PROCEEDINGS OF SCIENCE

Electroweak physics at HERA

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Neutral current and charged current deep inelastic scattering processes in ep collisions at HERA are sensitive to electroweak parameters. They are used to determine the couplings of the light quarks to the Z boson. The cross section of single W production and the W boson polarisation are determined.

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1. Introduction

The ep collider HERA, located at Hamburg, Germany, running 1994-2007, was an ideal facility to explore the structure of the proton in deep inelastic scattering at low Bjorken x and large momentum transfer Q^2 and at the same time to probe the theory of electroweak interactions in the regime of large Q^2.

2. Coupling of light quarks to the Z^0 boson

The inclusive charged current (CC) and neutral current (NC) cross sections are not only sensitive to the PDFs but also to the electroweak parameters (c.f. [1]). Indeed, the NC cross section at high Q^2 depends on the weak vector (v_q) and the axial-vector (a_q) couplings of up- and down-type quarks to the Z-boson via structure functions (c.f. [1]). Such sensitivity on the quark couplings at HERA has been exploited using full HERA-I and HERA-II data. The results of the H1 collaboration are compared to similar results obtained previously by the CDF experiment [2] and the combined LEP/SLC experiments [3]. The new determination has better precision for the vector couplings, especially for the u quark, compared to the published HERA-I result, due to the longitudinal polarisation of the electron beam at HERA-II. These determinations are sensitive to u and d quarks separately, contrary to other measurements of the light quark-Z^0 couplings in νN scattering [4] and atomic parity violation [5] on heavy nuclei. They also resolve any sign ambiguity and the ambiguities between v_q and a_q ($q = u, d$) of the determination based on observables measured at the Z^0 resonance [3] at LEP/SLC (see figure 1).

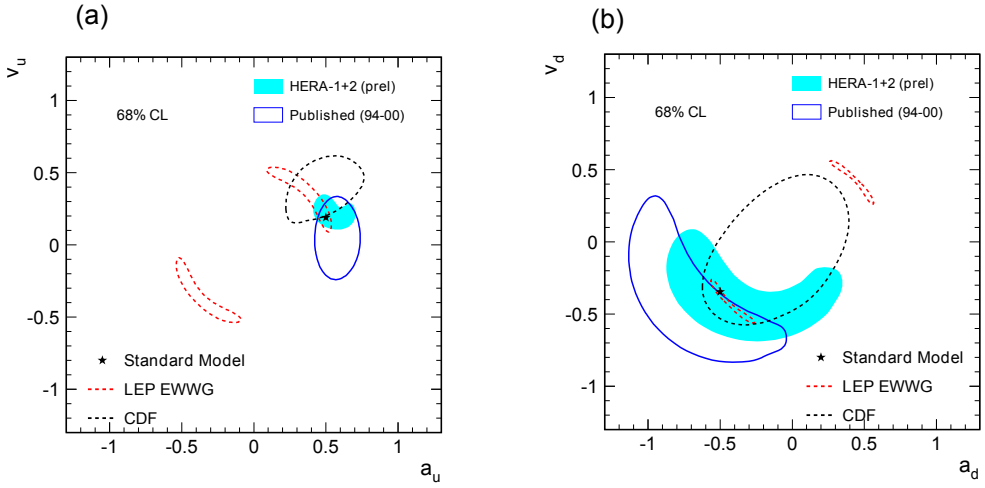

Figure 1: Weak neutral axial and vector couplings of u (a) and d (b) quarks to the Z boson determined by the H1 collaboration in comparison with similar results from CDF and combined LEP experiments.

3. Single W production and W polarisation fraction

Single W-boson production can occur at HERA through either neutral or charged current like interactions: $ep \to eWX$ or $ep \to \nu WX$. The total single W-boson production cross section at HERA is measured as $\sigma_{\text{data}} = 1.06 \pm 0.16(\text{stat.}) \pm 0.07(\text{sys.})$ pb (c.f. [6]). The measured cross section is in good agreement with the Standard Model expectation of 1.26 ± 0.19 pb (see figure 3(a)). The fractions F_0, F_- and F_+, where F_0 is the fraction of longitudinally polarized W bosons, F_- the

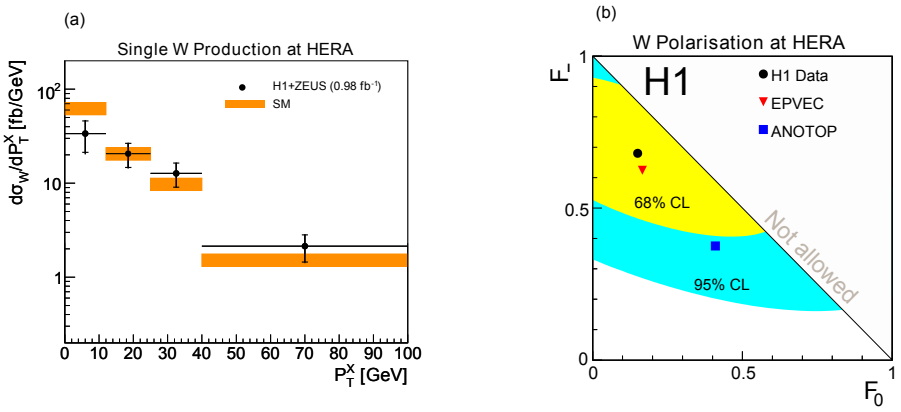

Figure 2: (a) Single W production as a function of the hadronic transverse momentum, P_T^X, measured using H1 and ZEUS data at a center-of-mass energy of $\sqrt{s} = 319$ GeV. The inner error bar represents the statistical error and the outer error bar indicates the statistical and systematic uncertainties added in quadrature. The shaded band represents the uncertainty on the Standard Model prediction. (b) The plane showing the fit result for the simultaneously extracted left handed (F_-) and longitudinal (F_0) W boson polarization fractions (point) with the corresponding 68% and 95% CL contours. The standard model expectation is given by the triangle (EPVEC), while the square (ANOTOP) shows the expectation for W boson from top decay.

fraction of left-handed and F_+ the fraction of right-handed W bosons (c.f. [7]) are extracted by the H1 collaboration simultaneously by a fit to the decay spectrum of the charged lepton from the W decay. The fit is constrained by $F_+ + F_- + F_0 = 1$. The results are found to be in good agreement with the SM (see figure 3(b)).

4. Summary

Many aspects of electroweak physics have been studied at HERA. The single W production cross section and the measurement of W polarisation fraction have been measured and found to be in good agreement with the SM predictions. The longitudinal lepton polarisation enhances significantly the measurement of the quark coupling to Z-boson at HERA.

References

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