ZEUS results on rapidity gap events in charged and neutral current processes at large Q^2

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Abstract. The observation of large rapidity gap(LRG) events in charged and neutral current deep inelastic scattering using e^+p data collected with the ZEUS detector is reported. These events are compared with phenomenological models. The ratio of LRG to inclusive cross sections have been determined at $Q^2 > 200$ GeV^2, where Q^2 is the negative square of the four-momentum of the exchanged boson, both for neutral and charged current processes.

Keywords: charrged current DIS, diffraction, large rapidity gap, neutral curent DIS
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INTRODUCTION

A significant fraction of the neutral current (NC) deep inelasitic scattering (DIS) measured at HERA was found to result from diffractive processes [1, 2]. The exchange of colour singlet leads to formation of a large rapidity gap (LRG) in the hadronic final state, located between the exchanged boson and the proton fragmentation regions.

ZEUS has observed LRG events also in charged current (CC) DIS, $e^+p \to \bar{\nu}_e XY$, at $Q^2 > 200$ GeV^2 [3]. This analysis presents the corresponding measurement for NC DIS, $e^+p \to e^+XY$, in the same kinematic region. Both CC and NC results are based on the same data sample collected during the running periods of 1999 and 2000 when HERA collided 27.5 GeV positrons with 920 GeV protons, yielding a centre-of-mass energy of $\sqrt{s} = 318$ GeV.

MONTE CARLO MODELS AND DATA SELECTION

Diffractive NC and CC events were modelled with the RAPGAP 2.08/06 [4] generator, in which colour singlet exchange occurs between virtual boson and proton.

Non-diffractive NC and CC events were produced with the DJANGOH 1.1 [5] generator interfaced to the colour-dipole model of ARIADNE 4.10 [6] for the fragmentation.

Soft Colour Interaction (SCI) model interfaced with the MEPS version of LEPTO 6.5 [7] gives rise to LRG events without introducing the concept of diffractive exchange. This model was used instead of the combination of the ARIADNE and RAPGAP samples.

The reconstruction and selection criteria for CC and NC event candidates are identical to those of inclusive CC [8] and NC [9] measurements. The kinematic requirements $Q^2 > 200$ GeV^2, $x_{\mathrm{Bj}} < 0.05$ and $y < 0.9$ were imposed, where x_{Bj} is the Bjorken scaling

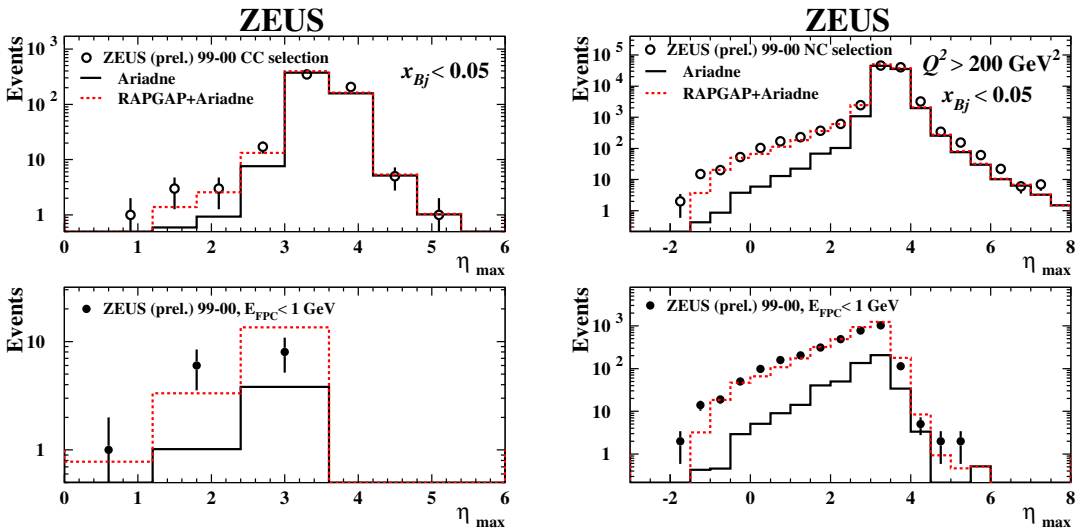

FIGURE 1. The distribution of $\eta_{\max}$ is shown in the upper left(right) plot for CC(NC) DIS events in the kinematic range $Q^2 > 200$ GeV^2, $y < 0.9$ and $x_{\mathrm{Bj}} < 0.05$. The circles are the data points, the solid histogram is the result of the non-diffractive (ARIADNE) MC simulation and the dashed histogram is that of the sum of non-diffractive and diffractive (RAPGAP) MC sample. The bottom plots show the same distributions with an additional requirement of $E_{\mathrm{FPC}} < 1$ GeV.

variable, and y is the inelasticity parameter. To observe events with a LRG, the variable $\eta_{\max}$, defined as the pseudorapidity of the energy deposit in the calorimeter closest to the proton direction, was considered. The distributions of $\eta_{\max}$ for the CC and NC candidates are shown in Fig. 1. The following criteria were applied to both the NC and CC samples to select LRG events:

- $E_{\mathrm{FPC}} < 1.0$ GeV, where E_{FPC} is the energy deposited in the forward plug calorimeter (FPC). The FPC increased the forward calorimeter coverage by about 1 unit of pseudo-rapidity to $\eta < 5$;
- $\eta_{\max} < 2.9$. This cut together with $E_{\mathrm{FPC}} < 1.0$ GeV cut ensures a gap of at least two units of rapidity;
- $x_{\mathrm{IP}} < 0.05$, where x_{IP} is the fraction of proton four-momentum carried by the exchanged colour singlet (Pomeron).

RESULTS

Figure 2 shows the distributions of relevant variables for CC and NC DIS events for data and the sum of non-diffractive (ARIADNE) and diffractive (RAPGAP) MC simulations. The MC simulations describe well both the inclusive sample and the LRG subsample for both the CC and NC.

Figure 3 shows the distributions of relevant variables for CC and NC DIS events together with the results of the MEPS with SCI included MC simulation. The rate of

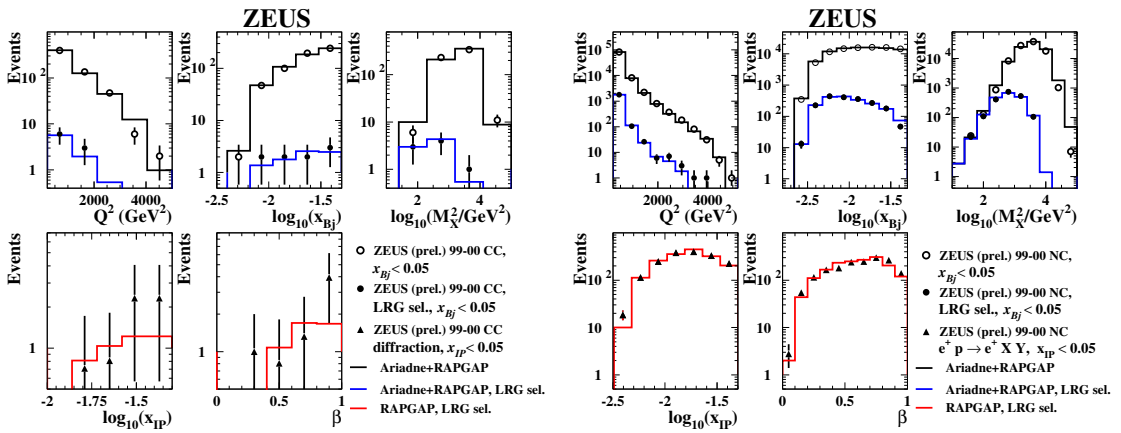

FIGURE 2. The upper left(right) plots show the distributions of Q^2, $\log x_{\mathrm{Bj}}$ and $\log M_X^2$, where M_X is the mass of the hadronic system X measured in the main detector, for CC(NC) DIS events in the kinematic range of $Q^2 > 200$ GeV^2, $y < 0.9$ and $x_{\mathrm{Bj}} < 0.05$. The circles are the data points and the solid histograms are the sum of results of non-diffractive (ARIADNE) and diffractive (RAPGAP) MC simulations. The lower data points and MC histograms on each plot correspond to the subsamples satisfying the LRG selection criteria. The bottom plots show the $\log x_{\mathrm{IP}}$ and β, distributions of the DIS events satisfying the LRG selection criteria. The triangles are the data points after statistical subtraction of non-diffractive (ARIADNE) contribution. The histogram is the result of diffractive (RAPGAP) MC simulation.

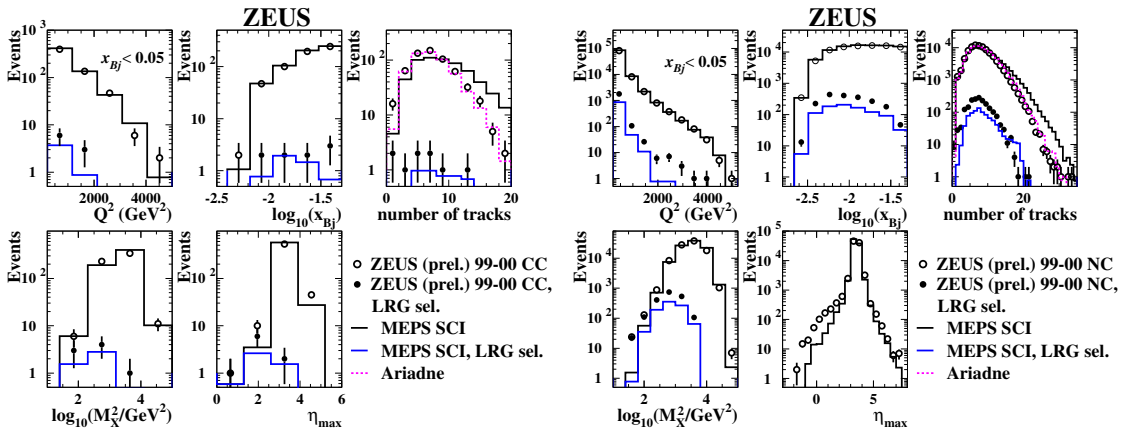

FIGURE 3. The left(right) plots show the distributions of Q^2, $\log x_{\mathrm{Bj}}$, number of tracks, $\log M_X^2$ and η_{max} for CC(NC) DIS events in the kinematic range $Q^2 > 200$ GeV^2, $y < 0.9$ and $x_{\mathrm{Bj}} < 0.05$. The circles are the data points and the solid histograms are the results of MEPS with SCI included MC simulations. The dashed histogram superimposed on the distribution of the number of tracks is the result of ARIADNE simulation. The lower data points and MC histograms on each plot correspond to the subsamples satisfying the LRG selection criteria.

events with a LRG expected by this MC model is smaller than observed in the data.

The ratio of LRG cross section to the total cross section was measured in the kinematic region of $Q^2 > 200$ GeV^2 and $x_{\mathrm{Bj}} < 0.05$ for both NC and CC processes. These ratios were found to be compatible as shown in Fig. 4.

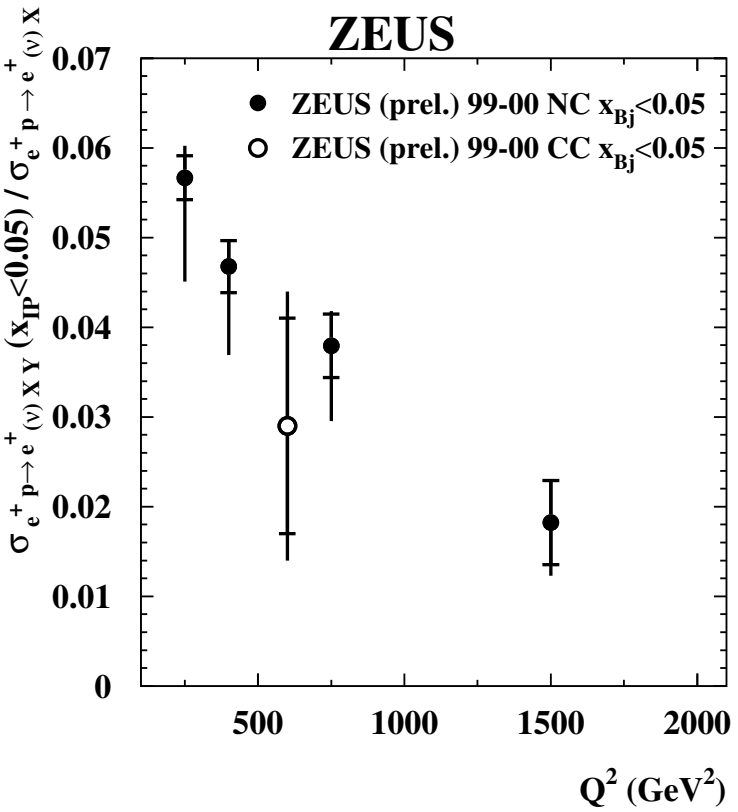

FIGURE 4. The ratio of the LRG cross section to the total cross section measured in the kinematic region $x_{\mathrm{Bj}} < 0.05$ as a function of Q^2 is presented both for NC and CC processes.

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