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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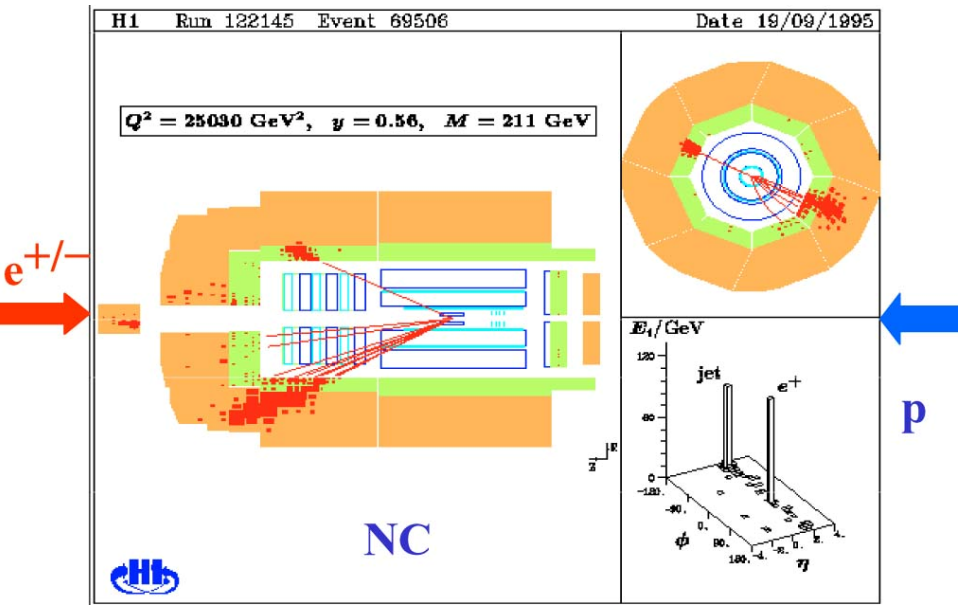
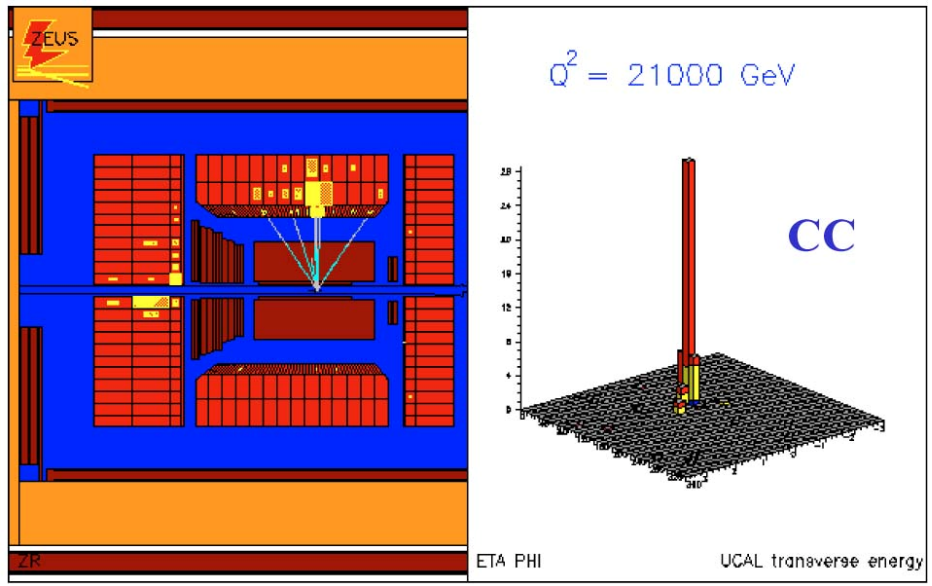
H1 and ZEUS at HERA

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

H1 and ZEUS experiments

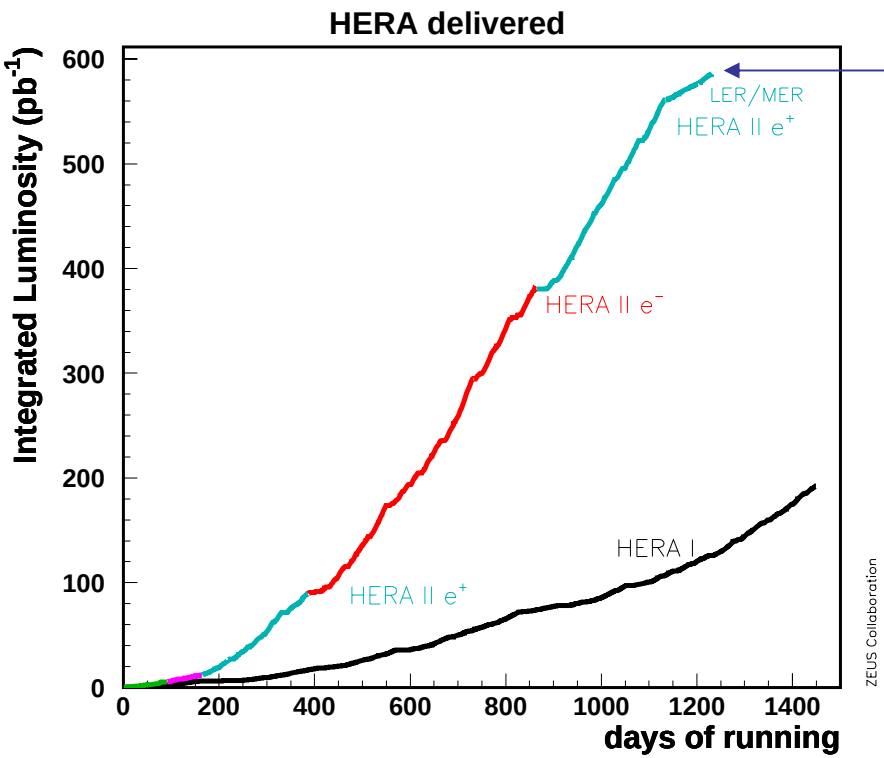
- Nearly 4π detector coverage
- Collected data: 1992-2007
- HERA 2: higher luminosity since 2002
- p-beam running at 460GeV and 575GeV in 2007





HERA luminosity

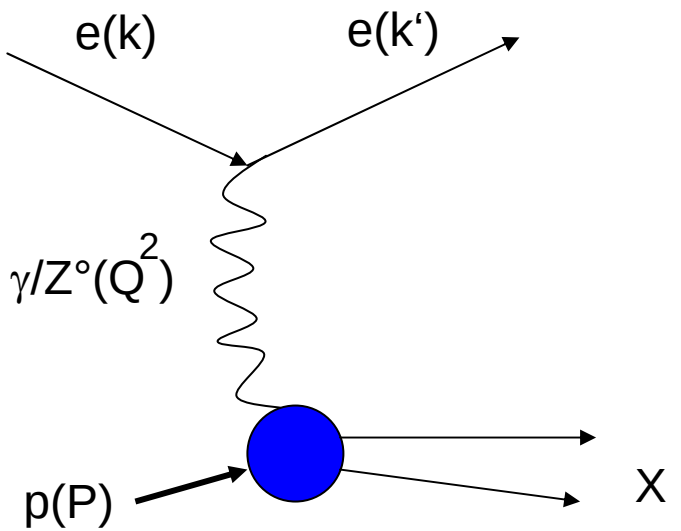
- Luminosity upgrade: mid 2000 – end 2001
- Improvement in machine performance
- Low energy running: March – June 2007



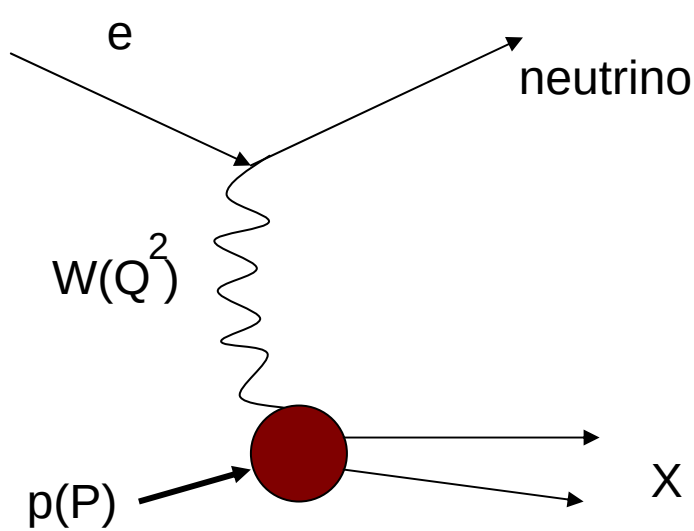
End of HERA operation: June 30, 23:25

Inclusive Deep Inelastic Scattering at HERA

Neutral current



Charged current



$Q^2 = -(k-k')^2$ - four momentum transfer squared in the reaction

$x = \frac{Q^2}{2P(k - k')}$ - fraction of the proton momentum carried by the parton

$y = Q^2/sx$ - inelasticity

$s = 4E_eE_p$ - center-of-mass energy squared

Cross section and structure functions

NC Cross Section:

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

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

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

Dominant contribution

Sizeable only at high y (y>~0.6)

Contribution only important at high Q^2

(from γZ interference)

Structure functions

- The proton structure function in QPM:

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

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

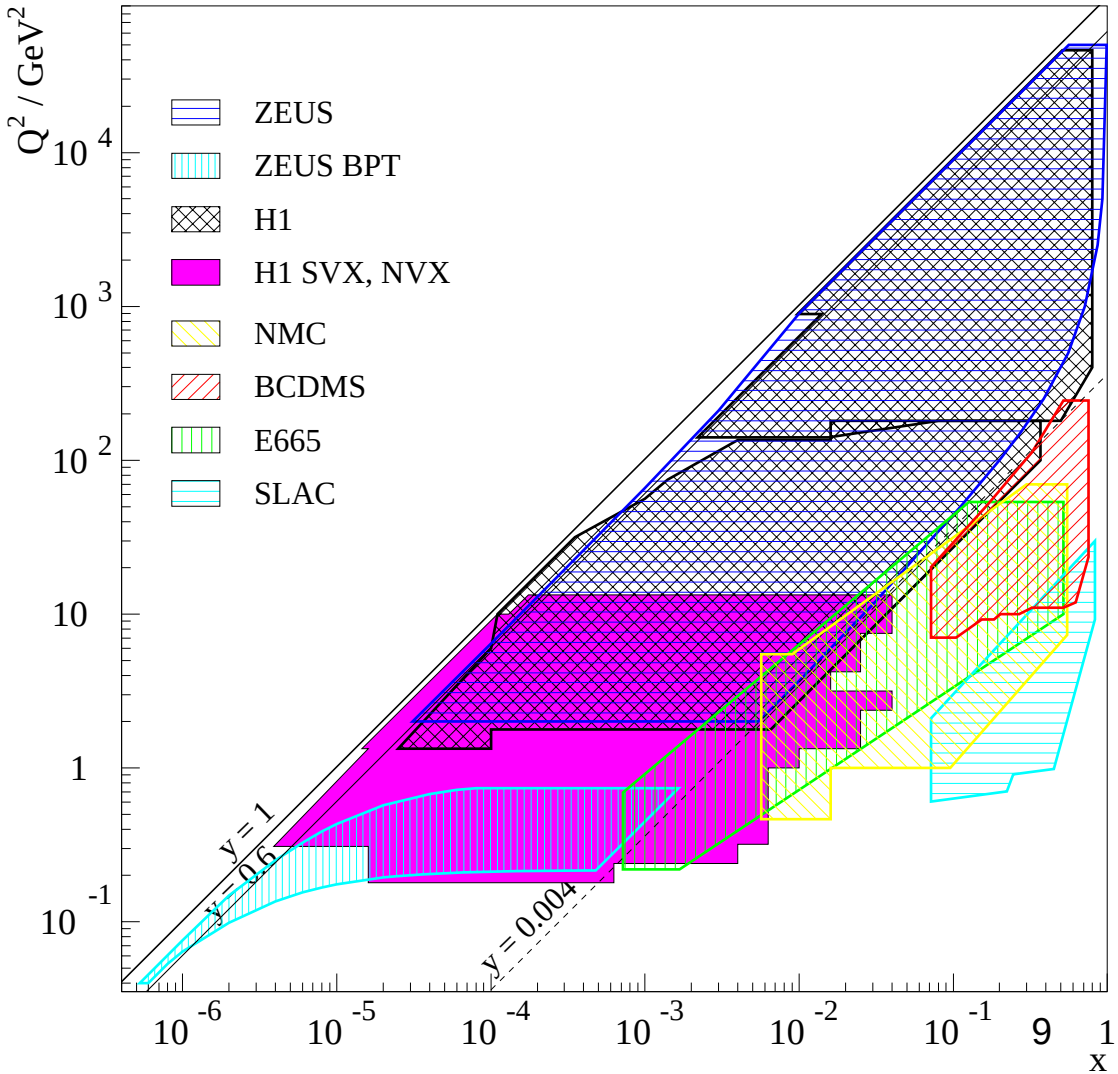
- $xF_3 \sim 2\sum_i e_i a_i x[q_i(x) - \bar{q}_i(x)]$ - determines the valence quark distributions $xq_v(x, Q^2)$

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

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

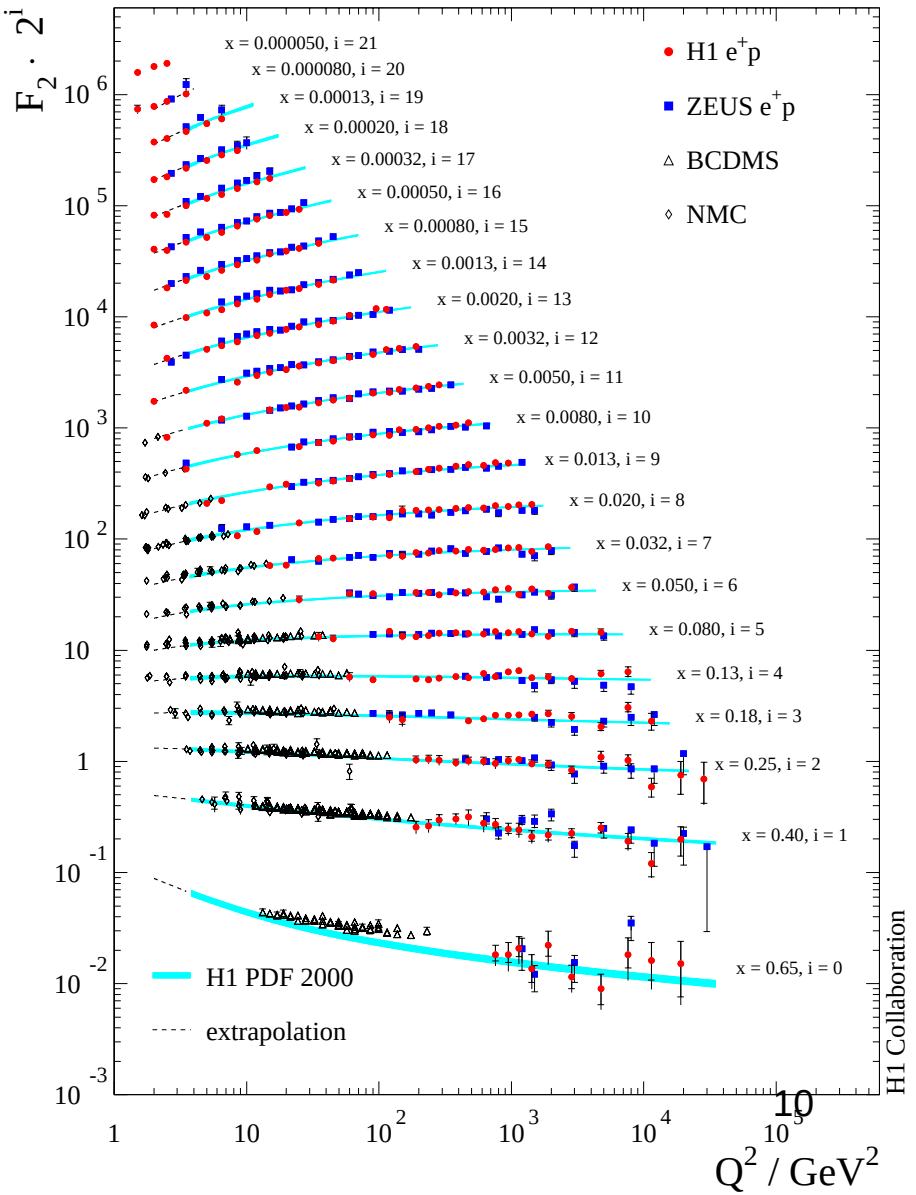
Kinematic plane coverage

- 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

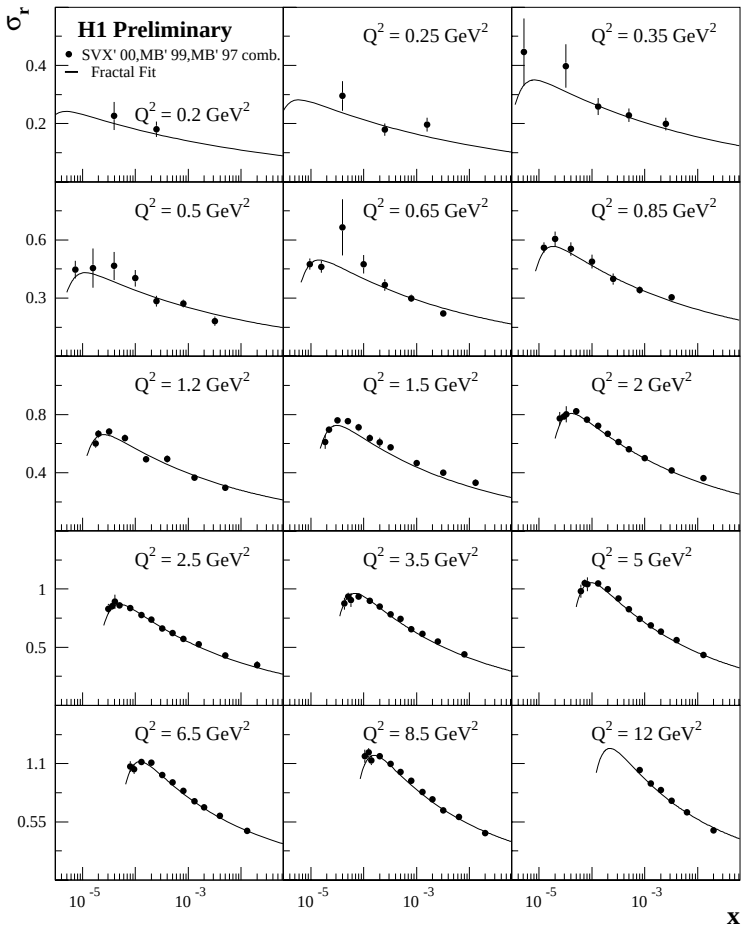


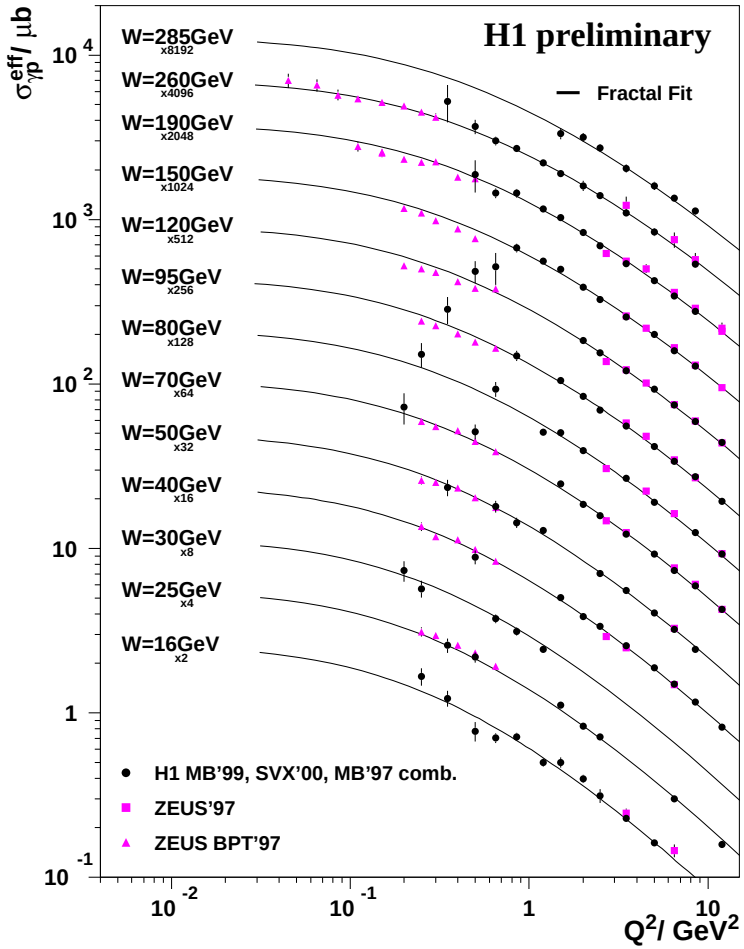
F_2 measurements

- F_2 across the whole kinematic plane
- Extend low Q^2 measurements consistent with them
- Negative scaling violation for x>0.18: running of αs
- 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 Q^2 by DGLAP fit
- 2-3% precision



Lowest Q^2 data



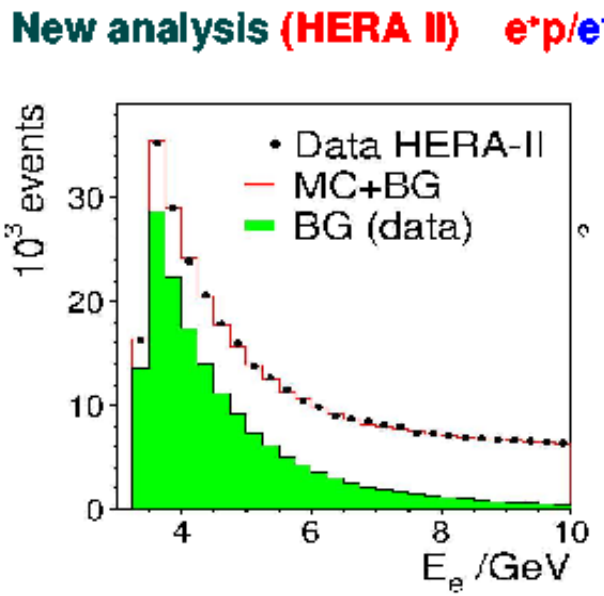


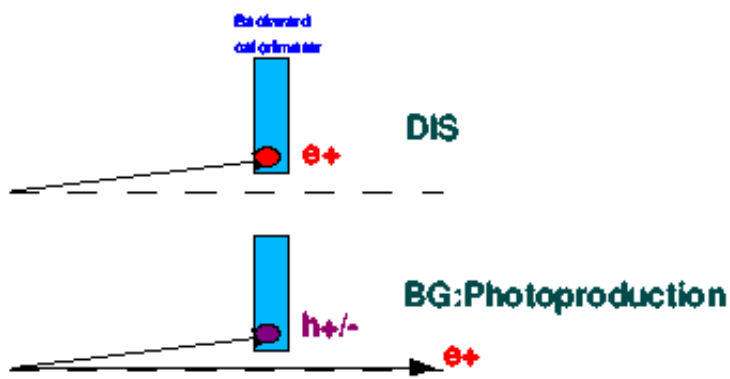
- New precision of Preliminary H1 data:1.5% for $Q^2 > 5\text{GeV}^2$
- H1 combined data cover the gap between published ZEUS results and agree with them in regions of overlap

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

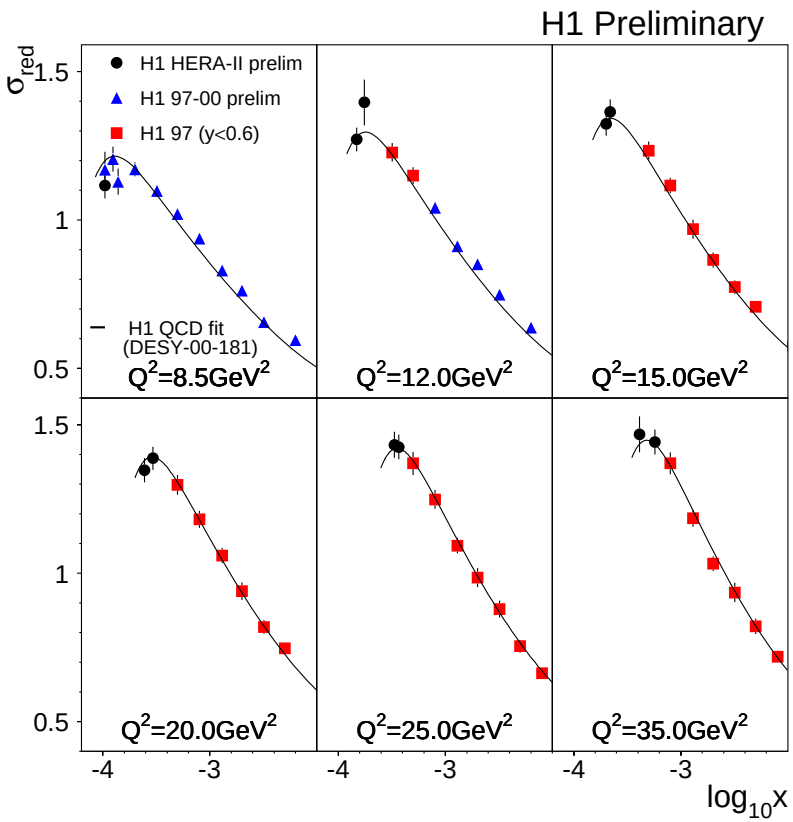
The high y measurements

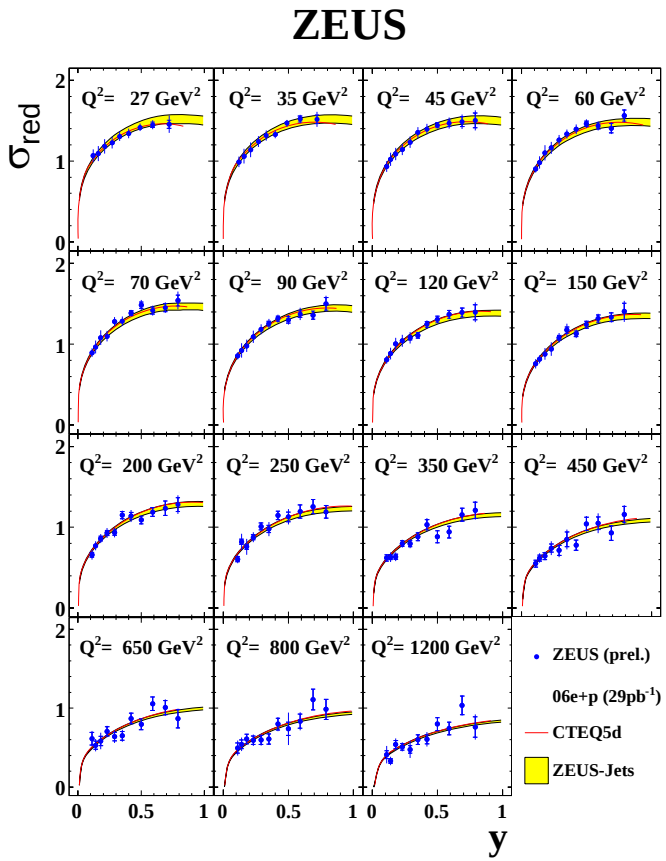
- Results of high y > 0.6 are interesting because of sensitivity to F_L : $\sigma_r(ep) = F_2 - \frac{y^2}{Y_+} F_L$
- Difficult measurements- high γp background
- H1 and ZEUS experiments have released the preliminary high y cross section results using data with E'_{min}=3.3GeV, y_{max}=0.9 for H1 and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





The high y data



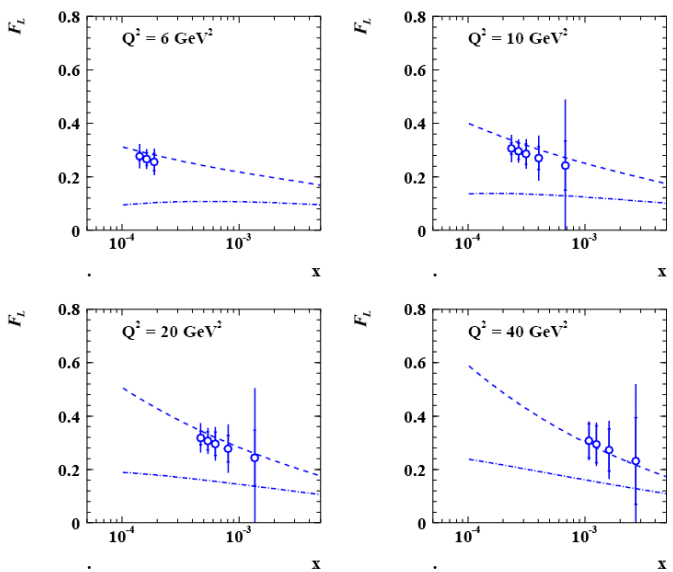


- 96 pb^{-1} for H1 result
- H1 total errors are on the level of 2-3% and improved by factor of 2 compare to published HERA 1 data
- Good sample to study experimental conditions for F_L measurement

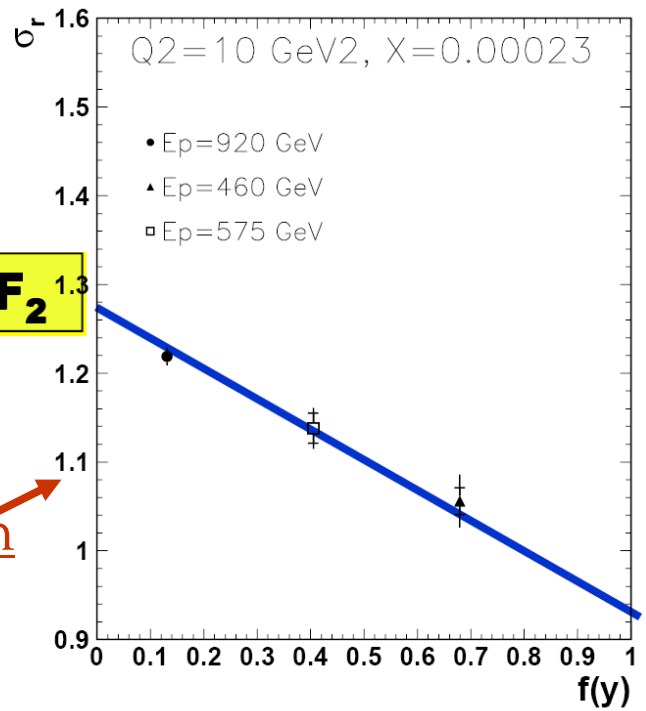
F_L measurement

- 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 Q^2-x but with different proton beam energies (different y):

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



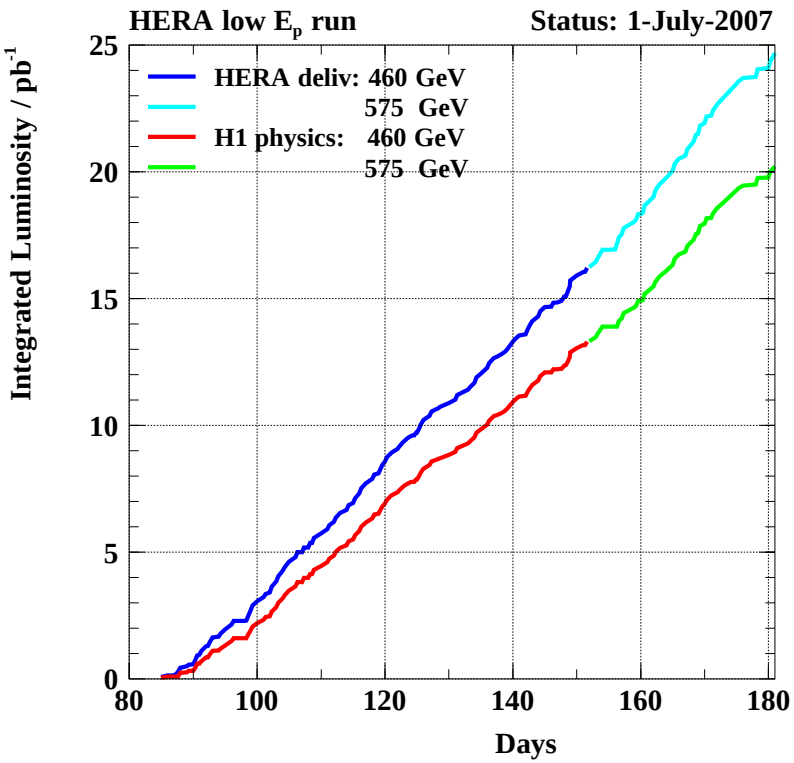
simulation

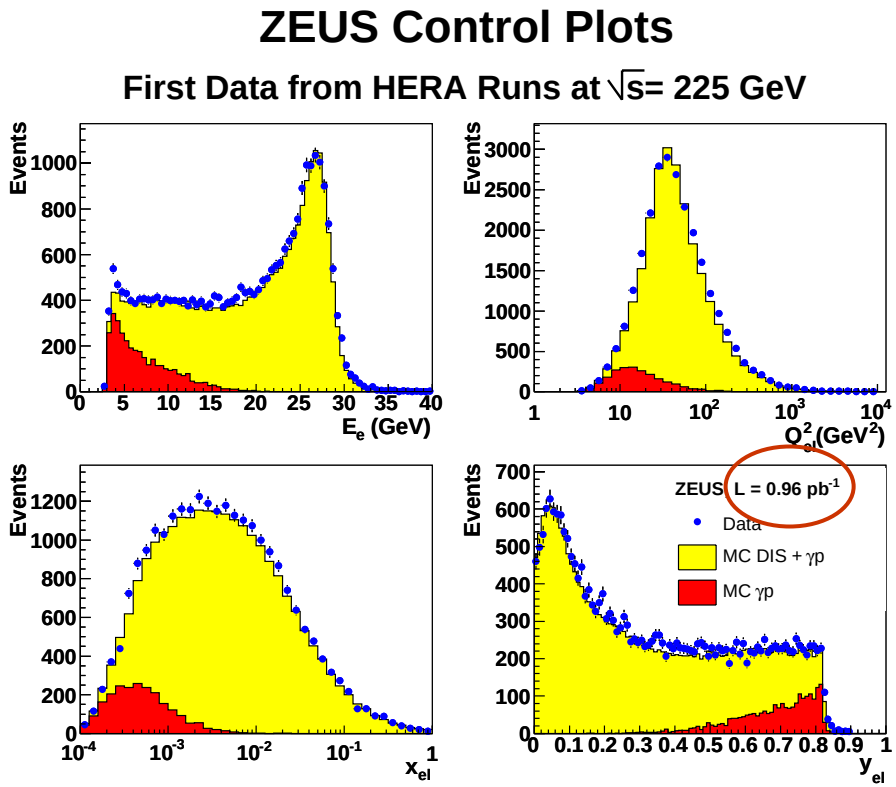


MRST CTEQ

F_2-F_L

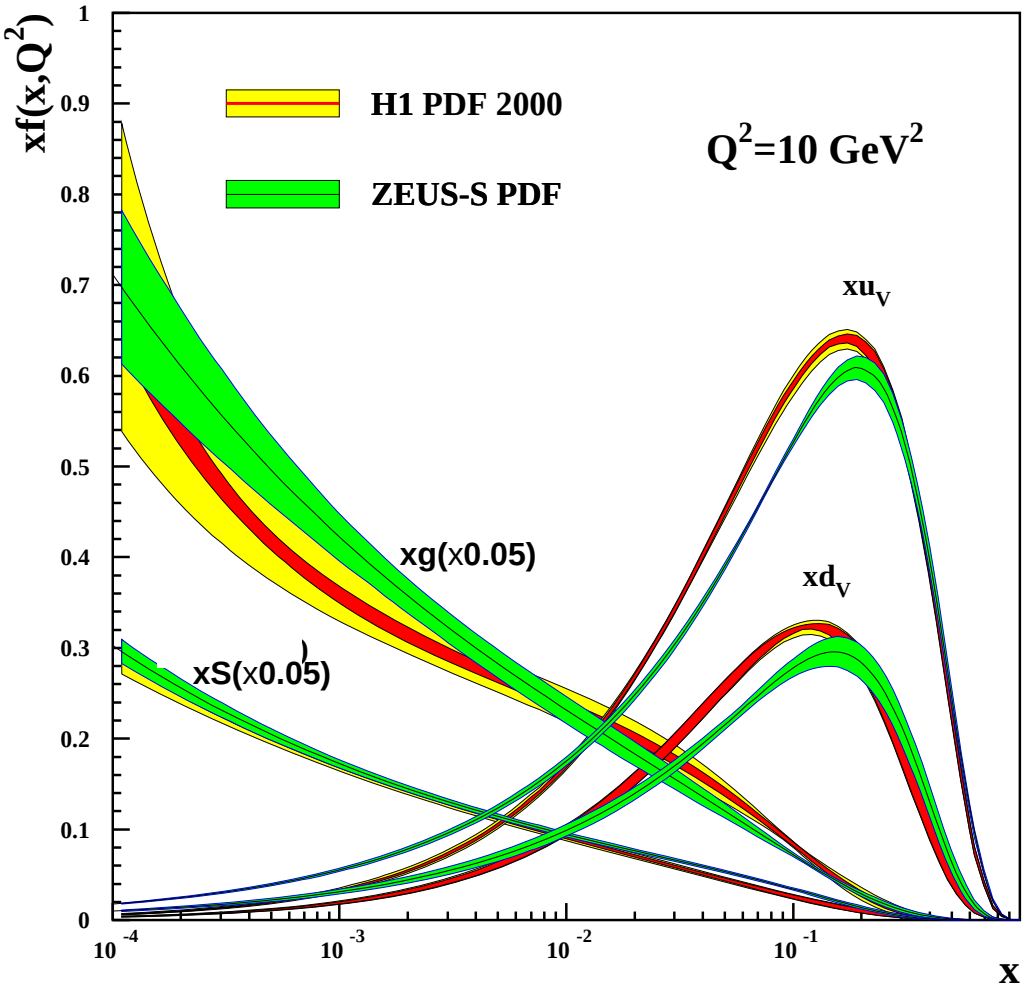
Low energy data





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

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 ~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