

Measurement of the Inclusive ep Scattering Cross Section at HERA

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(on behalf of H1 and ZEUS collaborations)

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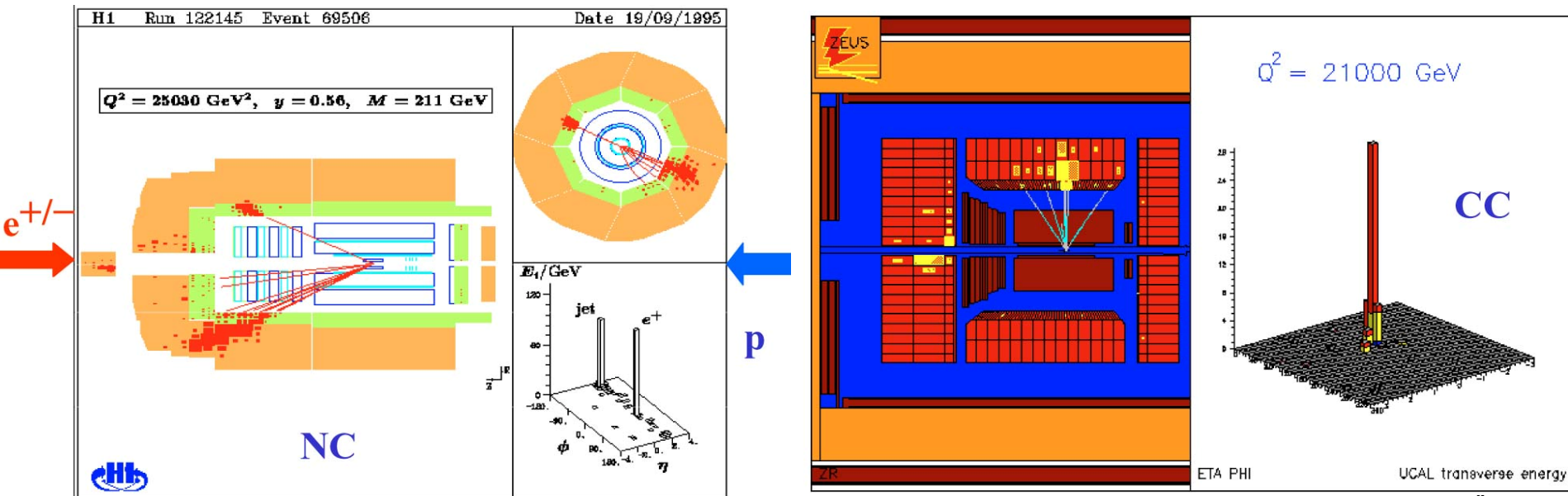
H1 and ZEUS at HERA

- HERA collider at DESY, Hamburg
- ep accelerator ring, 27.5×920 GeV, $\sqrt{s_{ep}} = 319$ GeV
- Circumference: 6.3km
- 4 experimental halls, 2 collider experiments



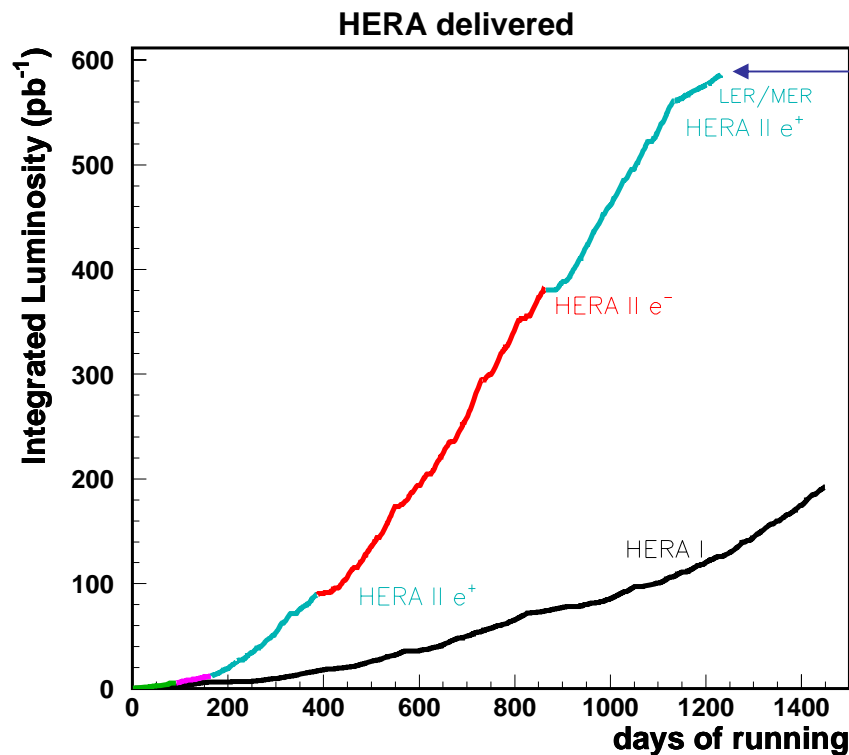
H1 and ZEUS experiments

- Nearly 4π detector coverage
- Collected data: 1992-2007
- HERA 2: higher luminosity since 2002
- p-beam running at 460GeV and 575GeV in 2007



HERA luminosity

- Luminosity upgrade: mid 2000 – end 2001
- Improvement in machine performance
- Low energy running: March – June 2007

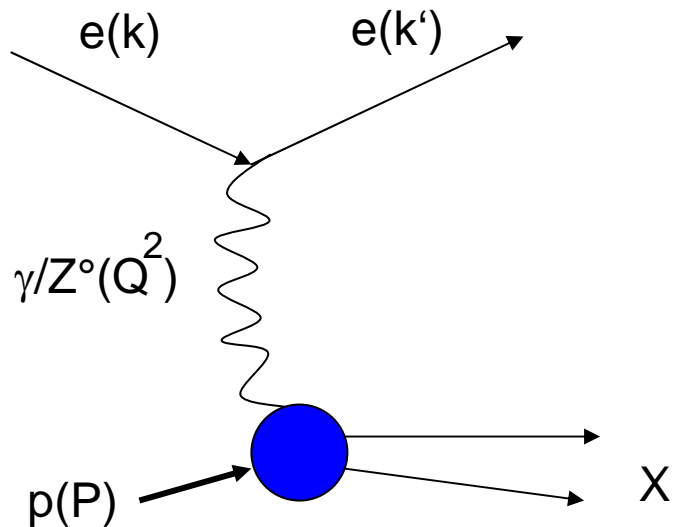


End of HERA
operation: June 30,
23:25

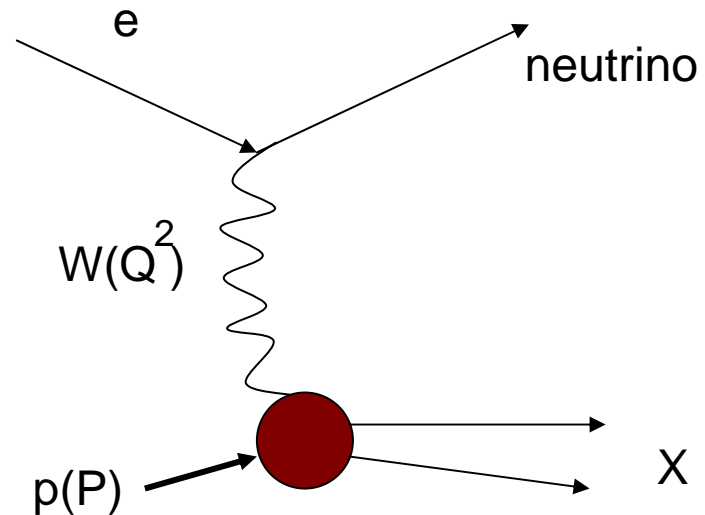
Inclusive Deep Inelastic Scattering at

HERA

Neutral current



Charged current



$$Q^2 = -(k - k')^2 \text{ - four momentum transfer squared in the reaction}$$
$$x = \frac{Q^2}{2P(k - k')} \text{ - fraction of the proton momentum carried by the parton}$$
$$y = Q^2 / sx \text{ - inelasticity}$$
$$s = 4E_e E_p \text{ - center-of-mass energy squared}$$

Cross section and structure functions

NC Cross Section:

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

$$\frac{d^2 \sigma_{NC}(e^\pm p)}{dx dQ^2} = \frac{2\pi \alpha^2}{x Q^4} Y_\pm \left[\tilde{F}_2 - \frac{y^2}{Y_+} \tilde{F}_L \mp \frac{Y_-}{Y_+} x \tilde{F}_3 \right]$$

$$Y_\pm = 1 \pm (1-y)^2$$

Dominant contribution

Sizeable only at high y ($y > \sim 0.6$)

Contribution only important at high Q^2
(from γZ interference)

Structure functions

- The proton structure function in QPM:

$$F_2 = \sum_i e_i^2 x [q_i(x) + \bar{q}_i(x)] \quad \text{- sum of the (anti)quarks density distributions weighted with their electric charge squared}$$

- Structure function $F_L \sim$ gluon density $g(x)$ in NLO QCD and 0 in QPM

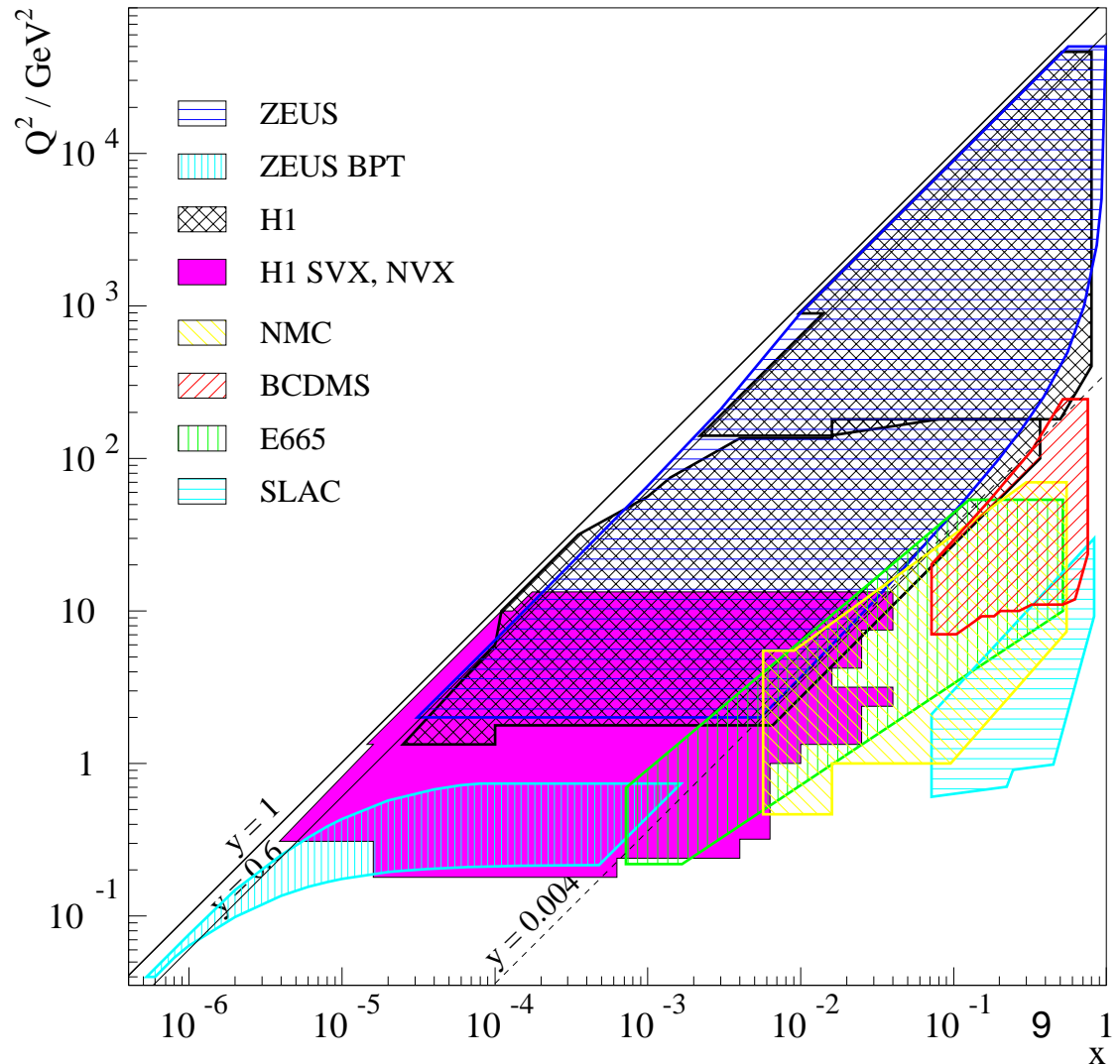
- $x F_3 \sim 2 \sum_i e_i a_i x [q_i(x) - \bar{q}_i(x)]$ - determines the valence quark distributions $x q_v(x, Q^2)$

- $\left. \begin{aligned} \sigma_{e^+p}^{CC} &\sim x(\bar{u} + \bar{c}) + x(1-y)^2(d + s) \\ \sigma_{e^-p}^{CC} &\sim x(u + c) + x(1-y)^2(\bar{d} + \bar{s}) \end{aligned} \right\} \text{flavour separation at high } x$

➤ Combinations of structure functions allow to unfold PDF and check QCD

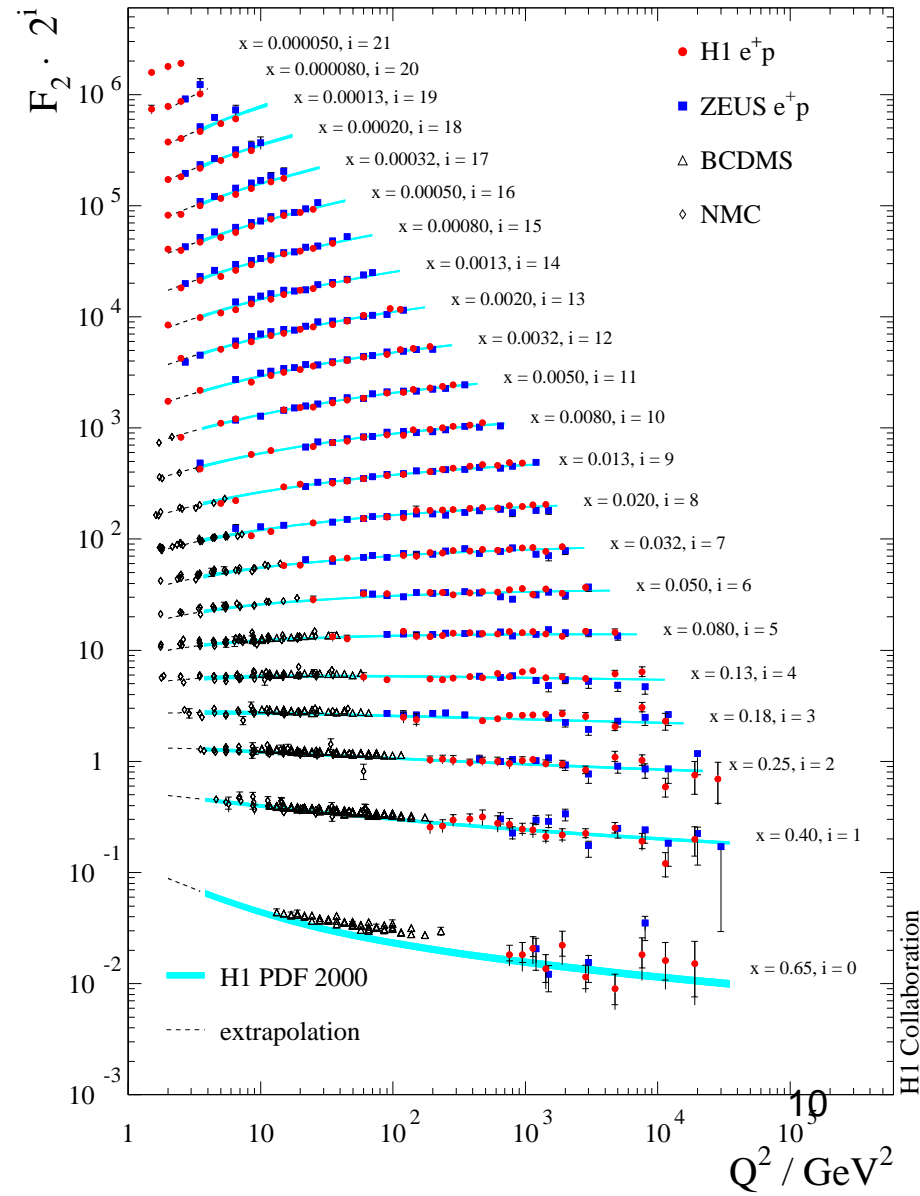
Kinematic plane coverage

- HERA extends kinematic plane coverage to lower x and higher Q^2 by 2 orders of magnitude
- H1 and ZEUS overlap with fixed target results in wide range of x and Q^2

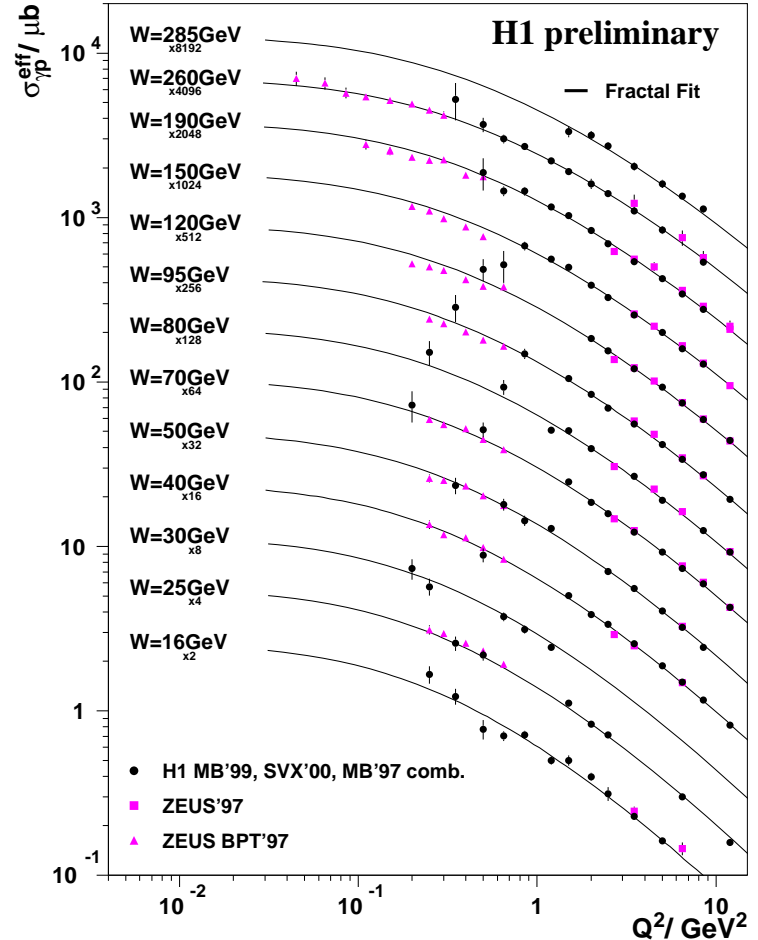
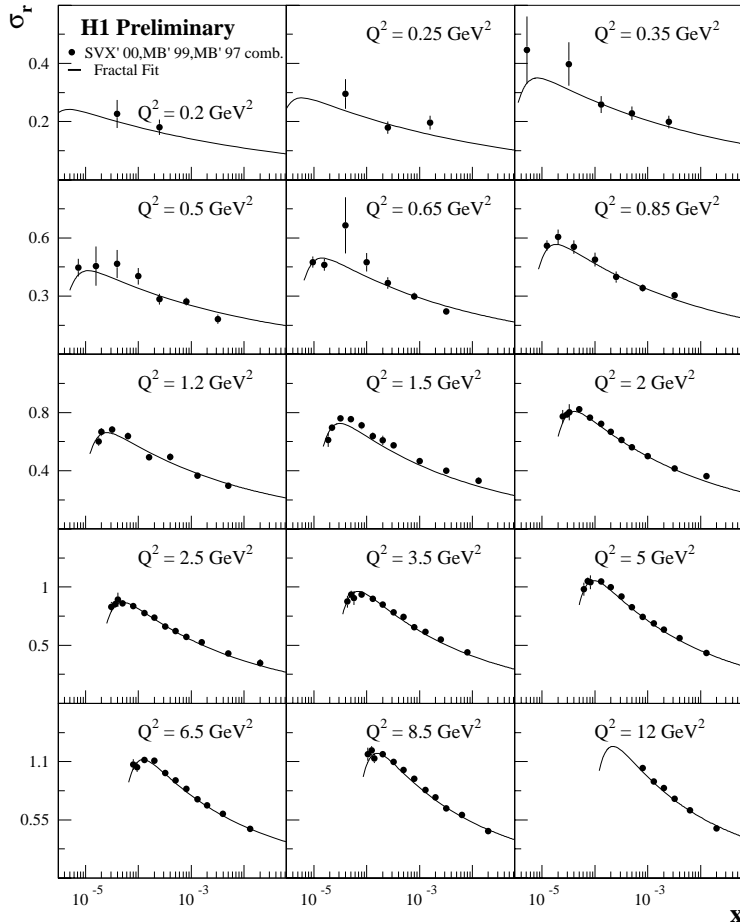


F₂ measurements

- F₂ across the whole kinematic plane
- Extend low Q² measurements consistent with them
- Negative scaling violation for x>0.18: running of α_s
- Positive scaling violation for x<0.1: effect of high gluon density
- Scaling violations are well described over 4 orders of magnitude in both x and Q² by DGLAP fit
- 2-3% precision



Lowest Q^2 data



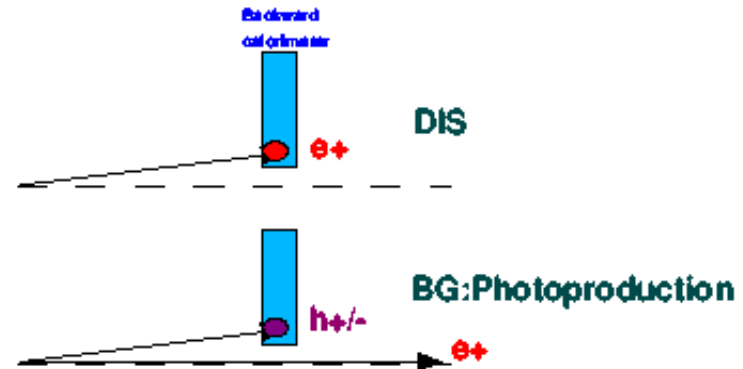
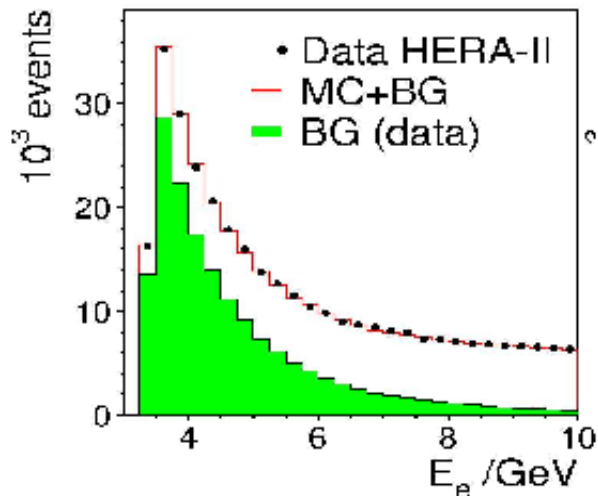
- New precision of Preliminary H1 data: 1.5% for $Q^2 > 5 \text{ GeV}^2$
- H1 combined data cover the gap between published ZEUS results and agree with them in regions of overlap

$$\sigma_{\gamma^* p}^{\text{eff}} = \sigma_T + [1 - f(y)]\sigma_L$$

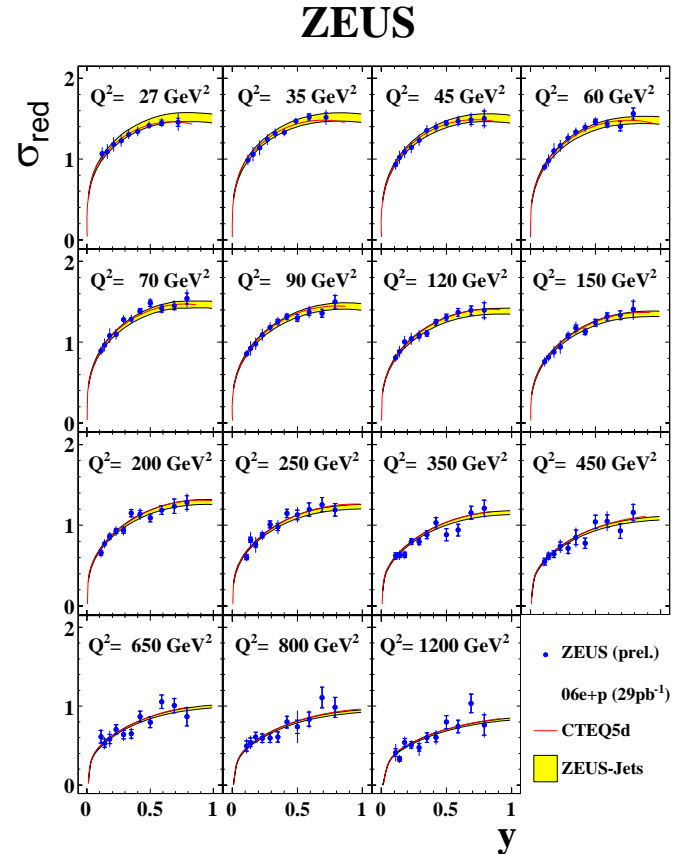
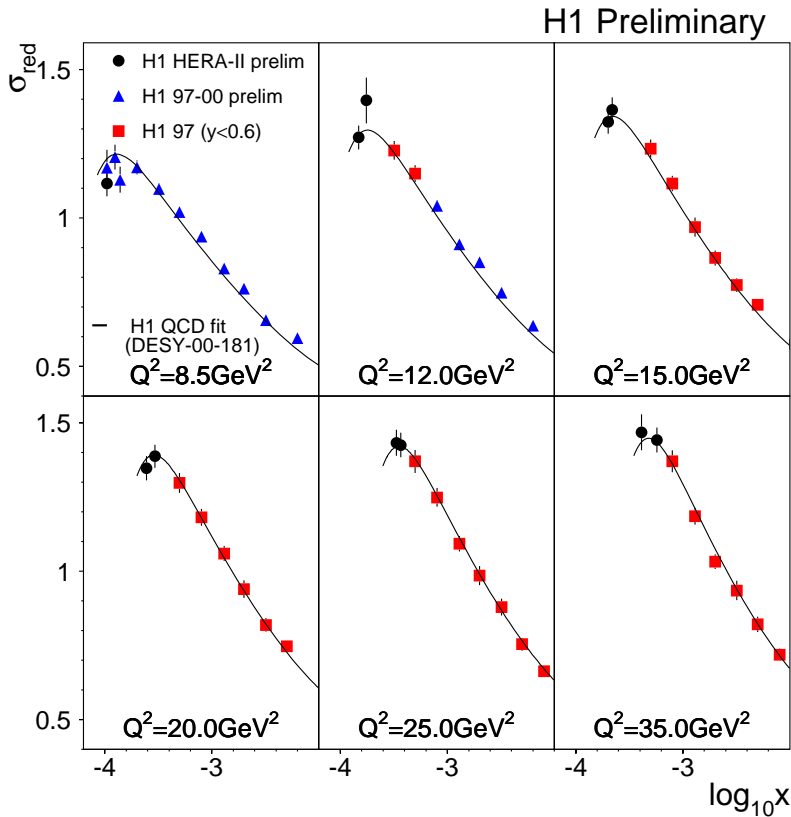
The high y measurements

- Results of high $y > 0.6$ are interesting because of sensitivity to F_L : $\sigma_r(ep) = F_2 - \frac{y^2}{Y_+} F_L$
- Difficult measurements- high γp background
- H1 and ZEUS experiments have released the preliminary high y cross section results using data with $E'_{\min} = 3.3 \text{ GeV}$, $y_{\max} = 0.9$ for H1 and with $E'_{\min} = 5 \text{ GeV}$, $y_{\max} = 0.8$ for ZEUS

New analysis (HERA II) e^+p/e^-p Data



The high y data

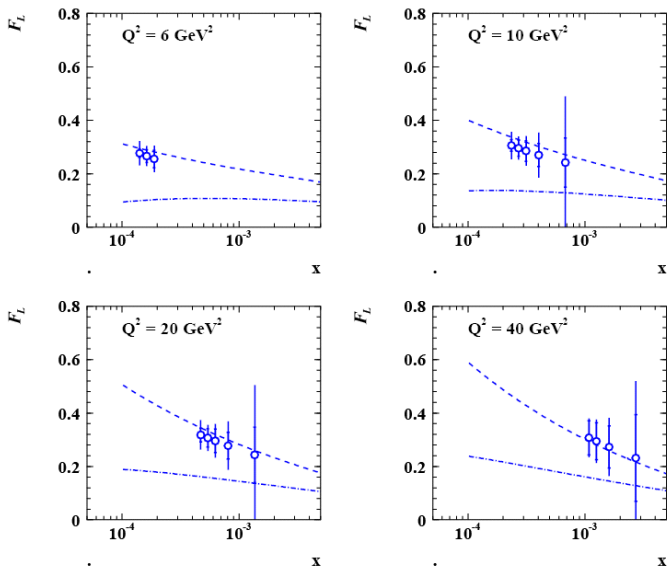


- 96 pb⁻¹ for H1 result
- H1 total errors are on the level of 2-3% and improved by factor of 2 compare to published HERA 1 data
- Good sample to study experimental conditions for F_L measurement

F_L measurement

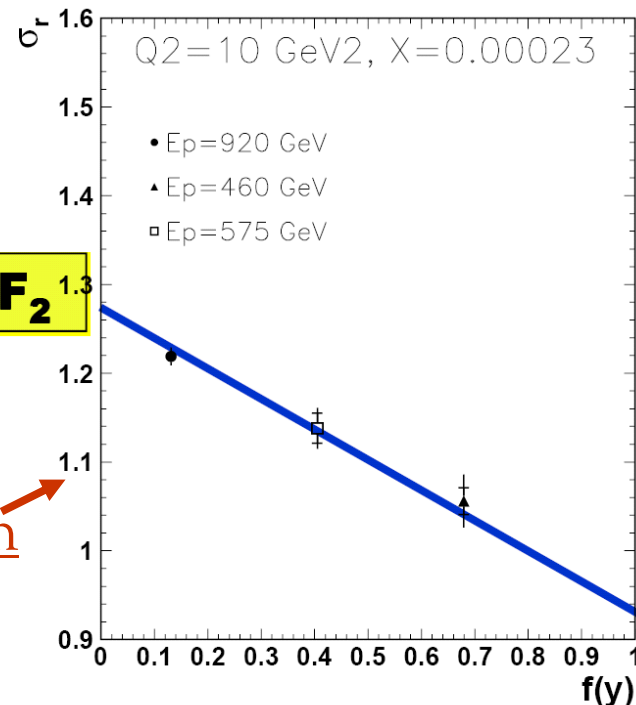
- HERA structure function measurement program will be completed by measuring of F_L
- Direct measurement of F_L can be performed only by measuring cross section for the same Q²-x but with different proton beam energies (different y):

$$\sigma_r = F_2 - f(y)F_L$$



— · — MRST

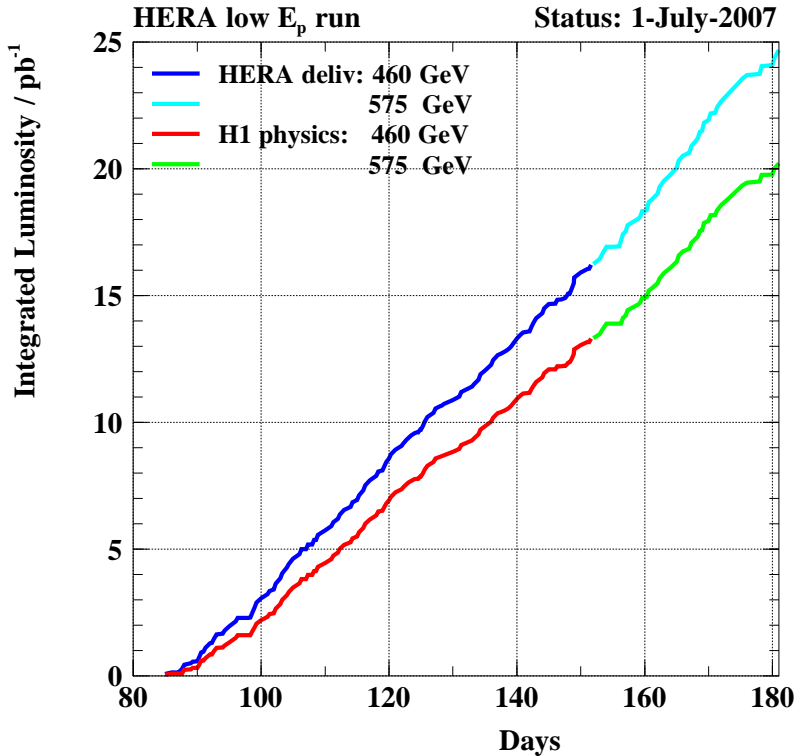
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simulation

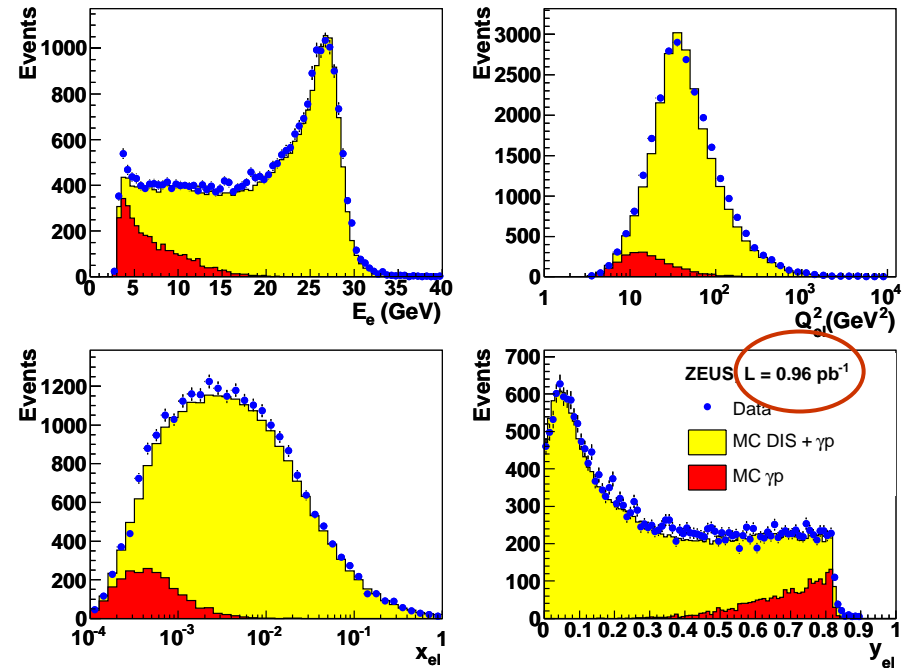
F₂-F_L

Low energy data



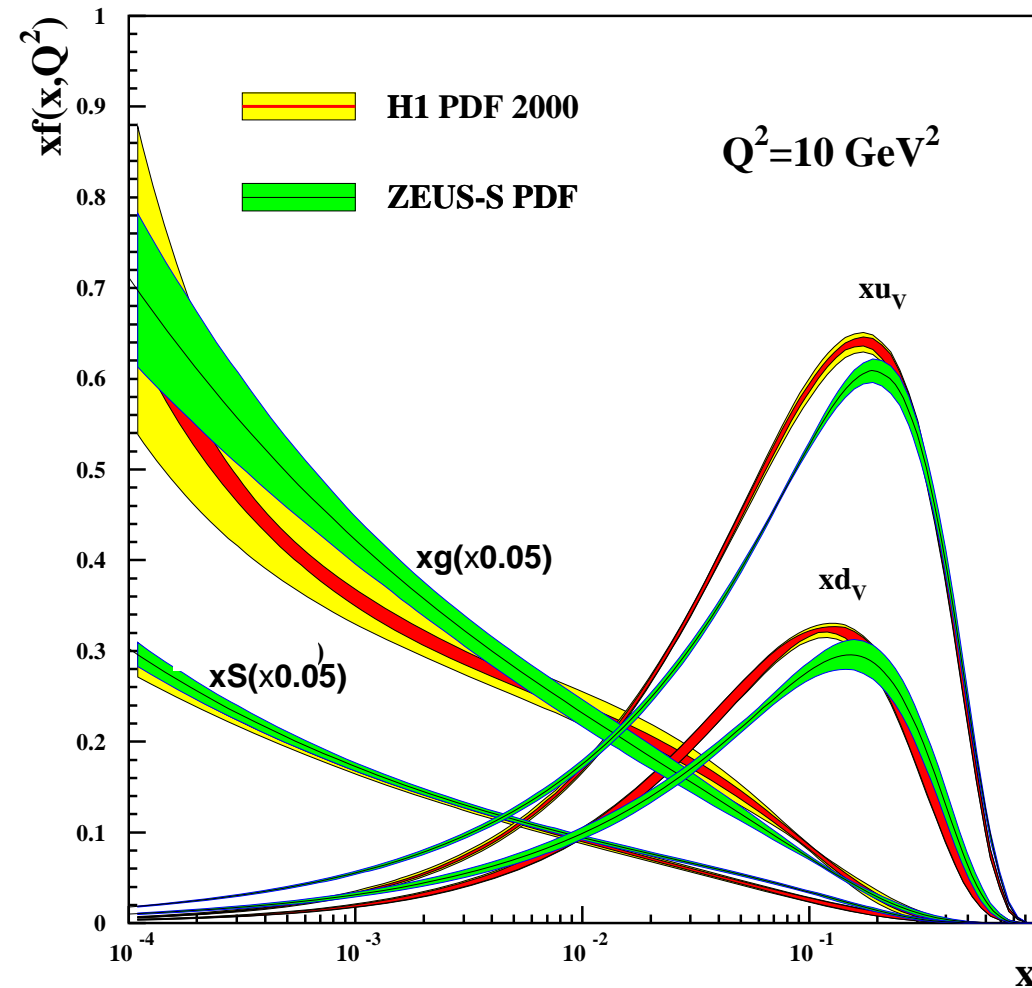
ZEUS Control Plots

First Data from HERA Runs at $\sqrt{s} = 225$ GeV



- ✓ Since March 2007 HERA performance allowed to collect $L=13\text{pb}^{-1}$ at lowest $E_p=460\text{GeV}$ and $L=7\text{pb}^{-1}$ at intermediate $E_p=575\text{GeV}$

Parton density functions (PDFs)



✓ Cross section measurements in ep interactions at HERA allow PDF fits

- Sea and gluon distributions are divided by a factor of 20

Conclusions

- HERA experiments continue to deliver many interesting results
- Precision of $\sim 2-3$ % achieved for F_2 (also at high y) and still being improved
- New high y and low Q^2 results presented
- Low E_p HERA running is finished successfully. F_L will be measured directly using this data