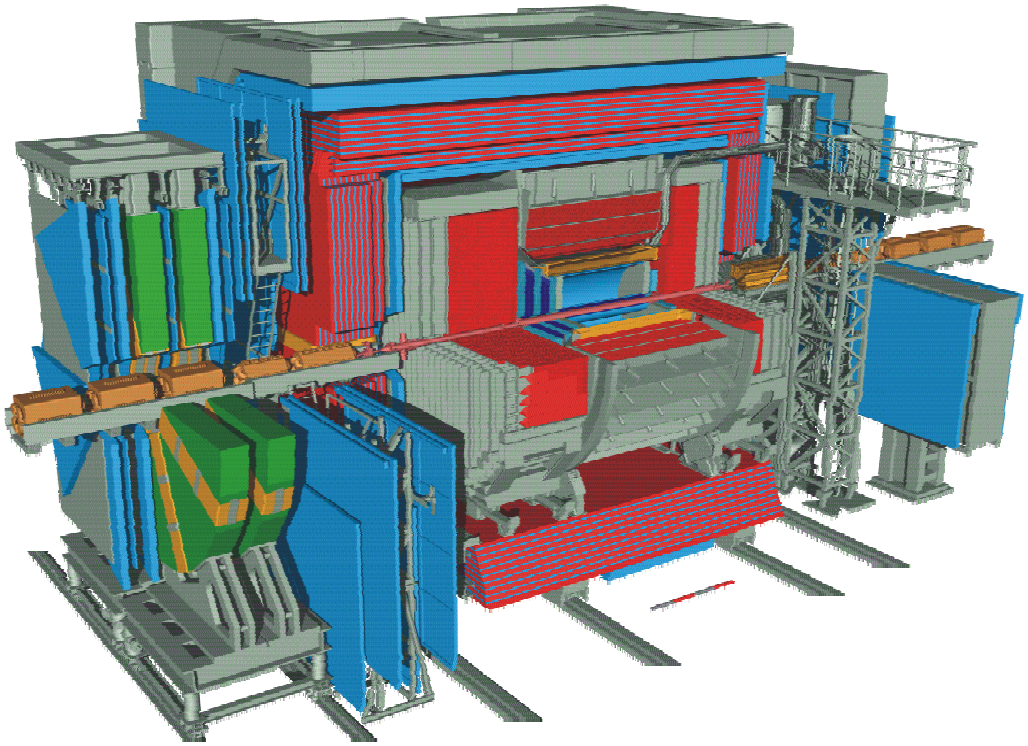
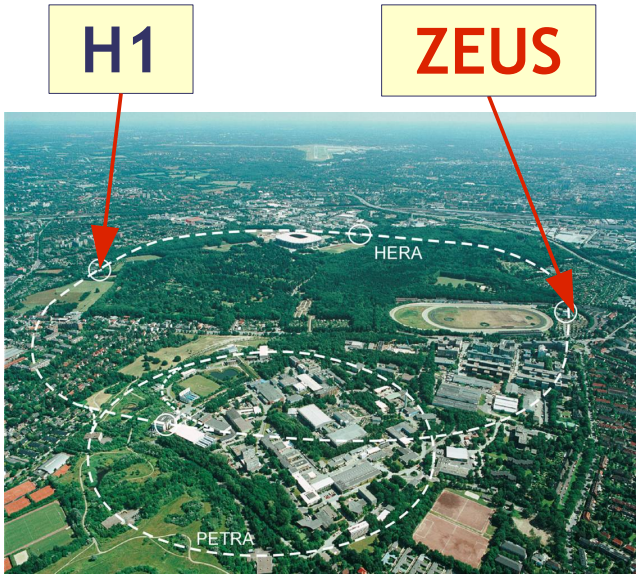
ZEUS Status Report

Daniel Kollár



MPI Project Review 2006

December 18 – 19, 2006

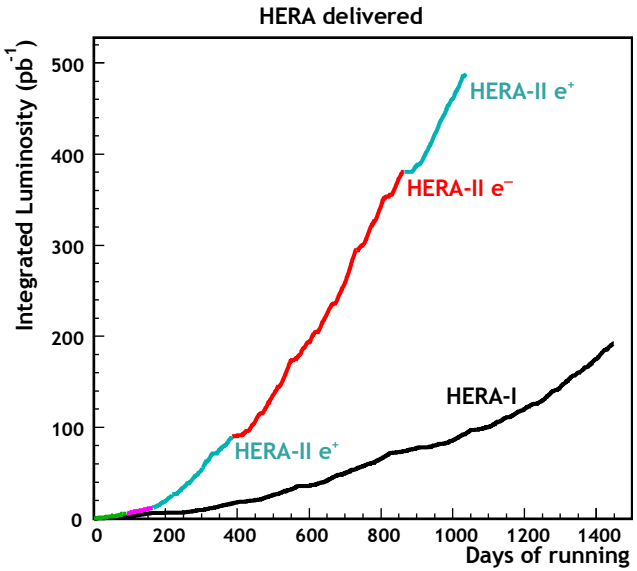


HERA

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

$e^{\pm}$ **27.5 GeV** ← **920 GeV** p

$\sqrt{s}$ = 320 GeV



– delivered 197 pb^{-1} in 2006 (as of December 17)

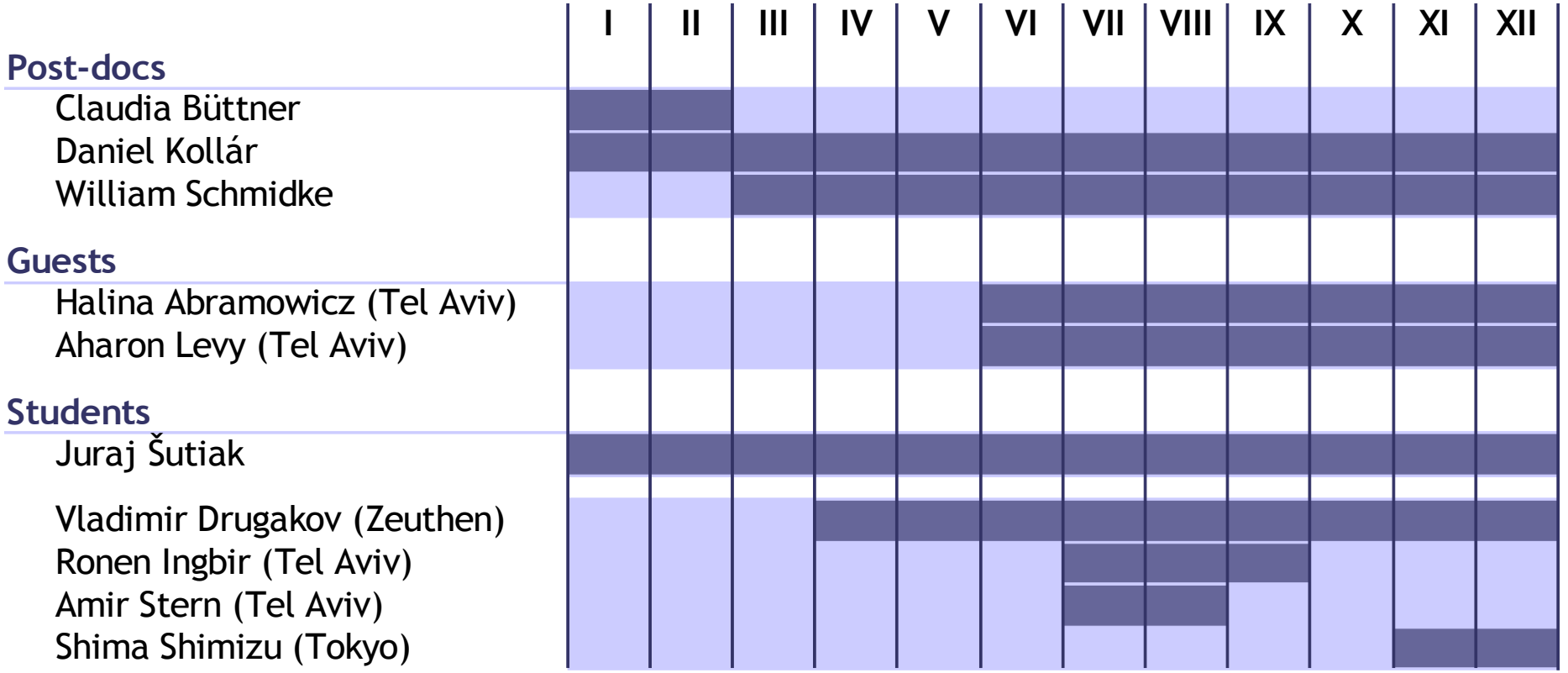
– ZEUS gated 154 pb^{-1} → 78% efficiency

– polarization ~ 40%

The MPI ZEUS team

Responsible Director: Allen Caldwell

Project Leader: Iris Abt



Starting in January 2007: 1 Post-doc (Burkard Reisert), 2 PhD Students (Panjab University)

Responsibilities & Analyses

Responsibilities: (taken over from Columbia group)

- **Luminosity Spectrometer** — W. Schmidke, J. Šutiak, V. Drugakov
- **BCAL** — W. Schmidke

Analyses:

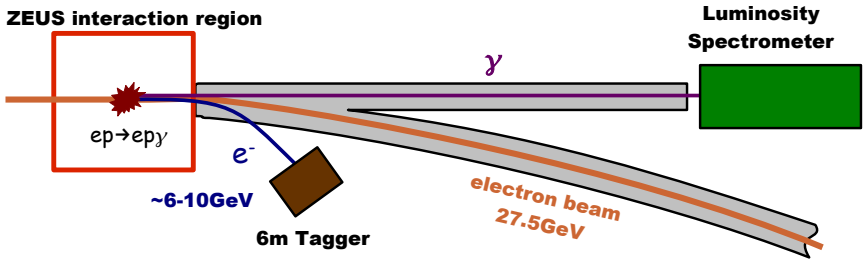
- **Cross-Section Measurement at High Bjorken-*x*** — C. Büttner
  → *finished, more to come*
- **Charged-Current Cross-Section** — J. Šutiak
  → *finished*
- **F_2 at High *y* and F_L** — D. Kollár
  → *ongoing*
- **Leading Neutrons** — W. Schmidke
  → *finished*

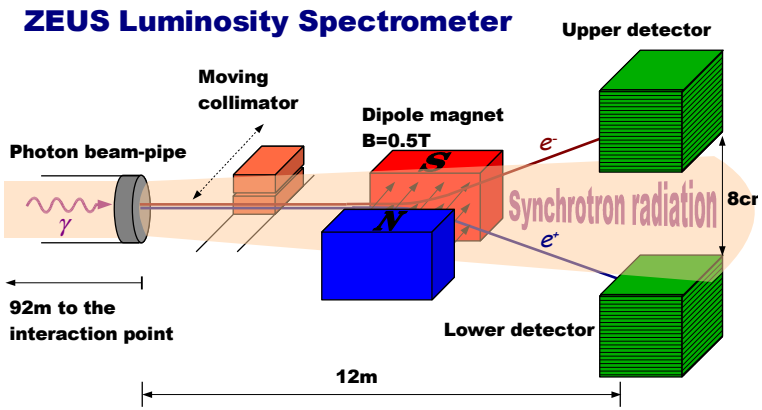
Luminosity Spectrometer

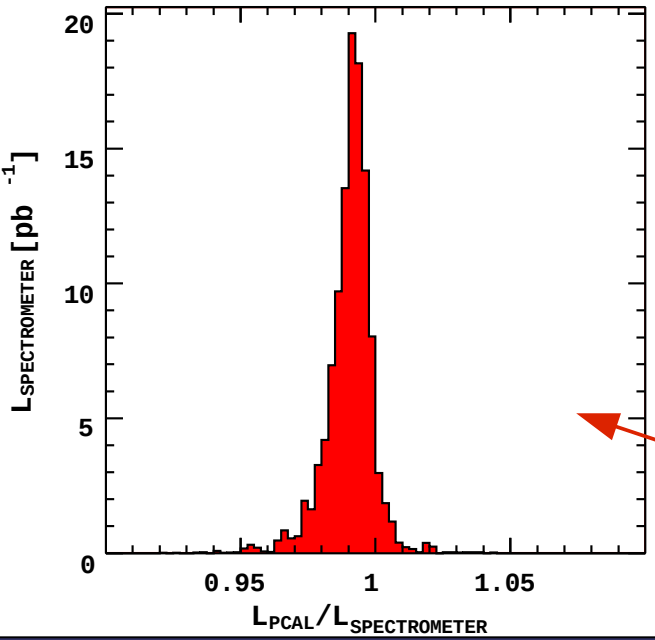
W. Schmidke, J. Šutiak, V. Drugakov

Two independent luminosity monitors:

- **Luminosity Spectrometer** (since 2003) & Photon Calorimeter
- measuring the rate of bremsstrahlung photons created in the Bethe-Heitler process in the interaction region
  - the cross section is well known (QED process)
  - high rate ⇒ high statistics ⇒ accurate





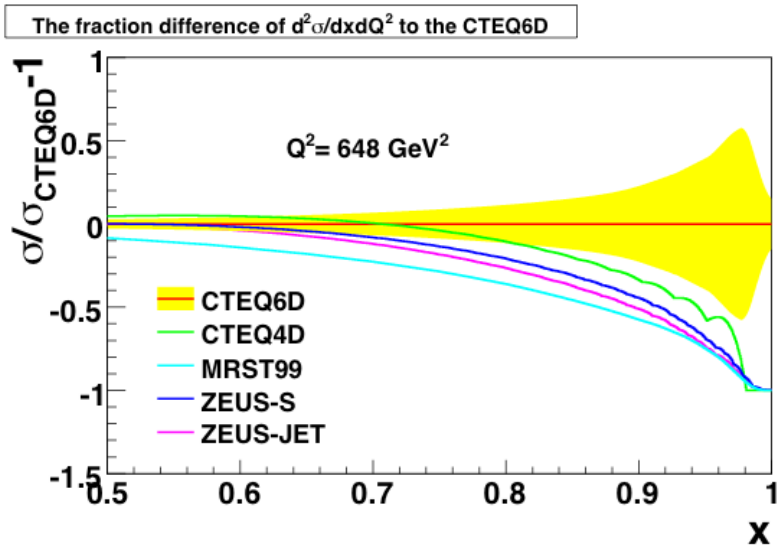


Problems:

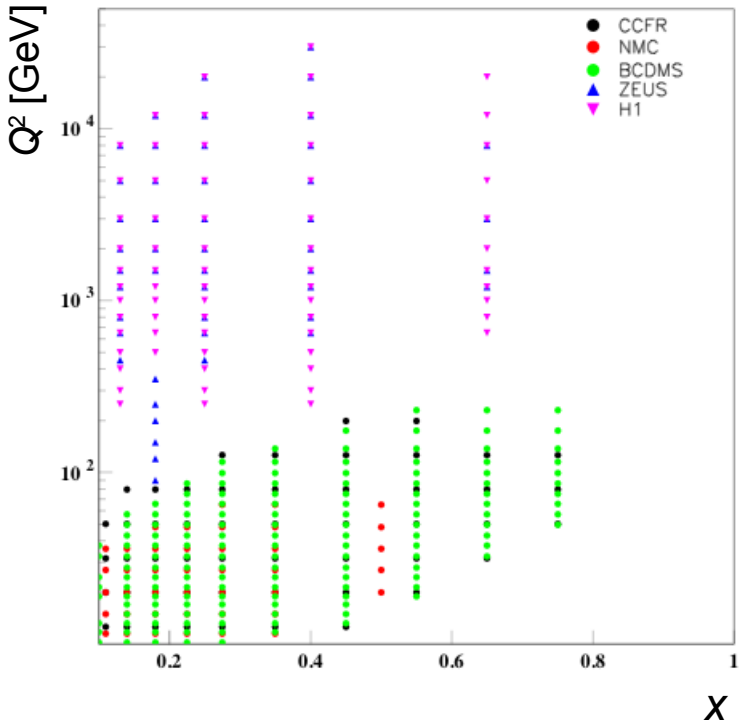
- more than 1 photon at a time
- strong synchrotron radiation
- need precise acceptance measurement
- good agreement between the two monitors
- at present, the uncertainty on luminosity 3.5% the goal is <2%

Motivation:

- Limited cross-section data at high Bjorken-x and high Q^2
  - BCDMS has measured F_2 up to x=0.75
  - ZEUS and H1 have measured F_2 up to x=0.65 before
- PDF's are poorly determined at high x
  - sizeable differences and large uncertainties



F_2 data at high x



Cross-Section at High x – Th Idea

C. Büttner

Main ideas:

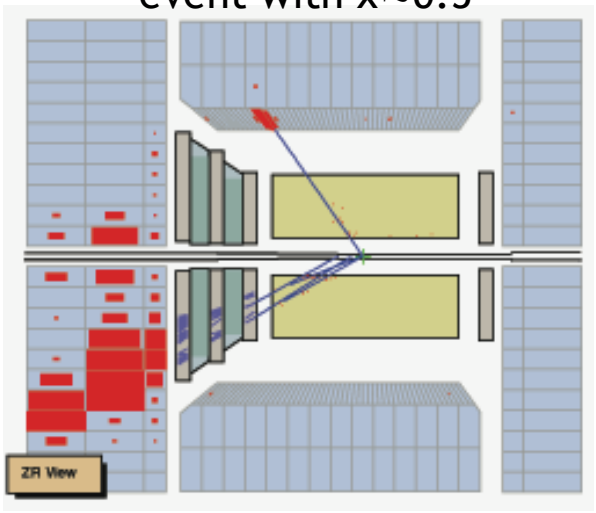
- high x high Q^2 event ➔ clean high-energy electron
- measure Q^2 with the electron
- however, x resolution very bad

therefore

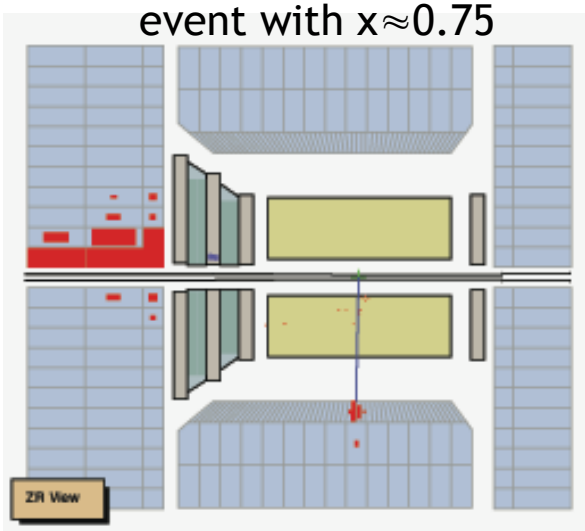
- for not too high x, reconstruct x from reconstructed jet
- for very high x, jet partly lost in beam pipe

  → events above some x_{cut} (depending on Q^2) are counted to get an integral cross section

event with x≈0.5

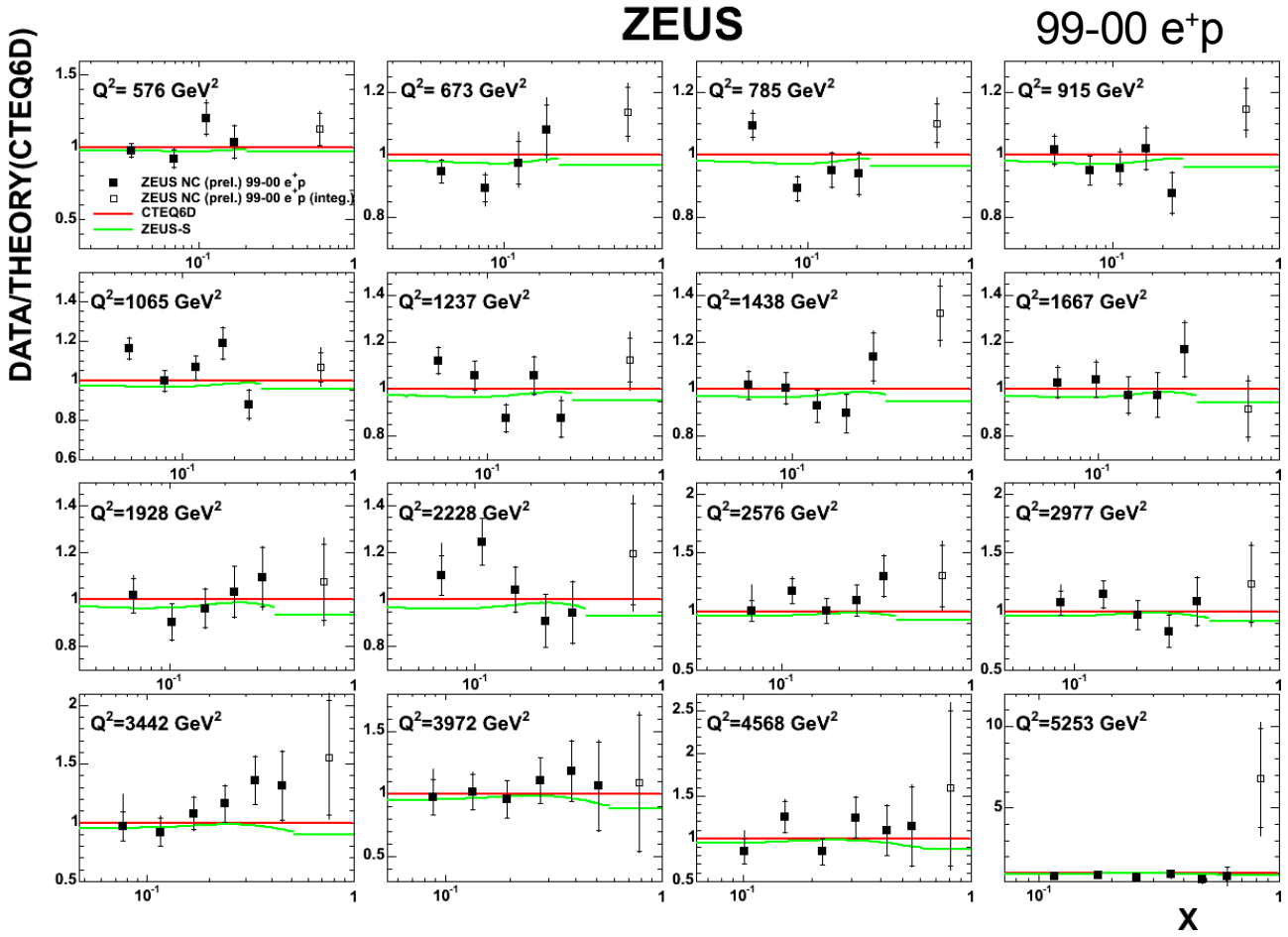


event with x≈0.75



Measured cross-section comparison to the expectations from CTEQ6D

- good agreement in previously measured region
- data tend to lie above the expectations at highest ***x***



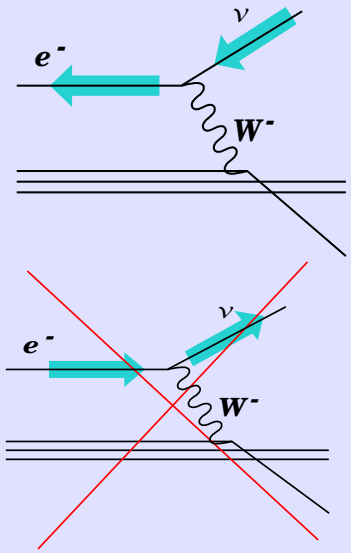
- now published
- first fits show that data will have considerable impact on PDF's
- new PhD student should redo the analysis with the full HERA-II data

Motivation:

- high luminosity polarized beams – both polarizations available in HERA-II data
- CC cross section:

$$\frac{d^2\sigma^{e^- p}}{dxdQ^2} = (1-P)\,\frac{G_F^2}{2\pi}\,\frac{M_W^4}{(Q^2+M_W^2)^2}\,[(u+c)+(1-y)^2(\bar{d}+\bar{s})]$$

Direct search for right-handed weak currents:



Measurement of M_W and G_F in a "space-like" process:
LEP ("time-like"): $e^+e^- \rightarrow W^+W^-$
HERA ("space-like"): $e^-p \rightarrow \nu X$

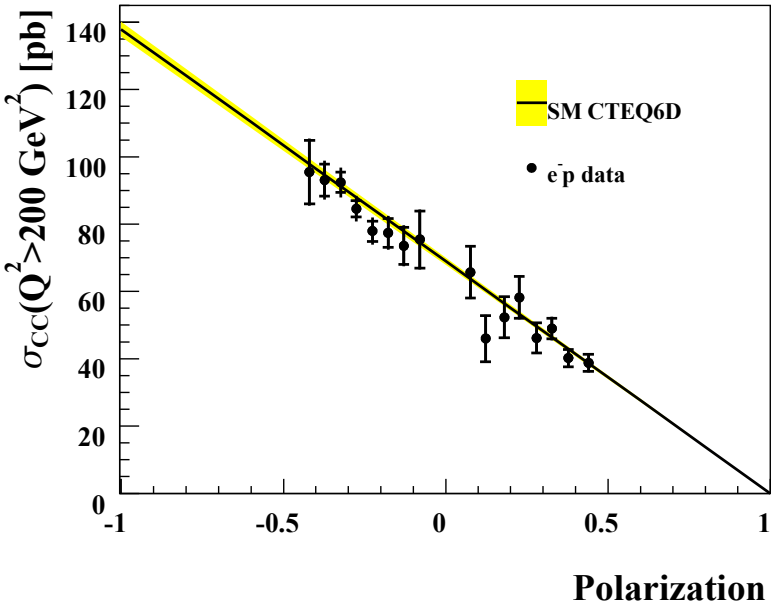
PDF constraints:
The combination of charge and helicity conservation provide a selective sensitivity of the CC cross section on the quark flavour.

CC – Polarization dependence

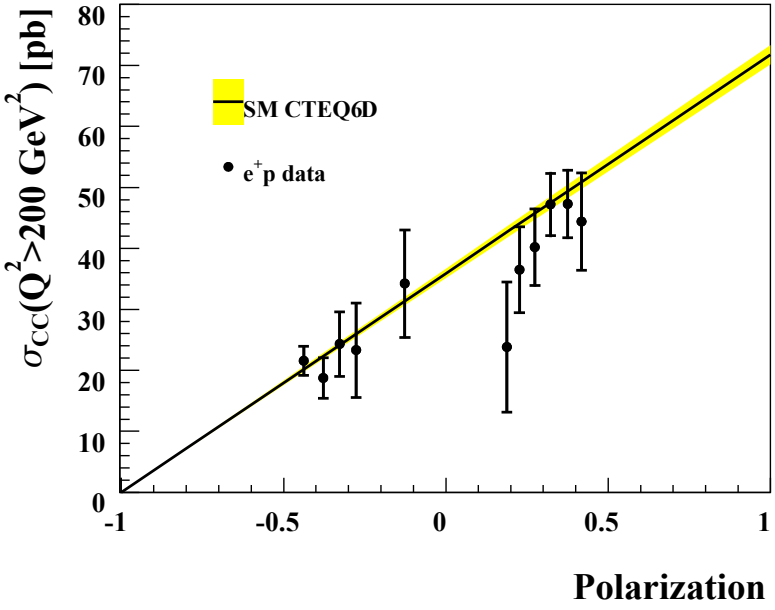
J. Šutiak

- total CC cross section has linear dependence on polarization

e^-p data 121 pb^{-1}



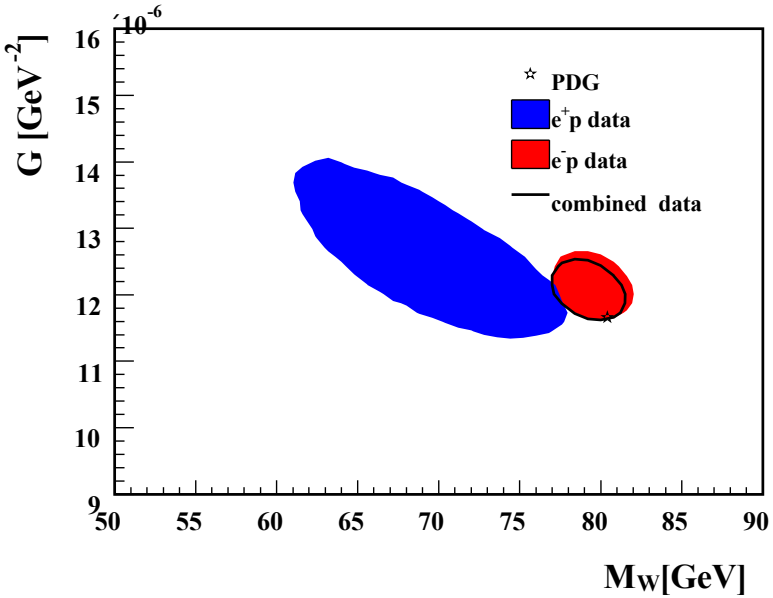
e^+p data 30 pb^{-1}



- right-handed cross-section limit
  - **e^-p: σ(P=1) < 7.1 pb** with probability 0.95 $\sigma(P=1)/\sigma(P=-1) = 0.05$
  - **e^+p: σ(P=1) < 9.9 pb** with probability 0.95 $\sigma(P=-1)/\sigma(P=1) = 0.14$

- 2 methods to determine the W mass in SM
- using the Q^2 dependence of the cross section, the coupling G_F is a free parameter

$$\frac{d^2\sigma}{dxdQ^2} = \frac{G_F^2}{2\pi}\frac{M_W^4}{(Q^2+M_W^2)^2}\tilde{\sigma}$$



- results of combined fit:

$$M_W = 79.0^{+1.7}_{-1.2}\,\text{GeV}$$

$$G_F = 1.2^{+0.33}_{-0.26}\times 10^{-5}\,\text{GeV}^{-2}$$

- using the SM relation between M_W and G_F ⇒ enhanced sensitivity to M_W

$$G_F = \frac{\pi\alpha}{\sqrt{2}\left(1-\frac{M_W^2}{M_Z^2}\right)M_W^2}\frac{1}{1-\Delta r}$$

$$M_W = 81.05^{+0.29}_{-0.41}\,\text{GeV}$$

PDG values: $M_W = 80.403 \pm 0.029\,\text{GeV}$

$G_F = 1.16637 \pm 0.00001\,\text{GeV}^{-2}$

- left-right symmetric models allow right-handed W (g_l=g_r in simplest models)

$$\frac{d\sigma}{dxdQ^2} = \frac{1}{128\pi x}\left[(1+P)\frac{g_R^4}{\left(Q^2+M_{W,R}^2\right)^2} + (1-P)\frac{g_L^4}{\left(Q^2+M_{W,L}^2\right)^2}\right]\tilde{\sigma}$$

Determine limits on the mass of W_R using Bayesian approach

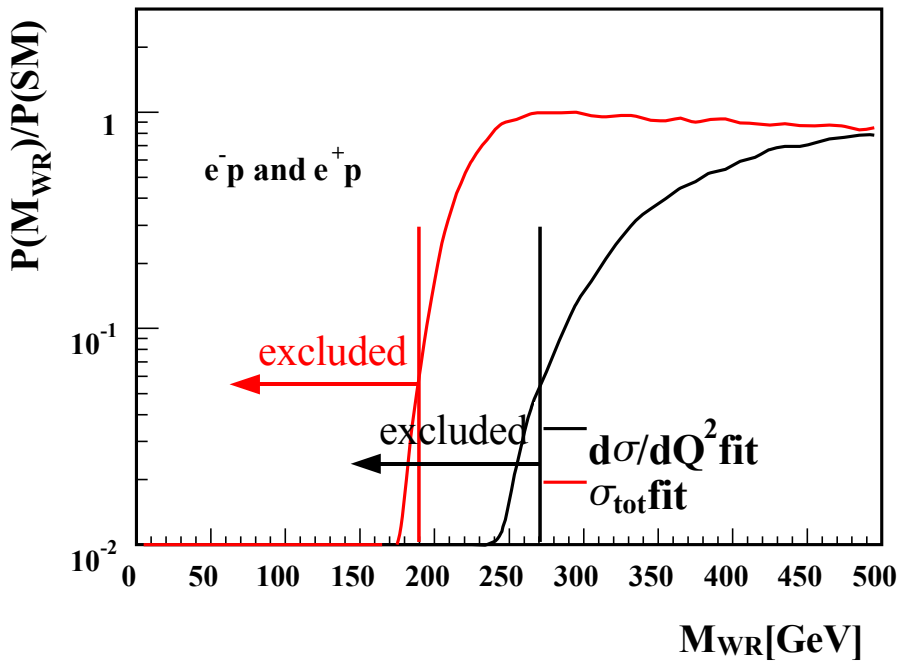
- from total cross-section vs. polarization

  $M_{W,R}$ > 190 GeV

- using the Q^2 dependence of the cross section

  $M_{W,R}$ > 270 GeV

Combined e^+p, e^-p dataset



Neutral Current cross section:

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

$Y_+ = 1+(1-y)^2$ (at low $Q^2 \Rightarrow xF_3$ neglected)

F_L – related to cross section of longitudinally polarised photon $F_L=\frac{Q^2}{4\pi^2\alpha}\sigma_L$

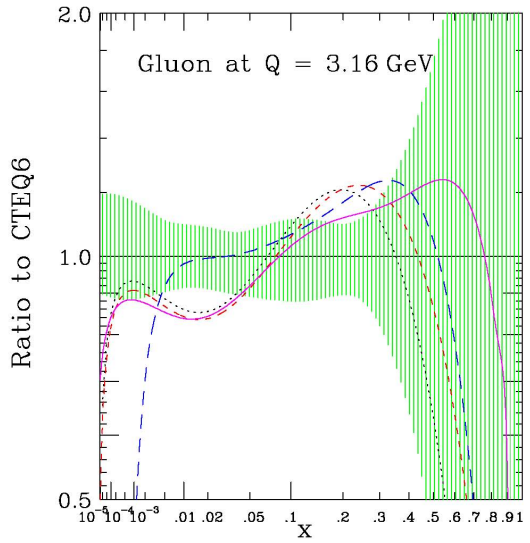
– in Quark-Parton Model (QPM): $\sigma_L = 0 \Rightarrow F_L = 0$

– F_L nonzero in pQCD, in LO

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

At small x the gluon density dominates

→ F_L has never been measured at small x



mrst2001, mrst2002, mrst2003, mrst2004

Theory predictions

- Relatively large uncertainties in gluon densities at small x
- Measurement of F_L → test of our QCD understanding
  → important input to QCD fits of PDF's

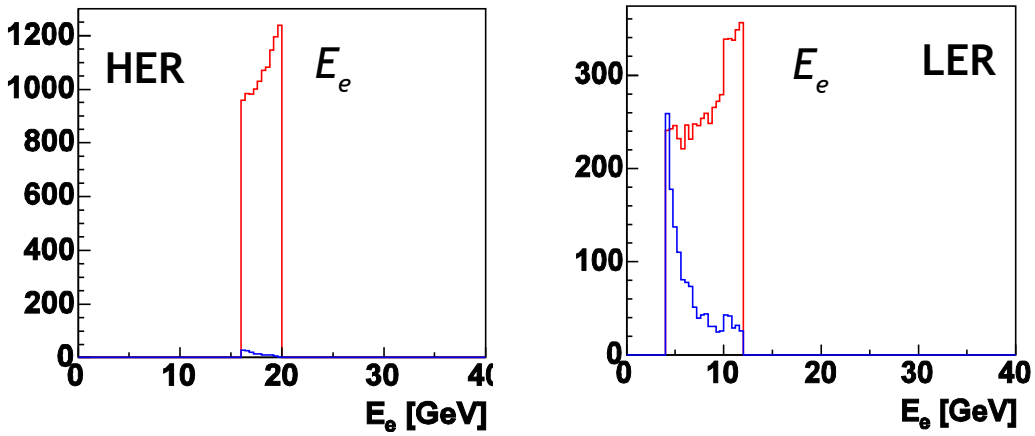
Measurement at HERA

- to separate F_2 and F_L one needs to measure the cross section at the same (x, Q^2) but different values of y $\Rightarrow$ different s (different beam energies)
- **we made a feasibility study of this measurement with the ZEUS detector**
- supposing scenario with low energy running (LER) at proton beam energy 460 GeV in the last three months of HERA (accumulating 10 pb^{-1})

Key issues for ZEUS:

- electron finding at low energies to reach high y
- background rejection
  - ↳ photoproduction is the largest contribution to background especially at low energies

Distribution of electron energy in HER and LER

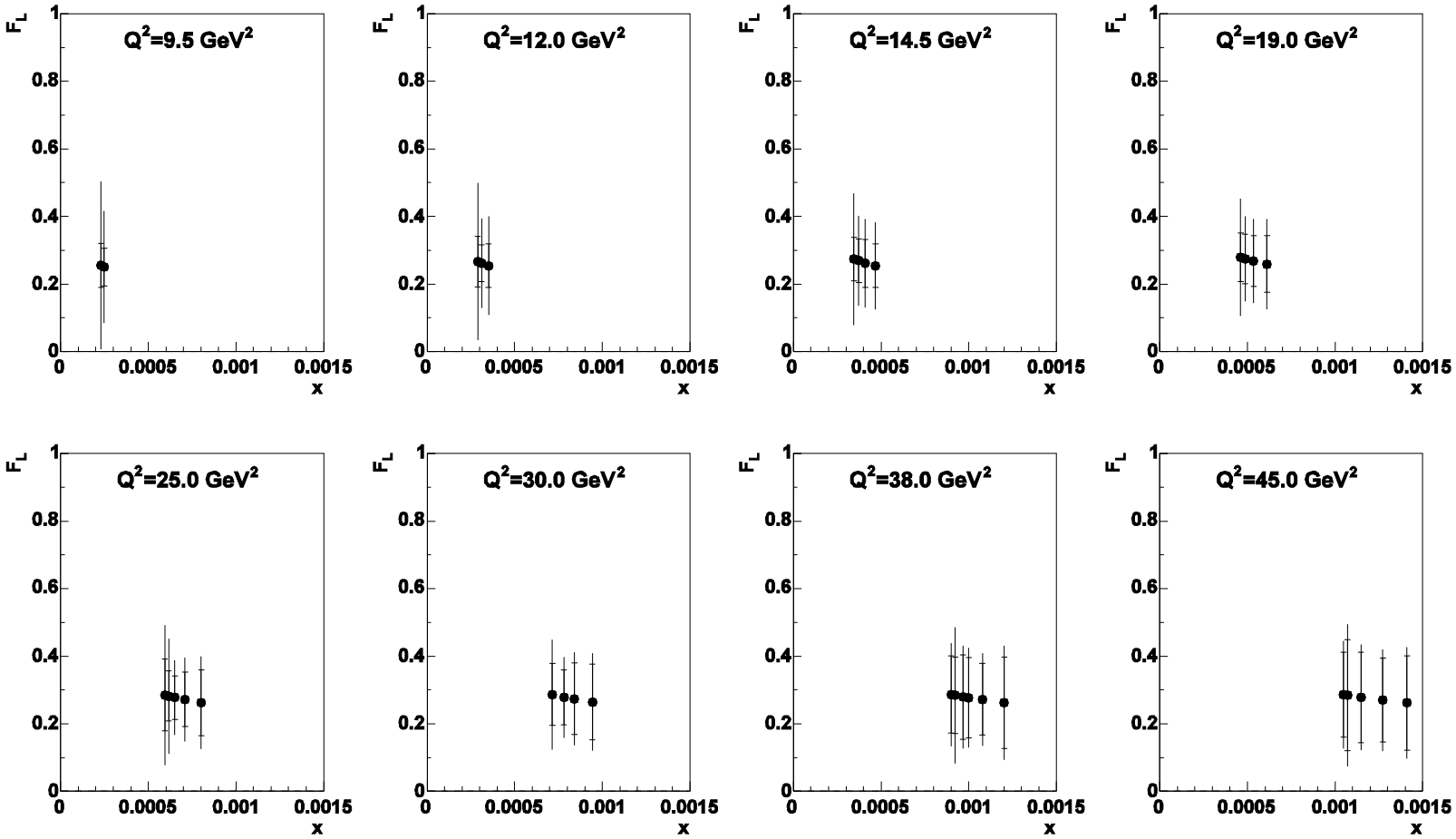


Uncertainties of F_L extraction

D. Kollár

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.

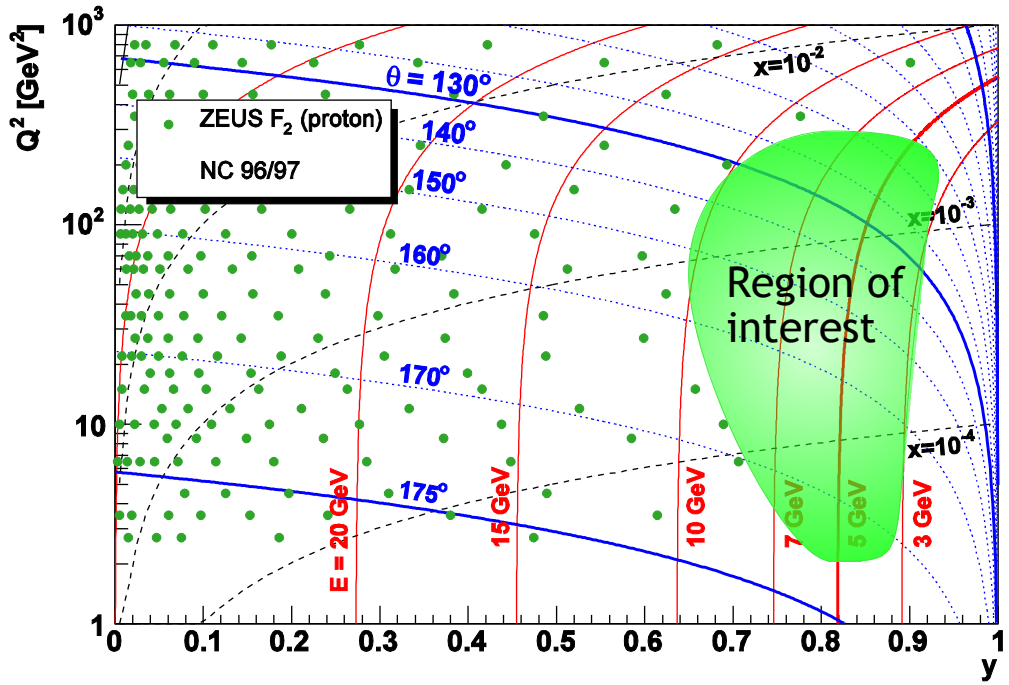
Low energy running at HERA

D. Kollár

- we have presented the F_L study to the ZEUS Collaboration in February 2006
- **ZEUS Collaboration has expressed interest in low energy running (LER) to the DESY PRC** (meeting in May 2006)
- **DESY PRC has recommended to the directorate that the LER takes place before the HERA shutdown**
- present status: waiting with the final decision of H1 (isolated high p_T leptons issue) to come in the beginning of next year
- HERA preparation for LER are ongoing
- **LER expected to start in March 2007**

ZEUS tasks: (lot of work before LER)

- work on detailed understanding of
  - electron finding,
  - photoproduction background rejection,
  - tracking
- **F_2 measurement at high y**
  - new region for ZEUS
  - allows developing techniques for F_L measurement



Conclusions

- MPI ZEUS group is expanding
- now took over some more hardware responsibilities
- some analyses finished
- bulk of the HERA-II data still to be analyzed

F_L measurement

- our F_L study led to ZEUS Collaboration supporting the low energy running
- we have initiated creation of new physics group in ZEUS → **the F_L group**
- MPI plays a leading role in the ZEUS F_L group
  ↪ new Post-doc and PhD student are supposed to work on F_L (starting in January)
- even though HERA is going to shutdown at the end of June 2007, we're looking forward to the exciting measurements still to come
  (especially the F_L measurement)