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Diffractive hadroproduction of $W^{\pm}$ and Z^0 bosons at high energies

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Results from a phenomenological analysis of W and Z hard diffractive hadroproduction at high energies are reported. Using the Regge factorization approach, we consider the recent diffractive parton density functions extracted by the H1 Collaboration at DESY-HERA. In addition, we take into account multiple Pomeron exchange corrections considering a gap survival probability factor. It is found that the ratio of diffractive to nondiffractive boson production is in good agreement with the CDF and D0 data. We make predictions which could be compared to future measurements at the LHC.

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I. INTRODUCTION

Recently, the diffractive processes are attracting much attention as a way of amplifying the physics program at proton colliders, including new channels searching for New Physics. The investigation of these reactions at high energies gives important information on the structure of hadrons and their interaction mechanisms. Hard diffractive processes, such as the diffractive production of massive electroweak bosons and dijets, allow the study of the interplay of small- and large-distance dynamics within QCD. The existence of a hard scale provides the normalization of the Born term diagram. For boson hadroproduction, single diffractive dissociation can occur characterized by the existence of one large rapidity gap, which can be represented by the Pomeron exchange. At high energies, there are important contributions from unitarization effects, and the suppression of the single-Pomeron Born cross section due to the multiple-Pomeron contributions depends, in general, on the particular hard process. At the Tevatron energy, $\sqrt{s} = 1.8$ TeV, the suppression is in the range 0.05–0.2 [1–4]; whereas for LHC energy, $\sqrt{s} = 14$ TeV, the suppression appears to be of order 0.08–0.1 [1,2,4]. Therefore, the correct treatment of the multiple scattering effects is crucial for the reliability of the theoretical predictions of the cross sections for these diffractive processes.

In the present study, our motivation to perform a new analysis on diffractive boson production is twofold: to produce updated theoretical estimations compatible with the current Tevatron data on single diffractive W and Z hadroproduction [5,6] and to perform reliable predictions to the future measurements at the LHC. In order to do so, we use Regge factorization (single-Pomeron exchange) and the corresponding corrections for multiple-Pomeron scatterings. Factorization for diffractive hard-scattering is equivalent to the hard-scattering aspects of the Ingelman and Schlein (IS) model [7], where diffractive scattering is attributed to the exchange of a Pomeron, i.e., a colorless object with vacuum quantum numbers. The Pomeron is treated like a real particle, and one considers that a diffractive electron-proton collision is due to an electron-Pomeron collision and that a diffractive proton-proton collision is due to a proton-Pomeron collision. Therefore, the diffractive hard cross sections are obtained as a product of a hard-scattering coefficient, a known Pomeron-proton coupling, and parton densities in the Pomeron. The parton densities in the Pomeron have been systematically extracted from diffractive deep inelastic scattering measurements. In particular, the quark singlet and gluon content of the Pomeron is obtained from the diffractive structure function $F_2^{D(3)}(x_{\mathbb{P}}, \beta, Q^2)$. Recently, a new analysis of these diffractive parton distributions has been presented [8] by the H1 Collaboration in DESY-HERA. On the other hand, it is well known that the single-Pomeron approach produces results that overestimate the experimental values by a large factor [9,10]. Thus, in the present analysis the corresponding multiple-Pomeron exchange corrections will be taken into account.

This paper is organized as follows: In the next section, we present the main formulas to compute the inclusive and diffractive cross sections for W and Z hadroproduction. We show the details concerning the parametrization for the diffractive partons distribution in the Pomeron, extracted recently in DESY-HERA. In addition, we present the theoretical estimations for the gap survival probability factor that will be used in the comparison of our results with experimental measurements from Tevatron and extrapolations to the LHC energy. In the last section we present our numerical results and perform predictions to future measurements in CERN LHC experiments. The compatibility with data is analyzed, possible additional corrections are investigated, and the comparison with other approaches is considered.

II. DIFFRACTIVE HADROPRODUCTION OF MASSIVE GAUGE BOSONS

Let us start by introducing the main expressions to compute the inclusive and diffractive cross sections. For the *hard* diffractive processes we will consider the IS picture [7], where the Pomeron structure (quark and gluon content) is probed. The starting point is the generic cross section for a process in which partons of two hadrons, A and B, interact to produce a massive electroweak boson, $A + B \rightarrow (W^{\pm}/Z^0) + X$,

$$\frac{d\sigma}{dx_a dx_b} = \sum_{a,b} f_{a/A}(x_a, \mu^2) f_{b/B}(x_b, \mu^2) \times \frac{d\hat{\sigma}(ab \rightarrow [W/Z]X)}{d\hat{t}},$$

where $x_i f_{i/h}(x_i, \mu^2)$ is the parton distribution function (PDF) of a parton of flavor $i = a, b$ in the hadron $h = A, B$. The quantity $d\hat{\sigma}/d\hat{t}$ gives the elementary hard cross section of the corresponding subprocess and $\mu^2 = M^2_{W/Z}$ is the hard scale in which the PDFs are evolved in the QCD evolution. The equation above expresses the usual leading-order QCD procedure to obtain the nondiffractive cross section. Next-to-leading-order contributions are not essential for the present purposes.

In order to obtain the corresponding expression for diffractive processes, one assumes that one of the hadrons, say hadron A, emits a Pomeron whose partons interact with partons of the hadron B. Thus the parton distribution $x_a f_{a/A}(x_a, \mu^2)$ in Eq. (1) is replaced by the convolution between a distribution of partons in the Pomeron, $\beta f_{a/\mathbb{P}}(\beta, \mu^2)$, and the "emission rate" of Pomerons by the hadron, $f_{\mathbb{P}/h}(x_{\mathbb{P}}, t)$. The last quantity, $f_{\mathbb{P}/h}(x_{\mathbb{P}}, t)$, is the Pomeron flux factor, and its explicit formulation is described in terms of Regge theory. Therefore, we can rewrite the parton distribution as

$$x_a f_{a/A}(x_a, \mu^2) = \int dx_{\mathbb{P}} \int d\beta \int dt f_{\mathbb{P}/A}(x_{\mathbb{P}}, t) \beta f_{a/\mathbb{P}}(\beta, \mu^2) \times \delta\left(\beta - \frac{x_a}{x_{\mathbb{P}}}\right), \quad (1)$$

and, now defining $\bar{f}(x_{\mathbb{P}}) \equiv \int_{-\infty}^{0} dt f_{\mathbb{P}/A}(x_{\mathbb{P}}, t)$, one obtains

$$x_a f_{a/A}(x_a, \mu^2) = \int dx_{\mathbb{P}} \bar{f}(x_{\mathbb{P}}) \frac{x_a}{x_{\mathbb{P}}} f_{a/\mathbb{P}}\left(\frac{x_a}{x_{\mathbb{P}}}, \mu^2\right). \quad (2)$$

Concerning the $W^{\pm}$ diffractive production, one considers the reaction $p + \bar{p}(p) \rightarrow p + W(\rightarrow e\nu) + X$, assuming that a Pomeron emitted by a proton in the positive z direction interacts with a $\bar{p}$ (or a p) producing $W^{\pm}$ that subsequently decays into $e^{\pm}\nu$. The detection of this reaction is triggered by the lepton (e^+ or e^-) that appears boosted towards negative η (rapidity) in coincidence with a rapidity gap in the right hemisphere.

By using the same concept of the convoluted structure function, the diffractive (single diffraction, SD) cross section for the inclusive lepton production for this process becomes

$$\frac{d\sigma^{\rm SD}_{\rm lepton}}{d\eta_e} = \sum_{a,b} \int \frac{dx_{\mathbb{P}}}{x_{\mathbb{P}}} \bar{f}(x_{\mathbb{P}}) \int dE_T f_{a/\mathbb{P}}(x_a, \mu^2) f_{b/\bar{p}(p)}(x_b, \mu^2) \times \left[\frac{V^2_{ab} G^2_F}{6s\Gamma_W}\right] \frac{\hat{t}^2}{\sqrt{A^2 - 1}}, \quad (3)$$

where

$$x_a = \frac{M_W e^{\eta_e}}{(\sqrt{s} x_{\mathbb{P}})}[A \pm \sqrt{(A^2 - 1)}], \quad (4)$$

$$x_b = \frac{M_W e^{-\eta_e}}{\sqrt{s}}[A \mp \sqrt{(A^2 - 1)}], \quad (5)$$

and

$$\hat{t} = -E_T M_W [A + \sqrt{(A^2 - 1)}] \quad (6)$$

with $A = M_W/2E_T$, E_T being the lepton transverse energy and G_F the Fermi constant and the hard scale $\mu^2 = M^2_W$. The quantity V_{ab} is equal to the Cabibbo-Kobayashi-Maskawa matrix element if $e_a + e_b = \pm 1$ and zero otherwise, where a, b denote quark flavors and e_q the fractional charge of quark q. The upper signs in Eqs. (4) and (5) refer to W^+ production (that is, e^+ detection). The corresponding cross section for W^- is obtained by using the lower signs and $\hat{t} \leftrightarrow \hat{u}$.

In a similar way, the cross section for the diffractive hadroproduction of neutral weak vector boson Z is given by

$$\sigma^{\rm SD}_Z(\sqrt{s}) = \sum_{a,b} \int \frac{dx_{\mathbb{P}}}{x_{\mathbb{P}}} \int \frac{dx_b}{x_b} \times \int \frac{dx_a}{x_a} \bar{f}(x_{\mathbb{P}}) f_{a/\mathbb{P}}(x_a, \mu^2) f_{b/\bar{p}(p)}(x_b, \mu^2) \times \left[\frac{2\pi C^Z_{ab} G_F M^2_Z}{3\sqrt{2}s}\right] \frac{d\hat{\sigma}(ab \rightarrow ZX)}{d\hat{t}}, \quad (7)$$

where $C^Z_{q\bar{q}} = 1/2–2|e_q|\sin^2\theta_W + 4|e_q|^2\sin^4\theta_W$, with θ_W being the Weinberg or weak-mixing angle. The definitions for $x_{a,b}$ are similar as for the W case and now $\mu^2 = M^2_Z$. The values of the electroweak parameters that appear in the various formulas were taken from the Particle Data Group handbook [11], and we use only four flavors (u, d, s, c) in the weak-mixing matrix, with the Cabibbo angle $\theta_C = 0.2269$.

A. The Pomeron flux factor

An important element in the calculation of hard diffractive cross sections is the Pomeron flux factor, introduced in Eq. (1). We take the experimental analysis of the diffractive structure function [8], where the $x_{\mathbb{P}}$ dependence is parametrized using a flux factor motivated by Regge theory [12],

$$f_{\mathbb{P}/\mathrm{p}}(x_{\mathbb{P}}, t) = A_{\mathbb{P}} \cdot \frac{e^{B_{\mathbb{P}} t}}{x_{\mathbb{P}}^{2\alpha_{\mathbb{P}}(t)-1}}, \qquad (8)$$

where the Pomeron trajectory is assumed to be linear, $\alpha_{\mathbb{P}}(t) = \alpha_{\mathbb{P}}(0) + \alpha'_{\mathbb{P}} t$, and the parameters $B_{\mathbb{P}}$ and $\alpha'_{\mathbb{P}}$ and their uncertainties are obtained from fits to H1 forward proton spectrometer (FPS) data [13]. The normalization parameter $A_{\mathbb{P}}$ is chosen such that $x_{\mathbb{P}} \cdot \int_{t_{\mathrm{cut}}}^{t_{\mathrm{min}}} f_{\mathbb{P}/\mathrm{p}} dt = 1$ at $x_{\mathbb{P}} = 0.003$, where $|t_{\mathrm{min}}| \simeq m_p^2 x_{\mathbb{P}}^2/(1 - x_{\mathbb{P}})$ is the minimum kinematically accessible value of $|t|$, m_p is the proton mass, and $|t_{\mathrm{cut}}| = 1.0\ \mathrm{GeV}^2$ is the limit of the measurement.

The flux factor above corresponds to the standard Pomeron flux from Regge phenomenology, based on the Donnachie-Landshoff model [14]. On the other hand, there is an alternative Pomeron flux, proposed first by Goulianos [15], which considers it as a probability density. Thus, the integral over the diffractive phase space could not exceed the unit and the standard flux should be normalized. For instance, see Ref. [10] for previous phenomenology using the normalized flux in boson hadroproduction.

B. The Pomeron structure function

In the estimates for the diffractive cross sections, we will consider the diffractive PDFs recently obtained by the H1 Collaboration at DESY-HERA [8]. The Pomeron structure function has been modeled in terms of a light flavor singlet distribution $\Sigma(z)$, consisting of u, d and s quarks and antiquarks with $u = d = s = \bar{u} = \bar{d} = \bar{s}$, and a gluon distribution $g(z)$. Here, z is the longitudinal momentum fraction of the parton entering the hard subprocess with respect to the diffractive exchange, such that $z = \beta$ for the lowest order quark-parton model process, whereas $0 < \beta < z$ for higher order processes. The quark singlet and gluon distributions are parametrized at Q_0^2 with the general form,

$$z f_i(z, Q_0^2) = A_i z^{B_i}(1 - z)^{C_i} \exp\left[-\frac{0.01}{(1 - z)}\right], \qquad (9)$$

where the last exponential factor ensures that the diffractive PDFs vanish at $z = 1$. The charm and beauty quarks are treated as massive, appearing via boson gluon fusion-type processes up to order α_s^2. To determine experimentally the diffractive PDFs, the following cuts have been considered: $\beta < 0.8$, $M_X > 2$ GeV, and $Q^2 < 8.5\ \mathrm{GeV}^2$, mostly in order to avoid regions influenced by higher twist contributions or large theoretical uncertainties [8].

For the quark singlet distribution, the data require the inclusion of all three parameters A_q, B_q, and C_q in Eq. (9). By comparison, the gluon density is weakly constrained by the data, which are found to be insensitive to the B_g parameter. The gluon density is thus parametrized at Q_0^2 using only the A_g and C_g parameters. With this parametrization, one has the value $Q_0^2 = 1.75\ \mathrm{GeV}^2$, and it is referred to as the "H1 2006 DPDF Fit A." It is verified that the fit procedure is not sensitive to the gluon PDF and a new adjustment was done with $C_g = 0$. Thus, the gluon density is then a simple constant at the starting scale for evolution, which was chosen to be $Q_0^2 = 2.5\ \mathrm{GeV}^2$, and it is referred to as the "H1 2006 DPDF Fit B." The quark singlet distribution is well constrained, with an uncertainty of typically 5%–10% and good agreement between the results of both fits [8].

C. The gap survival factor

In the following analysis we will consider the suppression of the hard diffractive cross section by multiple-Pomeron scattering effects. This is taken into account through a gap survival probability factor. There has been large interest in the probability of rapidity gaps in high energy interactions to survive as they may be populated by secondary particles generated by rescattering processes. This effect can be described in terms of screening or absorptive corrections, which can be estimated using the quantity [16]

$$\langle |S|^2 \rangle = \frac{\int |\mathcal{A}(s, b)|^2 e^{-\Omega(s,b)} d^2 b}{\int |\mathcal{A}(s, b)|^2 d^2 b}, \qquad (10)$$

where $\mathcal{A}$ is the amplitude, in the impact parameter space, of the particular process of interest at center-of-mass energy $\sqrt{s}$. The quantity Ω is the opacity (or optical density) of the interaction of the incoming hadrons. This suppression factor of a hard process accompanied by a rapidity gap depends not only on the probability of the initial state survival but also on its sensitivity to the spatial distribution of partons inside the incoming hadrons, and thus on the dynamics of the whole diffractive part of the scattering matrix.

For our purpose, we consider two theoretical estimates for the suppression factor. The first one is the work of Ref. [4] (labeled KMR), which considers a two-channel eikonal model that embodies pion-loop insertions in the Pomeron trajectory, diffractive dissociation, and rescattering effects. The survival probability is computed for single, central, and double diffractive processes at several energies, assuming that the spatial distribution in impact parameter space is driven by the slope B of the Pomeron-proton vertex. We will consider the results for single diffractive processes with $2B = 5.5\ \mathrm{GeV}^{-2}$ (slope of the electromagnetic proton form factor) and without N^* excitation, which is relevant to an FPS measurement. Thus, we have $\langle |S|^2 \rangle_{\mathrm{KMR}} = 0.15$ for $\sqrt{s} = 1.8$ TeV (Tevatron) and $\langle |S|^2 \rangle_{\mathrm{KMR}} = 0.09$ for $\sqrt{s} = 14$ TeV (LHC).

The second theoretical estimate for the gap factor is from Ref. [17] (labeled GLM), which considers a single-channel eikonal approach. We take the case where the soft input is obtained directly from the measured values of σ_{tot}, σ_{el}, and hard radius R_H. Then, one has $\langle |S|^2 \rangle_{\mathrm{GLM}} = 0.126$

for $\sqrt{s} = 1.8$ TeV (Tevatron) and $\langle |S|^2 \rangle_{\rm GLM} = 0.081$ for $\sqrt{s} = 14$ TeV (LHC). We quote Ref. [17] for a detailed comparison between the two approaches and further discussions on model dependence of inputs and consideration of multichannel calculations. It should be stressed that our particular choice by KMR and GLM (single-channel) models is in order to indicate the uncertainty (model dependence) of the soft interaction effects. It is worth mentioning that some implementations of the GLM model include the results of a two- or three-channel calculation for $\langle |S|^2 \rangle$, which are considerably smaller than the one-channel result [17].

III. RESULTS AND DISCUSSION

In the following, we present our predictions for hard diffractive production of W's and Z's based on the previous discussion. These predictions are compared with experimental data from Refs. [5,6] in Tables I and II. In addition, estimations for the LHC are presented. In the numerical calculations, we have used the new H1 parametrizations for the diffractive PDFs [8]. The H1 2006 DPDF Fit A was considered, and one verifies that the results are not quite sensitive to a replacement by H1 2006 DPDF Fit B. For the usual PDFs in the proton (antiproton) we have considered the updated MRST2004F4 parametrization [18], which is a four-fixed-flavor version of the standard MRST2004 parton distributions. As the larger uncertainty comes from the gap survival factor, the error in the predictions correspond to the theoretical band for $\langle |S|^2 \rangle$. In the theoretical expressions of the previous section only the interaction of Pomerons (emitted by protons) with antiprotons (protons in LHC case) are computed, that means events with rapidity gaps on the side from which antiprotons come from. The experimental rate is for both sides, that is events with a rapidity gap on the proton or antiproton side. Therefore, we have multiplied the theoretical prediction by a factor of 2 in order to compare it with data.

Let us start by the diffractive W production. In order to illustrate our investigation, in Fig. 1 we present the rapidity distribution of the electron (dot-dashed lines) and positron (solid lines) generated in both inclusive and diffractive $W^\pm$ hadroproduction in Tevatron for $\sqrt{s} = 1.8$ TeV. The diffractive cross sections are not corrected by the gap survival factor and they are given by Eq. (3). In this case, the diffractive production rate is approximately 7% (using the cut $|\eta| < 1$) being very large compared to the Tevatron data. When considering the gap survival probability correction, the values are in better agreement with data. When considering central W boson fraction, $-1.1 < \eta_e < 1.1$ (cuts of CDF and D0 [5,6]), we obtain a diffractive rate of 0.67% using the KMR estimate for $\langle |S|^2 \rangle$, whereas it reaches 0.76% for the GLM estimate. The average rate considering the theoretical band for the gap factor is then $R_W = 0.715 \pm 0.045\%$. This result is consistent with the experimental central values $R_W^{\rm CDF} = 1.15\%$ and $R_W^{\rm D0} = 1.08\%$. The agreement would be better if the subleading Reggeon contribution is added, which was not considered in the present calculation. In Ref. [19], it was shown that its introduction considerably enhances the diffractive ratio in the Tevatron regime. Considering the forward W fraction, $1.5 < |\eta_e| < 2.5$ (D0 cut), one obtains $R_W = 0.83\%$ for KMR and $R_W = 2.58\%$ for GLM, with an averaged value of $R_W = 1.7 \pm 0.875\%$. In this case, our estimate is larger than the central experimental value $R_W^{\rm D0} = 0.64\%$. For the total $W \to e\nu$ we have $R_W = 0.68\%$ for KMR and $R_W = 0.79\%$ for GLM and the mean value $R_W = 0.735 \pm 0.055\%$, which is in agreement with data and consistent with a large forward contribution. Finally, we estimate the diffractive ratio for the LHC energy, $\sqrt{s} = 14$ TeV. In this case we extrapolate the

TABLE I. Data versus model predictions for diffractive $W^\pm$ hadroproduction (cuts $E_{T_{\rm min}} = 20$ GeV and $x_{\mathbb{P}} < 0.1$).

$\sqrt{s}$	Rapidity	Data (%)	Estimate (%)
1.8 TeV	$\vert\eta_e\vert < 1.1$	1.15 ± 0.55 [5]	0.715 ± 0.045
1.8 TeV	$\vert\eta_e\vert < 1.1$	1.08 ± 0.25 [6]	0.715 ± 0.045
1.8 TeV	$1.5 < \vert\eta_e\vert < 2.5$	0.64 ± 0.24 [6]	1.7 ± 0.875
1.8 TeV	Total $W \to e\nu$	0.89 ± 0.25 [6]	0.735 ± 0.055
14 TeV	$\vert\eta_e\vert < 1$	$\cdots$	31.1 ± 1.6

TABLE II. Data versus model predictions for diffractive Z^0 hadroproduction (cuts $E_{T_{\rm min}} = 16$ GeV and $x_{\mathbb{P}} < 0.1$).

$\sqrt{s}$	Rapidity	Data (%)	Estimate (%)
1.8 TeV	Total $Z \to e^+e^-$	1.44 ± 0.80 [6]	0.71 ± 0.05
14 TeV	Total $Z \to e^+e^-$	$\cdots$	30.26 ± 1.41

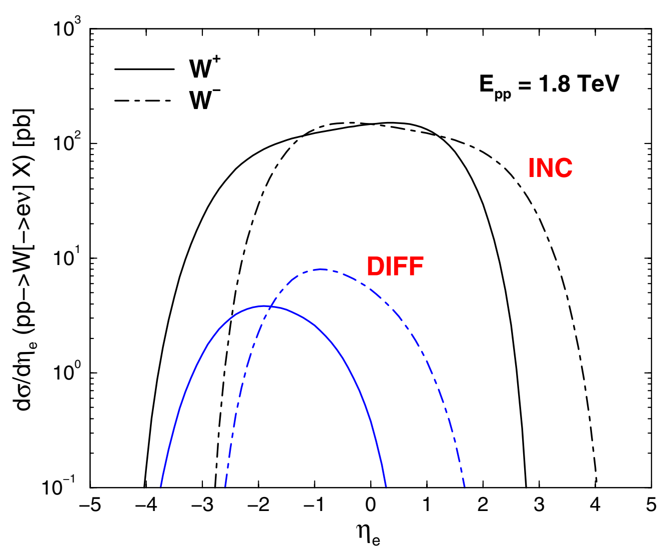

FIG. 1 (color online). The rapidity distribution of electron and positron generated in inclusive and diffractive W hadroproduction at $\sqrt{s} = 1.8$ TeV (see text).

PDFs in proton and diffractive PDFs in Pomeron to that kinematical region. This procedure introduces somewhat additional uncertainties in the theoretical predictions. We take the conservative cuts $|\eta_e| < 1$, $E_{T_{\min}} = 20$ GeV for the detected lepton, and $x_{\mathbb{P}} < 0.1$. We find $R_W = 32.7\%$ for KMR gap survival probability factor and $R_W = 29.5\%$ for GLM, with a mean value of $R_W^{\rm LHC} = 31.1 \pm 1.6\%$. This means that the diffractive contribution reaches one third, or even more, of the inclusive hadroproduction even when multiple-Pomeron scattering corrections are taken into account. The reason for this enhancement is the increasingly large diffractive cross section. The results presented above are summarized in Table I. The experimental errors have been summed into quadrature.

Now, we present the investigations for the diffractive Z hadroproduction. When the gap survival factor is not considered, the diffractive cross section is given by Eq. (7), producing a diffractive rate of 6.2%. This value is once again higher than the Tevatron data by a factor of 5. When considering the gap survival correction, we verify an agreement with experiment. For the total $Z \to e^+e^-$ we obtain a diffractive rate of 0.66% using the KMR estimate for $\langle|S|^2\rangle$, whereas it reaches 0.76% for the GLM estimate. The average value gives $R_Z = 0.71 \pm 0.05$, which is consistent with the experimental result $R_Z^{\rm D0} = 1.44 + 0.61–0.52$. A rough extrapolation to LHC energy gives $R_Z = 31.67$ with KMR gap factor and $R_Z = 28.85$ for GLM, with a mean value $R_Z^{\rm LHC} = 30.26 \pm 1.41$. We again consider the conservative cuts $E_{T_{\min}} = 16$ GeV and $x_{\mathbb{P}} < 0.1$. This estimate follows a similar trend as for the W case. The results presented above are summarized in Table II. The experimental errors have been summed into quadrature.

Our results can be compared with previous calculations in diffractive boson hadroproduction. For instance, in Ref. [10] one uses IS approach with a normalized Pomeron flux [15] and the corresponding diffractive PDFs. The data description for the W case is reasonable. However, the calculations are only compared to the CDF [5] data and they are somewhat larger than ours. In Ref. [19] a hard Pomeron flux is considered, i.e., $\alpha_{\mathbb{P}}(0) \simeq 1.4$, and multiple scatterings are taken into account by a Monte Carlo calculation. In addition, for Tevatron energies the Reggeon contribution is added. The results are compared only to CDF data [5] for the W production, and the description is consistent with experiment. It is an interesting fact that a hard Pomeron flux could mimic the multiple-Pomeron suppression or the effect of normalizing the standard Pomeron flux. Finally, we need call attention to the uncertainty in the determination of the gap survival probability. The estimates considered here (KMR and GLM) are compatible with each other for the case of single diffractive processes. However, recent calculations using a one-channel eikonal model give larger values for $\langle|S|^2\rangle$ [3,20]. For instance, in Ref. [20] an eikonal QCD model with a dynamical gluon mass (DGM) was considered. Using a gluon mass $m_g = 400$ MeV, one obtains $\langle|S|^2\rangle_{\rm DGM}({\rm Tevatron}) = 27.6 \pm 7.8\%$ and $\langle|S|^2\rangle_{\rm DGM} \times ({\rm LHC}) = 18.2 \pm 7.0\%$. These values give $R_W(\sqrt{s} = 1.8\ {\rm TeV}) \simeq 1.23\%$ and $R_Z(\sqrt{s} = 1.8\ {\rm TeV}) \simeq 1.21\%$. This illustrates the size of uncertainty when considering different estimates for the gap probability.

In summary, we have shown that it is possible to obtain a reasonable overall description of hard diffractive hadroproduction of massive gauge bosons by the model based on Regge factorization supplemented by the gap survival factor. For the Pomeron model, we take the recent H1 diffractive parton density functions extracted from their measurement of $F_2^{D(3)}$. The results are directly dependent on the quark singlet distribution in the Pomeron. We did not observe a large discrepancy in using the different fit procedure for diffractive PDFs (fit A and B). We estimate the multiple interaction corrections taking the theoretical prediction of distinct multichannel models, where the gap factor decreases on energy. That is, $\langle|S|^2\rangle \simeq 15–17.5\%$ for Tevatron energies going down to $\langle|S|^2\rangle \simeq 8.1–9\%$ at LHC energy. We find that the ratio of diffractive to nondiffractive boson production is in good agreement with the CDF and D0 data when considering these corrections. The overall diffractive ratio for $\sqrt{s} = 1.8$ TeV (Tevatron) is of order 1%. In addition, we make predictions which could be compared to future measurements at the LHC. The estimates give large rates of diffractive events, reaching values higher than 30% of the inclusive cross section.

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