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CHARGE CURRENT EVENTS WITH A LARGE RAPODITY GAP

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The observation of large rapidity gap events in charge current deep inelastic scattering using e^+p data corresponding to an integrated luminosity of 60.9 pb^{-1}, collected with the ZEUS detector at HERA is reported.

1 Introduction

A significant part of the total neutral current (NC) deep inelastic scattering (DIS) cross section measured at HERA comes from diffractive processes [1]. A large rapidity gap (LRG) in the hadronic final state is characteristic for diffractive interactions. The charged current (CC) diffractive proccess is also interesting to study. CC LRG events in the process $e^+p \to \nu W^+ p \to \nu X$, have already been studied at HERA [2]. Such processes may be interpreted as arising from diffraction exchange, or could be events from the tail of the non-diffractive rapidity distribution.

This analysis is based on 1999-2000 ZEUS CC DIS data [3], corresponding to an integrated luminosity of 60.9 pb^{-1}. In this period HERA collided 27.5 GeV positrons with 920 GeV protons, resulting in a centre-of-mass energy $\sqrt{s} = 318$ GeV. LRG events were selected and the CC diffractive cross section σ_{CC}^{diff} and ratio of diffractive to total CC cross sections $\sigma_{CC}^{diff}/\sigma_{CC}^{tot}$ calculated. The results were compared with predictions from different theoretical models of diffractive scattering in the electroweak regime.

2 Monte Carlo Simulations

The following MC models were used in the analysis:

- Non-diffractive CC events were produced with the DJANGOH [4] generator interfaced to the ARIADNE [5] generator for the fragmentation. ARIADNE was used to determin the number of events from non-diffractive CC processes and to calculate the total cross section. For a systematic check the MEPS model of LEPTO [6] was used. Both programs use the Lund string model of JETSET [7] for the hadronisation.

- Diffracive CC events were modelled with the RAPGAP [8] generator, were colour singlet exchange occures between the virtual W^+ boson and proton. RAPGAP was used extract diffractive cross section. As an alternative, the MEPS model of LEPTO including soft colour interactions (SCI) which can give a rise to LRG events without introducing the concept of diffractive exchange was used.

- The photoproduction background was estimated using HERWIG [9]. The background from di-lepton production was estimated with the GRAPE [10] generator and the background from W production was studied using the EPVEC [11] program.

3 Large Rapidity Gap Events

LRG events were selected from the CC DIS sample for exchanged boson virtualities $Q^2 > 200$ GeV^2 and for Bjorken scaling variable values satisfying $x_{Bj} < 0.05$. To select events with an LRG, the distribution of η_{max} was used, where η_{max} is defined as the pseudorapidity of the energy deposition in the calorimeter above 400 MeV which is closest to the outgoing proton direction. The distribution is shown in the upper plot in Fig. 1. An excess of events with a LRG over the non-diffractive ARIADNE MC expectation is seen at low η_{max}. The bottom plot in Fig. 1 shows the η_{max} distribution with the requirement that the energy in the Forward Plug Calorimeter (FPC) [a] satisfies $E_{FPC} < 1$ GeV, suppressing the contribution from non-diffractive processes. Additional requirements of $\eta_{max} < 2.9$ and $x_{I\!P} < 0.05$, where $x_{I\!P}$ is the fraction of proton four-momentum carried by the diffractive exchange, reduce the remaining non-diffractive background. The η_{max} requirement ensures a gap in rapidity of at least 2 units between the hadronic system measured in the detector and the rest of the hadronic final state.

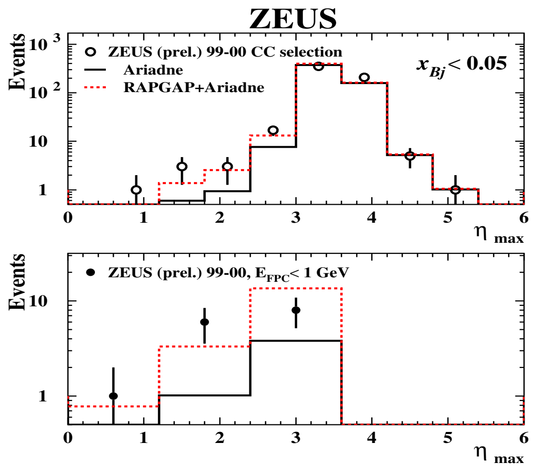

Figure 1. Comparison between data (dots) and MC models - non-diffractive ARIADNE (solid line) and ARIADNE plus diffractice RAPGAP for η_{max} distribution for CC DIS selection (upper plot) and for the same selection with additional $E_{FPC} < 1$ cut (lower plot).

Fig. 2 show the distributions of $\log(Q^2)$, x_{Bj} and $\log(M_X^2)$ for CC DIS events for data and the sum of non-diffractive (ARIADNE) and diffractive (RAPGAP) MC

[a] The FPC is a lead-scintillator calorimeter [12] installed in 1998 in the beam hole of the forward calorimeter [13], with a small hole of radius of 3.15 cm in the center to accommodate the beam pipe. It increases the FPC coverage by about 1 unit of pseudorapidity to $\eta < 5$.

simulations (upper plots), where M_X is the mass of the hadronic system X measured in the calorimeter. The same distributions are also shown for subsamples fulfilling the LRG selection criteria. The MC simulations correctly describe both the inclusive CC sample and the LRG subsample. The bottom plots in Fig. 2 show the distribution of the diffractive variables $\log(x_{I\!P})$ and β for LRG CC DIS events after statistical subtraction of non-diffractive background, where β is the fraction of pomeron momentum carried by the struck parton. The agreement with RAPGAP is satisfactory.

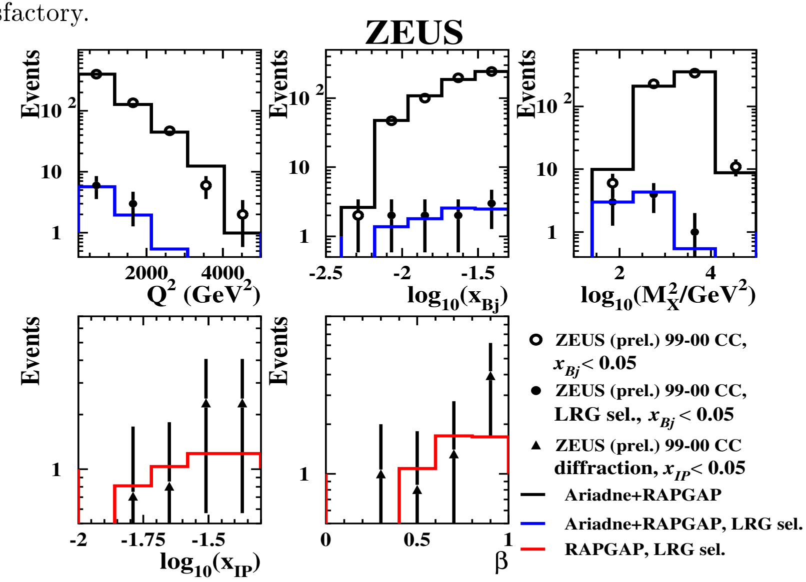

Figure 2. Comparison between data (dots) and MC models - non-diffractive ARIADNE and ARIADNE plus diffractive RAPGAP for various distributions for CC DIS selection and LRG selection (upper plot) and for the diffractive events, where in data the non-diffractive background was substracted statisticly (lower plot). In this case the data are compare to RAPGAP.

The rate of events with a LRG expected by MEPS MC with SCI model is smaller than observed in the data, but still compatible with data within large statistical uncertainty. In addition, the distribution of track multiplicity in inclusive sample is not described by this model, in contrast to ARIADNE. The MEPS version without SCI describes the track multiplicity distribution better, but the predicted rate of LRG events is reduced (not shown).

The numbers of selected CC events with LRG for 60.9 pb-1 of integrated luminosity were:

- 9 in the data,
- 5.6 ± 0.7 in the diffractive CC (RAPGAP) MC simulation,
- 2.1 ± 0.4 in the non-diffractive CC (ARIADNE) MC simulation. This number also includes a small contribution from di-lepton (GRAPE) background simulation,
- $3.9 \; {+1.0} \; {-0.7}$ in the CC MEPS MC simulation including SCI.

The sum of RAPGAP and ARIADNE expectations agrees with the number of CC LRG candidates observed in the data. The expectation from MEPS including SCI is below the data. Those observations suggest that the formation of large rapidity gap in CC DIS process is of diffractive nature. However, the data are still compatible with coming from the tail of the non-diffractive distribution.

4 Results

Under the assumption that the excess of LRG events over the non-diffractive expectation from ARIADNE is due to diffraction, the diffractive CC cross section, σ_{CC}^{diff}, was measured in the kinematic region $Q^2 > 200$ GeV^2 and $x_{I\!P} < 0.05$. In addition, the ratio of σ_{CC}^{diff} to the total CC cross section σ_{CC}^{tot} was calculated, where σ_{CC}^{tot} was measured in the kinematic region given by $Q^2 > 200$ GeV^2 and $x_{Bj} < 0.05$. The results are:

$$\sigma_{CC}^{diff}(e^+p \to \nu Xp) = 0.49 \pm 0.20(stat.) \pm 0.13(syst.)pb.$$

$$\sigma_{CC}^{diff}(e^+p \to \nu Xp)/\sigma_{CC}^{tot}(e^+p \to \nu Xp) = 2.9 \pm 1.2(stat.) \pm 0.8(syst.).$$

The ratio of diffractive to total CC cross sections is similar to that measured in the NC DIS process [14] in a similar kinematic region.

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