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Charged Current Interactions in $e^\pm p$ Scattering at H1 with Longitudinally Polarized Lepton Beams



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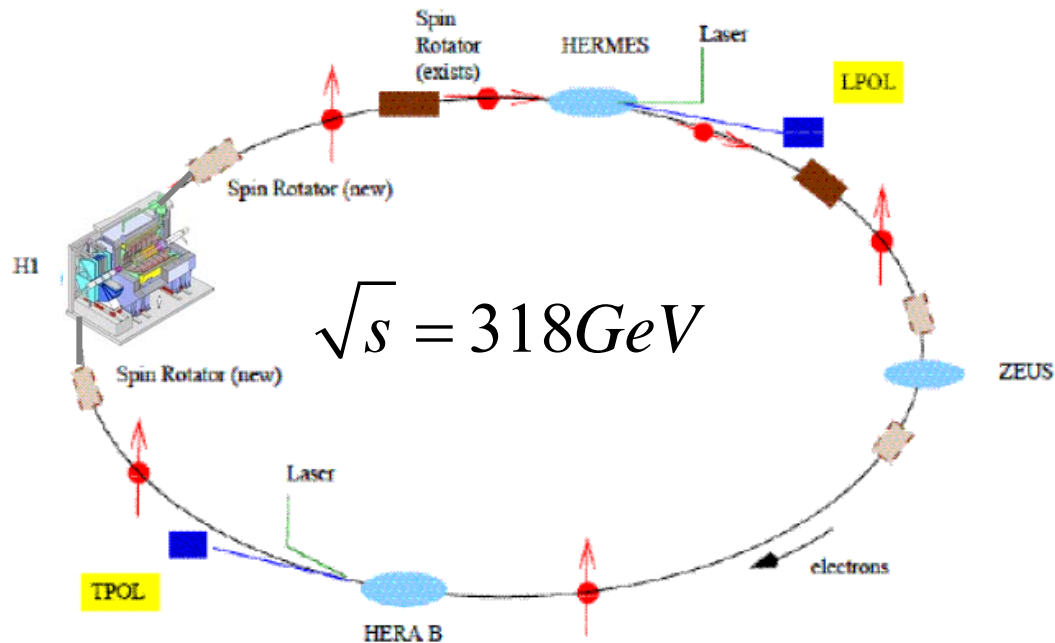
on behalf of the H1 collaboration

HERA II with Longitudinal Polarization of e^\pm Beams

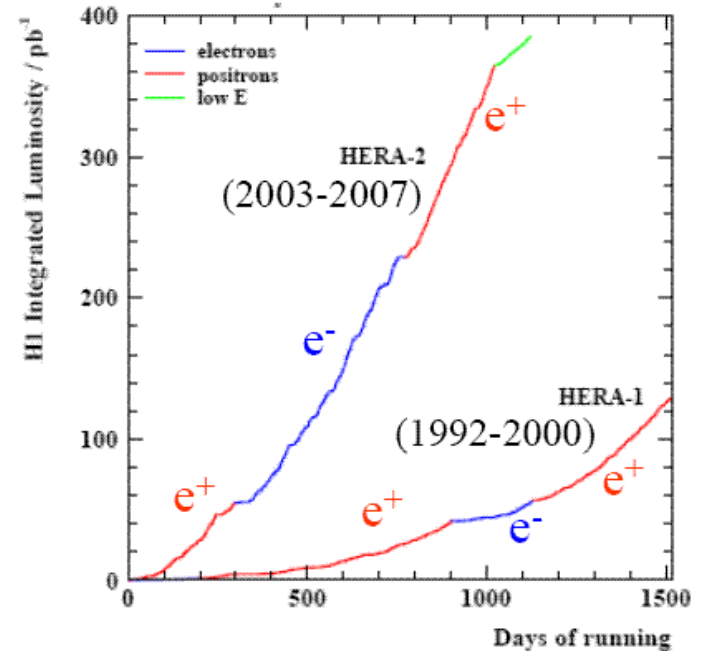
HERA upgrade

→ increase specific luminosity

→ provide longitudinally polarized lepton beam



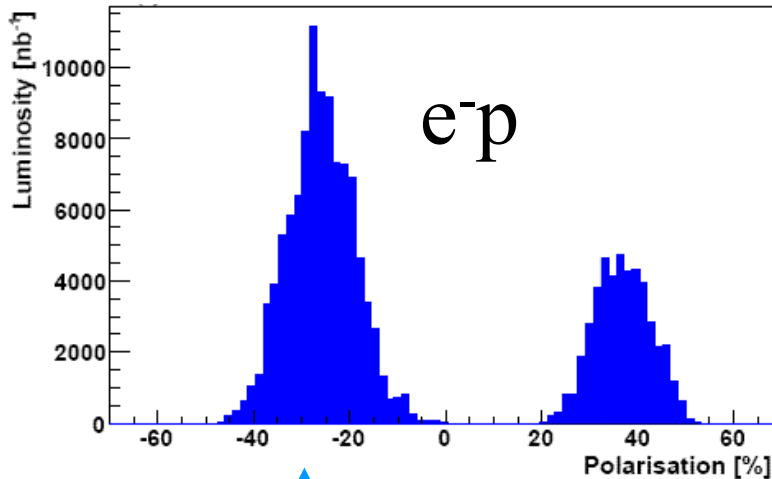
	HERA I	HERA II
e^+p	100 pb^{-1}	180 pb^{-1}
e^-p	15 pb^{-1}	150 pb^{-1}



Longitudinal polarization

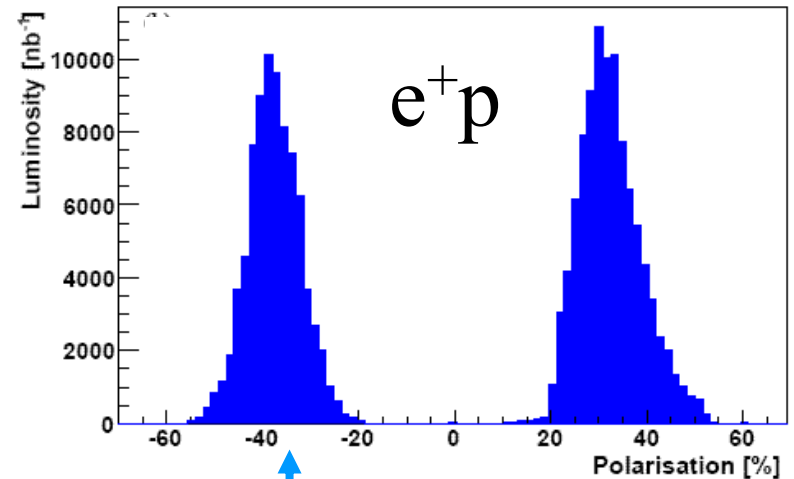
$$P_e = (N_R - N_L)/(N_R + N_L) \approx 40\%$$

Luminosity and Polarization for HERA II



Lumi = 103.2 pb^{-1}
 $P_e = (-26.1 \pm 1.0)\%$

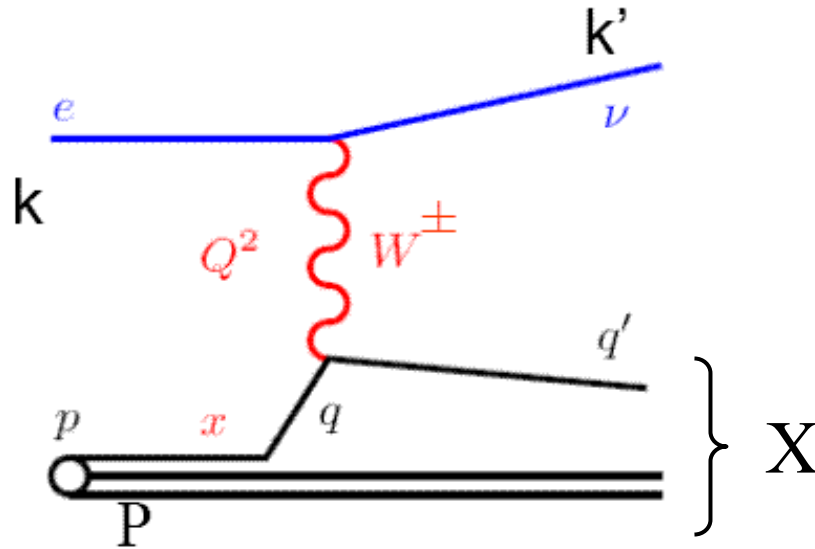
Lumi = 45.9 pb^{-1}
 $P_e = (+36.9 \pm 2.3)\%$



Lumi = 81.9 pb^{-1}
 $P_e = (-37.6 \pm 1.4)\%$

Lumi = 98.1 pb^{-1}
 $P_e = (+32.5 \pm 1.2)\%$

Deep Inelastic Scattering



Negative 4-momentum transfer squared

$$Q^2 = -(k - k')^2$$

Bjorken x: momentum fraction of proton carried by the struck quark

$$x = Q^2 / 2(Pq)$$

Inelasticity

$$y = (Pq) / (Pk)$$

Charge Current (CC) Interaction

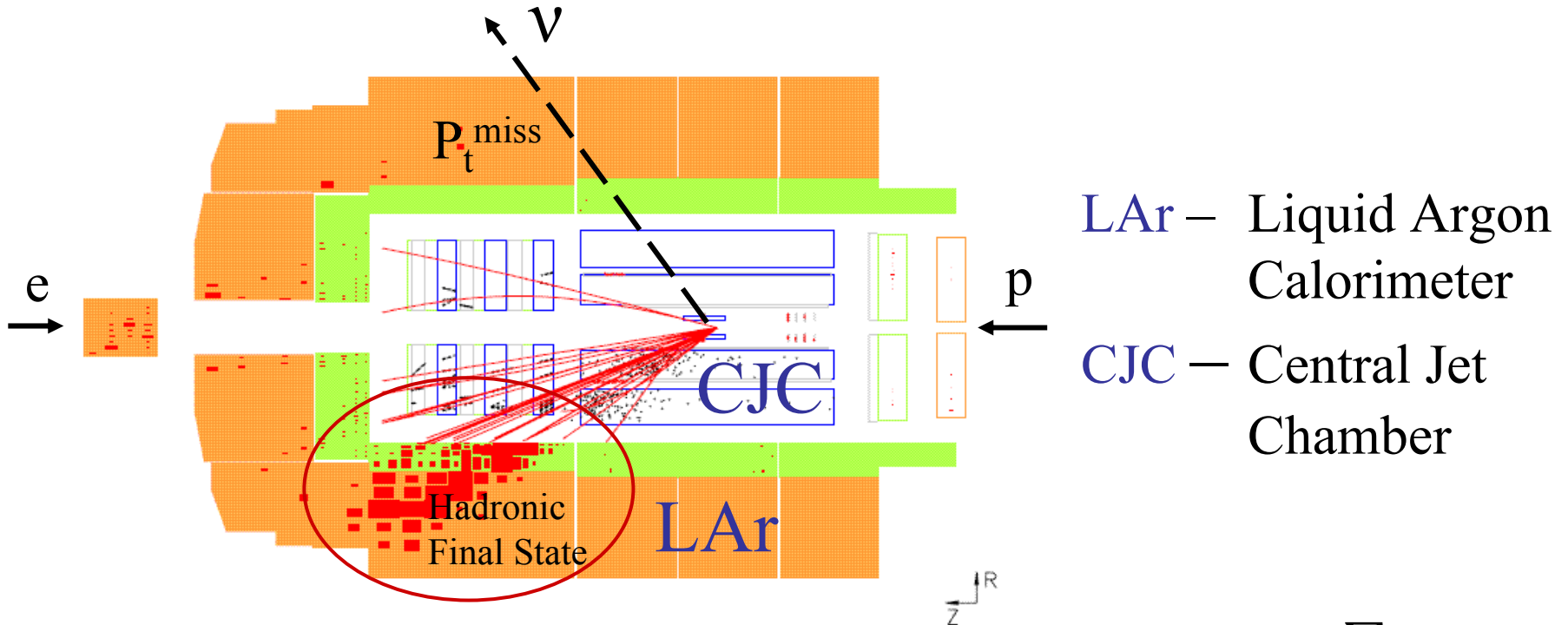
$$e p \rightarrow \nu X$$

Center-of-mass energy squared

$$s = (k + P)^2$$

are related as $Q^2 = sxy$

Charge Current in the H1 Detector



Kinematic variables

$$y_h = \frac{E_h - p_{z,h}}{2E_e}$$

$$Q_h^2 = \frac{P_{T,h}^2}{1 - y_h}$$

$$x_h = \frac{Q_h^2}{s y_h}$$

$$E_h - p_{z,h} \equiv \sum_i (E_i - p_{z,i})$$

Charged Current Cross Section

$$\frac{d^2 \sigma_{CC}^{\pm}}{dx dQ^2} = (1 \pm P_e) \frac{G_F^2}{4\pi x} \left[\frac{M_W^2}{M_W^2 + Q^2} \right]^2 \left(Y_+ W_2^{\pm} - Y_{\mp} x W_3^{\pm} - y W_L^{\pm} \right)$$

$$P_e = \frac{N_R - N_L}{N_R + N_L}, \quad N_R(N_L) \text{ - number of right (left) handed leptons in the beam} \quad Y_{\pm} = 1 \pm (1 - y)^2$$

in QPM: $W_2^- = x(u + c + \bar{d} + \bar{s}) \quad W_2^+ = x(\bar{u} + \bar{c} + d + s)$

$$xW_3^- = x(u + c - \bar{d} - \bar{s}) \quad xW_3^+ = x(d + s - \bar{u} - \bar{c})$$

Measurement Strategy

Selection

- $P_{\text{miss}}^t > 12 \text{ GeV}$
- $0.03 < y_h < 0.85$
- $Q_h^2 > 220 \text{ GeV}^2$
- Rejection of ep background
 - Photo-production
 - Neutral Current
- Rejection of non-ep background

Signal MC

- CC Djangoh:
HERACLES & LEPTO

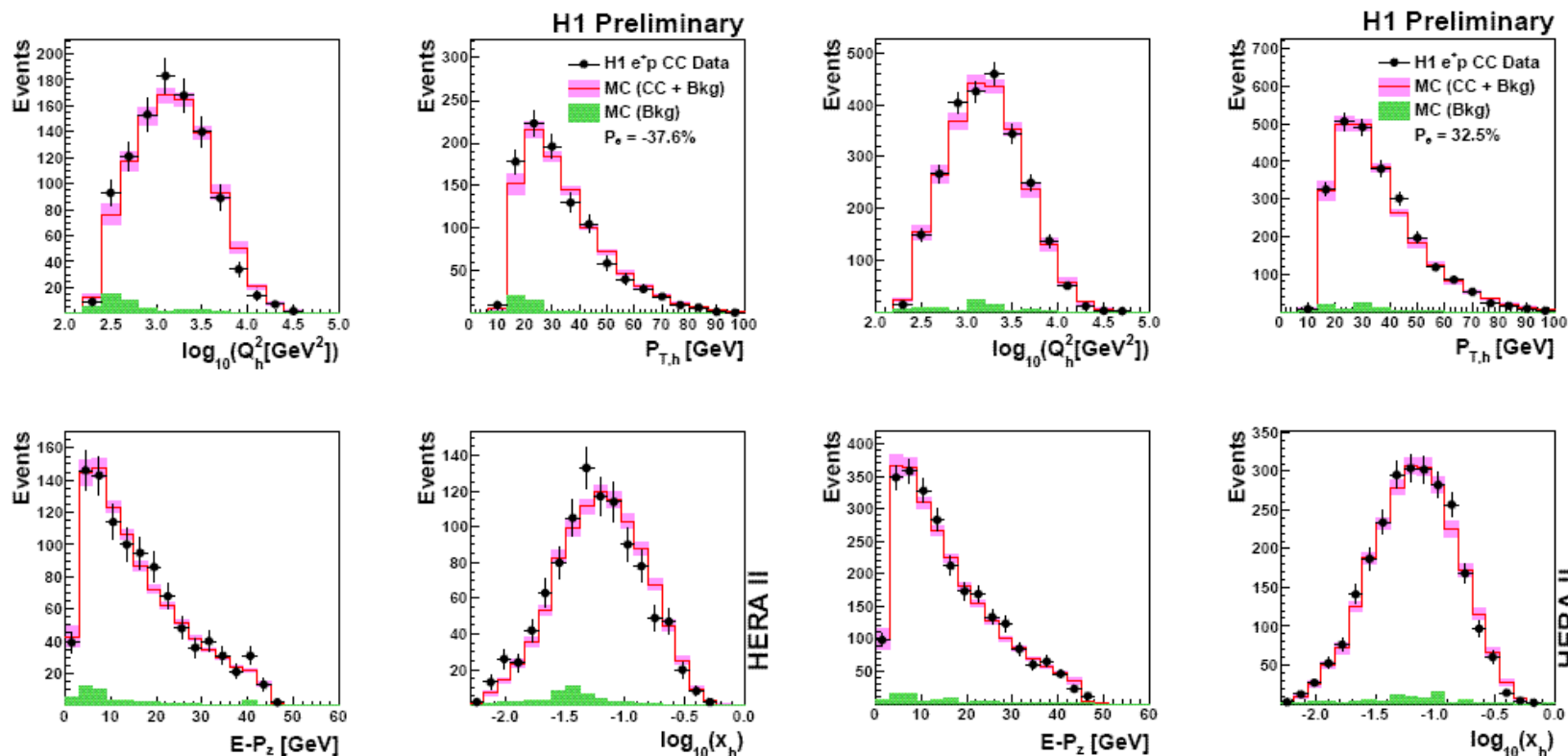
Background MC

- Photo-production: Pythia
- NC: Djangoh
- Lepton pairs: Grape
- W prod: Epvec

Data / Monte Carlo Comparisons: e^+p LH/RH

e^+p LH

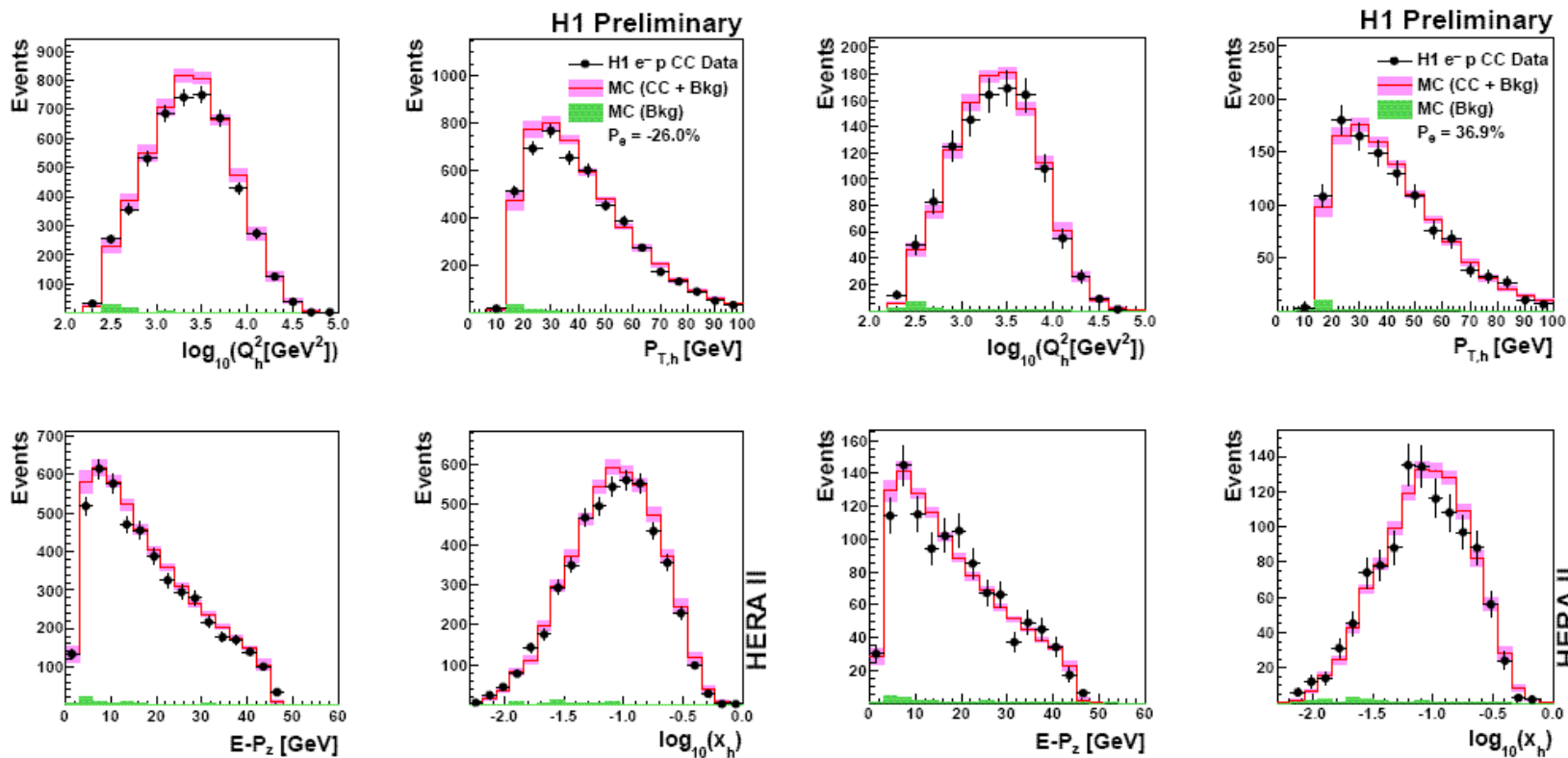
e^+p RH



Data / Monte Carlo Comparisons : e⁻p LH/RH

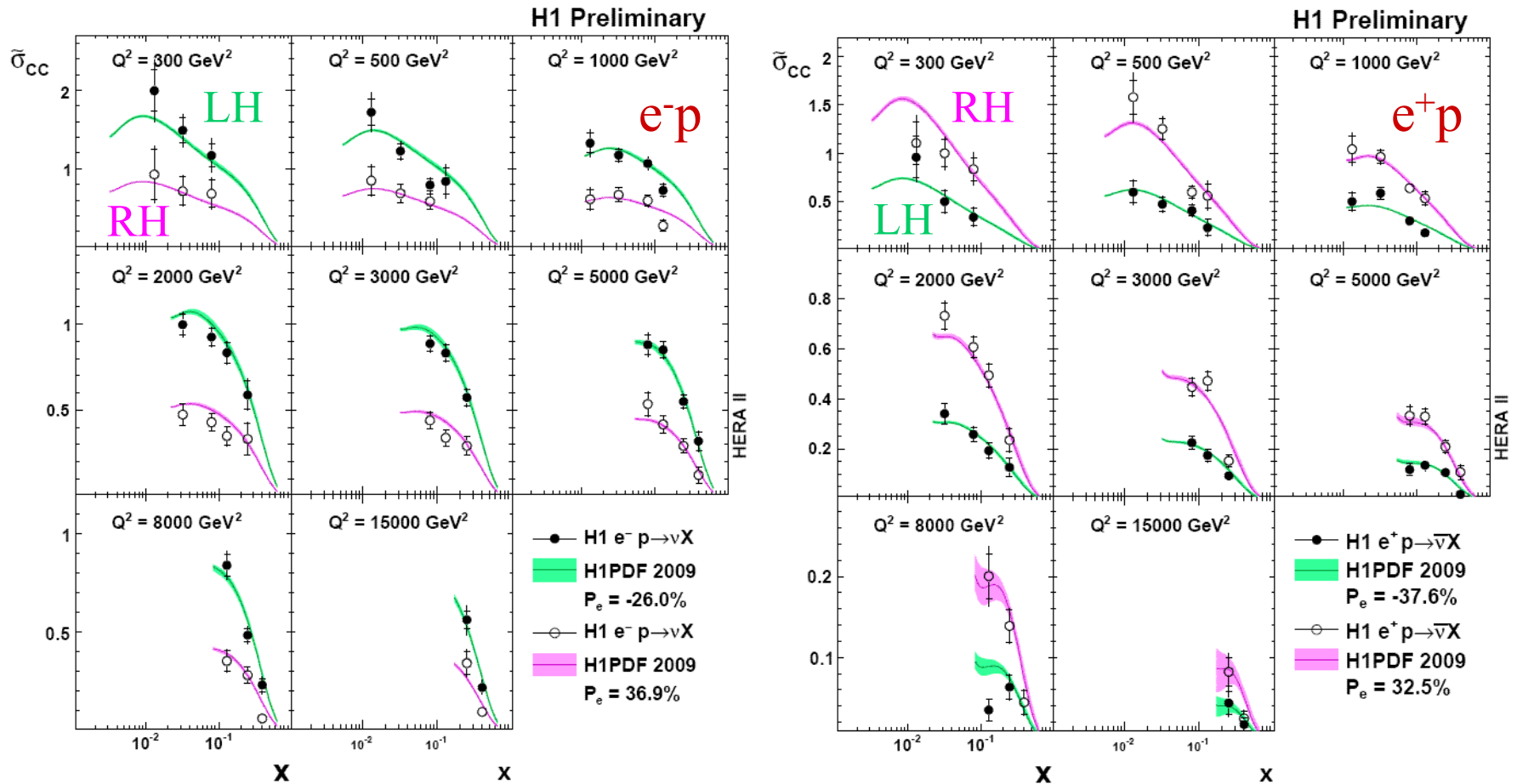
e⁻p LH

e⁻p RH



Double Differential Polarized CC Cross-Section

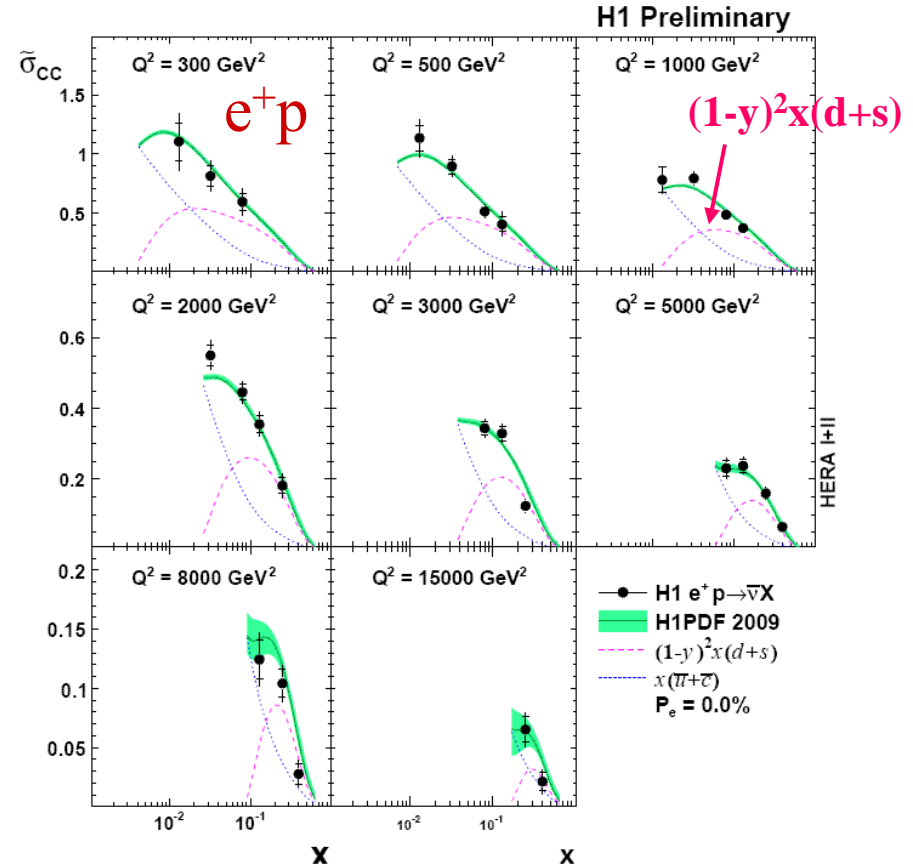
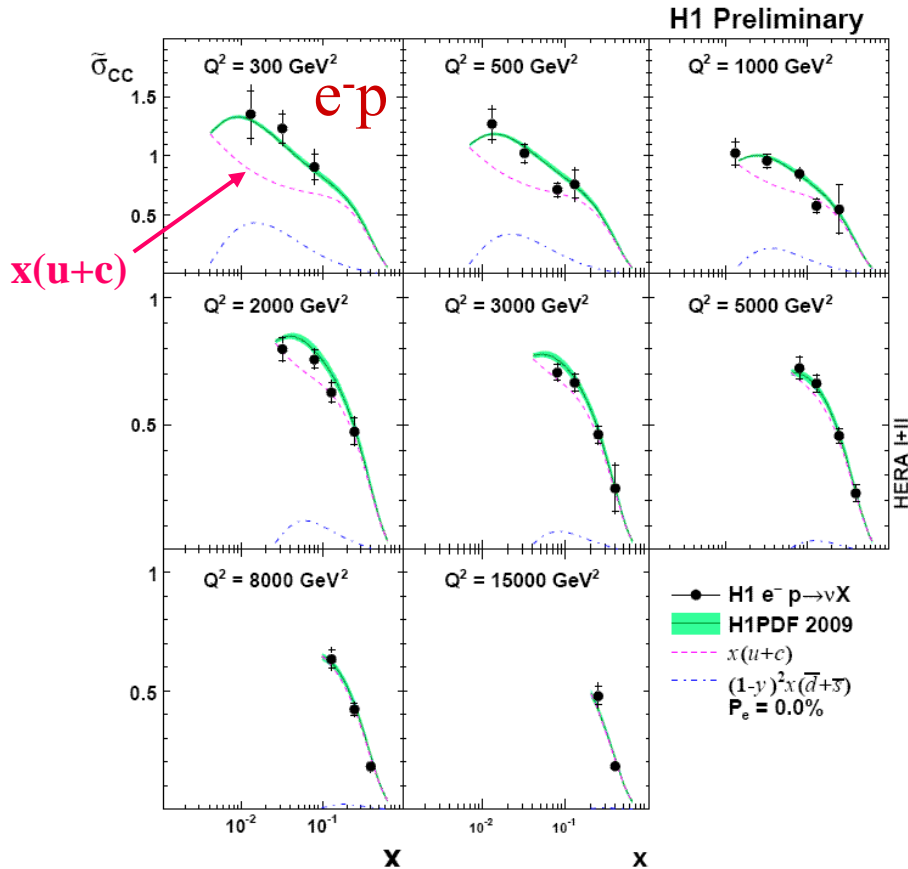
reduced cross-section $\tilde{\sigma}_{CC}(e^\pm p) = \frac{d^2\sigma_{CC}^{e^\pm p}}{dx dQ^2} \left/ \left[\frac{G_F^2}{2\pi x} \left(\frac{M_W^2}{Q^2 + M_W^2} \right)^2 \right] \right. = (1 \pm P_e) \tilde{\sigma}_{CC}^{P=0}(e^\pm p)$



Unpolarized Cross-Sections HERA I + II

$$\tilde{\sigma}_{CC}(e^- p) \propto (xu + xc) + (1-y)^2(x\bar{d} + x\bar{s})$$

$$\tilde{\sigma}_{CC}(e^+ p) \propto (x\bar{u} + x\bar{c}) + (1-y)^2(xd + xs)$$

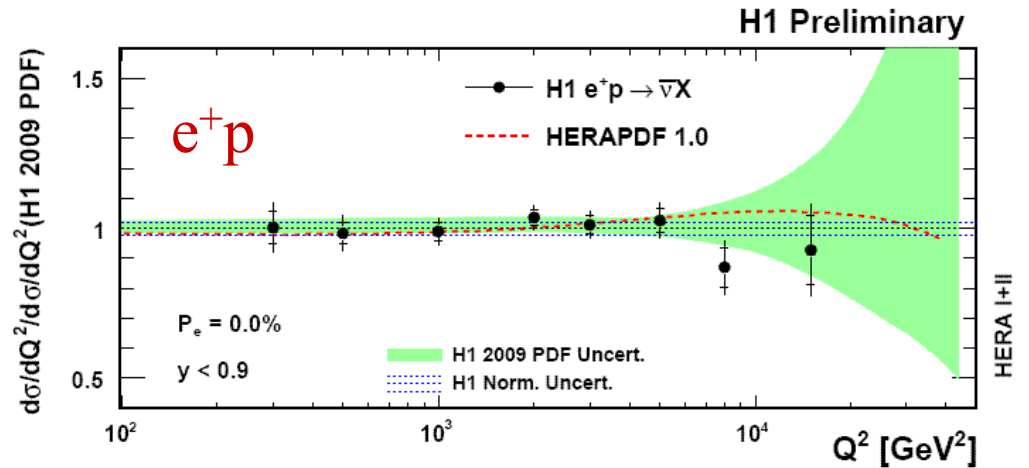
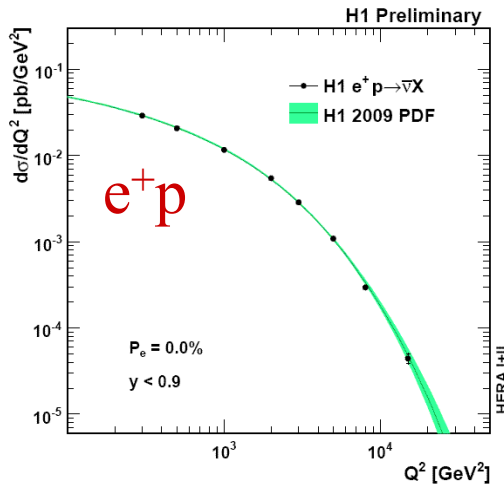
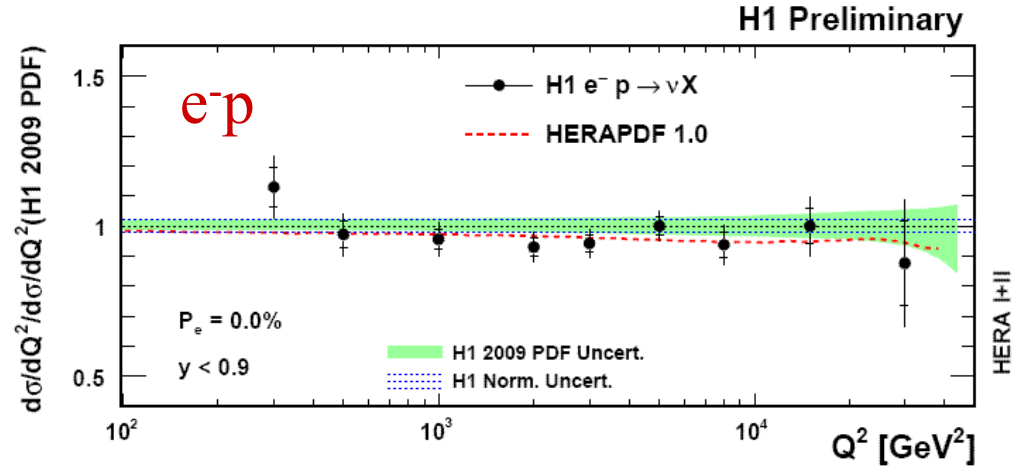
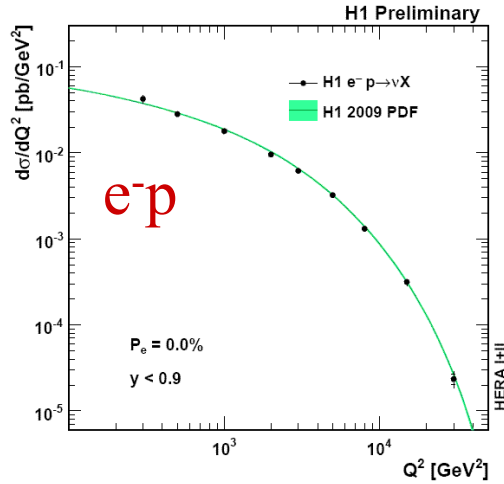


→ Constrain u and d quark densities

→ for combination method see talk of S.Habib

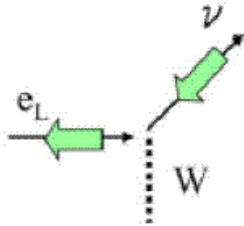
→ Free of nuclear corrections and isospin assumptions

Single Differential CC Cross-Section



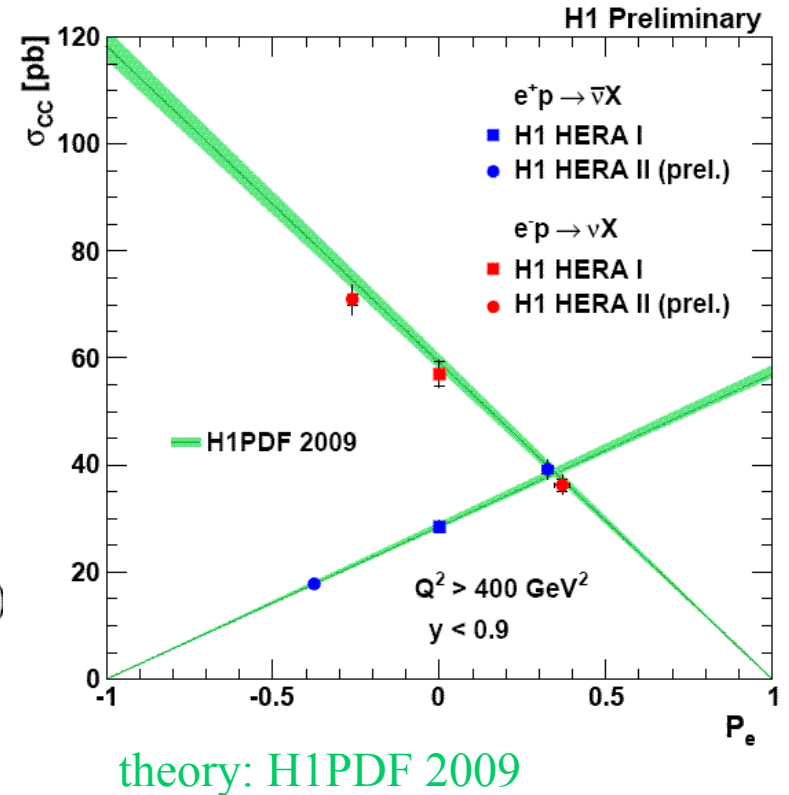
Total Charge Current Polarized Cross-Section

SM: weak CC is purely left-handed (V-A)



$$\tilde{\sigma}_{CC}(e^\pm p) = (1 \pm P) \tilde{\sigma}_{CC}^{P=0}(e^\pm p)$$

longitudinal polarization $P_e = (N_R - N_L)/(N_R + N_L)$



- Linear dependence of σ_{CC} on polarization observed
- No right-handed charged current contribution is visible

Summary

The e^-p/e^+p LH/RH CC cross-sections are measured by H1 using the HERA II data

Unpolarized CC cross-section from HERA II and HERA I are combined, representing the full HERA statistics of 0.5 fb^{-1}

→ Significant impact on PDF QCD fits is expected at high x and high Q^2

Polarization dependence of the CC cross-section is measured

→ Textbook demonstration of the left-handed nature of the charged current