PROCEEDINGS OF SCIENCE

Diffractive asymmetry of electroweak vector bosons at the LHC

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We analyse diffractive weak boson production in pp collisions. We show that the measurement of W boson production asymmetry in the diffractive pp collisions is a valuable method to test the concept of the flavour symmetric pomeron parton distributions.

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1. Diffractive production of W bosons

In the diffractive case, the standard inclusive parton distributions are replaced by diffractive parton distributions. The asymmetry is a particularly good observable since it is insensitive to the gap survival probability which in most of the approaches multiplies both the cross sections $d\sigma_{W^\pm}/dy$. The charge asymmetry in the W boson decays at Tevatron is presented in [1]. Forward-backword asymmetry of electron charged pairs is discussed in [2]. Basic papers on diffractive hadroproduction of $W^\pm$ and Z^0 bosons and also dijets at high energies are: [3, 4]. The single diffractive dissociation (SD), which we consider from now on, can be interpreted as a proton-pomeron ($p\mathbb{P}$) collision, where pomeron is a vacuum quantum number object with the partonic structure decribed by totaly symmetric pomeron parton distributions

$$u_{\mathbb{P}}(x) = \bar{u}_{\mathbb{P}}(x) = d_{\mathbb{P}}(x) = \bar{d}_{\mathbb{P}}(x) = s_{\mathbb{P}}(x) = \bar{s}_{\mathbb{P}}(x) = \ldots \equiv q_{\mathbb{P}}(x)\,. \tag{1.1}$$

Thus the W production cross section are related to quark distributions in the following way

$$\begin{aligned} \frac{d\sigma_{W^+}}{dy} &\sim (u_p(x_1) + \bar{d}_p(x_1))\, q_{\mathbb{P}}(x_2/x_{\mathbb{P}}) \\ \frac{d\sigma_{W^-}}{dy} &\sim (d_p(x_1) + \bar{u}_p(x_1))\, q_{\mathbb{P}}(x_2/x_{\mathbb{P}})\,, \end{aligned} \tag{1.2}$$

where the longitudinal momentum fractions, $x_1 = \frac{M_W}{\sqrt{s}}\, e^y$ for the proton quark and $x_2 = x_{\mathbb{P}}\beta = \frac{M_W}{\sqrt{s}}\, e^{-y}$ for the pomeron quark, and $x_{\mathbb{P}} = M_D^2/s$ is a fraction of the proton's momentum transferred into the diffractive system of mass M_D which contains the W boson. In addition, β is a fraction of the pomeron momentum carried by the parton taking part in the W boson production. From the condition: $0 < x_{\mathbb{P}}, \beta < 1$, we have for the W boson rapidity

$$-y_{max} + \ln(1/x_{\mathbb{P}}) < y < y_{max}\,. \tag{1.3}$$

where $\Delta = \ln(1/x_{\mathbb{P}})$ is the lenght of the rapidity gap.

The W boson production asymmetry is a particularly good observable since it is insensitive to the gap survival probability [5] which multiplies both the $W^\pm$ cross sections The pomeron parton distributions also cancel, and we obtain for the W asymmetry in the diffractive case,

$$A^D(y) = \frac{u_p(x_1) - d_p(x_1) + \bar{d}_p(x_1) - \bar{u}_p(x_1)}{u_p(x_1) + d_p(x_1) + \bar{d}_p(x_1) + \bar{u}_p(x_1)}\,, \tag{1.4}$$

where the parton distributions are taken at the scale $\mu = M_W$. Notice that $A^D(y)$ is independent of $x_{\mathbb{P}}$, i.e. the length of the rapidity gap. Substituting the decomposition written below

$$\begin{aligned} u_p(x) &= u_{val}(x) + u_{sea}(x)\,, \qquad \bar{u}_p(x) = u_{sea}(x) \\ d_p(x) &= d_{val}(x) + d_{sea}(x)\,, \qquad \bar{d}_p(x) = d_{sea}(x)\,, \end{aligned} \tag{1.5}$$

we find diffractive asymmetry in terms of the valence and sea quark distributions

$$A^D(y) = \frac{u_{val}(x_1) - d_{val}(x_1)}{u_{val}(x_1) + d_{val}(x_1) + 2\,(u_{sea}(x_1) + d_{sea}(x_1))}\,. \tag{1.6}$$

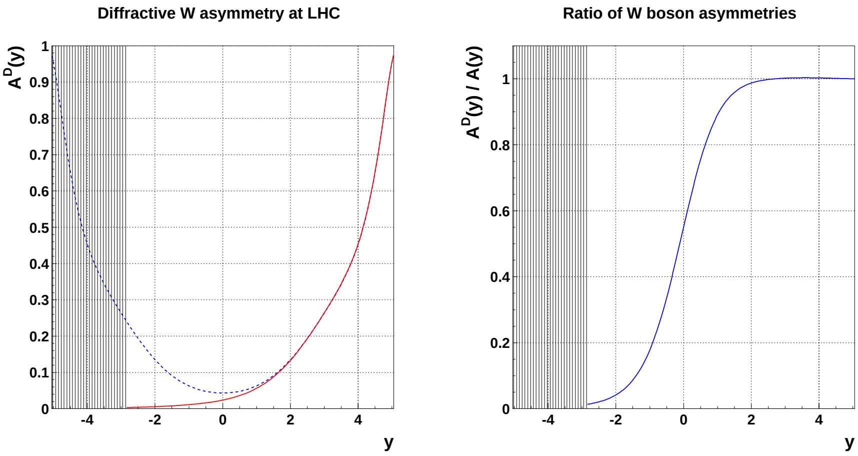

Figure 1: Left: The W boson asymmetry in $p\mathbb{P}$ collisions (solid line) together with the asymmetry in pp collisions (dashed line). The shaded area on both plots indicates the rapidity gap corresponding to $x_{\mathbb{P}} = 0.1$. Right: The ratio of the W boson production asymmetries in the diffractive and nondiffractive pp scattering.

This is an exact result obtained only under the assumption (1.1). In Fig. 1 (left) we show the asymmetry (1.6) (solid line) together with the W boson asymmetry in the inclusive case (dashed line), given in [6]. The ratio of these two asymmetries is shown on the right.

The pattern of the ratio is quite general and depends only on the assumption on flavour symmetry of the pomeron parton distributions, Eq. (1.1). Therefore, it would be interesting to test experimentally the very concept of the flavour symmetric pomeron parton distributions by measuring the ratio of the two W asymmetries in the diffractive and nondiffractive pp scattering. If it is true, the W asymmetry in the single diffractive case provides an additional constraint for the parton distribution functions in the proton.

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