論文内容の要旨

Measurement of charged current deep inelastic scattering cross sections with a longitudinally polarized positron beam at HERA.

(HERA における偏極陽電子・陽子荷電流深非弾性散乱の断面積測定)

岡崎奈緒

Measurements of the deep inelastic scattering (DIS) have taken essential roles in understanding behavior of quarks and gluons in hadron. They have lead to development of the Quantum Chormodynamics (QCD).

HERA—, which was the first electron/positron – proton (ep) collider constructed at Deutsches Elektronen Synchrotron (DESY), is the accelerator which enabled the DIS physics at the highest energy. Collision of the lepton beam of 27.5 GeV and the proton beam of 920 GeV gives 318 GeV of a center of mass energy. It enables measurements over a wide kinematic region, to the spatial resolution of 10^{-18} m.

The measurements of the high Q^2 (squared momentum transfer) DIS is very important for the proton structure investigation and also for the electroweak (EW) physics.

Charged current (CC) DIS is the weak interaction processes by exchanging $W^{\pm}$. The weak interaction doesn't conserve parity and CC is purely coupling to left-handed particles.

At HERA , the positron/electron can be longitudinally polarized since the accelerator upgrade during 2001-2002. It is the direct test of the weak interaction to measure CC DIS cross sections against the longitudinal polarisation of the positron/electron beam P_e.

In this study, the charged current cross sections with longitudinal polarised positron were measured by using data collected by ZEUS detector from 2006-2007 and they are 75.2 pb^{-1} for P_e of 32.9 % and 55.9 pb^{-1} for P_e of -36.2%.

Inclusive DIS can be expressed by using two of the following Lorentz invariant variables, Bjorken x, inelasticity y and the squared momentum transfer Q^2. Bjorken x corresponds to momentum fraction of the proton carried by the struck parton in the naïve quark-parton mode.

For measurements of the inclusive DIS, the accurate reconstruction of these three kinematic variables is essential. The kinematic variables must be reconstructed from only hadronic final state in CC events because the final state lepton is a neutrino which is undetected. The x, y and Q^2 are given by transverse momentum $P_{T,h}$ and longitudinal momentum difference $E\text{-}P_{z,h}$ which are reconstructed by using only hadron system. Therefore the bias and resolution of reconstruction of $P_{t,h}$ and $E\text{-}P_{z,h}$ were carefully . estimated. The good agreement between data and Monte Carlo (MC) simulation is demonstrated in both bias and resolution.

The CC events are selected and background events are rejected effectively. The undetected neutrino in the final state causes an imbalance in the measured P_T as missing transverse momentum. Hence a certain threshold of P_T is required of events in order to select CC events.

The main background events are from photoproduction (PHP) processes (Q^2~ 0 GeV), beam-gas interaction and muons from beam-halo and cosmic rays. The PHP events are rejected by using difference of azimuthal isotropy of hadrons from CC events. The non-ep backgrounds, the beam-gas or muon events are rejected by investigating the vertex, the inconsistency of CAL timing with ep interaction and a fraction of energy deposit on each CAL layer. As a result of the CC event selections, the CC event candidates of 2330 for positive polarization and 822 for negative polarization satisfied all selection criteria. The background contamination is estimated to be around 0.7 % and 1.5 % for positive and negative polarization, respectively. The distribution of the kinematical quantities for data and MCs are compared and it is found that the used MC reasonably describes the data.

The cross sections are measured from the bin-by-bin correction

The sources of the systematic errors considered in this study are CAL energy scale, PHP background normalization, FLT efficiency and efficiency of each selection criterion. A dominant systematic source is found to be the CAL energy scale.

The total uncertainty stays around 5% across the whole kinematic region except the largest in the high Q^2 bin where it reaches up to nearly 40%.

Compared with the statistical error, the systematic error is less than the statistic error in the whole kinematic region.

The measured cross sections in this study were single differential cross sections $d\sigma/dQ^2$, $d\sigma/dx$, $d\sigma/dy$ 、 reduced double differential cross sections $\tilde{\sigma} = [G^2_F/2\pi x (M^2_W/M^2_W+Q^2)^2]^{-1} \cdot d^2\sigma/dxdQ^2$ and total cross sections for P_e of 32.9 % and for P_e of -36.1%. The single differential cross sections showd that their magnitude was different between on the negative and positive polarisation while the shapes of the cross section against each kinematic variable were the same. The parity violation on the weak interaction is clearly demonstrated. The single differential and reduced double differential cross sections were compared with the standard model predictions and found to be consistent.

The measured total cross sections were as follows,

$\sigma^{e^+p}_{CC}$ (P_e = 32.9%) = 48.3 $\pm$ 1.01(stat.) $\pm$ 1.26 (lumi.) $^{+0.716}_{-0.695}$ (syst.) pb,

$\sigma^{e^+p}_{CC}$ (P_e = -36.2%) = 22.95 $\pm$ 0.817(stat.) $\pm$ 0.60(lumi.) $^{+0.350}_{-0.340}$ (syst.) pb,

where captions, stat., syst. and lumi. means the statistical error, uncertainty of the luminosity measurement, estimated total systematic uncertainty.

The measured total cross sections are presented in Fig. 1, together with the previous ZEUS measurements. Compared with the SM which predicts the linear polarization dependence of the CC cross sections, the measured cross sections are consistent with the theory.

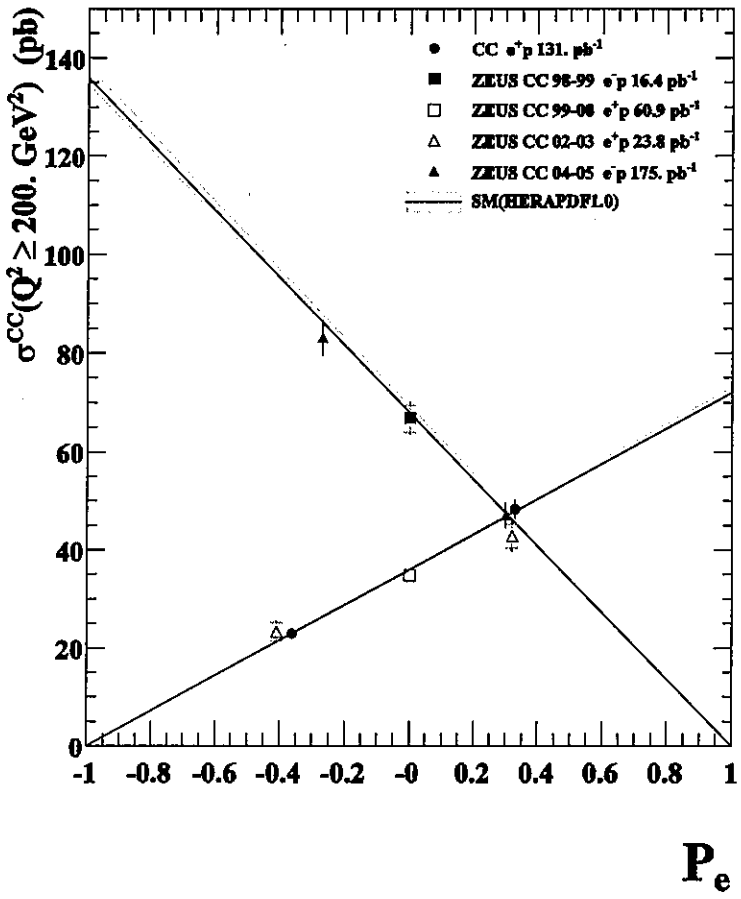

Fig 1. The CC DIS cross sections integrated over $Q^2 \geqq 200\ GeV^2$, which measured at $P_e = 32.9\%$ and $P_e = -0.362$. The SM predictions calculated by HERAPDF1.0 PDFs for e^+p and e-p collisions are also described with their uncertainties by the lines with shade band. The closed circles shows the result of this measurement and other markers show the previous ZEUS measurements for e^+p or e-p CC scattering.