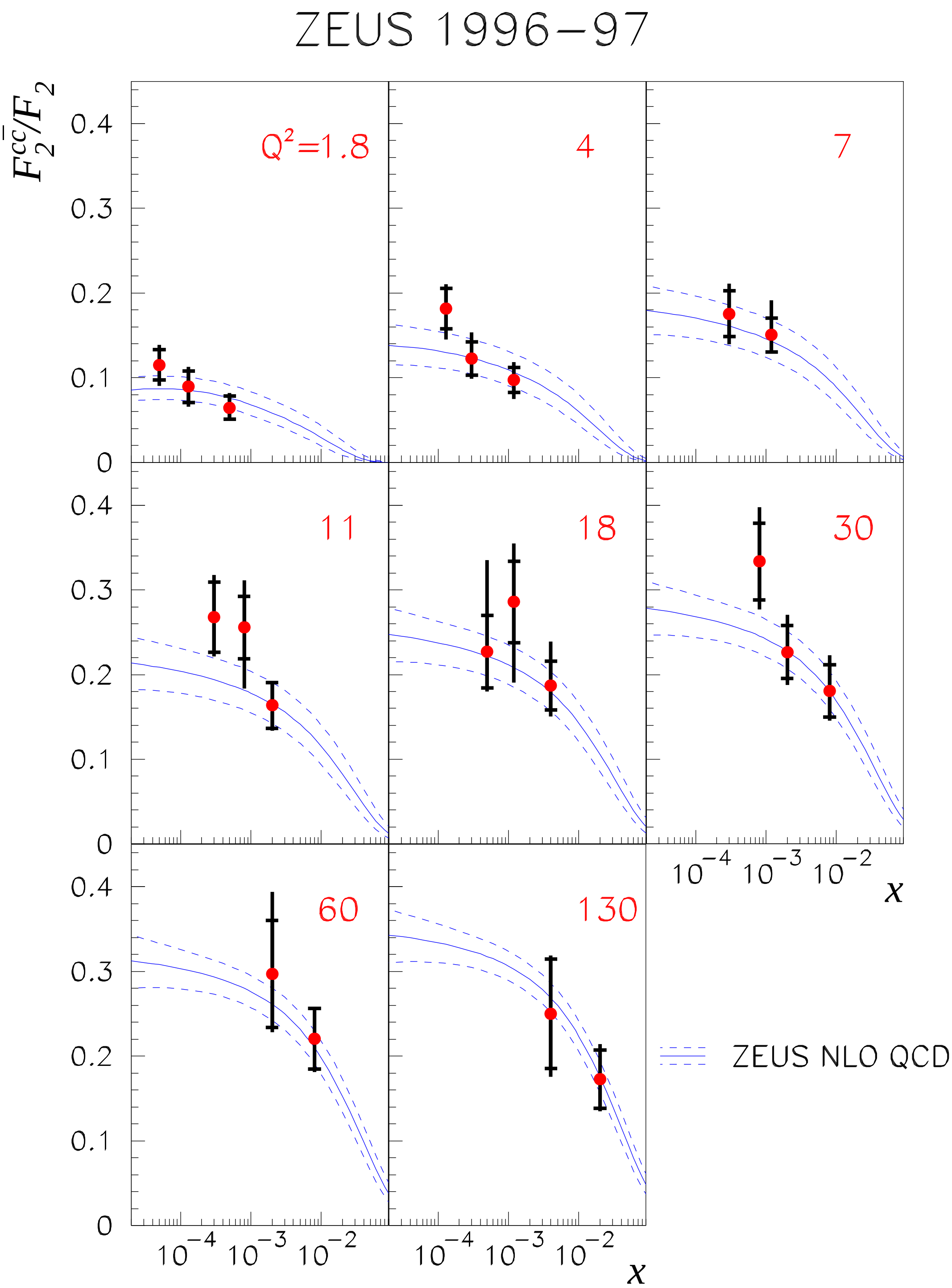
F_2^c vs. Q^2 in x bins.



≡≡ NLO QCD (ZEUS94 NLO pdf)

- **The dependence of F_2^c with Q^2 shows large scaling violations.**

$\frac{F_2^c}{F_2}$ vs. x in Q^2 bins.



- F_2^c rises more rapidly than F_2.

$\rightarrow$ F_2^c dominated by the gluon contribution while F_2 has also quarks.

- F_2^c is $\sim 25\%$ F_2 at low x and high Q^2.

Conclusions.

• Precise measurements of DIS D^* cross sections have been presented.

• Overall good description of the data by NLO QCD(TFNS).

$\Rightarrow$ Positive test of QCD and of the universality of the pdf's.

• The small disagreement found in $\eta(D^*)$ and $x(D^*)$ with NLO QCD (TFNS) is of fragmentation origin and shows that the Peterson fragmentation function is not fully appropriate at HERA.

• F_2^c has been extracted:

$\rightarrow$ It rises as we go to low x.
$\rightarrow$ It shows large scaling violations.
$\rightarrow$ It rises more rapidly than F_2 and reaches $\sim 25\%$ of F_2 at low x and high Q^2.