XVIII International Workshop on Deep-Inelastic Scattering and Related Subjects
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Charged Current Interactions in $e^{\pm}p$ Scattering at H1 with Longitudinally Polarized Lepton Beams

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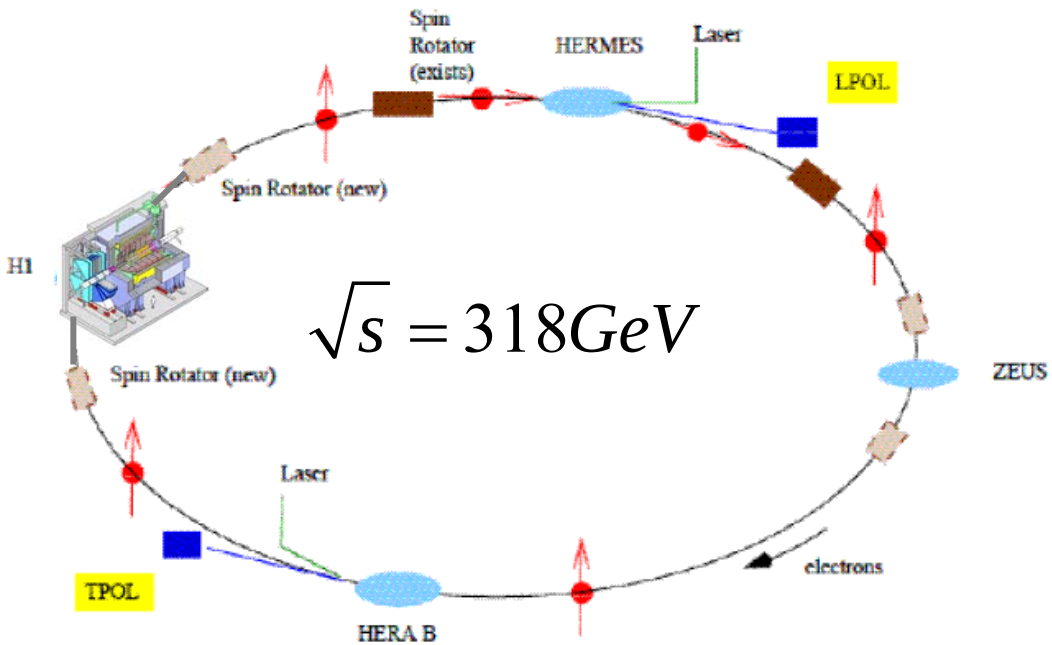
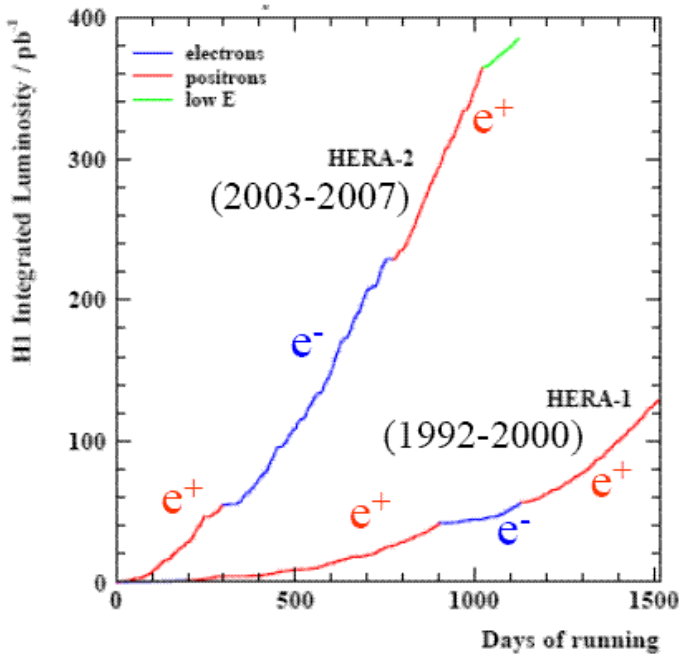
on behalf of the H1 collaboration

HERA II with Longitudinal Polarization of $e^{\pm}$ Beams

HERA upgrade
→ increase specific luminosity
→ provide longitudinally polarized lepton beam



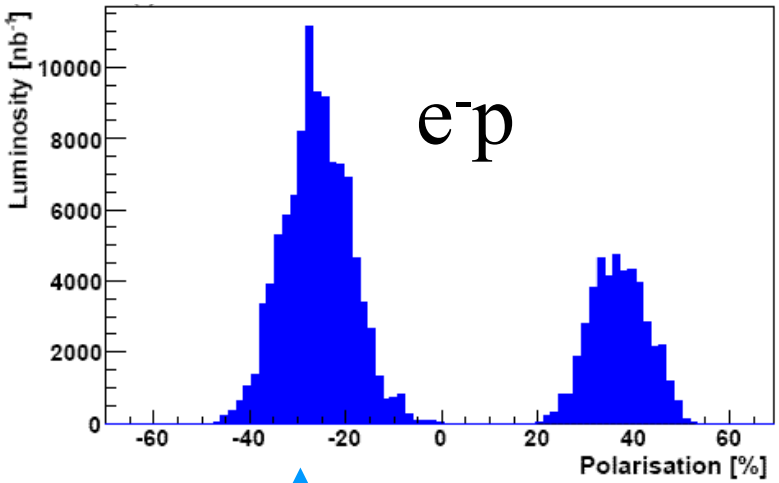
	HERA I	HERA II
e^+p	100 pb^{-1}	180 pb^{-1}
e^-p	15 pb^{-1}	150 pb^{-1}



Longitudinal polarization

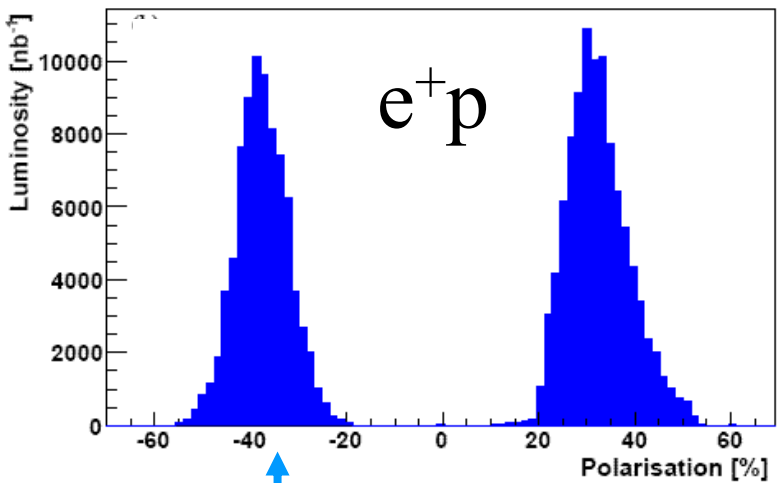
$$P_e = (N_R - N_L)/(N_R + N_L) \approx 40\%$$

Luminosity and Polarization for HERA II



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

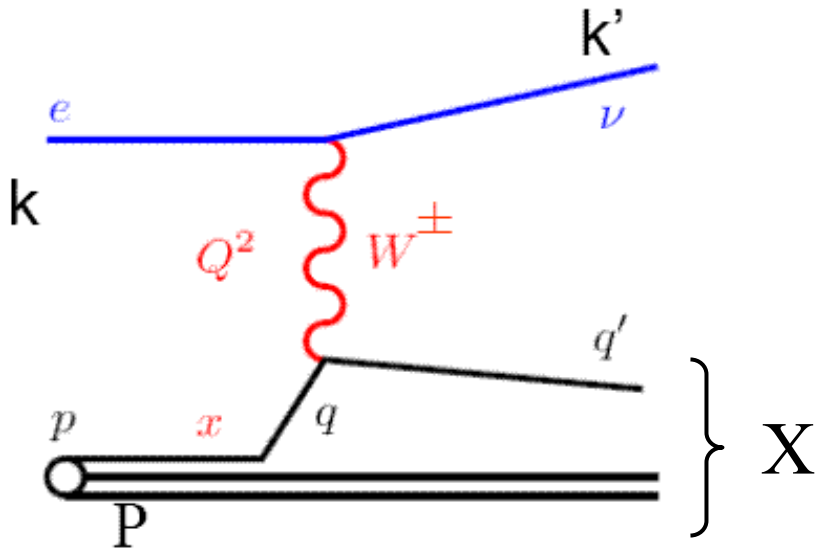
Lumi = 45.9 pb^{-1}
$P_e = (+36.9 \pm 2.3)\%$



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



Charge Current (CC) Interaction

$e\,p \rightarrow \nu\,X$

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

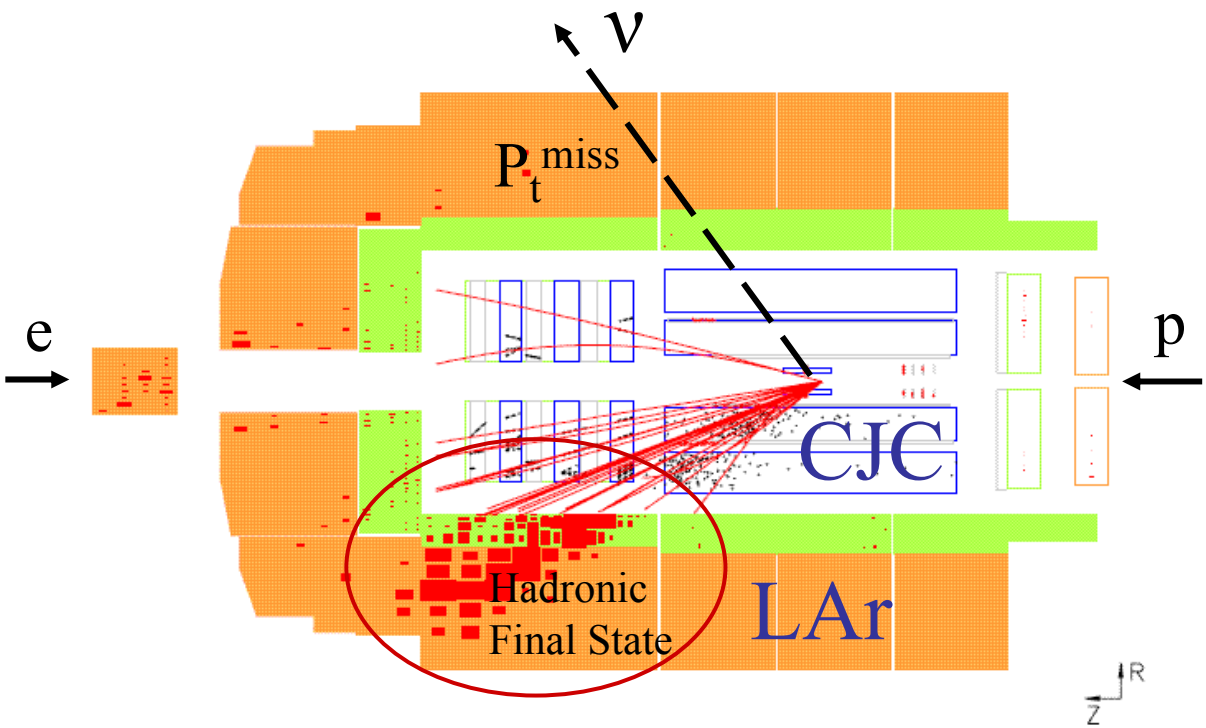
$$y = (Pq)/(Pk)$$

Center-of-mass energy squared

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

are related as $Q^2 = sxy$

Charge Current in the H1 Detector



LAr – Liquid Argon Calorimeter

CJC – Central Jet Chamber

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

Kinematic variables

$$y_h = \frac{E_h - p_{z,h}}{2E_e} \qquad Q_h^2 = \frac{P_{T,h}^2}{1 - y_h} \qquad x_h = \frac{Q_h^2}{s y_h}$$

Charged Current Cross Section

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

$P_e = \frac{N_R - N_L}{N_R + N_L}$, $N_R(N_L)$ - number of right (left) handed leptons in the beam

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

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

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

Measurement Strategy

Selection

→ $P^t_{miss} > 12$ GeV

→ $0.03 < y_h < 0.85$

→ $Q^2_h > 220$ 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

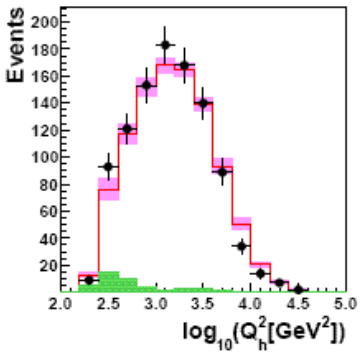
→ NC: Djangoh

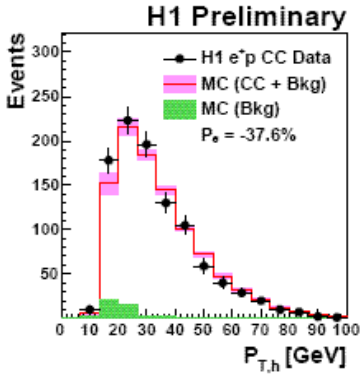
→ Lepton pairs: Grape

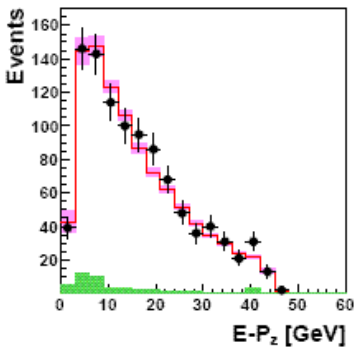
→ W prod: Epvec

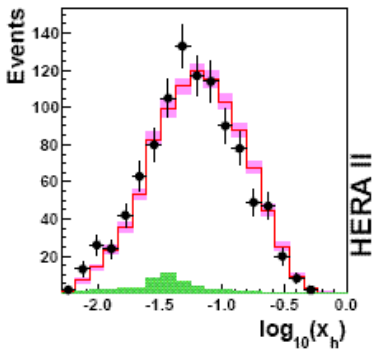
Data / Monte Carlo Comparisons: e^+p LH/RH

e^+p LH

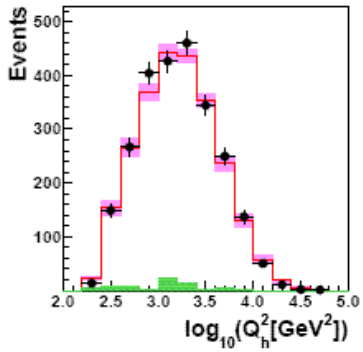


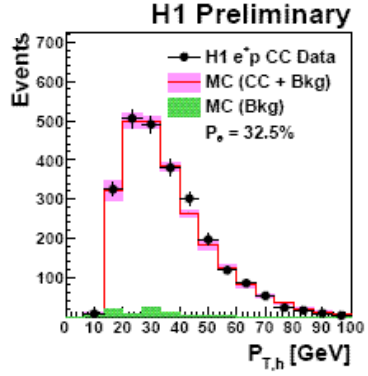


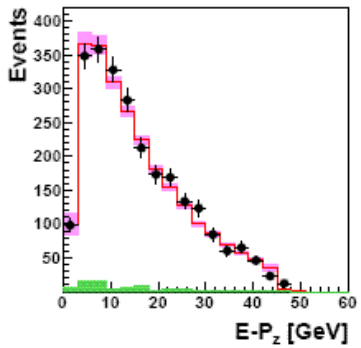


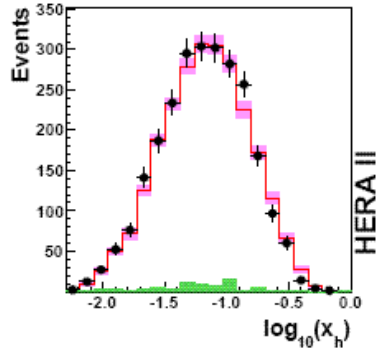


e^+p RH



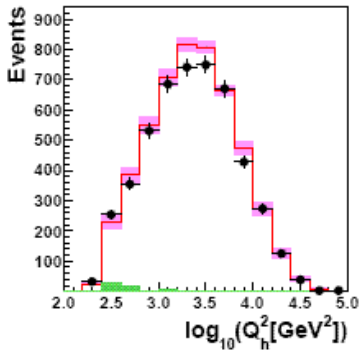


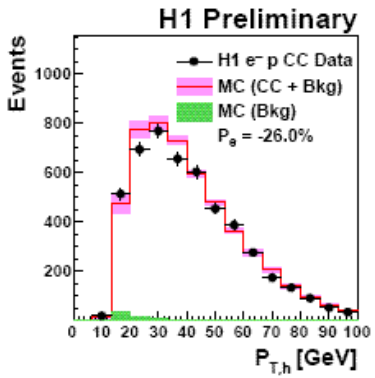


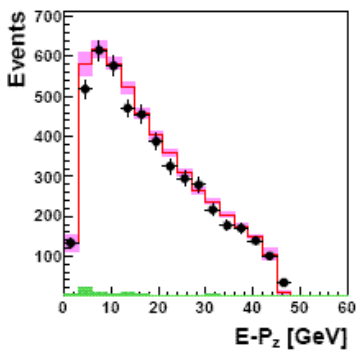


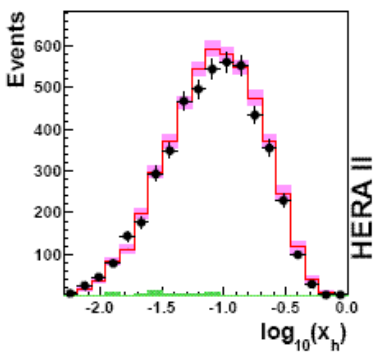
Data / Monte Carlo Comparisons : e^-p LH/RH

e^-p LH

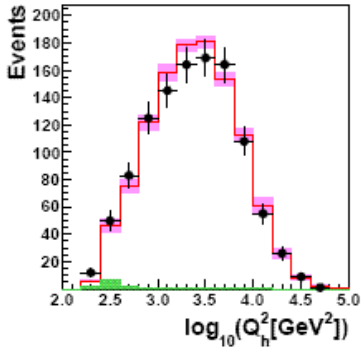


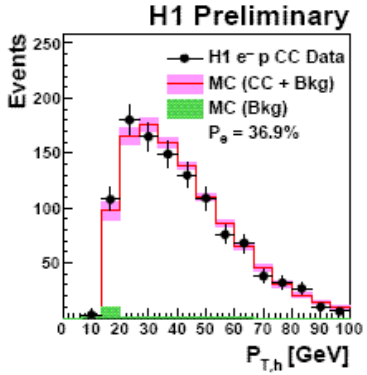


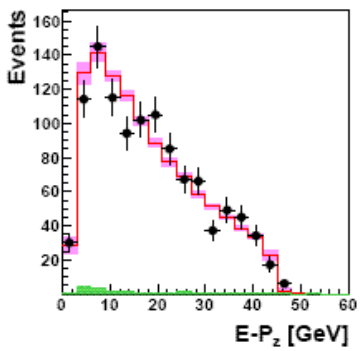


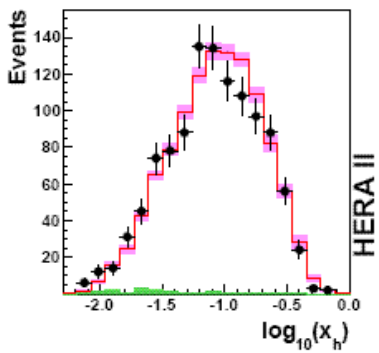


e^-p RH



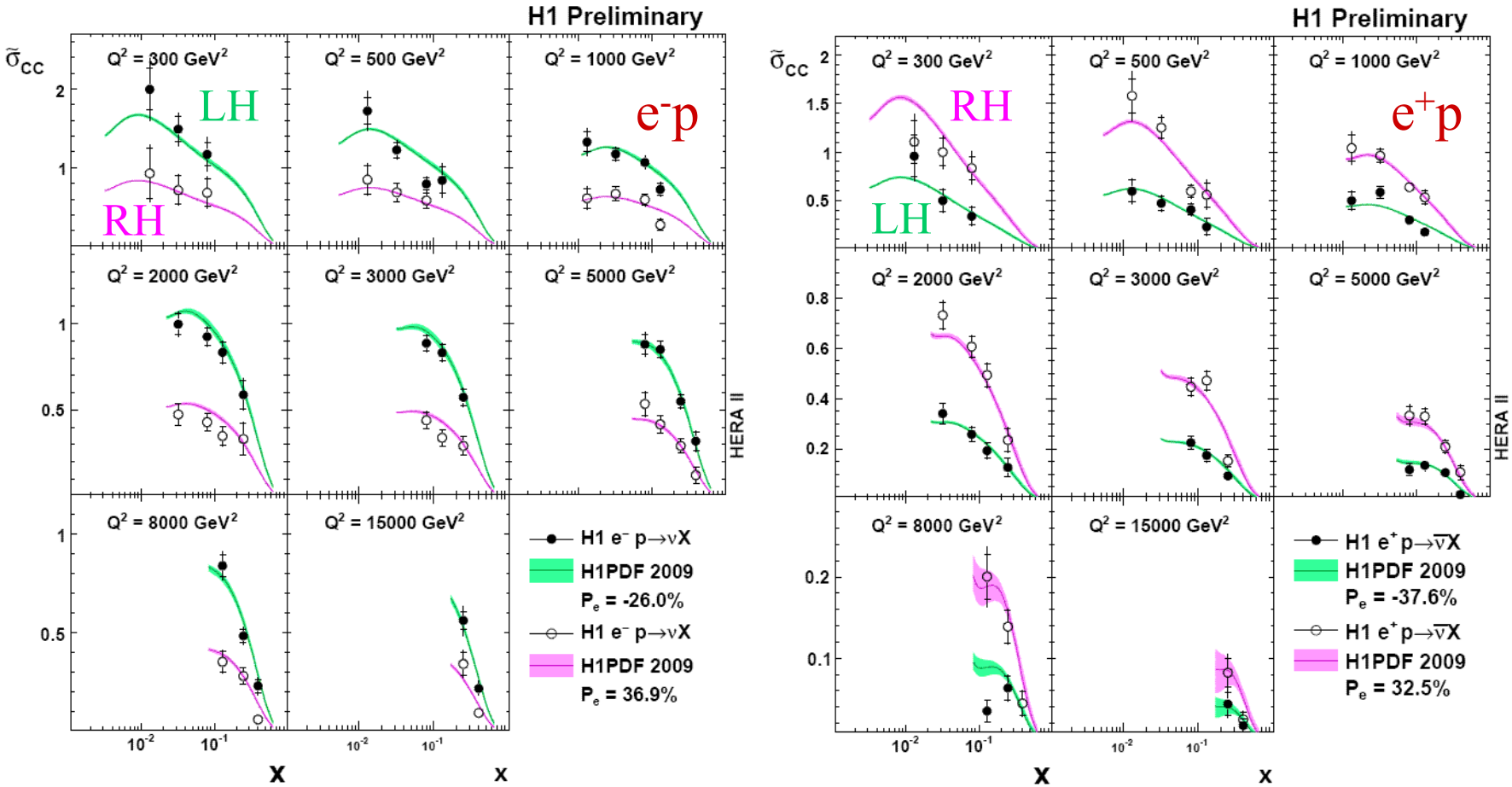






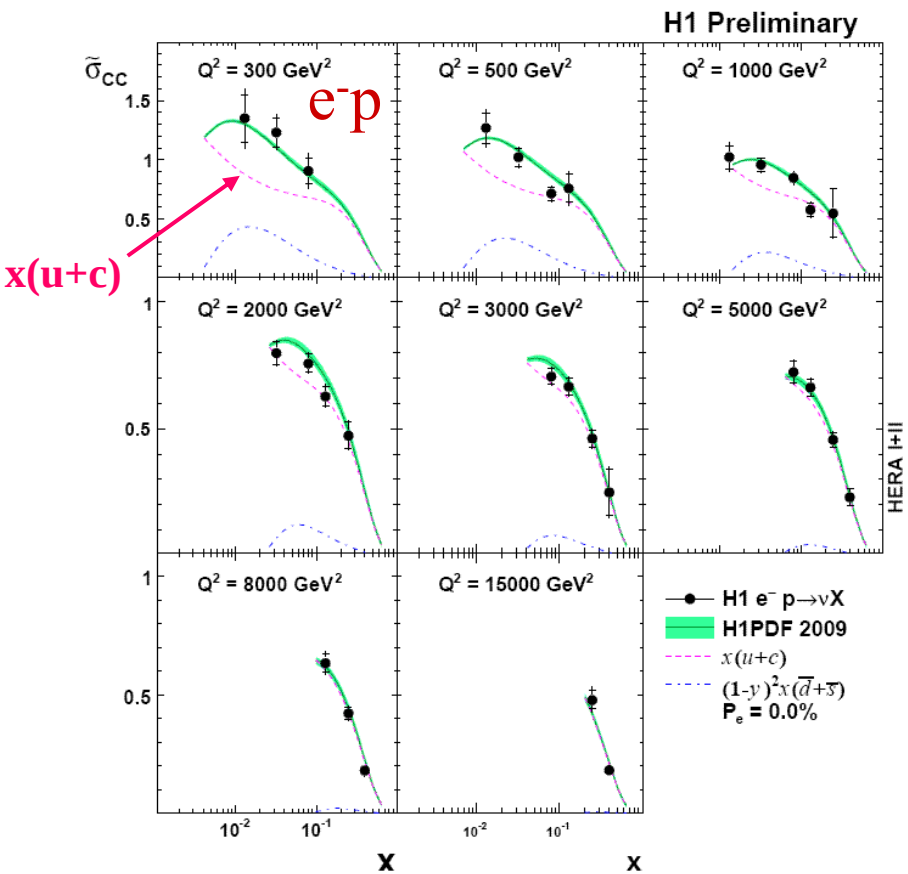
Double Differential Polarized CC Cross-Section

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

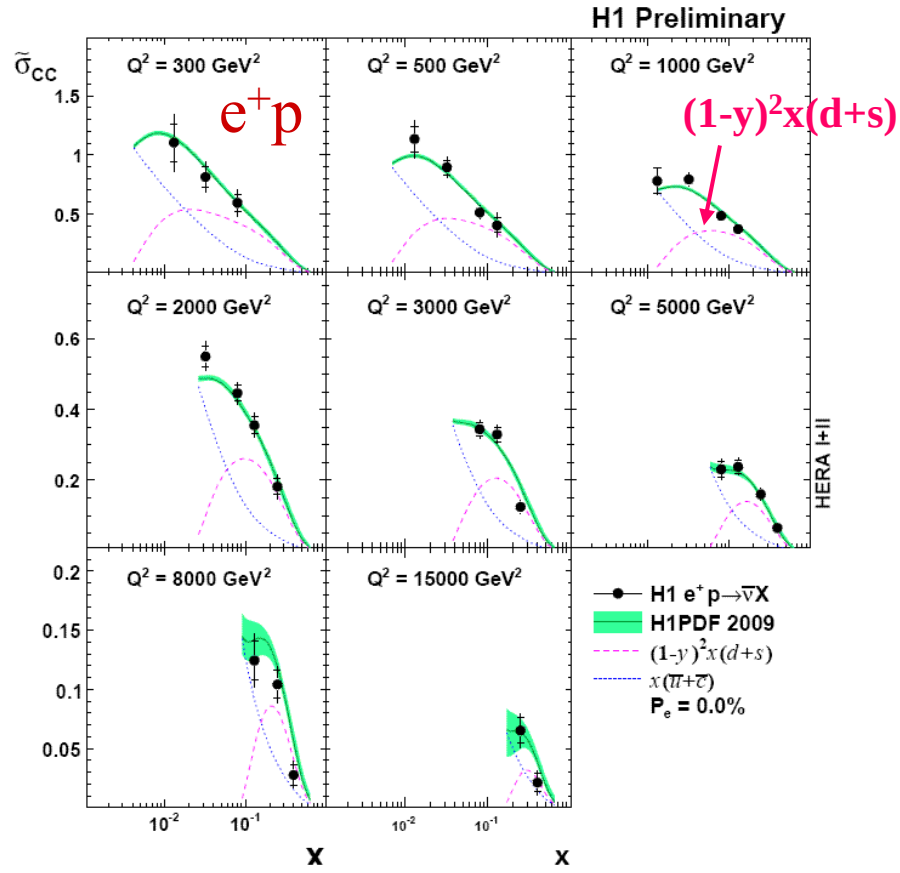


Unpolarized Cross-Sections HERA I + II

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



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

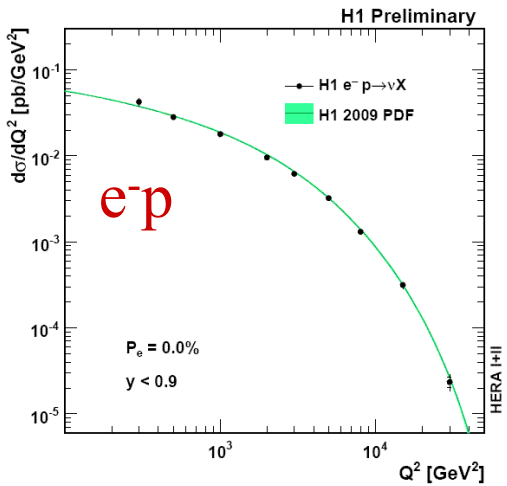


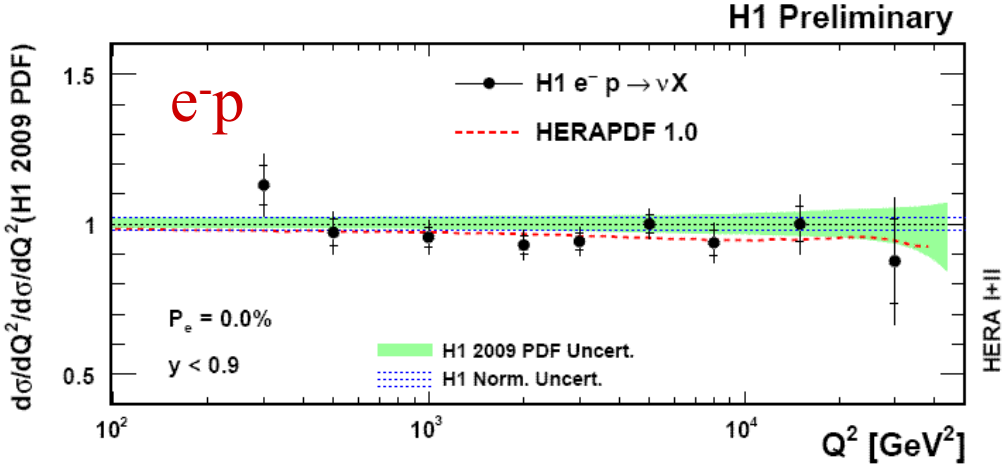
→ Constrain u and d quark densities

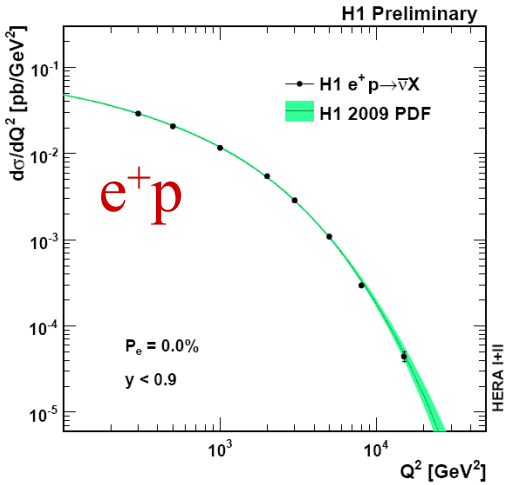
→ Free of nuclear corrections and isospin assumptions

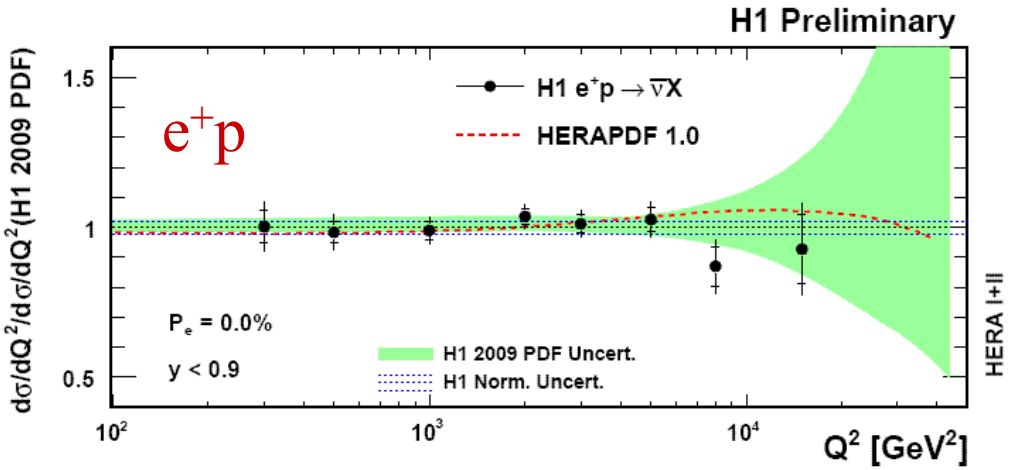
→ for combination method see talk of S.Habib

Single Differential CC Cross-Section



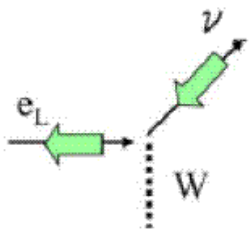






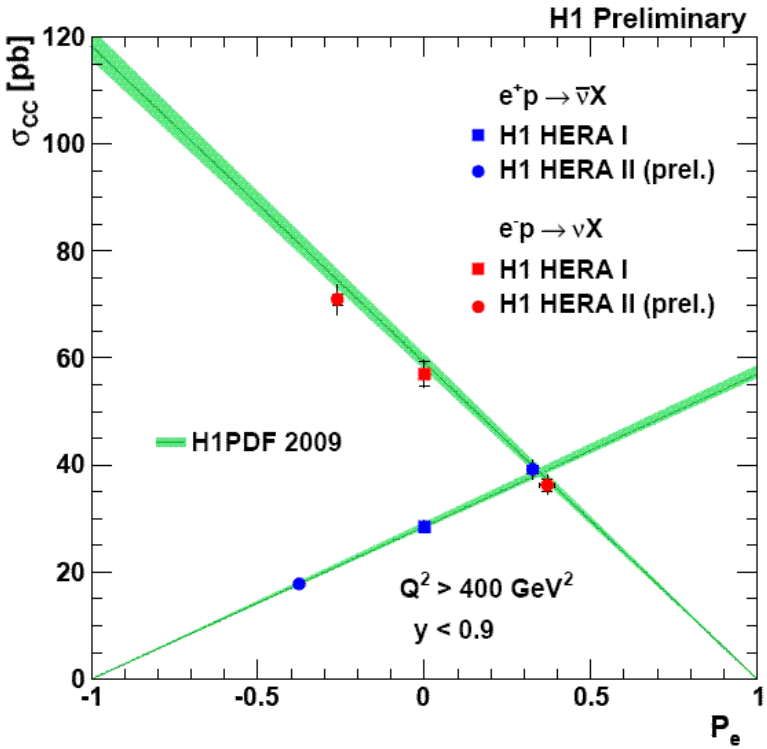
Total Charge Current Polarized Cross-Section

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



theory: H1PDF 2009

→ 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