



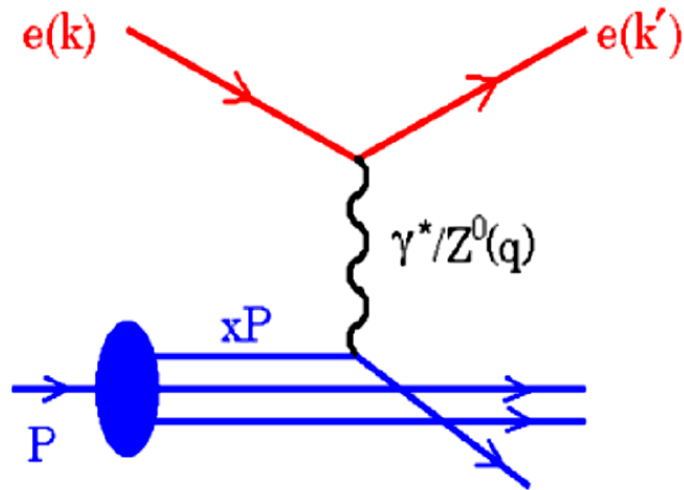
Measurement of F_L at low Q^2 by the H1 collaboration



DIS09, Madrid
S. Glazov, DESY

DIS kinematics

For low Q^2 :



$$\frac{d^2\sigma}{dx dQ^2} = \frac{2\pi\alpha^2 Y_+}{Q^4 x} \sigma_r =$$

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

where factors $Y_+ = 1 + (1 - y)^2$ and y^2 define polarization of the exchanged photon and $y = Q^2/(sx)$.

$$F_2 \sim \sigma_L + \sigma_T \quad F_L \sim \sigma_L$$

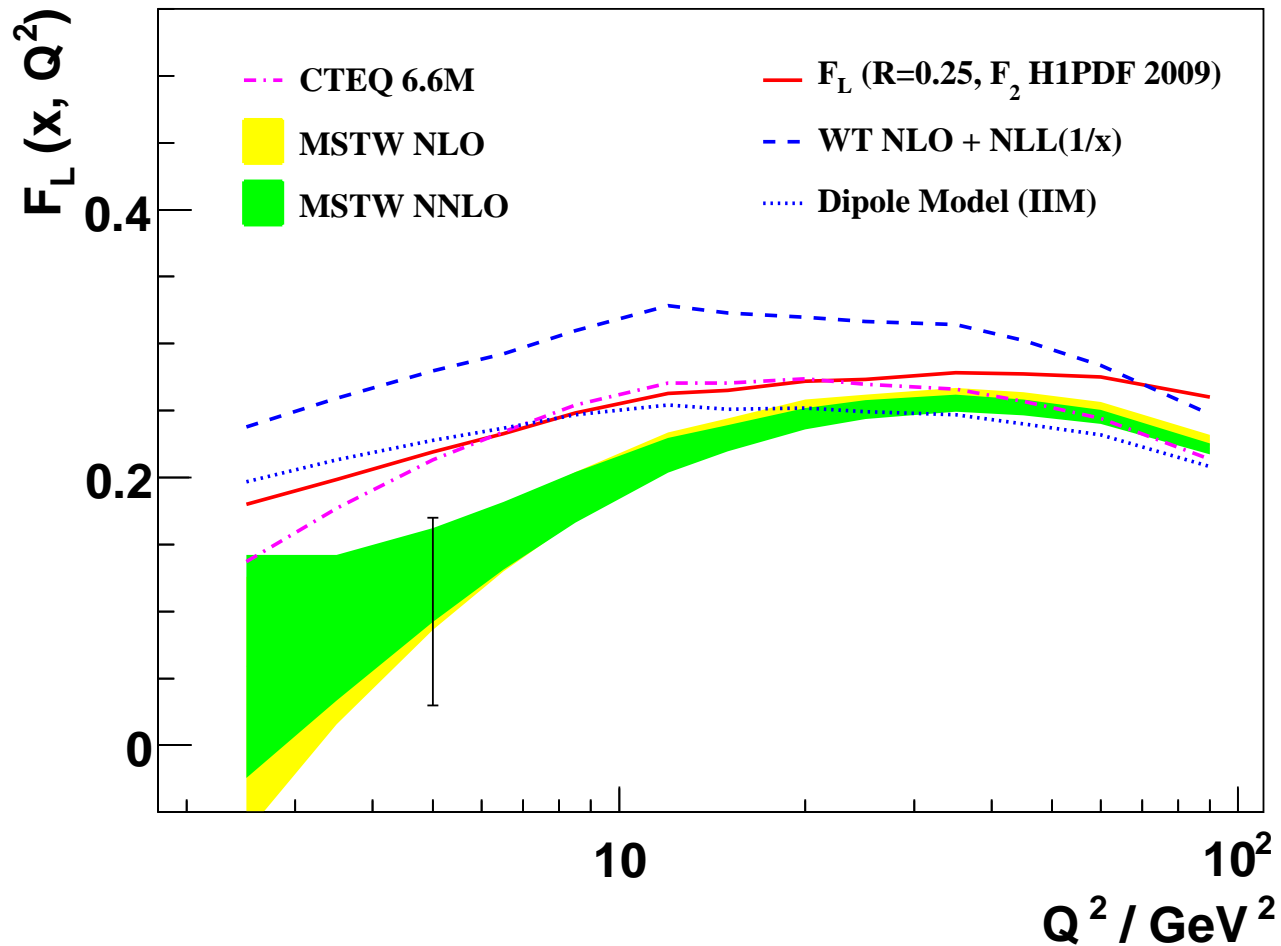
which implies $0 \leq F_L \leq F_2$.

One can define $R = \sigma_L/\sigma_T$, i.e. $F_L = \frac{R}{1+R} F_2$

- In Quark-Parton Model $F_L = 0$ for spin 1/2 quarks.
- In QCD, $F_L > 0$ due to gluon radiation.
- At low x , sea quark and gluon density are measured using F_2 and its scaling violation, $dF_2/d \log Q^2$.

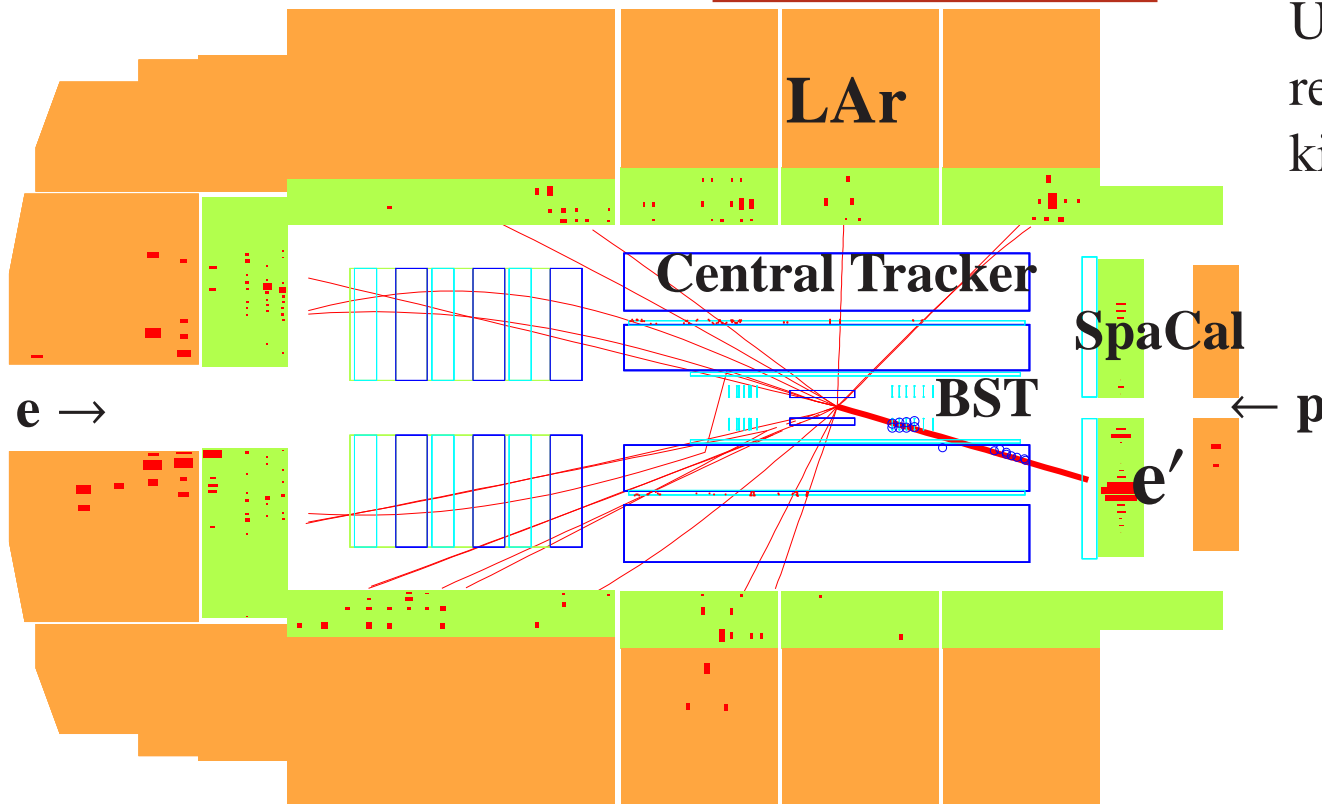
F_L measures gluon via cross section polarization decomposition.

F_L at low x and low Q^2



Significant spread of predictions for low Q^2 and low x compared to the experimental precision.

H1 Detector



Use the scattered electron to reconstruct event kinematics

$$Q^2 = 4E_e E'_e \cos^2 \frac{\theta_e}{2}$$

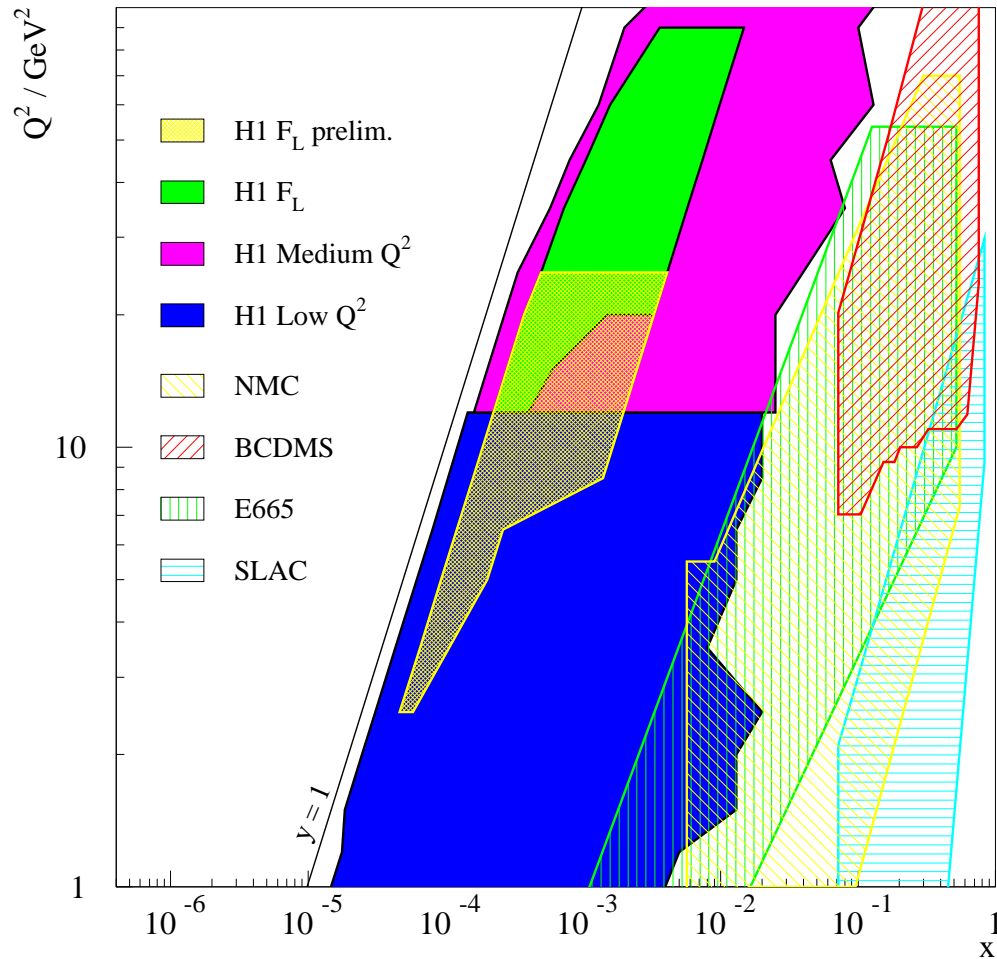
$$y = 1 - \frac{E'_e}{E_e} \sin^2 \frac{\theta_e}{2}$$

$$x = \frac{Q^2}{S y}$$

Three separate measurements, defined by electron measurement techniques:

- Medium Q^2 , $12 \leq Q^2 \leq 90 \text{ GeV}^2$, SpaCal+CT, Phys.Lett.**B665**:139 (2008)
- High Q^2 , $35 \leq Q^2 \leq 800 \text{ GeV}^2$, LAr + CT (H1 preliminary).
- low Q^2 , $2.5 \leq Q^2 \leq 25 \text{ GeV}^2$, SpaCal+BST+CT.

Kinematic Coverage

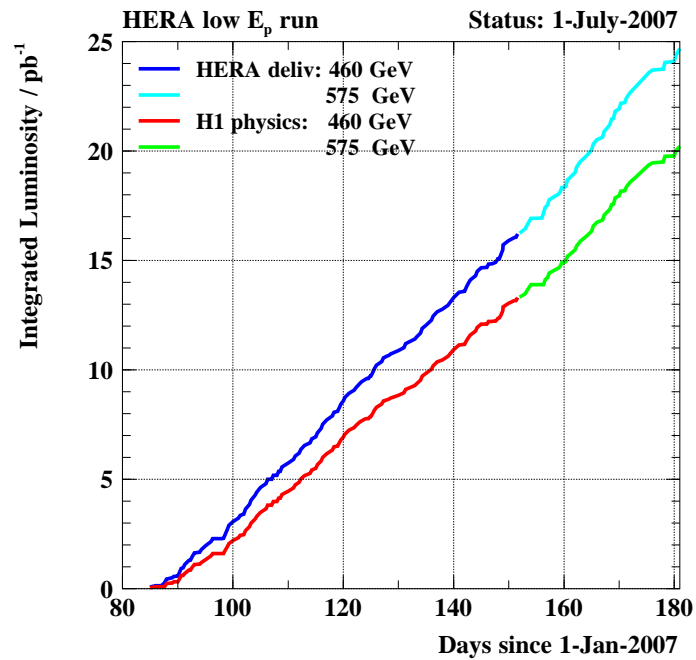
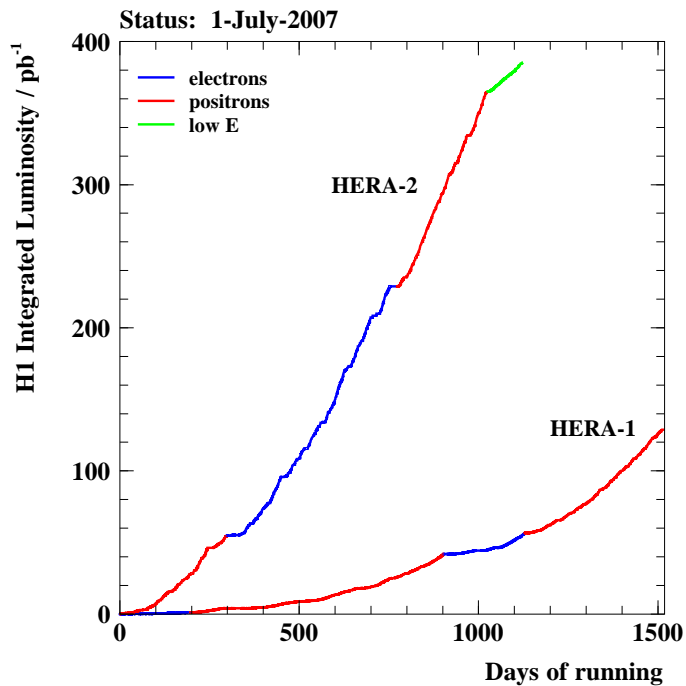


- Measure in the domain already covered by HERA DIS cross section measurements.
- Use data sets with 3 proton beam energies: $E_p=460, 575$ and 920 GeV . $E_p=920 \text{ GeV}$ sample comes from HERA-I 99-00 (see talks of J.Kretzschmar and A. Petrukhin). This gives
 - Extension of F_L measurement to $Q^2 < 6.5 \text{ GeV}^2$
 - Highest precision at low y .
- BST-CJC-SpaCal measurement for $2.5 \leq Q^2 \leq 25 \text{ GeV}^2$.
- Combined measurement using SpaCal and LAr for $Q^2 \geq 35 \text{ GeV}^2$ range.

Measurement Strategy

$$\sigma_r(x, Q^2; y) = F_2(x, Q^2) - \frac{y^2}{1 + (1 - y)^2} F_L(x, Q^2)$$

- Measure at the same x, Q^2 , different y — use different E_p
- Increase sensitivity by using largest spread in $f(y) = y^2 / (1 + (1 - y)^2)$: $E_p^{max} / E_p^{min} \rightarrow \max, y \rightarrow 1$.



High y Experimental Challenge

Measurement at both low and high y are required. High y is much more difficult.

$$y \approx 1 - \frac{E'_e}{E_e}$$

Measurement extends down to $E'_e = 3.4$ GeV.

- Trigger efficiency/rate
- Electron identification
- Radiative corrections
- Background

Background Estimation

Measure particle **charge** using curvature of the associated track.

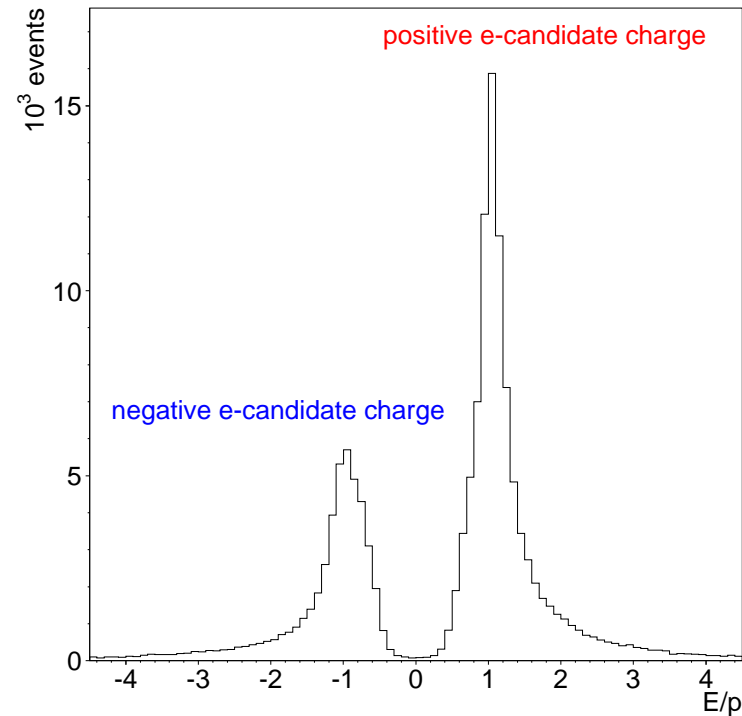
$e^+ p$ scattering:

+ Scattered lepton has the beam charge (**positive**).

– Background from hadronic particles, γ conversions is almost charge symmetric:

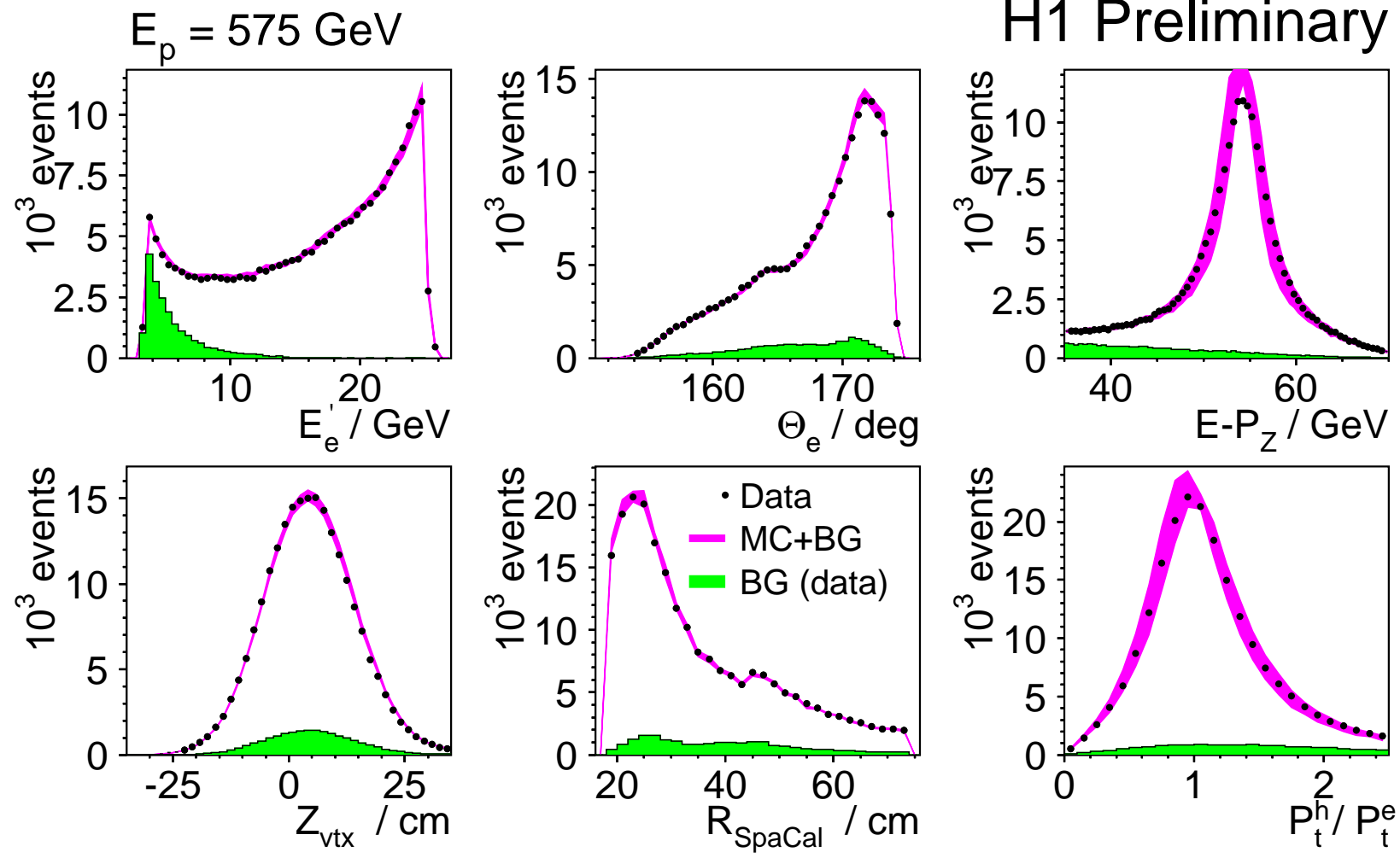
$$N_{bg}^+ \approx N_{bg}^-$$

→ require **positive** charge for the signal sample. Estimate remaining background using **negative** sample.



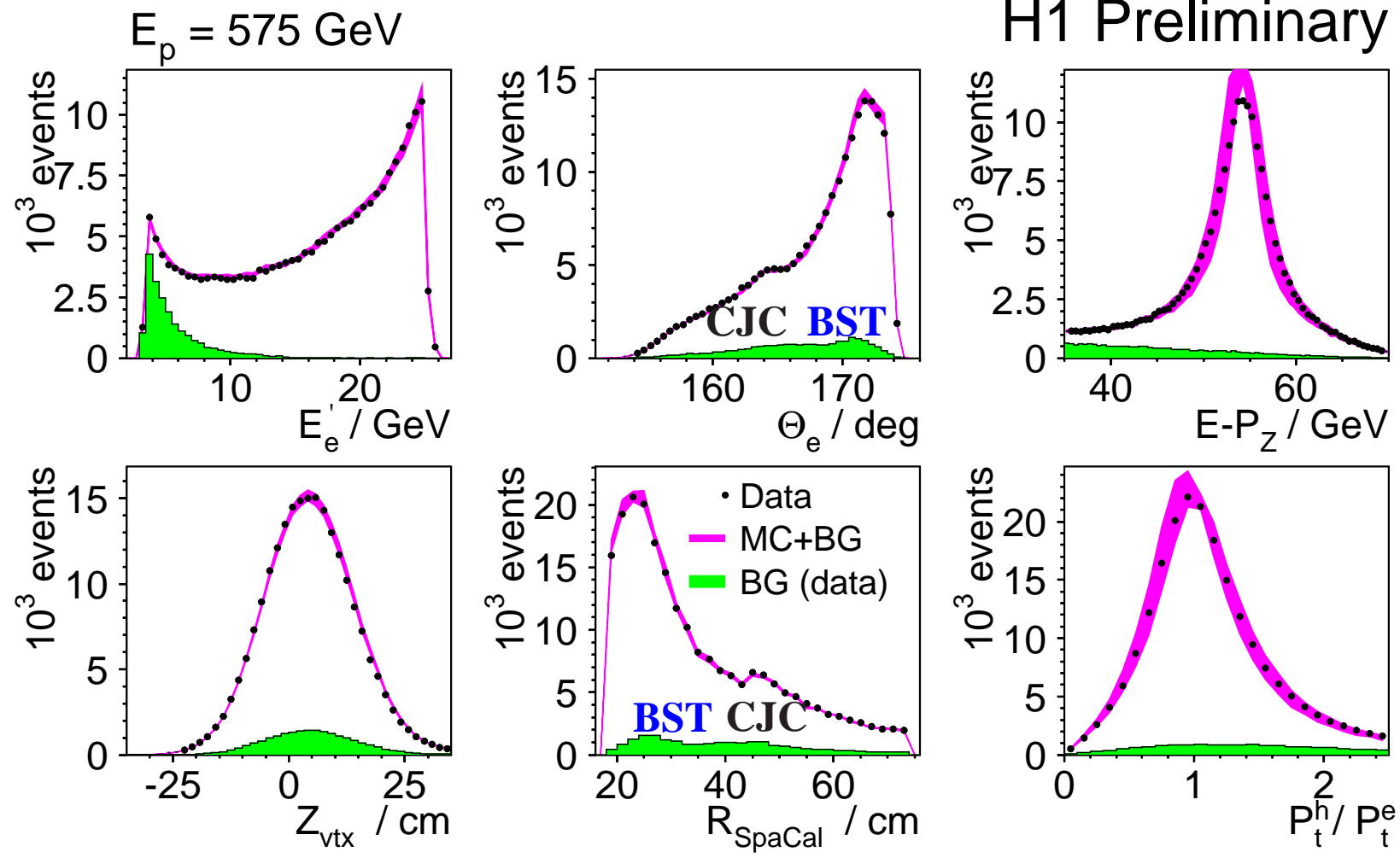
Control plots: $E_p = 575$ GeV

H1 Preliminary



Control plots: $E_p = 575$ GeV

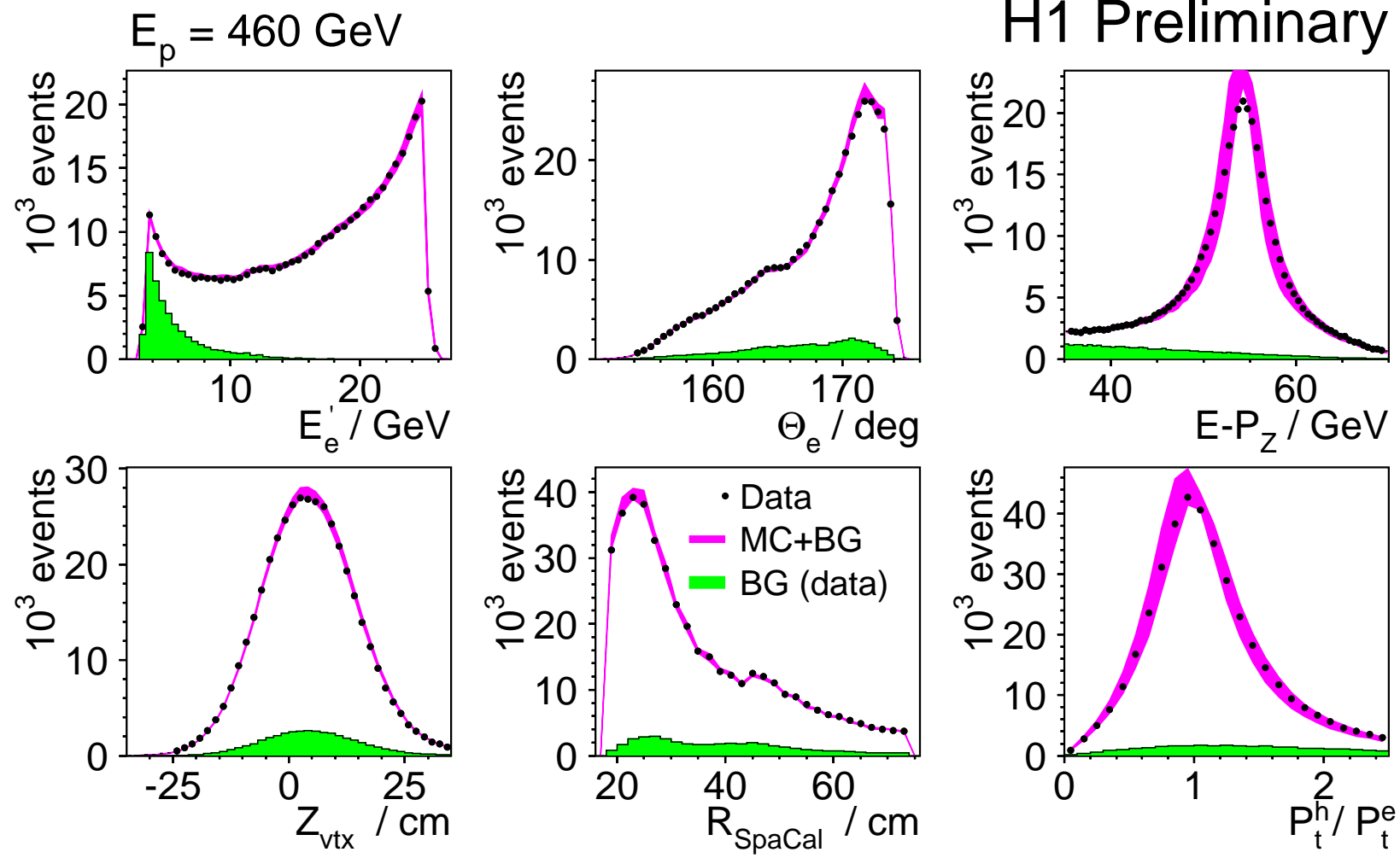
H1 Preliminary



Extension to $\theta_e > 165^\circ$, $R_{\text{SpaCal}} < 40$ cm vs previous analysis

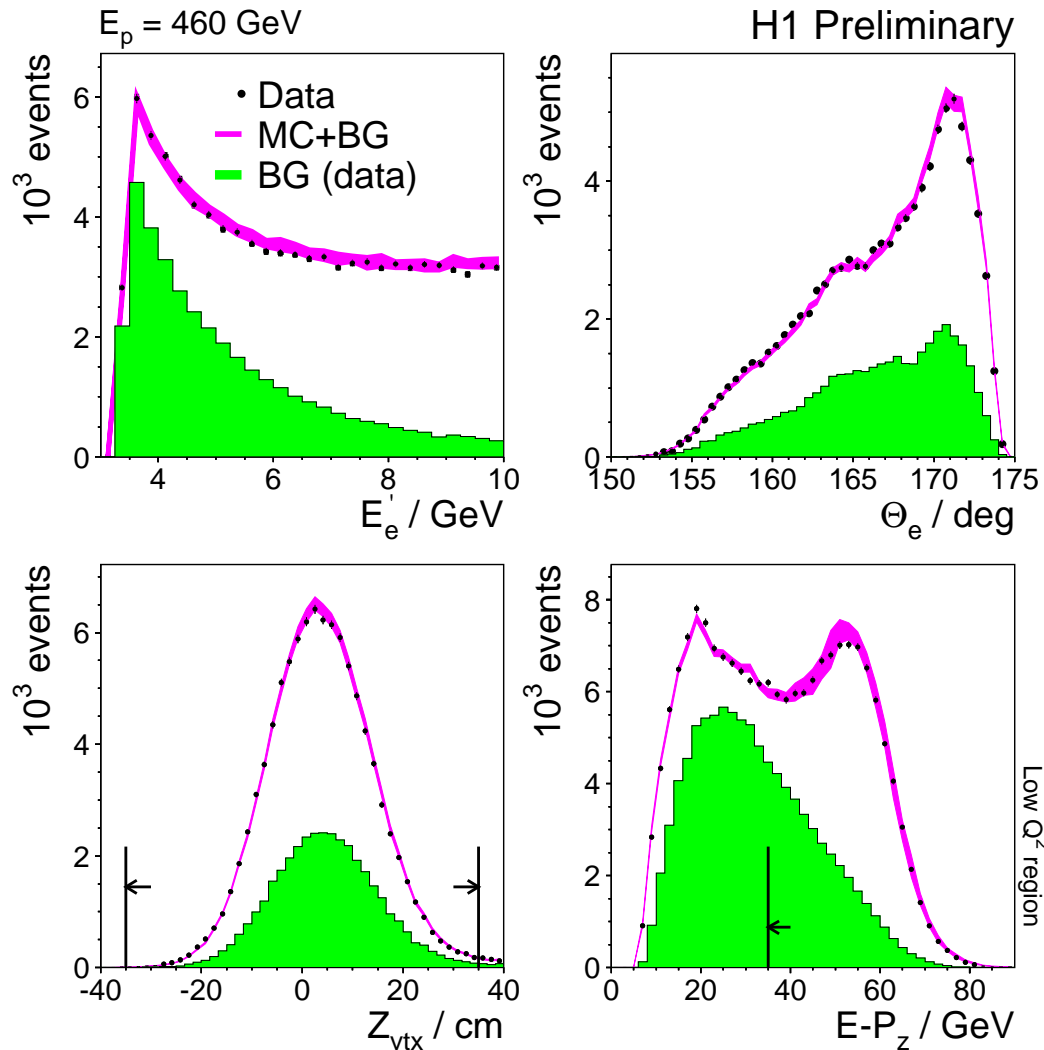
Control plots: $E_p = 460 \text{ GeV}$

H1 Preliminary



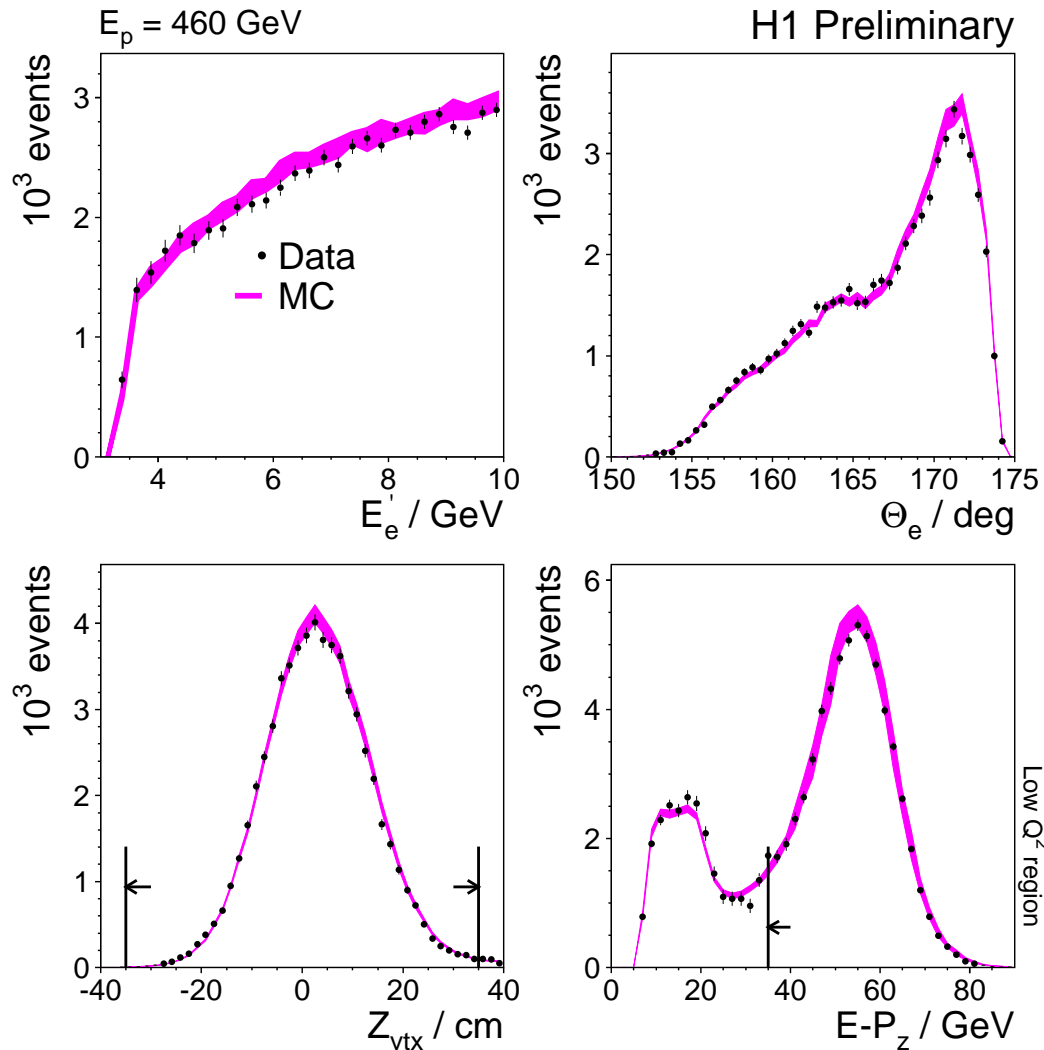
Band shows MC and background stat. and correlated syst. uncertainties.

Control plots: High y



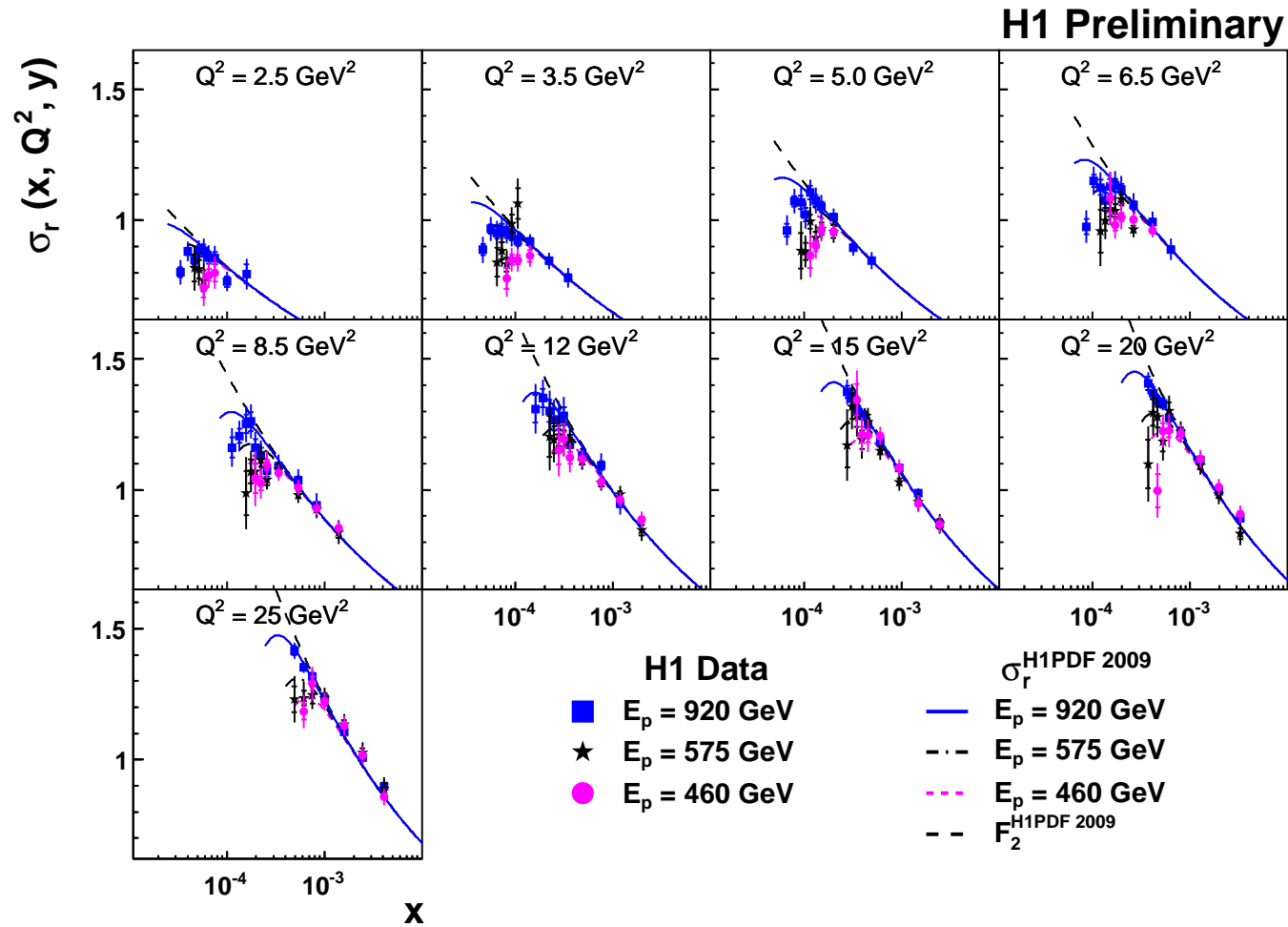
- Before background subtraction
- $E_p = 460$ GeV
- $E_e' > 3.4$ GeV.
- Lines indicate cut values
- $E - p_z$ is effective against background

Control plots: High y



- After background subtraction
- $E_p = 460$ GeV
- $E_e' > 3.4$ GeV.
- Lines indicate cut values
- $E - p_z$ is effective against ISR radiation

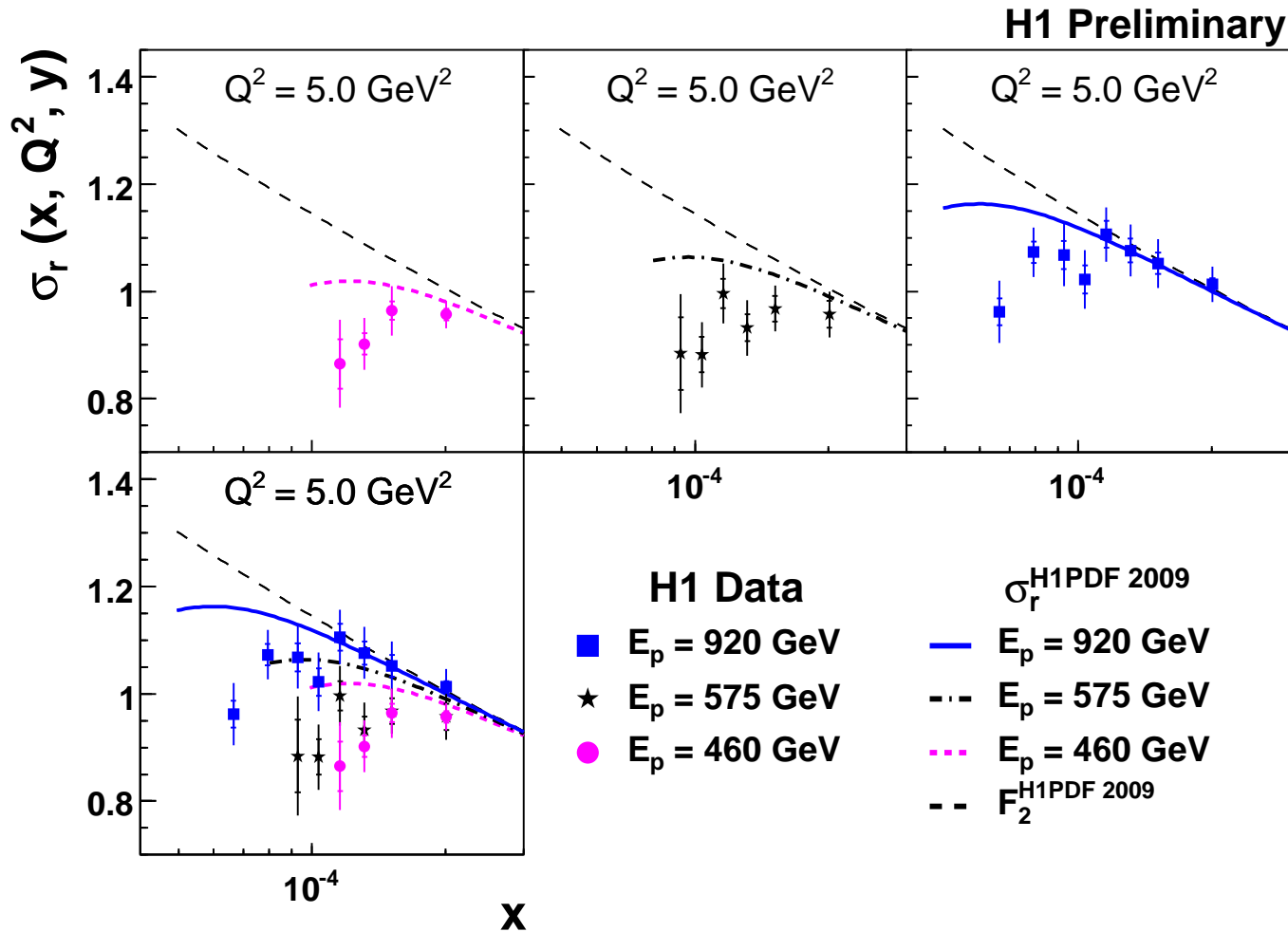
σ_r for $E_p = 460, 575$ and 920 GeV



H1PDF 2009 — New fit to H1 data, see talk of J. Kretzschmar

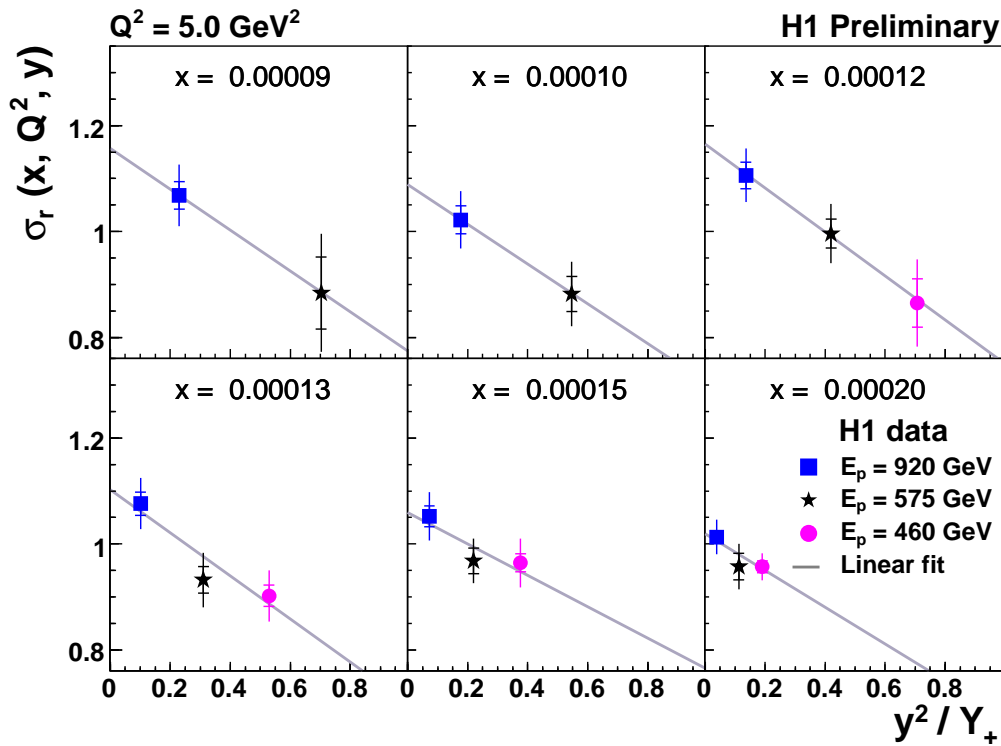
Turn-over of the cross section from F_2 at low x is due to F_L

σ_r for $E_p = 460, 575$ and 920 GeV for $Q^2 = 5$ GeV²



Data at low x is consistently lower vs H1PDF 2009 prediction.

F_L extraction



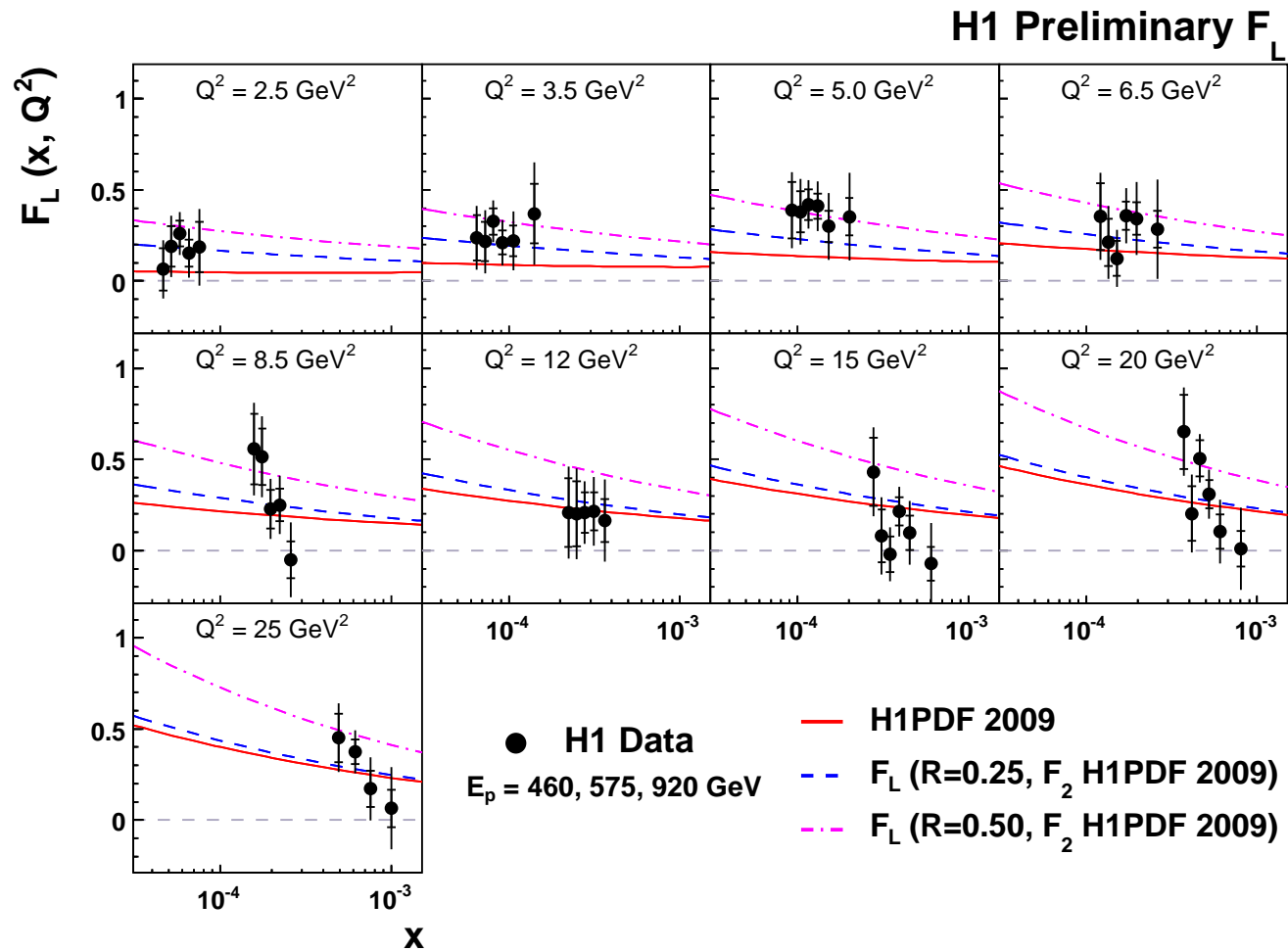
$$\sigma_r(y) = F_2 - \frac{y^2}{1 + (1 - y)^2} F_L$$

- Linear fit to get F_2 and F_L
- Relative normalization from low y data

Data at $E_p = 575$ provides cross check and extends measurement to low x .

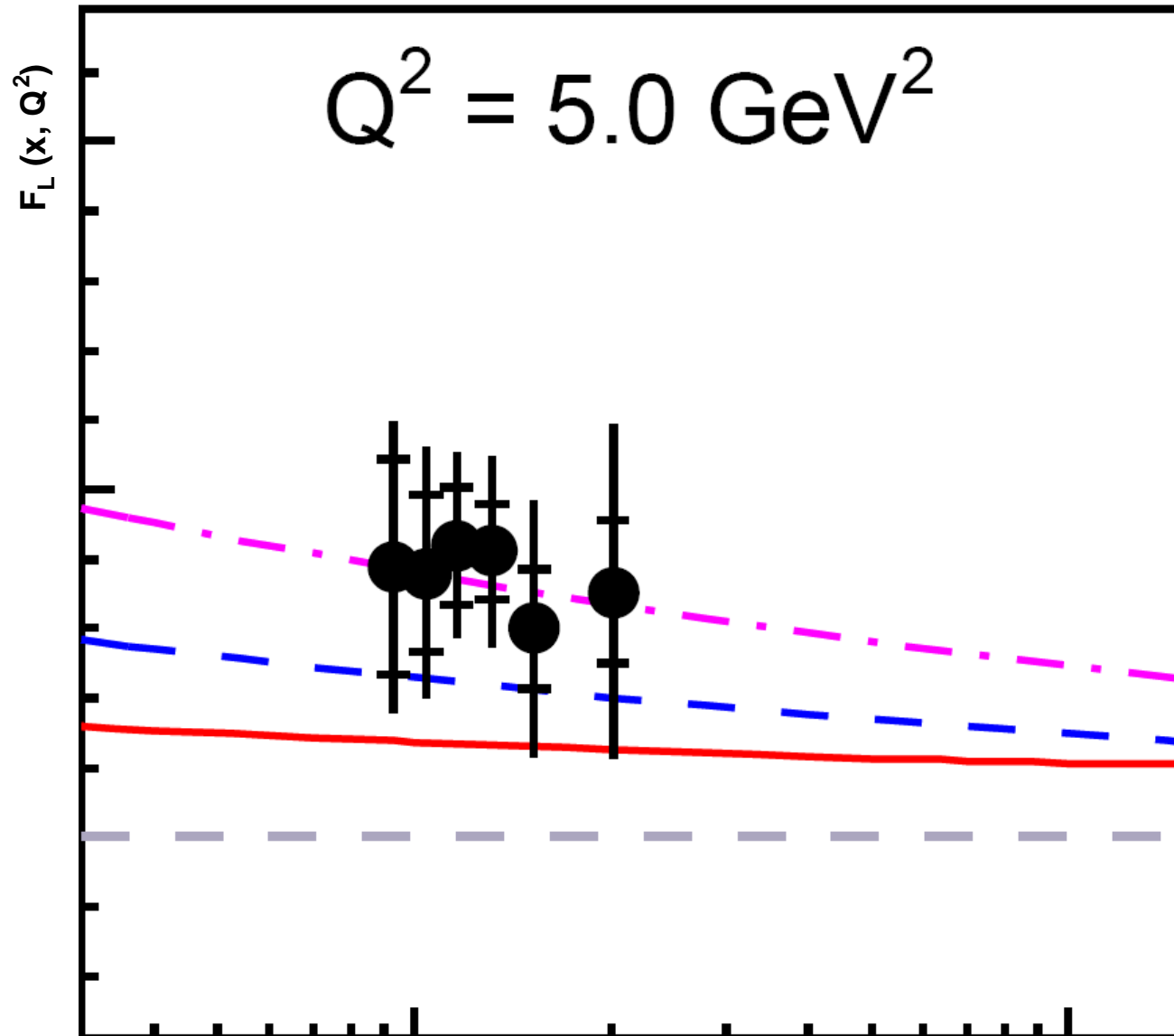
Consistent slope — consistent F_L for different x bins.

F_L vs x, Q^2

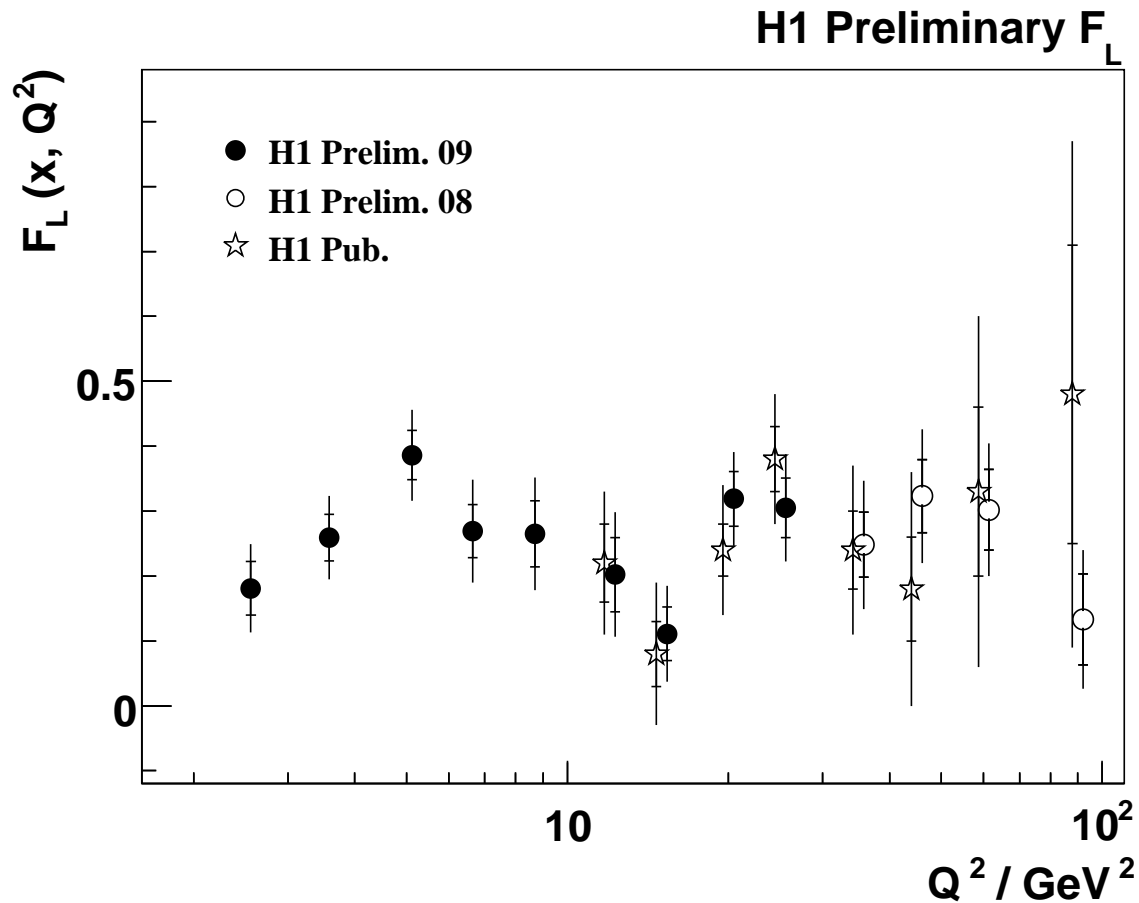


Data are consistent with $R \sim 0.25$ ($F_L = 0.2F_2$)

F_L vs x, Q^2

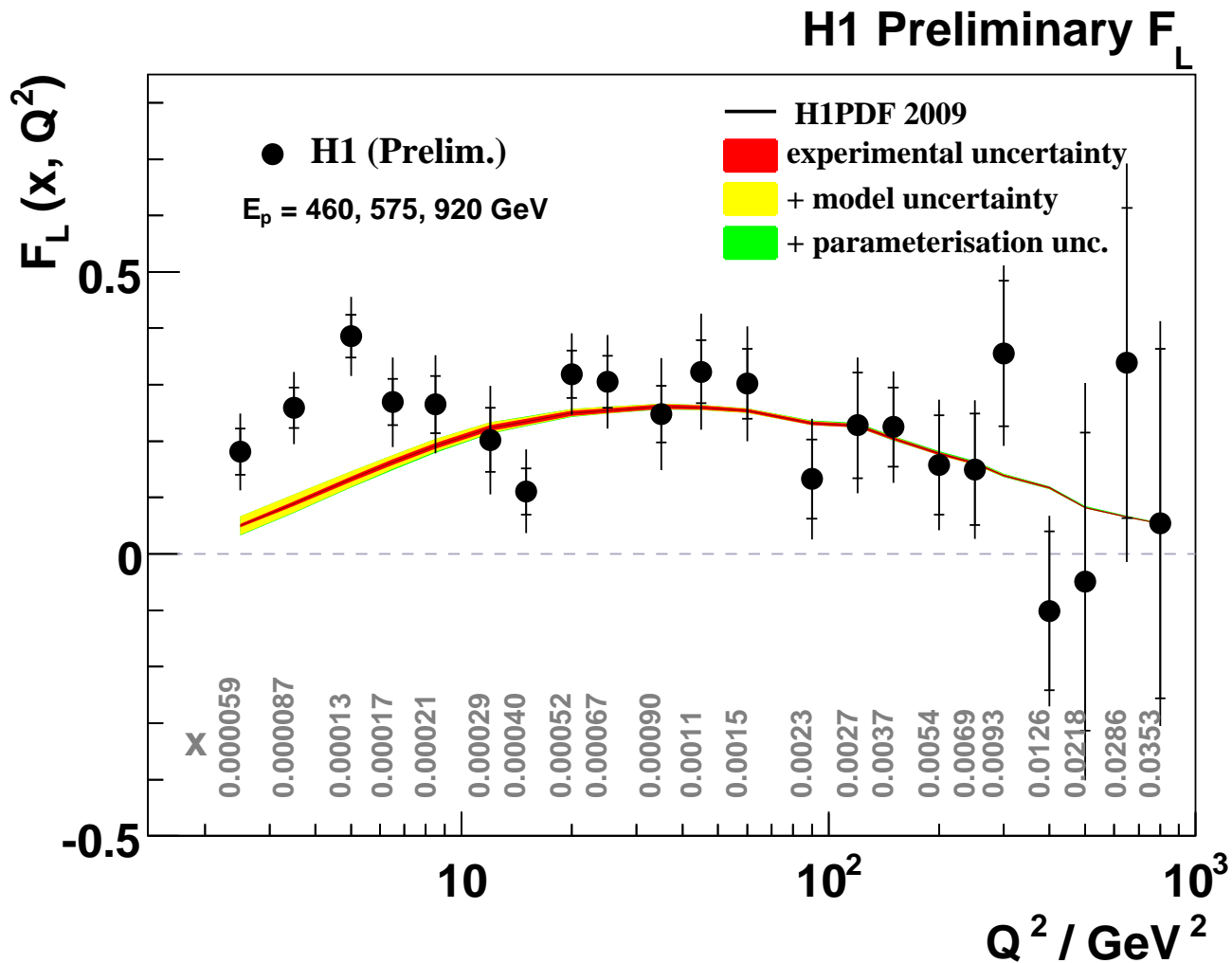


New vs previous H1 analyses



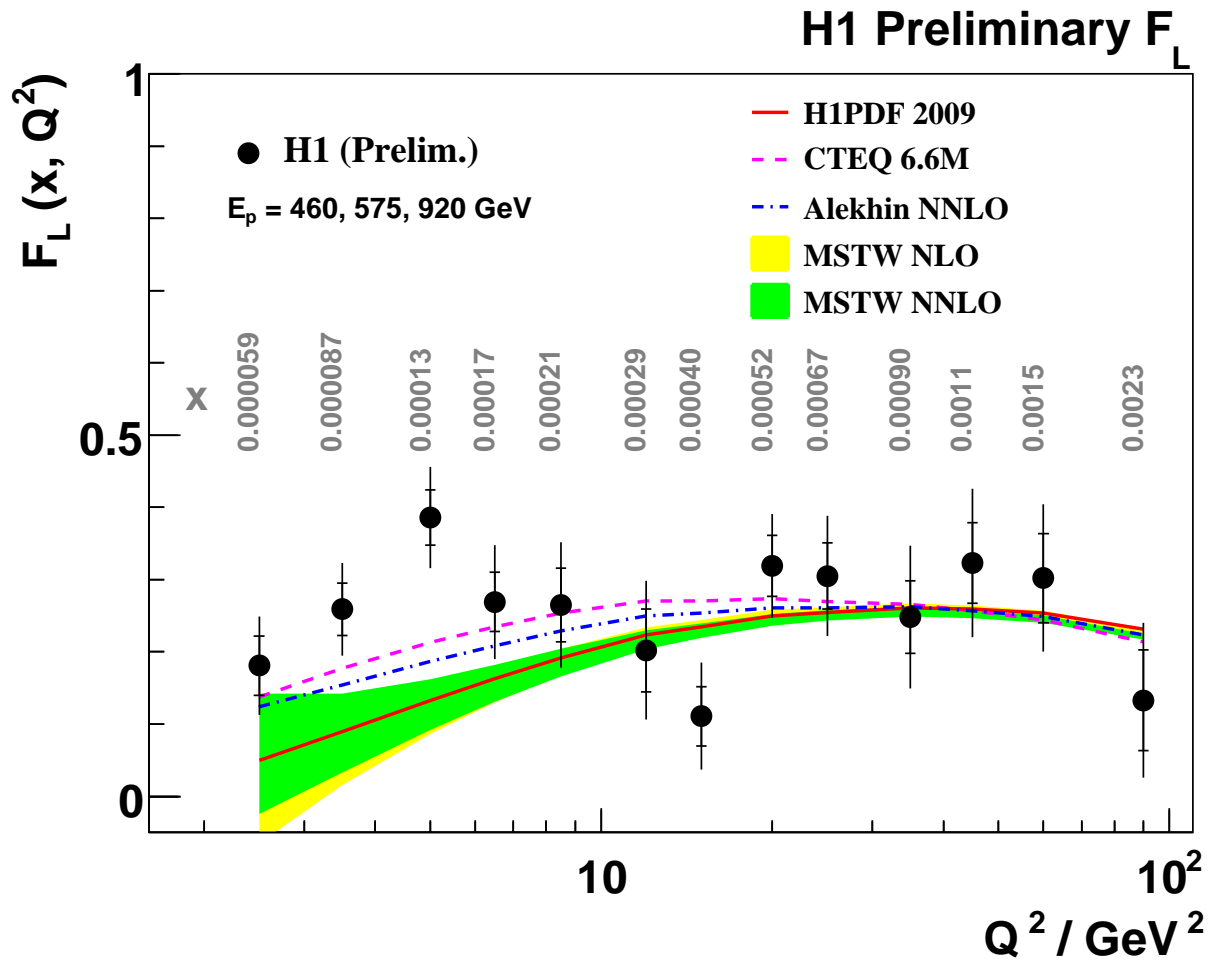
Averaged H1 data compared to the published CT-SpaCal and preliminary LAr-SpaCal analyses. Significant improvement for $Q^2 \leq 15 \text{ GeV}^2$.

F_L measured by H1



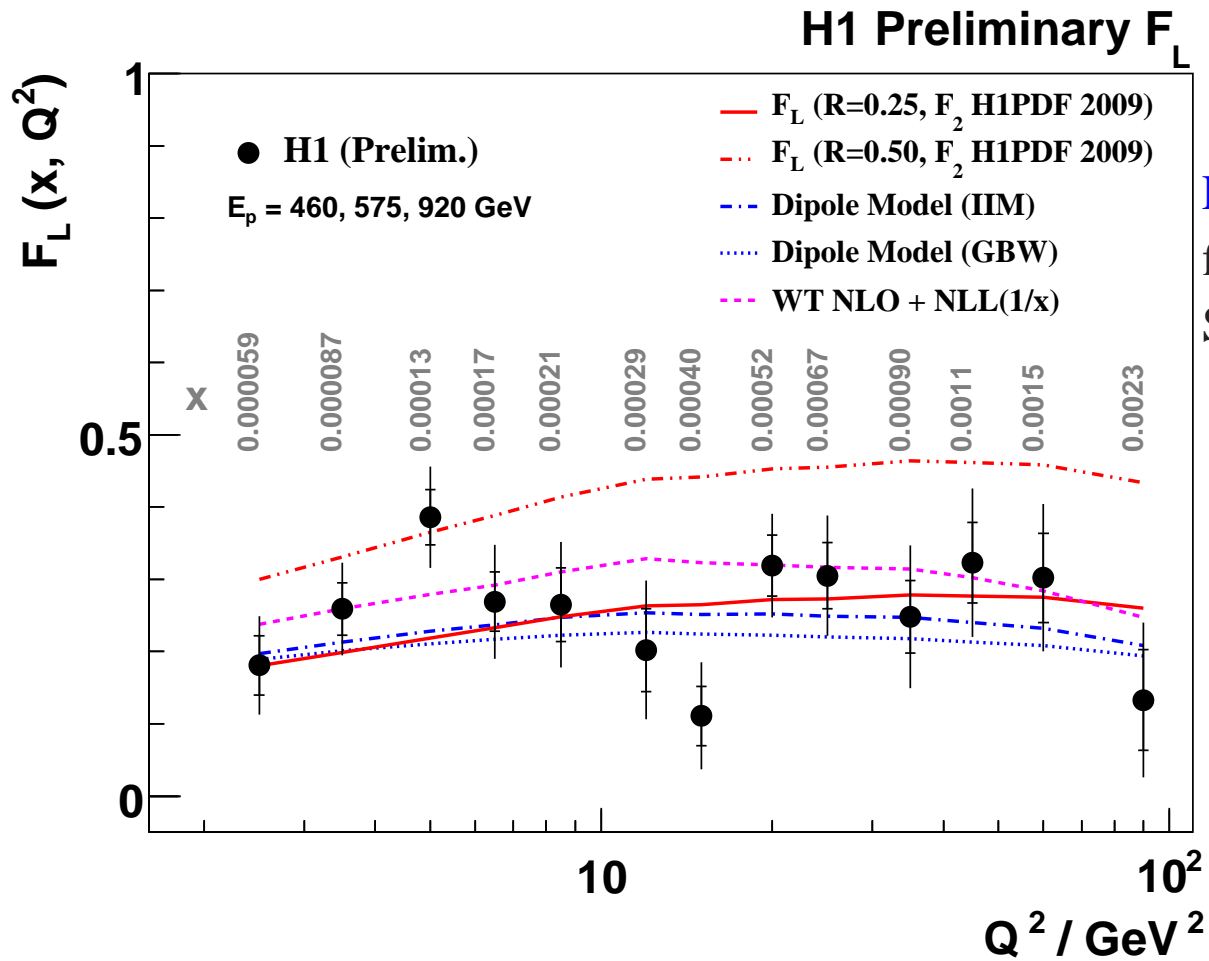
H1 measurements cover $2.5 \leq Q^2 \leq 800 \text{ GeV}^2$ and $0.00005 \leq x \leq 0.04$ range
 For $Q^2 \geq 10 \text{ GeV}^2$, agree well with H1PDF 2009 prediction.

F_L measured at $Q^2 < 100 \text{ GeV}^2$



MSTW and H1PDF 2009 predictions use the same scheme to calculate F_L .
Data agree better with calculation of CTEQ.

F_L vs phenomenological models.



Dipole Models:
fits to low Q² H1 data
See talk of A. Petrukhin

Data is consistent with constant $R \sim 0.25$.
 Good agreement with IIM and GBW dipole models, NLL(1/x) prediction.

Summary

- F_L is measured for the first time at HERA down to $Q^2 = 2.5 \text{ GeV}^2$.
- Data are consistent with constant $R \sim 0.25$ and well described by dipole models.
- Measured F_L is higher than the predictions of MSTW at NLO and NNLO as well as H1PDF2009 for $Q^2 < 10 \text{ GeV}^2$, agree better with the CTEQ 6.6M and Alekhin NNLO predictions.