DIFFRACTION IN CHARGED CURRENT DIS

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Following the observation of one large rapidity gap CC DIS event by ZEUS in 1994 dedicated studies were made on experimental and theoretical aspects of diffractive CC scattering. The signature of these events is sufficiently unique to enable efficient selection and background rejection. The theoretical estimate of the cross section is $\sigma^{(diff)}_{ep\rightarrow\nu X}(x_{I\!P} < 0.1) = 2.1\,^{+1.0}_{-0.7}$ pb.

1 Introduction

Within the ZEUS sample of charged current DIS events, selected from the 1994 e^+p data, one event was found satisfying a large rapidity gap (LRG) selection as used for NC DIS events. This corresponds to the cross section: [1]

$$\sigma^{(LRG)}_{e^+p\rightarrow\bar{\nu}X}(Q^2 > 200GeV^2) \;=\; 0.8\,^{+1.8}_{-0.7}(stat.) \pm 0.1(syst.)\ \mathrm{pb}. \qquad (1)$$

This event is interpreted as a diffractive charged current DIS event, where the W^+ exchange occurs between positron and pomeron. Following this observation dedicated studies were made on both experimental and theoretical aspects of diffractive CC scattering.

2 Cross section estimate

The cross section for diffractive CC DIS can be expressed, similarly as in the case of NC DIS, in terms of the diffractive structure functions ${}^{CC}F_2^D$ and ${}^{CC}F_3^D$:

$$\frac{d^3\sigma^{CC}_{diff}}{d\beta dQ^2 dx_{I\!P}} = \frac{G_F^2}{4\pi}\,\frac{M_W^4}{(Q^2+M_W^2)^2}\,\frac{1}{\beta}\cdot \qquad (2)$$
$$\cdot\left[(1+(1-y)^2)\;{}^{CC}F_2^D(\beta,Q^2,x_{I\!P}) \;\pm\; (1-(1-y)^2)\,\beta\;{}^{CC}F_3^D(\beta,Q^2,x_{I\!P})\right],$$

where $x_{I\!P}$ is the fraction of proton momentum carried by pomeron, whereas β is the fraction of pomeron momentum carried by parton coupling to the W. The cross section is integrated over the undetected four-momentum transfer to the proton system.

In the studies presented here factorization of diffractive structure functions is assumed, i.e. they are decomposed into a pomeron flux factor independent of the hard scattering process and the parton distribution in pomeron. The calculations were performed in QPM approximation, neglecting higher order QCD contributions as well as any scaling violation of diffractive structure functions.

Assuming that the pomeron contains equal amounts of up and down type quarks and antiquarks the ${}^{CC}F_3^D$ structure function vanishes and ${}^{CC}F_2^D$ can be related to the diffractive structure function measured in NC DIS: ${}^{CC}F_2^D = \frac{18}{5}\,{}^{NC}F_2^D$. Using this relation and the parameterization of the ZEUS diffractive structure function measurement [2] integration of the cross section formula 2 yields [a]

$$\sigma^{(diff)}_{ep\to\nu X}(x_{I\!P} < 0.1) = 2.1\ ^{+1.0}_{-0.7}\ pb. \tag{3}$$

The integration was limited to $x_{I\!P} < 0.1$, as for higher $x_{I\!P}$ diffraction is not well defined. In case of diffractive CC DIS this is a significant constraint, since, due to the W mass in the propagator term (eq. 2), the diffractive CC cross section decreases very slowly with $x_{I\!P}$.[b] It also means that, in contrast to what we observe in NC diffractive scattering, the cross section is dominated by events with high M_x (invariant mass of pomeron-W system).

3 Experimental signature

In 1995 a dedicated trigger was implemented to select diffractive CC events. The selection is based on two basic requirements: the event should have rapidity gap in the forward direction (to select diffractive events) and a significant missing transverse momentum (to select CC events).

Due to the high diffractive masses involved, the rapidity gap is much smaller than in diffractive NC DIS. Hence we require the minimal rapidity gap observable in the main detector, corresponding to no energy deposits in the calorimeter cells adjacent to the beam pipe hole. The contribution of non-diffractive events can be additionally suppressed by use of scintillator counters placed behind the main calorimeter very close to the beam pipe (the so called Proton Remnant Tagger), which tag charged particles produced in the pseudorapidity interval 4.3< η <5.8.

To select CC events it was required that there is missing transverse momentum be at least 4 GeV. [c] Monte Carlo studies show that using additional

[a] The assumption of equal u and d contents of the pomeron also implies that the e^-p and e^+p CC diffractive cross sections are equal.

[b] For the pomeron flux factor parametrized as $(\frac{1}{x_{I\!P}})^a$ the cross section decreases approximately like $(\frac{1}{x_{I\!P}})^{a-1}$. The ZEUS measurement[2] gives $a = 1.30 \pm 0.08\ (stat)^{+0.08}_{-0.14}\ (sys)$.

[c] The standard ZEUS CC analysis uses a transverse momentum cut at trigger level of 8 GeV.

cuts on the transverse momentum and the transverse energy [d] of the event, applied for both calorimeter and track variables, one can suppress both photoproduction and NC DIS background below the signal level.

The final efficiency of the diffractive CC selection is of the order of 20% with a purity of the final sample of about 80%. Most of the background comes from non-diffractive CC DIS.

4 Perspectives

The first studies described above show that diffractive CC can be studied using the ZEUS detector. As soon as high luminosity data samples are collected we should be able to address many interesting issues:

- diffractive structure function factorization,
- pomeron flux description at high $x_{I\!P}$,
- Q^2 evolution of diffractive structure function,
- flavor and gluon contents of pomeron (through measurement of gW fusion).

The measurement of diffractive CC DIS should give a significant contribution to our understanding of diffractive phenomena.

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References

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[d]The transverse energy E_T is defined as the scalar sum of the transverse momenta over all calorimeter energy deposits, or over all tracks coming from the primary vertex, respectively.