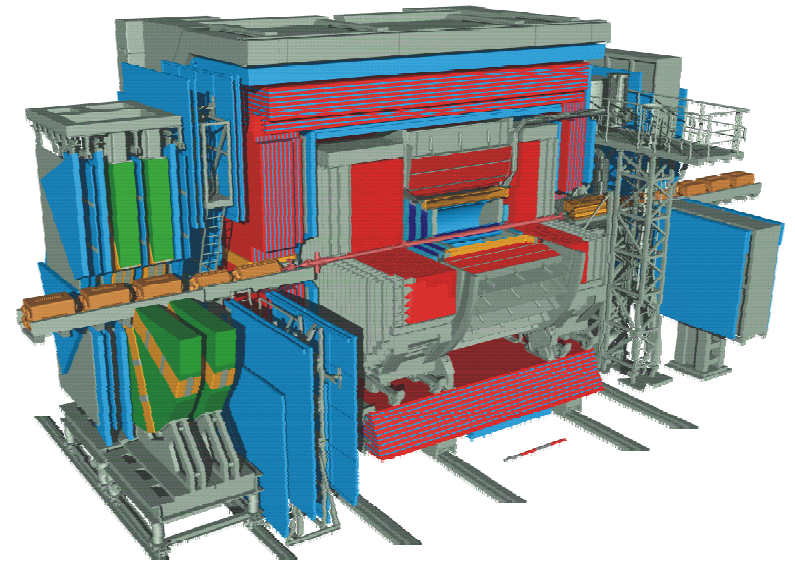




Measurement of the Neutral Current DIS Cross Section at ZEUS

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On behalf of ZEUS Collaboration

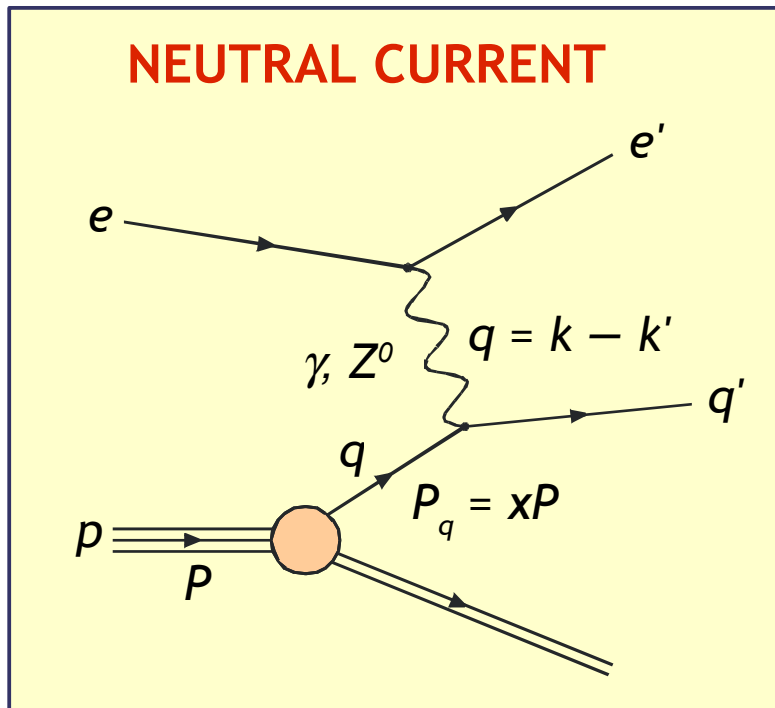
HEP 2007 Manchester, England, July 19-25 2007



Deep-Inelastic Scattering (DIS)

→ the key tool to study the structure of the proton

Kinematics of the Neutral current (NC) DIS



- s – CM energy of the lp system $s = (p + k)^2$
- Q^2 – virtuality of the intermediate boson
– measure of the probing power $Q^2 = -q^2 = -(k - k')^2$
- x – Bjorken scaling variable
– fraction of proton's momentum carried by struck parton $x = \frac{Q^2}{2P \cdot q}$
- y – inelasticity of the interaction $y = \frac{q \cdot P}{k \cdot P}$
- x, y, Q^2 are related by $Q^2 = x y s$



Neutral current cross section

Experiment measures cross-section → **Structure Functions (SF)**

$$\frac{d^2 \sigma^\pm}{d x d Q^2}(x, Q^2) = \frac{2 \pi \alpha^2}{x Q^4} Y_+ \left[F_2(x, Q^2) - \frac{y^2}{Y_+} F_L(x, Q^2) \right]$$

(for EM process)

$$Y_+ = 1 + (1 - y)^2$$

$\tilde{\sigma}$ – reduced cross section

F_2 – dominant contribution to cross section

$$F_2 = \sum_q e_q^2 x (q + \bar{q})$$

F_L – longitudinal SF, only important at high y

– $F_L = 0$ in Quark-Parton Model

– non-zero in NLO pQCD:

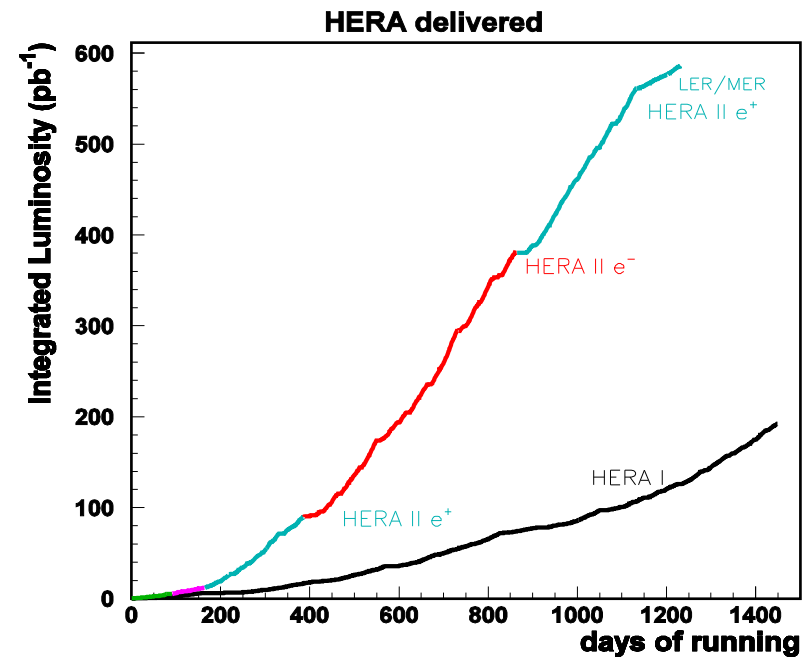
$$F_L = \frac{\alpha_s}{4 \pi} x^2 \int_x^1 \frac{d z}{z^3} \left[\frac{16}{3} F_2 + 8 \sum e_q^2 \left(1 - \frac{x}{z} \right) \text{zg} \right]$$

Direct sensitivity to gluon

↘ High y (low x) region is of particular importance

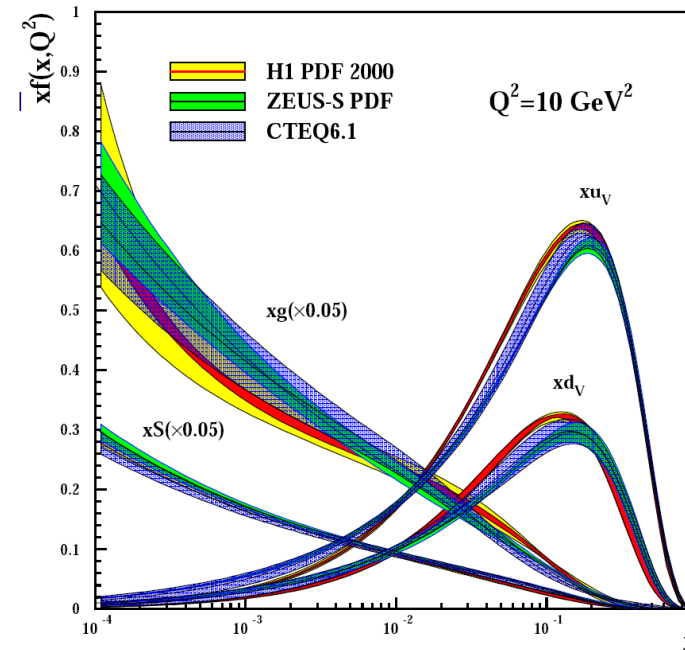
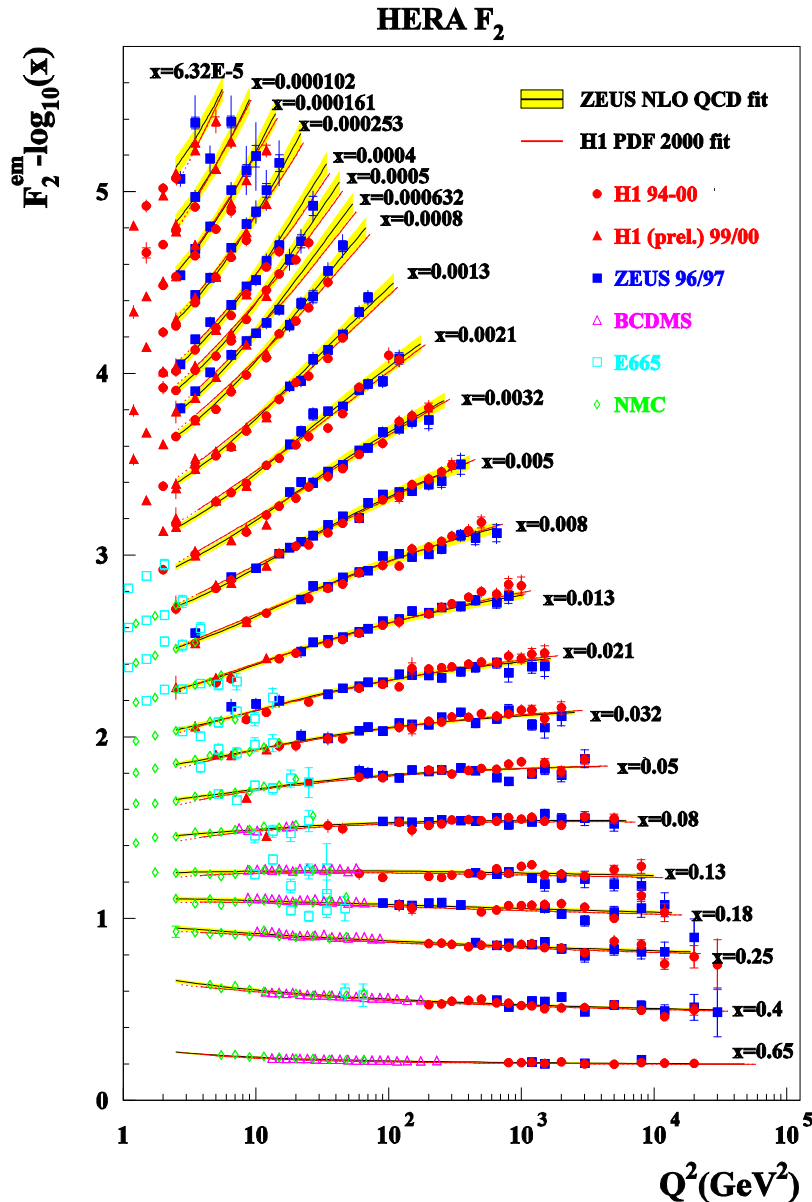


HERA – an **electron-proton collider** at DESY, Hamburg

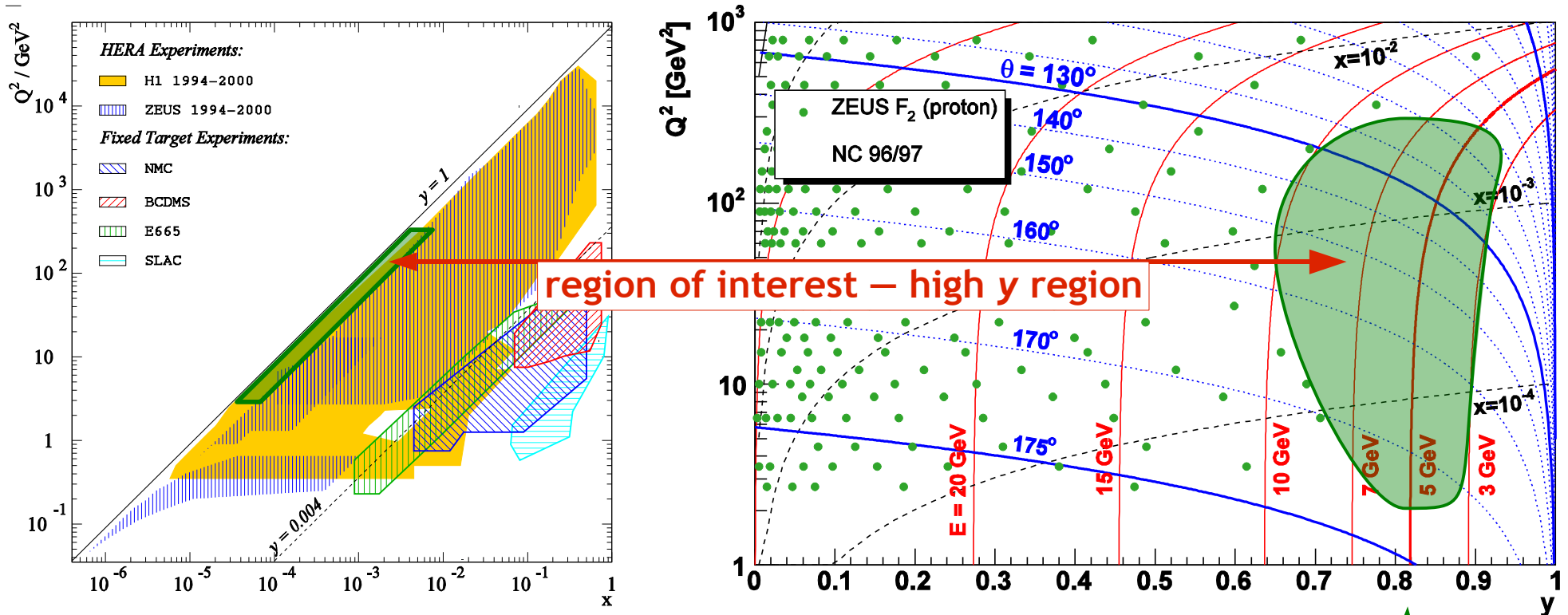


- in operation since 1992
- four different CM energies
- **HERA running ended June 30, 2007**
- total delivered lumi is 780 pb^{-1}

Total ZEUS integrated luminosity			
E_e [GeV]	E_p [GeV]	\sqrt{s} [GeV]	\mathcal{L} [pb^{-1}]
27.5	820	300	48
	920	318	456
	460	225	14
	575	252	7



- ➔ NLO perturbative QCD describes F_2 in wide range of kinematic space
- ➔ still, **differences exist in extracted PDFs**
- ➔ largest uncertainties on low x gluon
- ➔ can be improved by input from NC cross section measurement at high y and F_L measurement



High y region has not been measured by ZEUS

→ region where F_L and the gluon density are important

→ high y means low energy of the scattered electron

$$y = 1 - \frac{E'_e}{2E_e} (1 - \cos\theta_e)$$



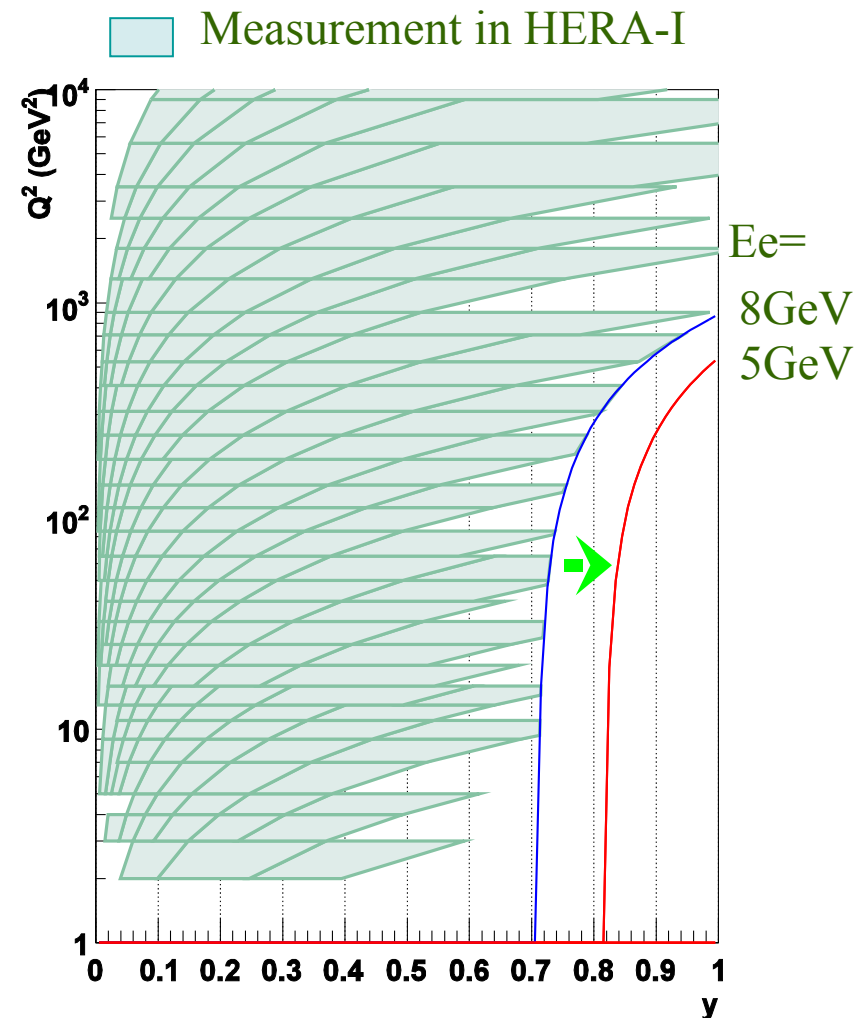
New NC cross section measurement @ ZEUS

Extension of previous ZEUS measurement to high y

- reliable reconstruction of scattered electron down to **5 GeV** (was 8 GeV in previous measurement)
- two special triggers were developed
 - recording of events with low E_e

Two main issues in the measurement:

- electron finding at low energies
- background rejection



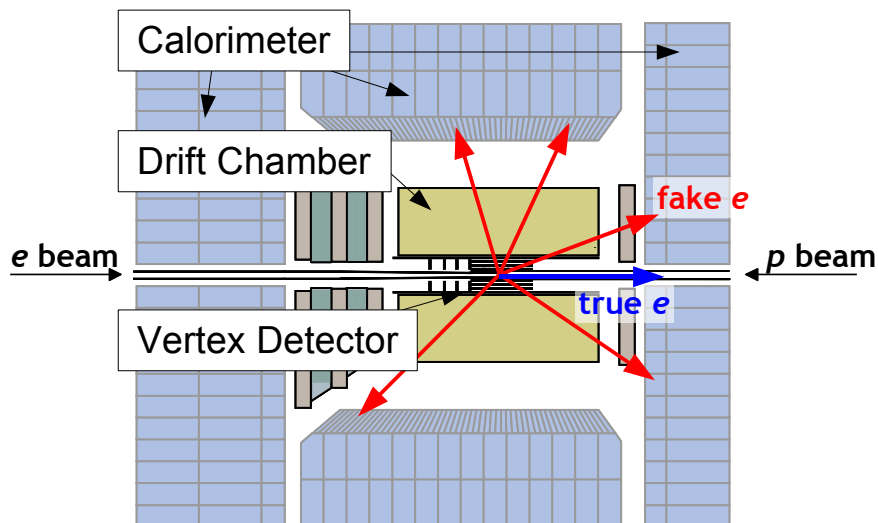


Photoproduction background

- largest contribution to background \Leftarrow large cross section at low Q^2

γp event:

- electron irradiates almost a real photon which then interacts with the proton
- electron with lower energy goes down the beam pipe
- one of the particles in the detector is misidentified as DIS electron
- problematic region: low Q^2 events with electron candidate close to the beam pipe
 - due to limited backward coverage of ZEUS tracking system



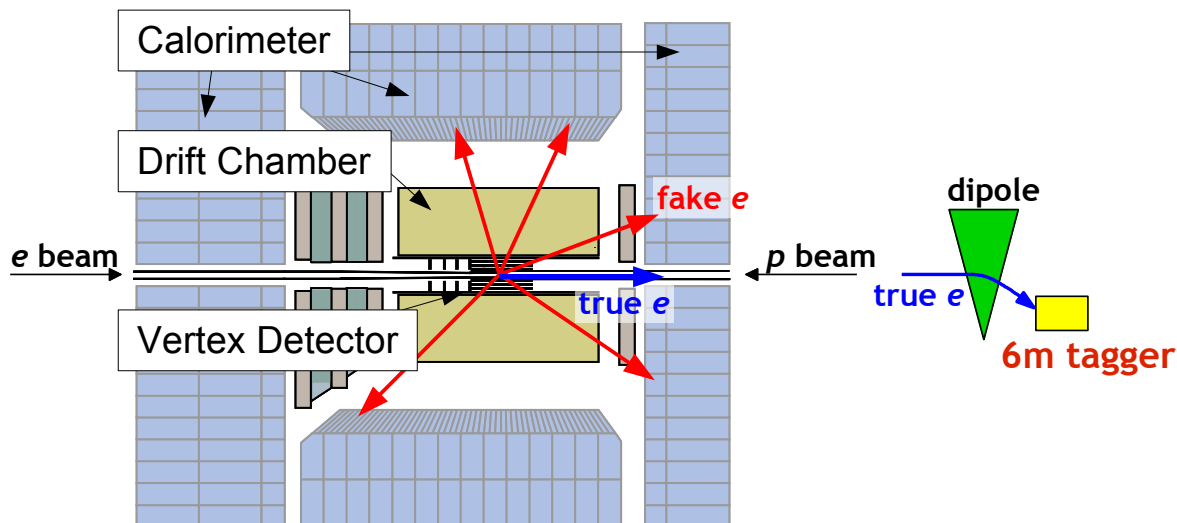


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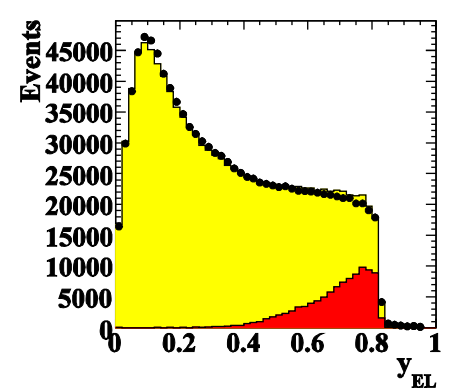
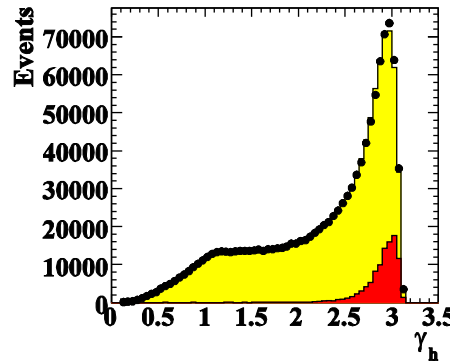
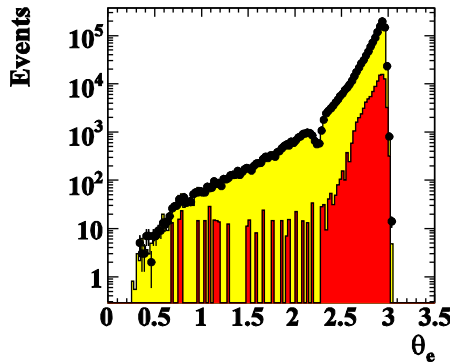
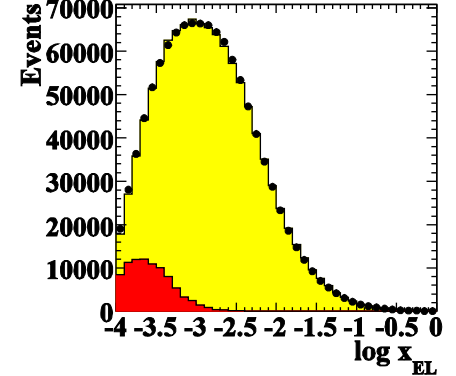
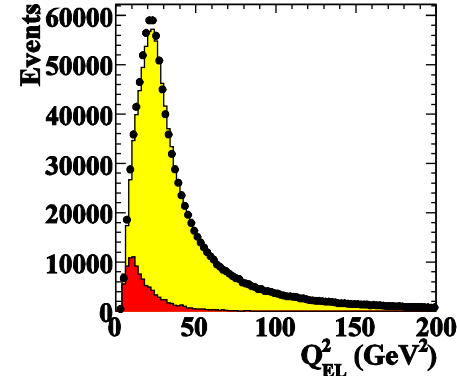
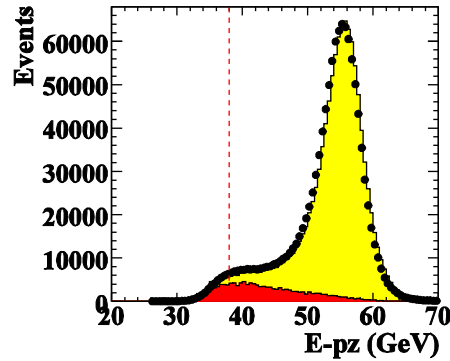
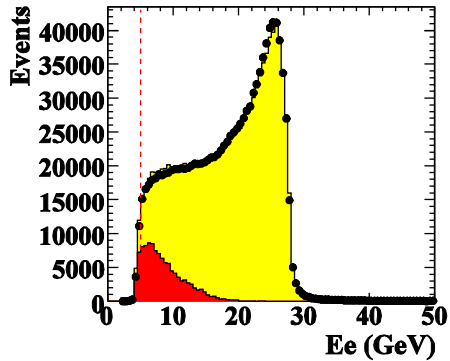
6m tagger:

- downstream of the electron beam
- detection of low energy electrons in the beam pipe
- allows for direct tagging of γp events

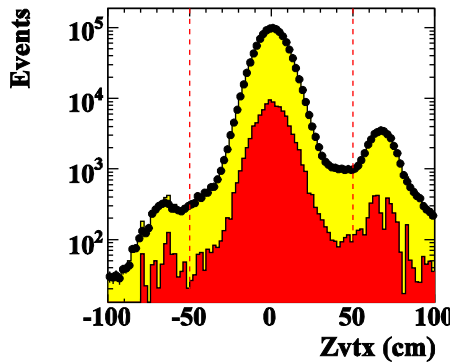


Control distributions

ZEUS



- ZEUS (prel.)
- 06e⁺p (29pb⁻¹)
- MC DIS+γp
- MC γp



- ZEUS (prel.)
- 06e⁺p (29pb⁻¹)
- MC DIS+γp
- MC γp

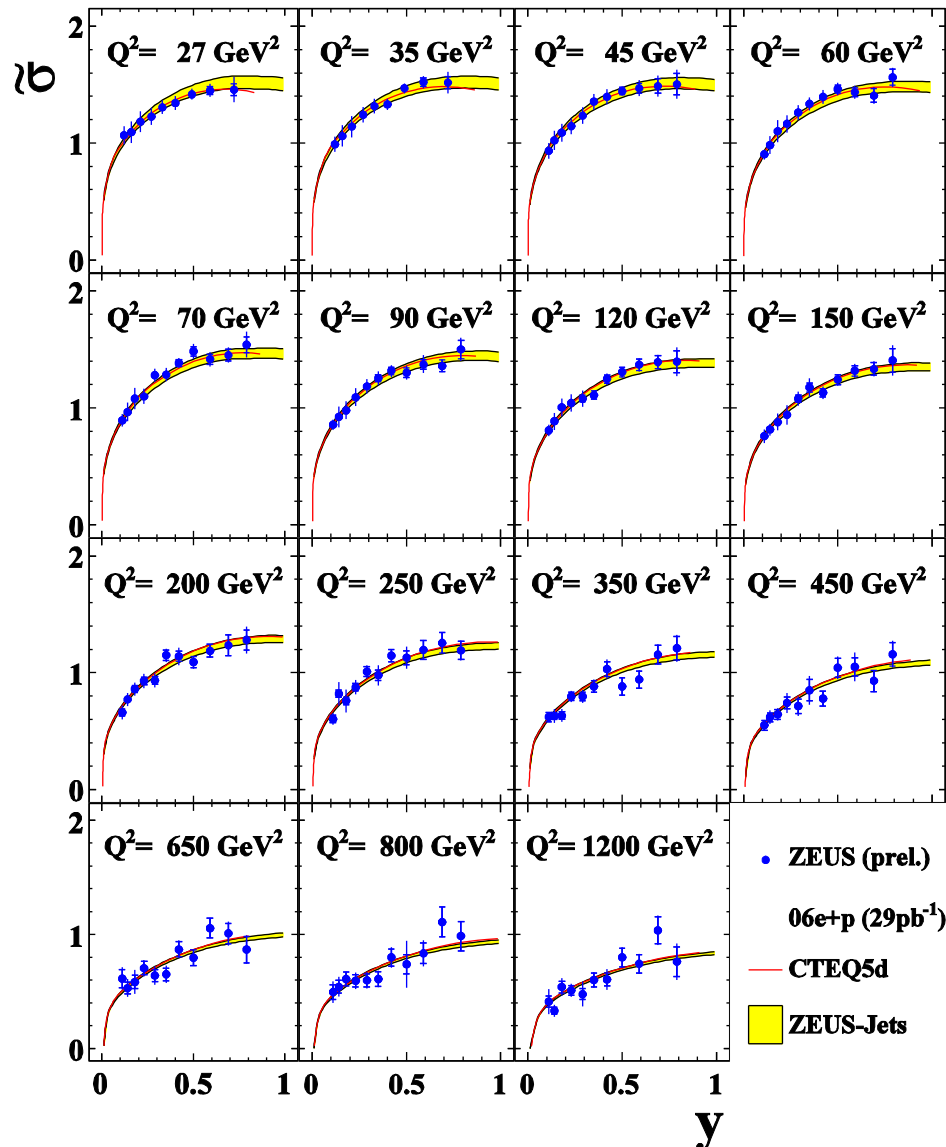
→ measurement was performed on 29 pb⁻¹ taken in 2006

→ good description of the data by the MC



Reduced cross sections

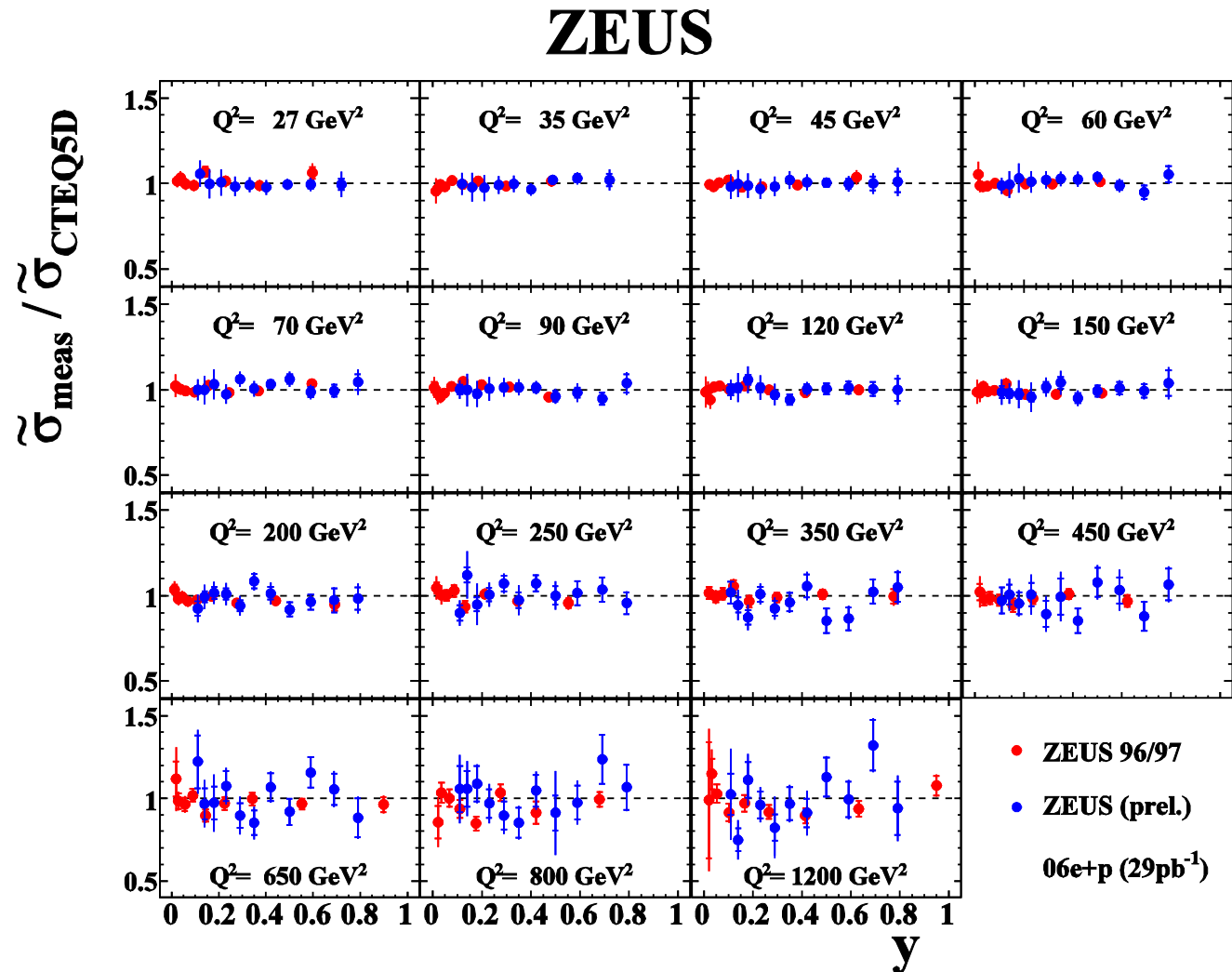
ZEUS



- cross section measurement was performed in kinematic range
 - $0.1 < y < 0.8$
 - $25 \text{ GeV}^2 < Q^2 < 1300 \text{ GeV}^2$
- cross sections well described by SM predictions with
 - CTEQ5d
 - ZEUS-JETS
- at high Q^2 – limitations by statistics



Comparison with previous measurement



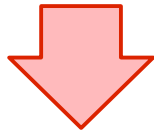
NC cross section measurement by ZEUS is extended to high y (especially at low Q^2)



Low energy running and F_L

For direct F_L measurement, the NC cross section has to be measured at two or more different beam energies (different y)

$$\tilde{\sigma} = F_2 - \frac{y^2}{Y_+} F_L$$

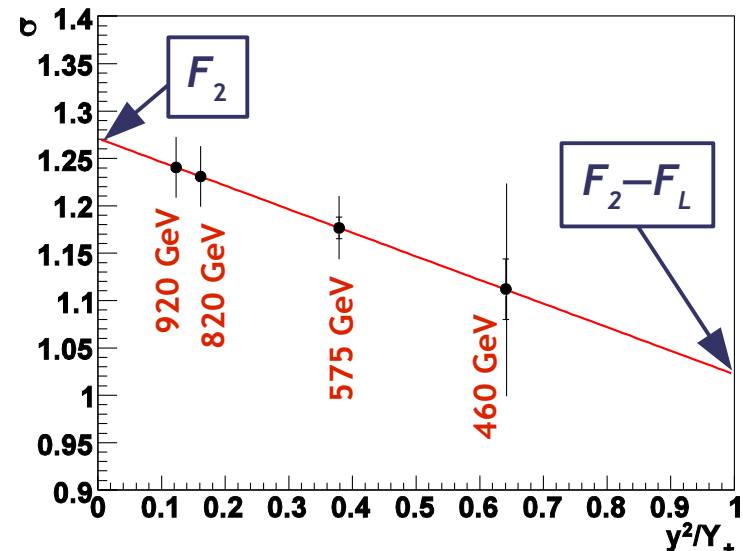


In the last three months of operation HERA was running at two lowered proton beam energies:

- $E_p = 460$ GeV ... 14 pb⁻¹
- $E_p = 575$ GeV ... 7 pb⁻¹

4 point F_L measurement is now possible:

920 GeV + 820 GeV + 575 GeV + 460 GeV

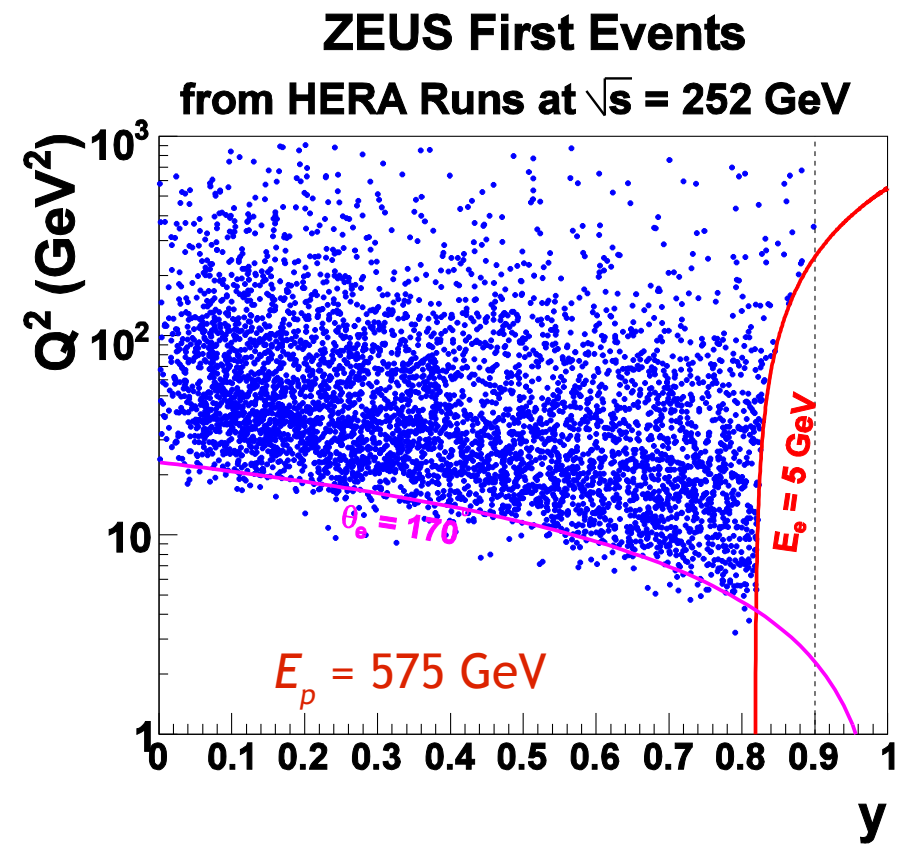
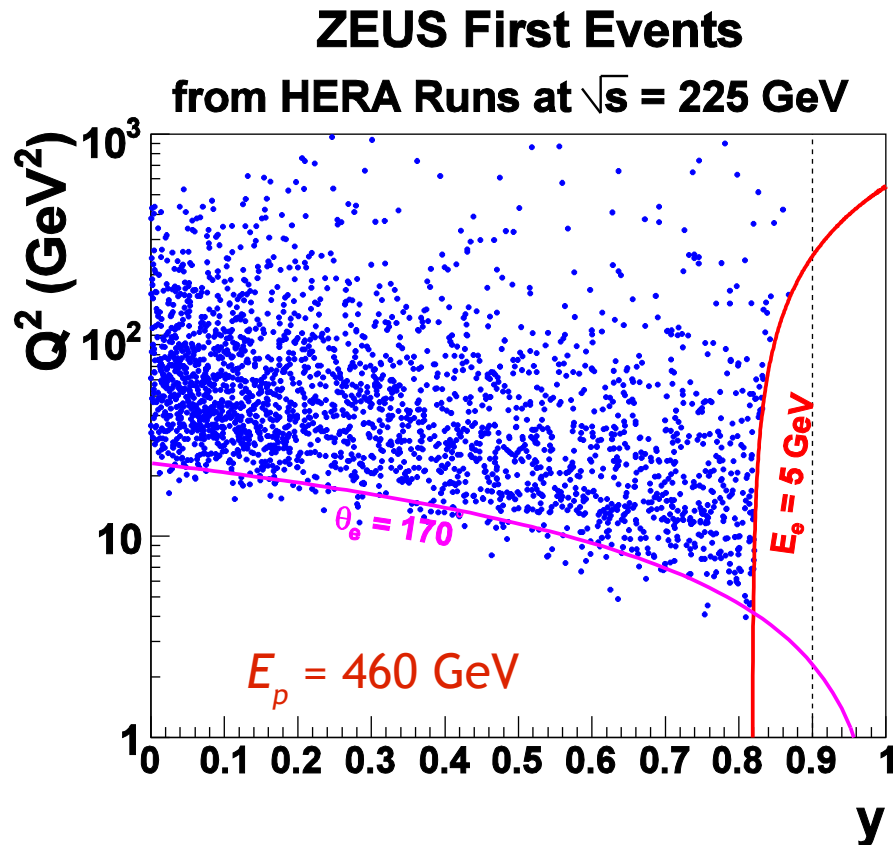




Quick look at LER data

Analysis of the data from runs with lowered proton beam energy has started

→ we were able to take good data in the region of kinematic space where the F_L measurement will be performed





- **ZEUS has performed new measurement of NC cross section at high y**
 - new techniques were developed that allow for measurement of scattered electron with low energy
 - 6m tagger allows to control the γp background
 - measured cross sections are in good agreement with the SM predictions
- **ZEUS now started to work on the F_L measurement**
 - before shutdown HERA has provided all the requested luminosity at $E_p = 460 \text{ GeV}$ and 575 GeV
 - 4 point F_L measurement is possible
- even though HERA is no longer running, there is still an exciting time ahead of us and lot of data to be analysed
 - measurement of F_L will significantly add to the legacy of HERA

Thanks to HERA for the exciting time!



BACKUP SLIDES

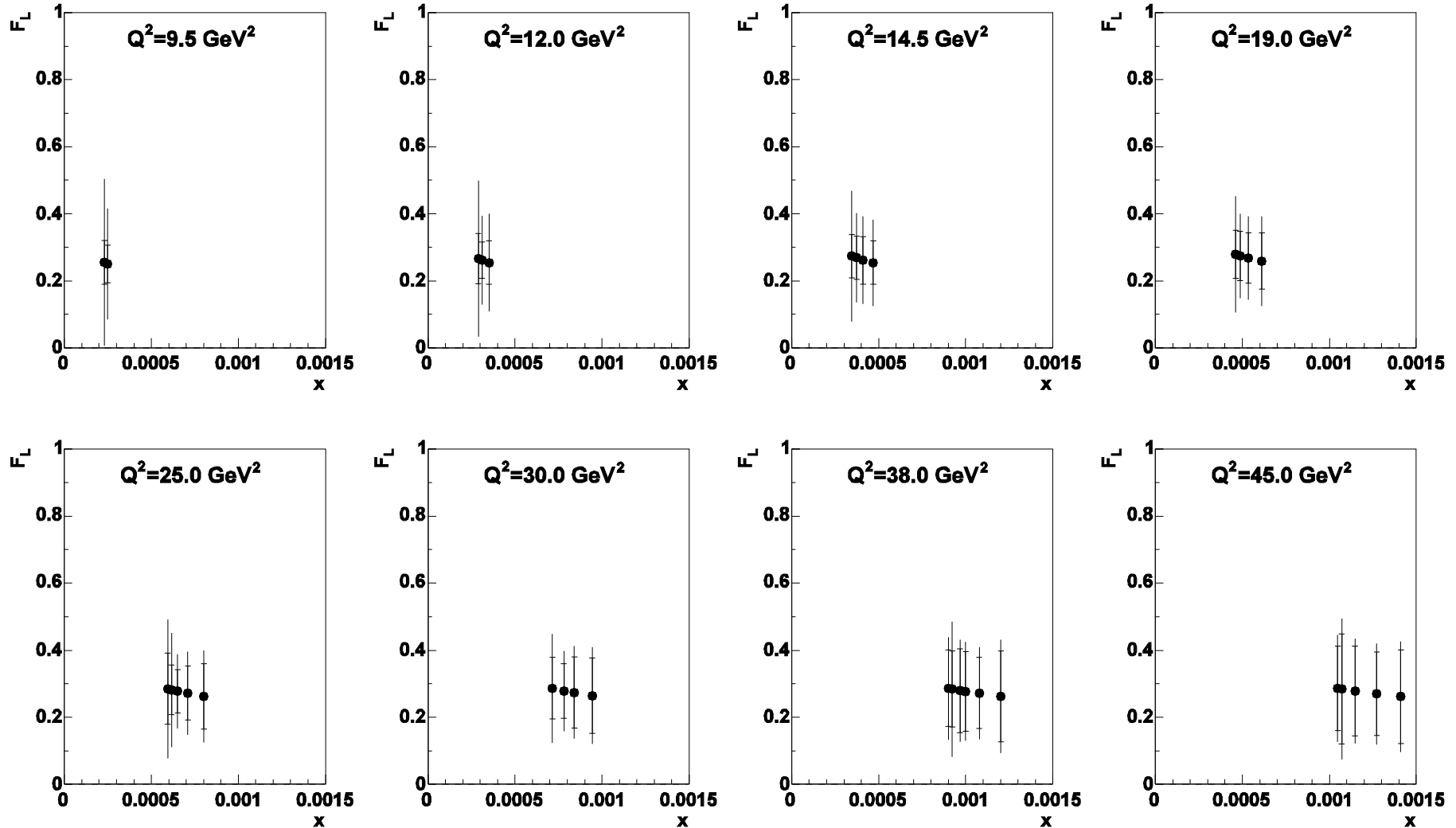


ZEUS F_L feasibility study

presented at DIS 2006 Tsukuba, Japan

Low Q^2 : small stat., big syst.

Note: F_L values set to $0.2 F_2$



Largest systematics from:
PhP background normalization and EF inefficiency

High Q^2 : big stat., small syst.