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A New Combined Electroweak and QCD Fit of Inclusive NC and CC Data with Polarised Lepton Beams at HERA

H1 Collaboration

Abstract

Using the deep inelastic e^+p and e^-p charged and neutral current scattering cross sections, including data with polarised electron beams, a new combined electroweak and QCD analysis is performed to determine electroweak parameters accounting for their correlation with parton distributions. The precision has been improved in particular for u quark vector and axial-vector couplings to the Z boson with respect to the published results based on the unpolarized HERA data only. The determinations from HERA are compared with those from LEP and Tevatron.

The ep collider HERA has been running in the second phase (HERA-II) since autumn 2003 with a longitudinally polarised positron or electron beam.

Previously with unpolarised electron[1] beams at HERA-I, several data sets have been used to measure neutral current (NC) and charged current (CC) cross sections covering more than 4 orders of magnitude in both Q^2, the negative four-momentum transfer squared, and Bjorken x. The large kinematic coverage and the different flavor sensitivity of the $e^{\pm}p$ NC and CC cross section data have enabled 5 sets of parton distribution functions (PDF) to be determined simultaneously in a previous QCD analysis [1]. These five PDF sets are the gluon, up-type and down-type quarks and their anti-quarks distributions.

The inclusive NC and CC cross sections are not only sensitive to PDFs but also to electroweak (EW) parameters. Indeed, the NC cross sections at high Q^2 depend on the weak vector (v_q) and axial-vector (a_q) couplings of up- and down-type quarks ($q = u, d$) to the Z boson via structure functions. Such sensitivity on the quark couplings at HERA has been exploited first by H1 in a recent publication [2].

The longitudinally polarised electron beam at HERA-II provides additional sensitivity on the quark couplings. This is studied here in a new combined fit. The new fit follows the same analysis strategy as in Ref. [2] and uses as in the previous fit all HERA-I data and includes in addition new preliminary NC and CC cross sections measured with HERA-II data [3]. The HERA-II data were taken by the H1 experiments in years from 2003 to 2005 in both the electron-proton (e^-p) and positron-proton (e^+p) modes. Both data sets are further subdivided into samples of left handed and right handed longitudinal polarisation, $P_e = (N_r - N_L)/(N_R + N_L)$, where $N_R(N_L)$ is the number of righ (left) handed leptons in the beam. The corresponding data sets are termed the R and L data sets respectively and are summarised in Table 1.

Table 1: The integrated luminosity ($\mathcal{L}$) and the luminosity weighted polarisation value (P_e) of the four data sets from HERA-II used in the new combined QCD and electroweak fit.

Beam	Data set	$\mathcal{L}(pb^{-1})$	$P_e(\%)$
e^+	L	20.7	-40.2 ± 1.1
	R	26.9	33.6 ± 0.6
e^-	L	68.6	-27.0 ± 1.3
	R	29.6	37.0 ± 1.8

The preliminary measurements of the NC and CC cross sections are shown in Figs. 1-4. The measurements are compared with the expectations from the new combined fit.

The fitted quark couplings are shown in Figs.5a for the u quark and 5b for the d quark and compared with similar results obtained by the CDF experiment [4] and combined LEP experiments [5]. The HERA determination has a better precision than that from the Tevatron in particular for the u quark. These determinations are sensitive to u and d quark separately, contrary to other measurements from the light quark-Z^0 couplings in νN scattering [6] and

[1]Unless stated explicitly, the electron is referred to both electron and positron in the following.

atomic parity violation [7] on heavy nuclei. They also resolve any sign ambiguity and the ambiguities between ν_q and $a_q (q = u, d)$ of the determinations based on observables measured at the Z^0 resonance [5].

A similar analysis from ZEUS has been reported recently [8]. In that analysis, the u (d) quark couplings were obtained by fixing d (u) quark couplings to their Standard Model (SM) values. The comparison between H1 and ZEUS is shown in Fig. 6.

Alternatively, one can also fit a (v) couplings by fixing v (a) couplings to their SM values. The results of such a fit are shown in Fig. 7.

References

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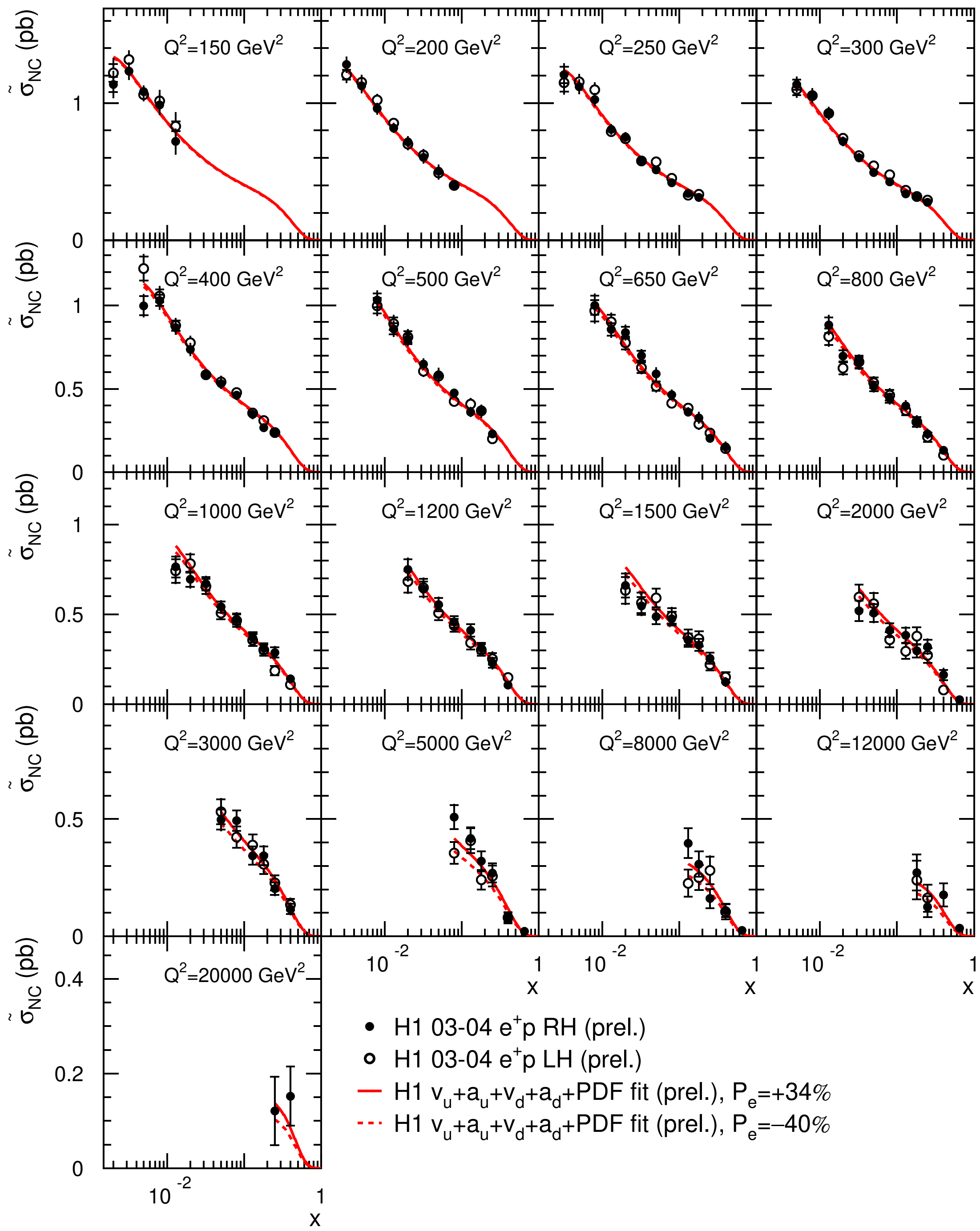

Figure 1: Preliminary NC cross section measurements based on the e^+p R (solid data points) and L (open data points) data sets in comparison with the expectations from the new combined fit (full and dashed curves).

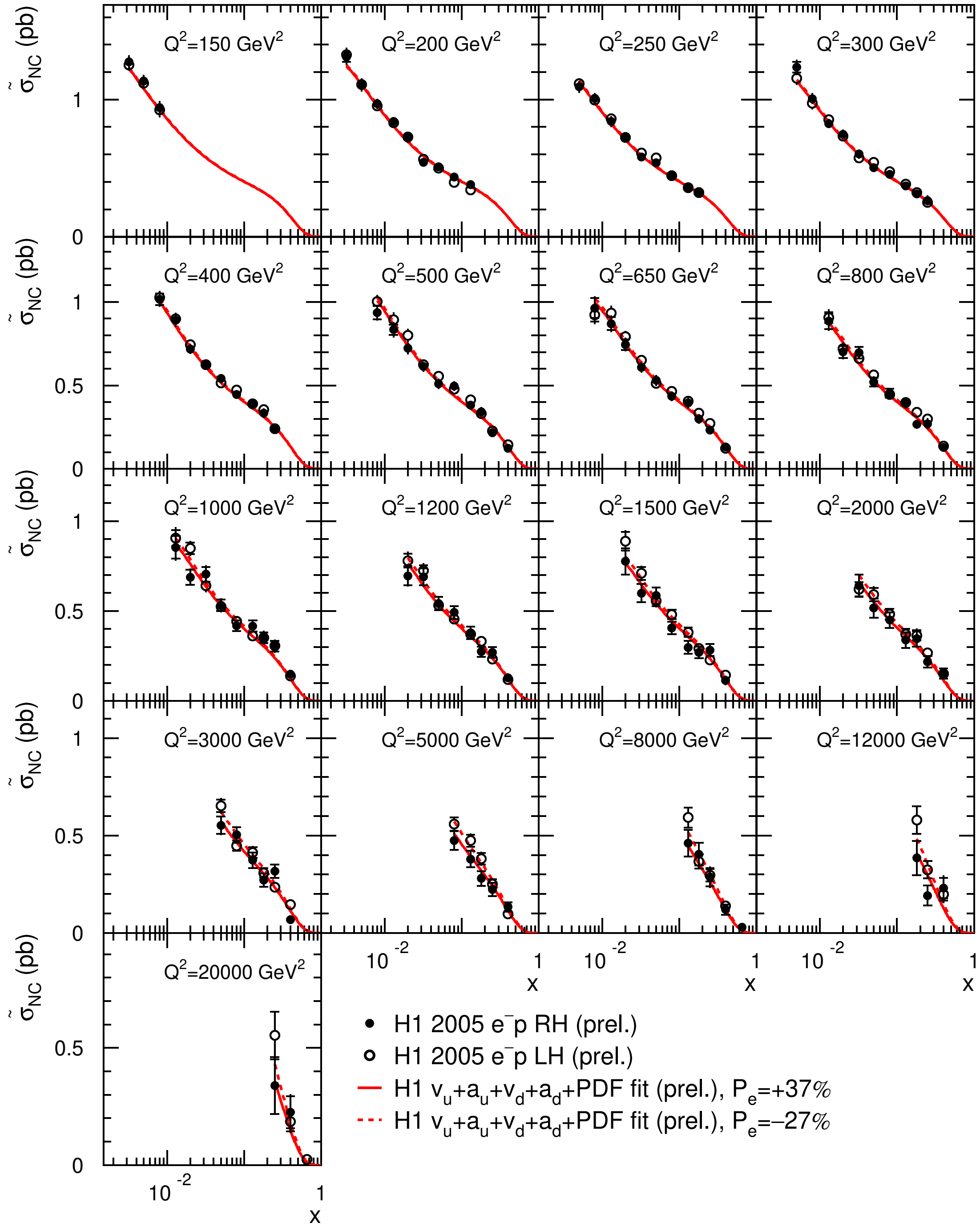

Figure 2: Preliminary NC cross section measurements based on the e^-p R (solid data points) and L (open data points) data sets in comparison with the expectations from the new combined fit (full and dashed curves).

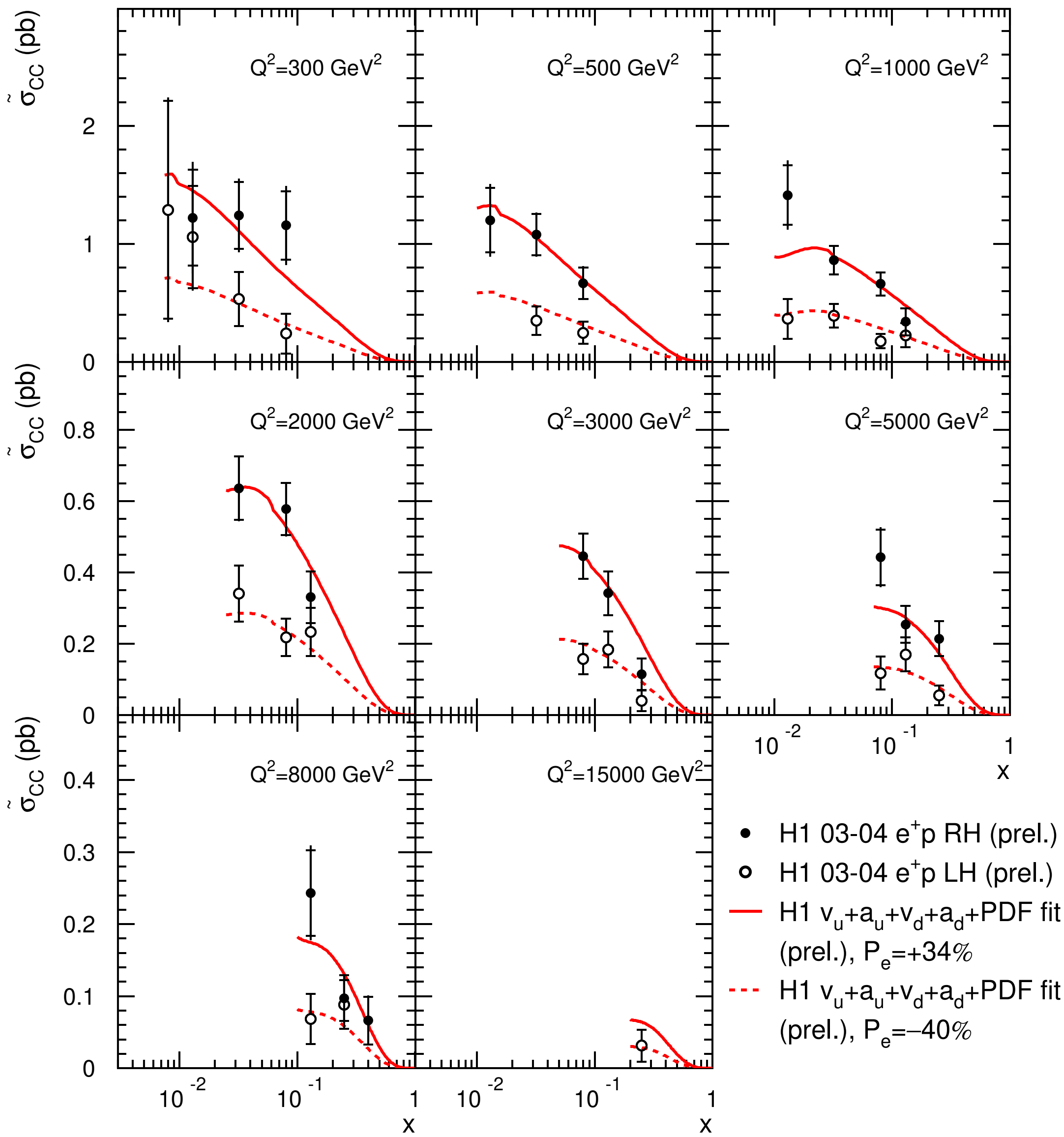

Figure 3: Preliminary CC cross section measurements based on the e^+p R (solid data points) and L (open data points) data sets in comparison with the expectations from the new combined fit (full and dashed curves).

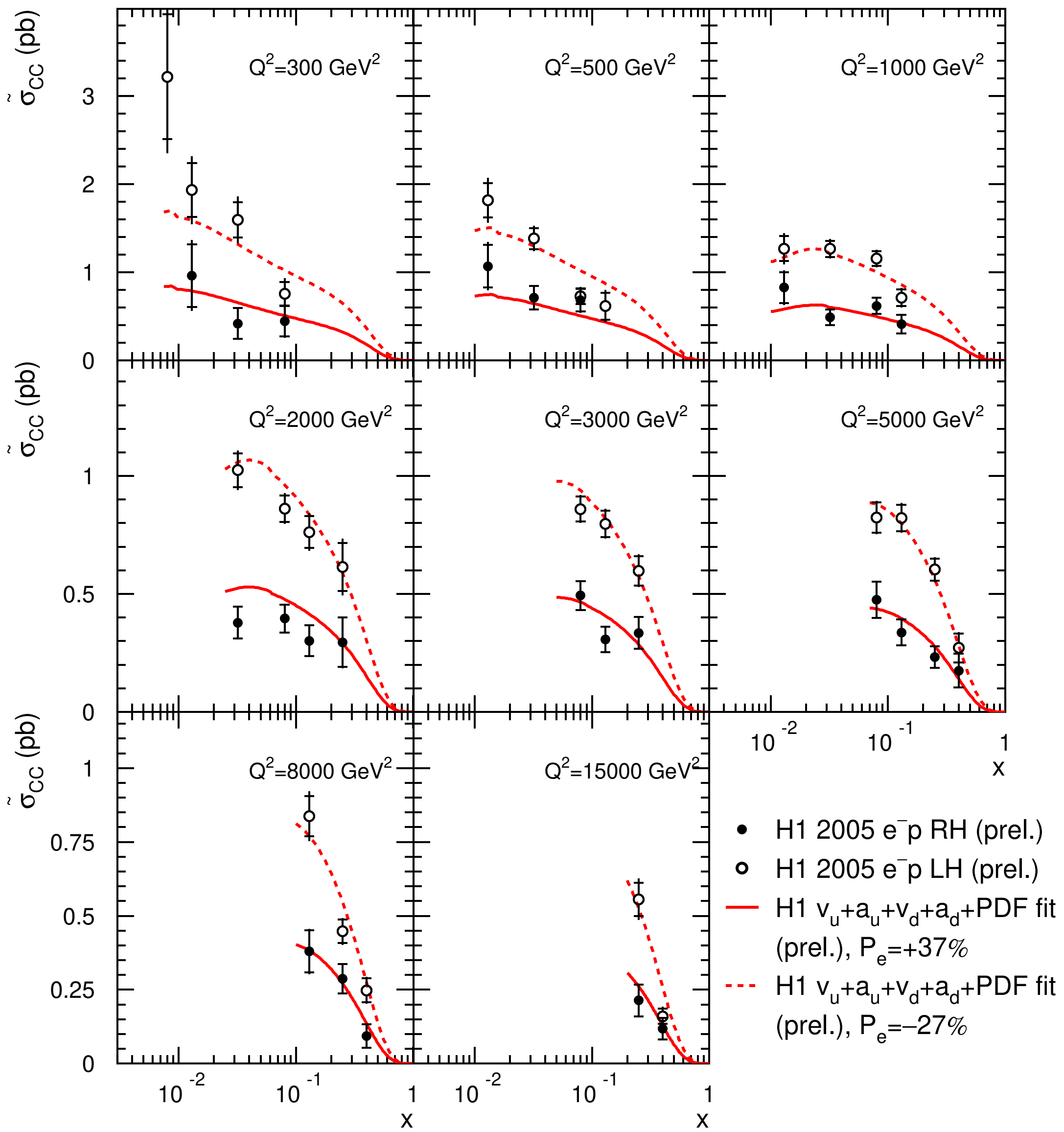

Figure 4: Preliminary CC cross section measurements based on the e^-p R (solid data points) and L (open data points) data sets in comparison with the expectations from the new combined fit (full and dashed curves).

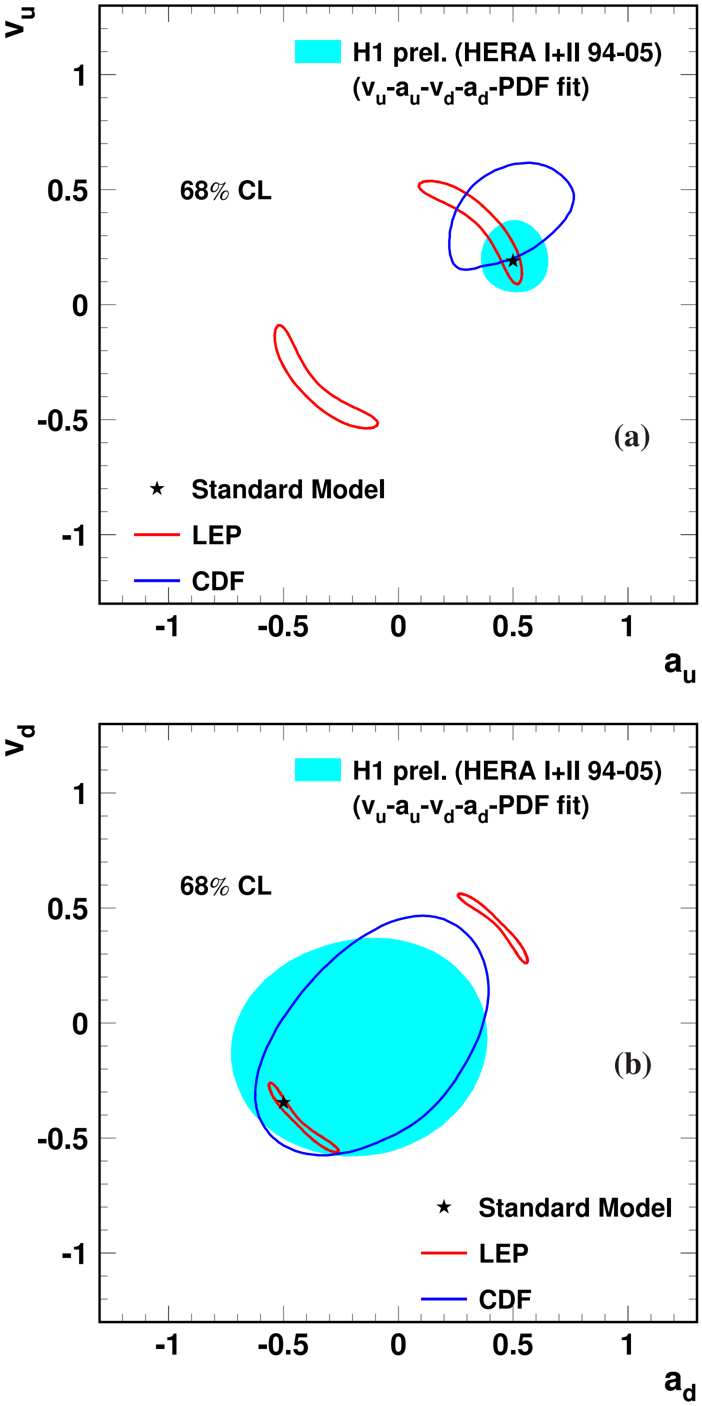

Figure 5: Preliminary results at 68% confidence level (CL) on the weak neutral couplings of u (a) and d (b) quarks to the Z^0 boson determined in this analysis in comparison with similar results from CDF and combined LEP experiments.

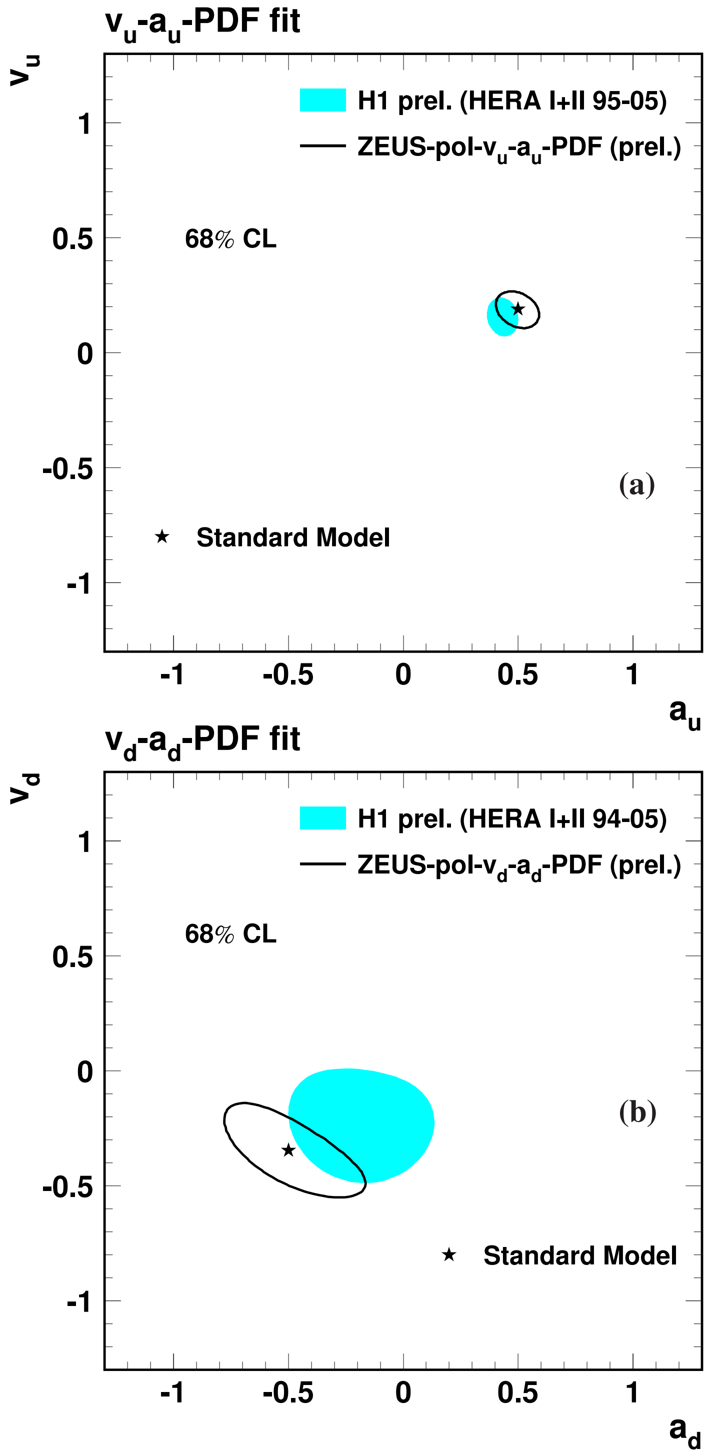

Figure 6: Similar results as in previous figures but with either d ou u quark coupling being fixed to their SM values. The H1 results are compared with those from ZEUS.

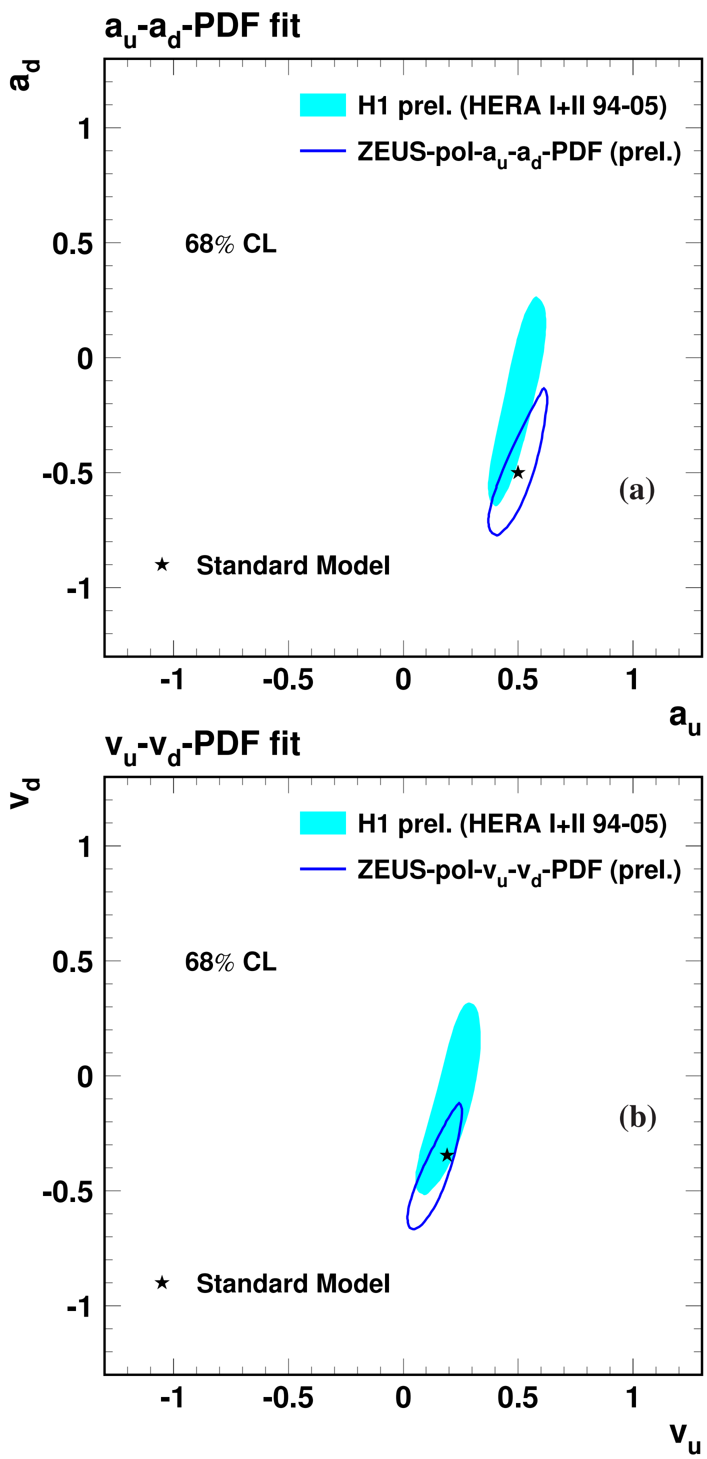

Figure 7: Similar results as in previous figures but with either v ou a couplings being fixed to their SM values. The H1 results are compared with those from ZEUS.